Stream Restoration Plan

Miller Site
Meat Camp Creek, Watauga County

North Carolina Wildlife resources Commission
Habitat Conservation Program

Joe Mickey & Staci Scott

June 2001

Stream Restoration Plan

Miller Site
Meat Camp Creek, Watauga County

North Carolina Wildlife resources Commission
Habitat Conservation Program

Joe Mickey & Staci Scott

June 2001

Stream Restoration Plan - Miller Site on Meat Camp Creek, Watauga County

Introduction

Objectives

Existing Conditions

Site Recommendations
- Stream Restoration/enhancement
- Riparian Improvements
- Livestock Exclusion
- Conservation Easement

Erosion Control

Spill Containment

Monitoring
- Photo Reference Sites
- Cross sections
- Longitudinal Profiles
- Pebble Counts
- Vegetative Cover
- Plant Survival

Conclusion

Appendix 1
- Site Map
- Site Photos

Appendix 2
- Longitudinal Profile
- Cross-sections
- Pebble Count Data
- Reach Parameters

Appendix 3
- Plan view of Stream Improvement Structures
- Structures (rock weirs, rock vanes, root wads)
- Typical Bank Profile (showing typical grading, vegetation)

Appendix 4
- Vegetation

Appendix 5
- Livestock Exclusion
- Conservation Easement Map

Appendix 6
- Monitoring

Introduction

This plan is submitted as part of the fulfillment of the off-site stream mitigation agreement between the North Carolina Department of Transportation (DOT) and North Carolina Wildlife Resources Commission (WRC) for the R-529 US 421 road improvement project in Watuaga County. Under this agreement, a total of 14,814 linear feet of stream mitigation is required by the United States Army Corps of Engineers (COE) and 7,407 linear feet of mitigation for the North Carolina Division of Water Quality (DWQ). The purpose of this plan is to document those practices that are suppose to restore/enhance approximately 652 linear feet of Meat Camp Creek located on the Dale Miller, Joe Proffitt (2 tracts), Burl Winebarger, Bruce Miller, and Janice Baxter property, Watauga County. This project is known as the Miller site since Dale Miller owns all of the land on the left bank. Most of the restoration activities will occur on Mr. Miller's property.

Objectives

The objectives of the stream restoration project on Meat Camp Creek at the Miller site are as follows:

1. Increase fish habitat by constructing three rock cross weirs between stations 1+00 to 3+00.

2. Stabilize, slope and vegetate the banks along the 110 foot section of eroding bank up and downstream from station 3+33 to reestablish a bankfull bench, create pool habitat in place of a riffle, and to make the banks more resistant to erosion and flooding. Root wads and rock vanes will be used at this location for long term bank stability

3. Where appropriate, install rootwads, rock vanes or rock weirs from stations 4+00 to 5+40 to provide long term bank stability, fish habitat, narrow and deepen the stream channel, and protect the SR 1335 road shoulder.

4. Plant native trees, shrubs and ground cover on all disturbed banks and along the channel to provide long term bank stability, stream shading, and cover and food for wildlife.

5. Exclude livestock from the riparian zone through fencing and alternate water source development as specified in the plan developed by the Natural Resource Conservation Service (Dale Miller site only).

Existing Conditions

Appendix 1 provides a map and photos of the site. Meat Camp Creek is a tributary to the South Fork New River in the New River drainage, Watauga County. The watershed area of the proposed project is approximately 3.5 square miles. Land use consists of small rural farms containing pastures, home sites and forested wood lots. Most of the flatter valleys are used for home sites, to raise crops and graze livestock. Minimal livestock grazing occurs on steep slopes. A significant portion of the watershed remains in secondary growth forest. There is some conversion of agricultural land to single family home sites. Meat Camp Creek has suffered from past and ongoing land disturbing activities within the watershed. Old aerial photos and field observations show that the stream in the alluvial valley has been channelized at numerous locations to consolidate fields and accommodate road and home construction. Streambank instability from poor riparian zone management in the watershed has continued for many years, causing adverse water quality impacts through increased sedimentation from eroding streambanks.

The stream flows through an alluvial valley (Valley Type VIII) with soils in the Dellwood series. Dellwood soils consist of gravelly loamy sand on 2 to 5 percent slopes. These soils are moderately well drained soils on floodplains. The surface layer is loamy with underlying material consisting of sand, gravel, and cobbles within a depth of 8 to 20 inches. Permeability is moderately rapid in the surface layer and rapid or very rapid in the underlying material. These soils are subject to frequent flooding.

At the restoration site the riparian zone is narrow (less than 10 feet, each bank) except along the lower third of the Miller property, where a secondary growth forest exists. Along the right bank the stream parallels SR 1335. At several locations there is very little room between the stream and the road. Vegetation along this narrow riparian zone consists primarily of buckeye (*Aesculus octandra*), hickory (*Carya spp.*), basswood (*Tilia heterophylla*), umbrella tree (*Magnolia tripetala*), red maple (*Acer rubrum*), chestnut oak (*Quercus prinus*), white

pine (*Pinus strobus*), black locust (*Robinia pseudoacacia*), rhododendron (*Rhododendron catawbiense*), and multiflora rose (*Rosa multiflora*). The lack of riparian vegetation along one 110 foot section of bank on the Miller property has resulted in severe bank loss during flood events. There is some bank erosion occurring at several other locations, most notably along the right bank paralleling SR 1335. The instability of the streambanks at other locations is causing adverse water quality impacts through increased sedimentation. Fish cover exists in the form long shallow riffles, two small pools, some woody debris and areas of undercut banks. These conditions provide fair habitat for aquatic species.

Appendix 2 provides a summary of the existing condition survey (longitudinal profile, cross-sections, pebble counts, and reach parameters). The stream at this location is composed of 96% riffles and 4% pools. Bankfull was determined using field-identified indicators, primarily a scour line and point bar height, and evaluated using regional curve information (NCSU-Stream Restoration Institute). Three riffle cross-sections (stn.2+06, 3+33 and 4+16) were analyzed to obtain existing stream type data (Appendix 2). For design purposes, stable riffle reference reach data was taken from Meadow Fork Creek (4.5 sq. mi. watershed) and Big Sandy Creek (1.6 sq mi. watershed). These sites, in conjunction with regional curve data, were used as the only reference sites since no change in pattern is planned. Sinuosity is 1.1, water surface slope 0.012 ft, valley slope 0.013 ft, entrenchment ratio 3.5, and width/depth ratio 12. Medium to course cobble is the bed material at cross-section 3, station 3+33 (D50 = 110mm, D95 115mm). At this location the stream appears to be in transition from a Class B3 to Class C3. Channel sinuosity is low because the stream has been channelized due to past land use practices (agriculture, gristmills, and road construction). The stream should have more sinuosity based on the existing wide floodplain and Valley Type III. The stream type at the Miller site is a C3b.

Site Recommendations

Stream Restoration/enhancement

Appendix 3 shows the plan view of the proposed restoration and planned structures. At selected locations we propose to construct rock weirs, rock vanes, log vanes, and root wad structures to improve in-stream aquatic habitat and provide long term bank stability. Approximately 110 feet of eroding streambank at cross-section 3+33 will be reshaped with a bankfull bench and sloped above the bench on a 2:1 slope. The purpose of this activity is to reduce streambank erosion. Disturbed banks will be revegetated and planted with riparian shrubs and trees.

Rock/log vanes, rock weirs and root wads will be used to reduce the near bank water velocity and stress. Rock for vanes and weirs will be collected on site from a section of riprapped channel or hauled to the site from US 421 waste areas or a local quarry. Root wads and logs will be hauled to the site from stockpiles along the new section of US 421. Structures will be built by a track-hoe working from the top of the bank or from within the channel if necessary. Vanes and weirs will be off-set from the bank 20-30 degrees and will be sloped from a bankfull or inner berm elevation upstream and into the bed of the stream on a 8-15% slope. Footer rocks will be placed under these structures. Root wads will be used to protect the outside of meanders and provide in-stream cover. These structures will raise the water level in the near bank region and cause it to fall toward mid-channel, moving the thalwag to the center of the channel to create a deeper pool or run and reduce near-bank stress.

Riparian Improvements

The current riparian zone provides stream shading in many locations required to maintain cold water temperatures during the summer months necessary for cold water aquatic species (trout). The rooting depth of existing vegetation is deep enough to provide long-term bank stability. However, at several locations a lack of riparian vegetation contributes to streambank failure and increased sedimentation.

We propose to improve the riparian zone at this site with a number of practices. "Riparian Seeding and Planting Guidelines for the WRC Mitigation Program" are given in Appendix 4. Streambanks at selected sites will be sloped to approximately a 2:1 or 3:1 slope (Appendix 3). Sloping should reduce undercutting, improve the ability of vegetation growth to cover the slope and increase the stability of the bank. This will allow the water to rise along the sloped surface rather than eroding a vertical bank. After the riverbank has been sloped it will be vegetated with sod mats removed from the existing bank or covered with erosion control matting. Disturbed areas will be reseeded with brown top millet or winter wheat/rye and with a native all-purpose grass/wildflower seed mix (Appendix 4). Woody vegetation, including live stakes and bare root vegetation will be used in all areas within the

Conservation Easement boundaries. We will plant silky willow (*Salix sericea*) and silky dogwood (*Cornus amomum*) along repaired streambanks. On the upper banks we will plant native trees that provide shade, bank stability and cover and food for wildlife. Woody plantings will be at the rate of 320 per acre as per DWQ guidelines.

Livestock Exclusion

An important part of the stream mitigation plan is exclusion of livestock from the riparian buffer of the stream within the CE boundaries (Appendix 5). In a large part, livestock management will determine the success of the other practices. The Natural Resource Conservation Service (NRCS) has developed a livestock exclusion proposal for this site (D. Miller property only). The estimated total cost of the practices proposed for installation on the Dale Miller property should be approximately $ 9,729. The attached Conservation Plan details the planned treatments and the costs by treatment (see appendix). The NRCS will administer all phases of this part of the mitigation plan.

Conservation Easement

A permit condition for landowner participation in the stream mitigation program requires that the proposed stream restoration and riparian corridor be placed in a conservation easement (CE). The CE boundary line is determined based on the size of the stream, the amount of land needed to provide a significant vegetative cover for the stream and desires of the landowner. DOT Location and Survey is currently developing the CE for this site. Right-of-way access to the easement by WRC personnel will be stated in the agreement. The final CE document will be held by the WRC and the agreement will be between the landowner and the WRC.

Erosion Control

During construction, equipment will only access the stream when absolutely necessary. For this project, it is anticipated that half of the track hoe work can be accomplished from the top of the bank. All construction materials including rock, root wads, logs, and erosion control materials will be stockpiled at a central location at the site. To limit disturbance of soils, all equipment will travel along identified travel corridors.

Disturbance of soils will be limited to only what work can be accomplished and stabilized on a daily basis. As a structure is completed, the site will be sloped and seeded. Stockpiled soils or disturbed areas on steep slopes will have erosion control fencing installed as needed. Once the banks are sloped, they will be hand seeded with a "native all-purpose seed mix" (10 lbs. per acre) that was prepared for this region (see attached planting guidelines) and browntop millet or winter wheat/rye grain (1 lb. per 1,000 sq. ft). The surface of the sloped bank will be covered with sod mats salvaged from the site or with excelsior erosion control matting. These materials will be anchored in place with stakes and landscape staples. We will also plant low growing woody species such as tag alder or rhododendron, and silky willow and silky dogwood as dormant cuttings along the stream banks. Medium to large shrub/tree species will be planted throughout the CE area where applicable as bare-root materials during the dormant season.

Spill Containment

All equipment supplied by the contractor must be in good working order and should not be leaking any fluids that could contaminate the stream or property. In case of an accidental spill of hazardous materials (hydraulic fluids, gas, oil) two Attack Pac emergency spill kits will be on site during construction. Any spills of hazardous materials will be cleaned up immediately with contaminated soils disposed of according to state regulations.

Monitoring

Environmental components monitored at this site will be those that allow an evaluation of channel stability and improvements to fish habitat. Specifically we will evaluate the success of channel modification, erosion control, shading, seeding, and woody vegetation plantings. Biological monitoring will not be done at these sites since the project is not a Priority I restoration. This monitoring plan is based on the WRC Mitigation Site Monitoring Protocol for the NCWRC/NCDOT Mitigation Program (Appendix 6).

Photo Reference Sites

Photographs used to evaluate reference sites will be made before, during, and post-construction. Reference sites should be photographed twice a year for at least 5 years following construction. Reference photos should be taken in winter and summer at approximately the same date and under similar weather conditions. After construction has taken place, reference sites should be permanently marked with stakes, above the bankfull elevation. Detailed notes and a map describing the location of reference points should be made.

The stream will be photographed longitudinally beginning at one end of the site and moving to the other end with photographs taken at delineated locations. Reference photo locations should be marked and described for future reference. Points should be close enough together to get an over all view of the reach. The angle of the shot will depend on what angle provides the best view and should be noted and continued in future shots. Reference points should not be changed unless absolutely necessary. When reference photos have to be moved the new position should be as close as possible to the old with changes noted. The new position should be used in all future photos.

Lateral Reference photo transects should be established based on criteria which is described in the initial monitoring data summary and followed in subsequent data collections. Most often these may be the reference cross-sections. Permanent photo points should be demarcated using wooden stakes and duplicated each year. Photographs will be taken of both banks at each transect. The transect line will be centered in the photographs of the bank. Photographers should make an effort to consistently maintain the same area in each photo over time. Photos of areas that have been treated differently should also be included; for example, two different types of erosion control material used. This will allow for future comparisons.

Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures. Longitudinal photos should indicate the absences of developing bars within the channel or an excessive increase in channel depth. Lateral photos should not indicate excessive erosion or continuing degradation of the bank over time. A series of photos over time should indicate successional maturation of riparian vegetation. Vegetative succession should include initial herbaceous growth, followed by increasing densities of woody vegetation and then ultimately a mature overstory with herbaceous understory.

Cross-sections

Permanent cross-sections will be established in minimum of four riffles and two pools. These cross-sections may be at the same location as those taken to develop construction plans or they may be different. New cross-sections should be developed to monitor structures or features that may have an increased risk of failure. Each cross-section should be marked on both banks to establish the exact transect location. A common benchmark should be used for cross-sections and consistently used to facilitate easy comparison of year to year data. The annual cross section survey should include points measured at all breaks in slope, including top-of-bank, bankfull, inner berm, edge of water, and thalwag. Riffle cross-sections should be classified using the Rosgen stream classification system. Data should be taken at a scale that allows the evaluation of bank and channel changes. Photos of each cross-section should be made. Data should be collected once a year for the first 3 years and then again on the 5th year to evaluate stability of the bank and channel.

There should be little or no change in as-built cross-sections. If changes do take place they should be evaluated to determine if they represent a movement toward a more unstable condition (down-cutting, erosion) or are minor changes that represent an increase in stability (settling, vegetative changes, deposition along the banks, decrease in width/depth ratio). Unstable conditions that require remediation will indicate failure of restoration activities.

Longitudinal Profile

A longitudinal profile will be developed for each site prior to construction. This profile will be duplicated on the 1st, 3rd and 5th years after construction for data comparison. The beginning and end of each profile should be well demarcated and the length should be at least 20 bankfull widths.

The as-built longitudinal profile should show that the bedform features are remaining stable, e.g. they are not aggrading or degrading. The pools should remain deep with flat-water surface slopes and the riffles should remain steep and shallow. There should be little change in the as-built longitudinal profile. Unstable conditions that require remediation will indicate failure of restoration activities.

Pebble Counts

Two types of pebble counts should be collected in each reach including 100 counts reach wide stratified by the percentage of riffles and pools and 100 counts from each permanent cross section. The Wolman pebble count procedure will be used. Plots will be made showing the cumulative frequency curve and histogram for each cross-section and reach wide. The pebble counts should be completed at the same time as the cross-sections and longitudinal surveys. The pebble count data should show a coarsening of the entire frequency distribution in the reach and a coarsening of the pools over time.

Vegetative Cover

One objective of the mitigation program is to increase the quantity of shade, through vegetative cover of the stream. This will be accomplished by planting herbaceous and woody vegetation along the riparian zone. As this vegetation grows and matures the stream should become more and more shaded. As vegetation matures, the air temperature along the stream corridor should become more stable and water temperatures should not rise in the affected reach. Because most of the reach, except for approximately 110 feet of streambank, is already shaded we will not evaluate light penetration over time or water temperatures as done on some on other 421 mitigation projects. It is expected that this project will not have a major impact on stream temperature or light penetration.

Plant Survival

Where bare root tree stock or live stakes are planted, survival of vegetation will be evaluated using survival plots or direct counts. Coverage by the cover crop will be evaluated at regular intervals the first 2 months following construction. Seeded areas will be subjectively evaluated using photographs of at least 4 survival plots. Plots will be 1 meter square and photos will be taken at least twice a year, in winter and summer. Survival of live stakes will be evaluated using at least 3 plots. Plot size should allow for evaluating at least a total of 100 live stakes. Evaluations of live stake survival will continue for at least 3 years before success or failure is assessed. All bare root trees will be enumerated and flagged. Trees will be examined twice a year in winter and spring. Survival will be determined during the second summer after planting.

When seeded vegetation does not show satisfactory germination and plant density, plans will be made to either sow more seed, fertilize the site or both. Successful growth of seeded vegetation will be based on 75% coverage in photos of survival plots. Success of live stake plantings will require an 80% survival rate, based on sample plots. Success of bare root trees will require an 80% survival rate, based on examination of all planted trees. An attempt will be made to replace all dead bare root trees. The goal is to have 320 trees per acre inside the CE boundary.

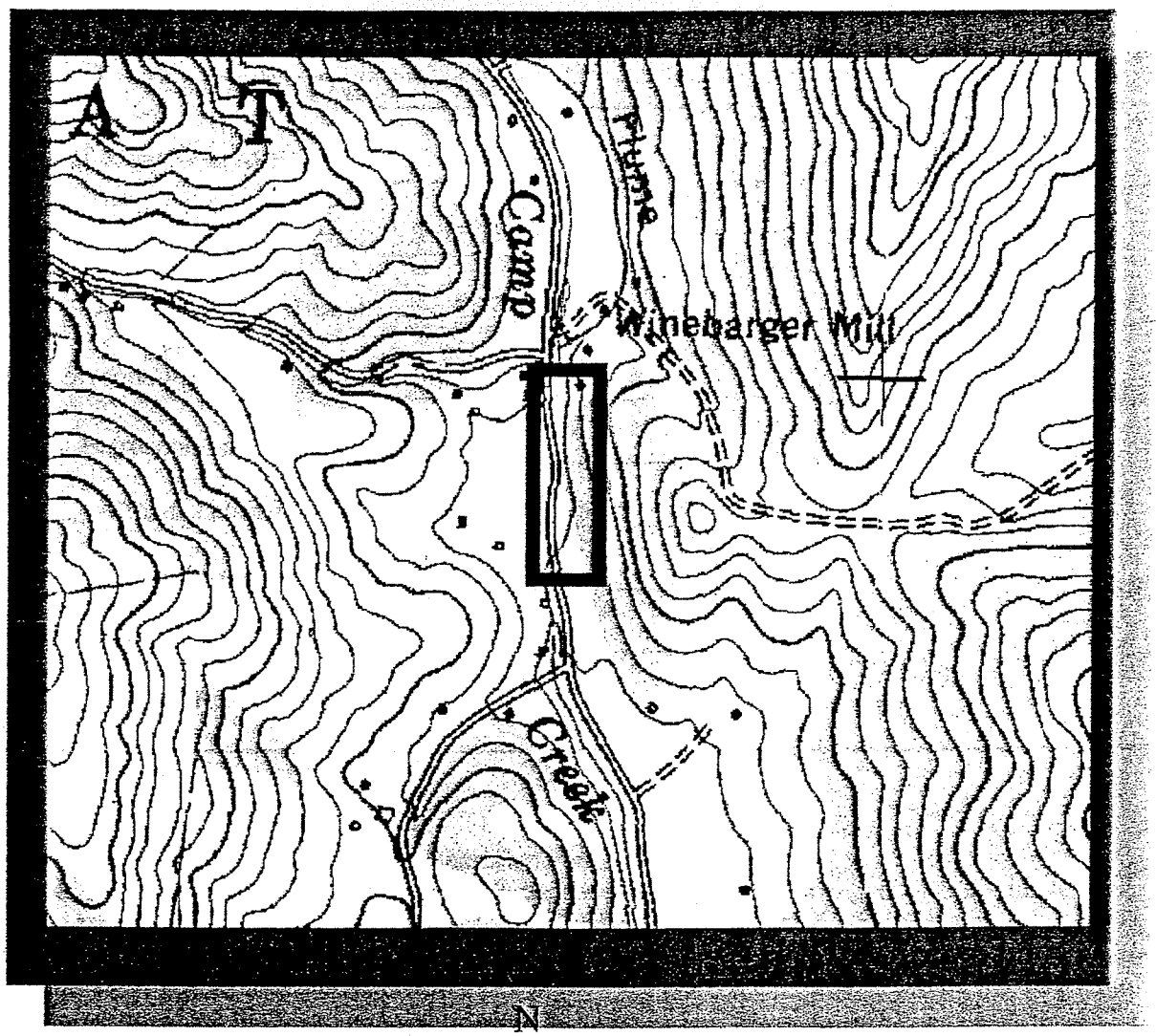
Conclusion

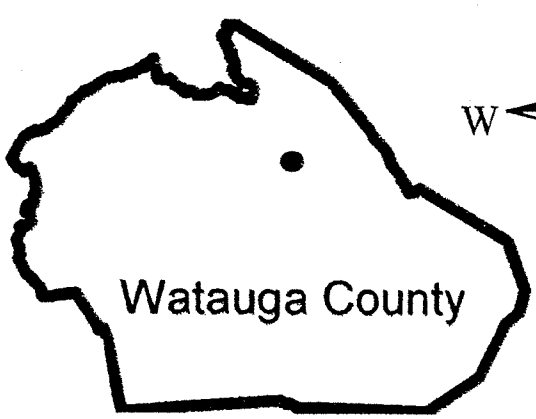
Past disturbances have impacted aquatic and riparian habitat along Meat Camp Creek. Through stream restoration techniques, riparian corridor enhancement and livestock exclusion the stream can be improved to resemble a more natural stream environment. Water quality will be improved through reduced sedimentation, aquatic habitat will be improved for fish and other organisms, and wildlife habitat will be improved along the riparian corridor.

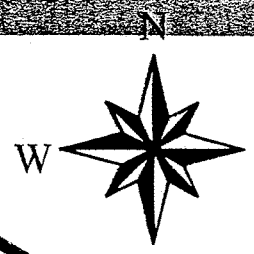
Appendix 1

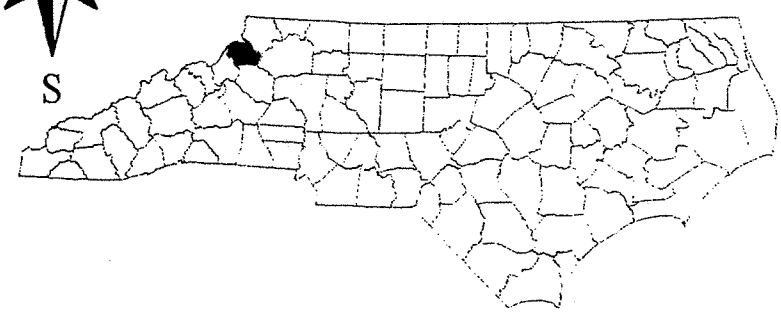
Site Map
Site Photos

D Miller and Others Project Site Meat Camp









PICTURES OF MILLER SITE

Looking upstream to SR1339 bridge

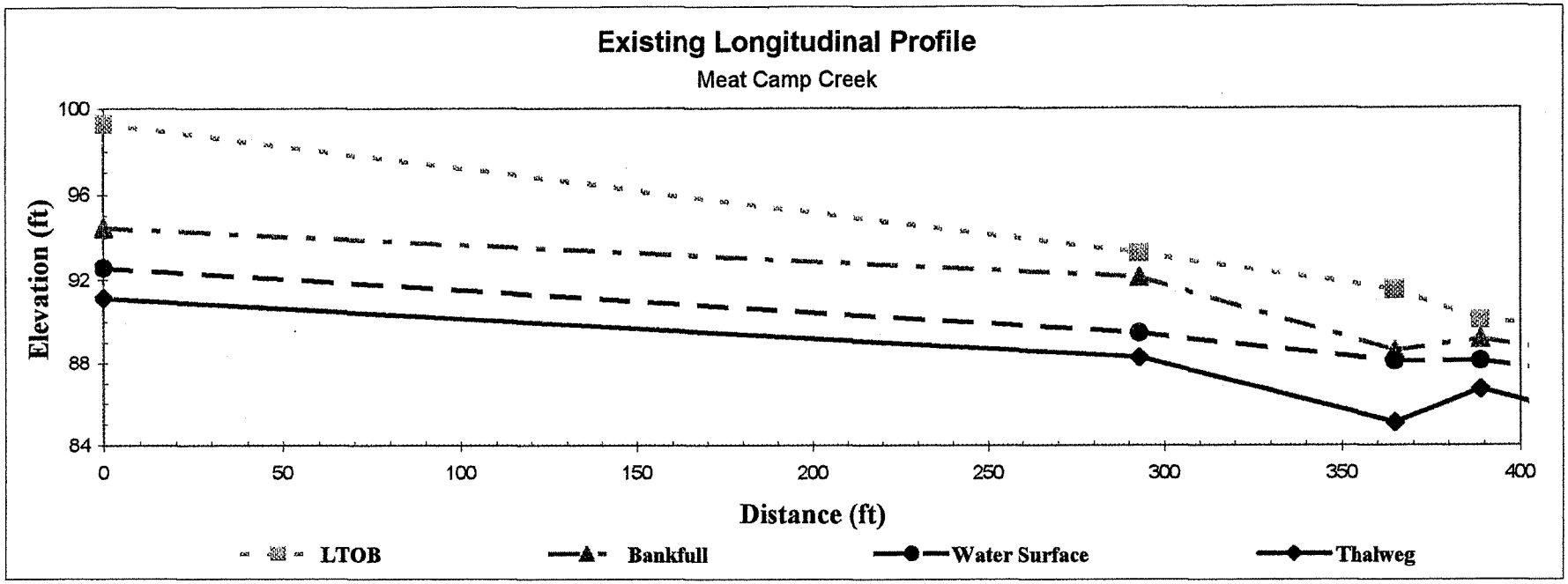
Looking downstream from the SR1339 bridge (upper end of project site) to eroding bank at station 3+33.

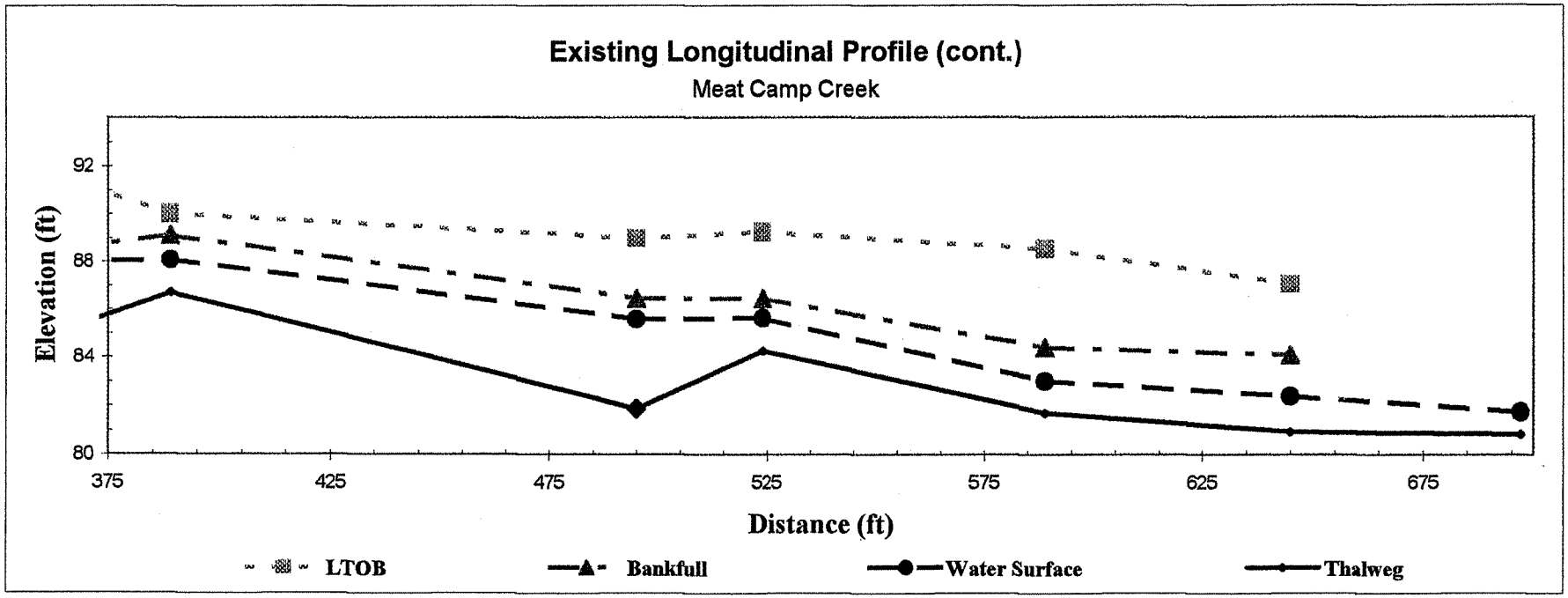
Major bank erosion site, approximately 110' in length at station 3+33.

Looking upstream from station 5+31. This area will have structures installed to confine the thalweg towards the center to prevent any further bank erosion and to protect the road shoulder.

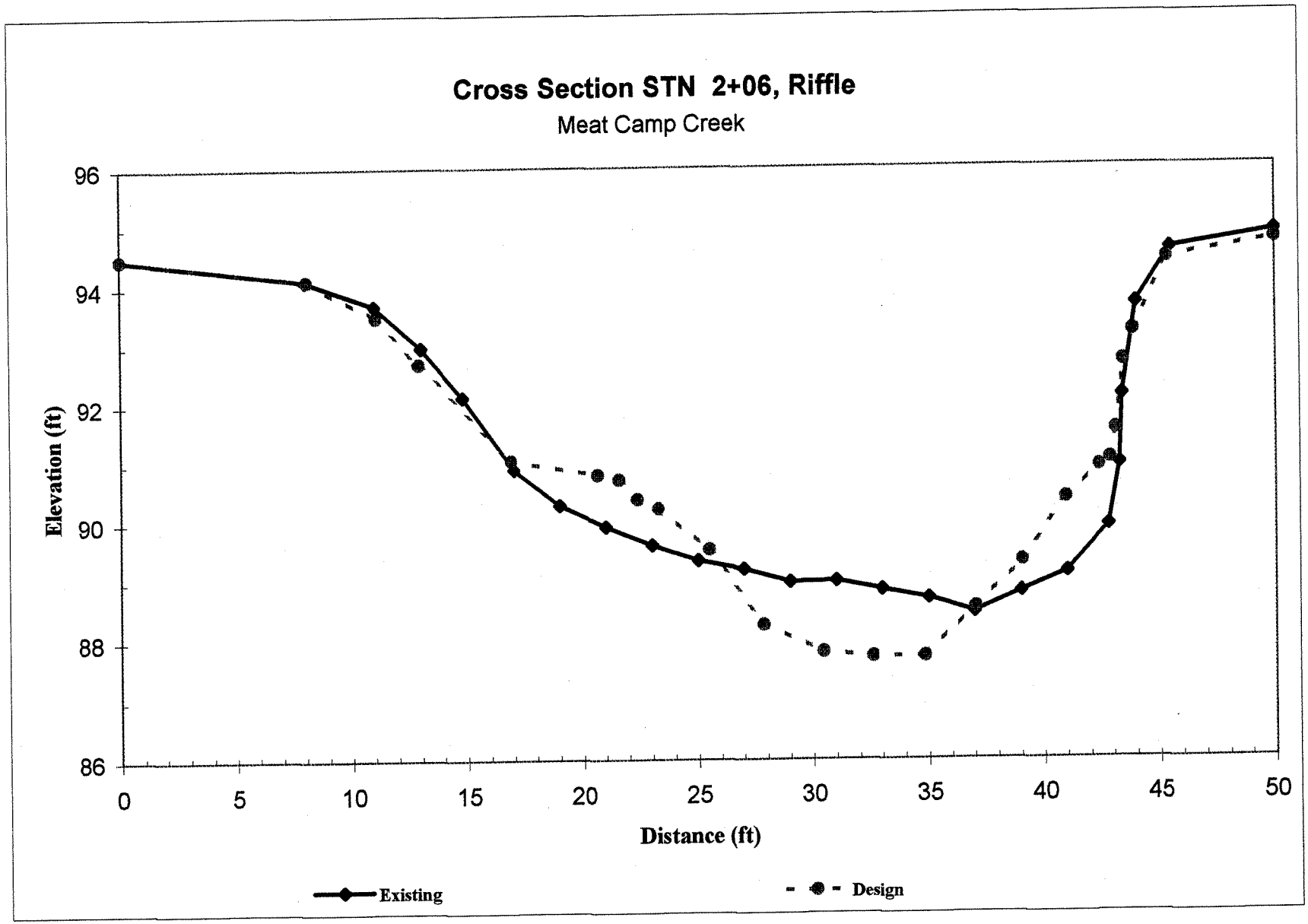
Appendix 2

Longitudinal Profile
Cross-sections
Pebble Count Data
Stream Reach Data

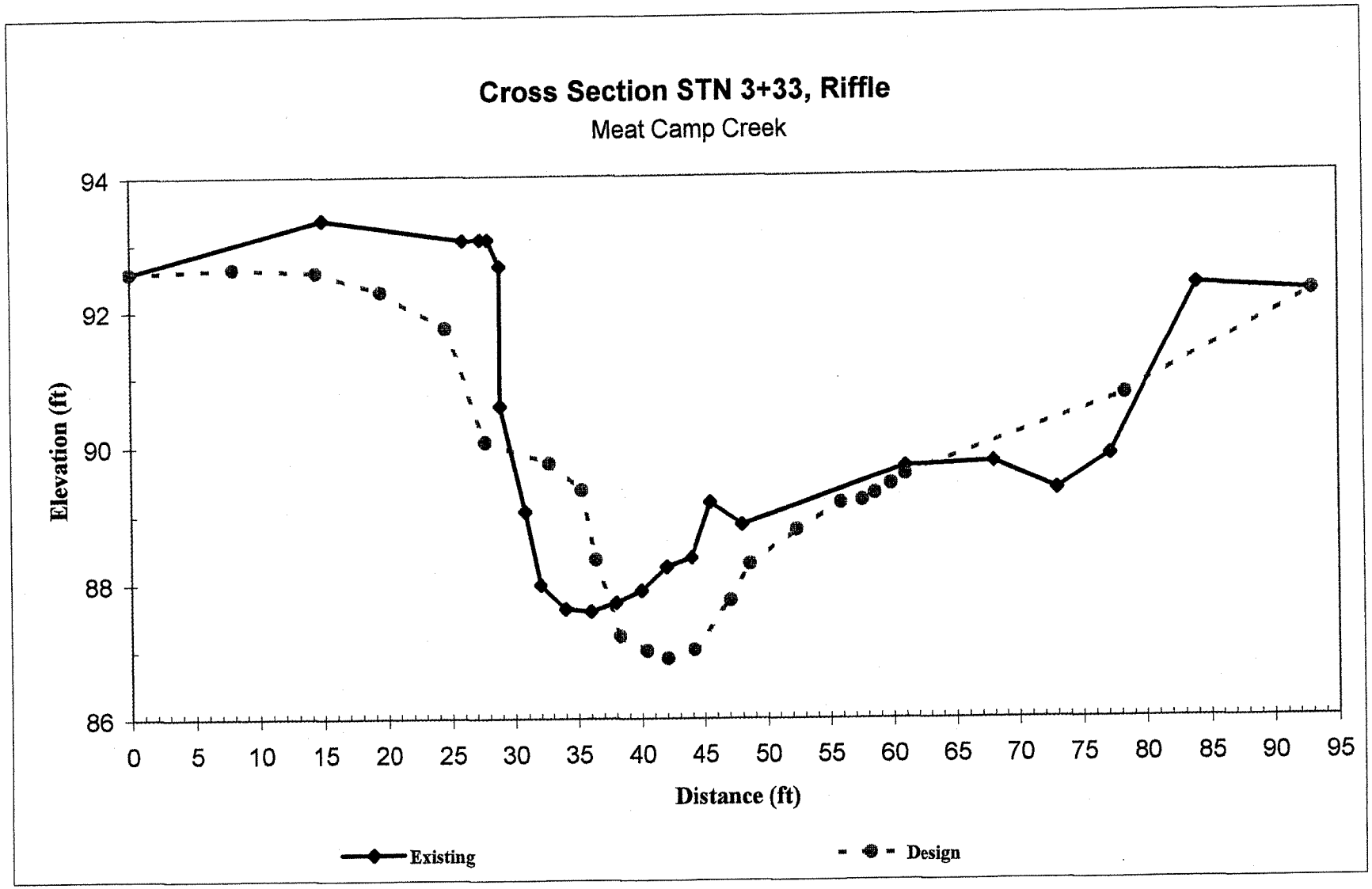

Existing Longitudinal Profile
Meat Camp Creek
Elevation (ft)
100
96
92
88
84
0
50
100
150
200
250
300
350
400
Distance (ft)
LTOB
Bankfull
Water Surface
Thalweg


Existing Longitudinal Profile (cont.)
Meat Camp Creek
Elevation (ft)
92
88
84
80
375
425
475
525
575
625
675
Distance (ft)
LTOB
Bankfull
Water Surface
Thalweg

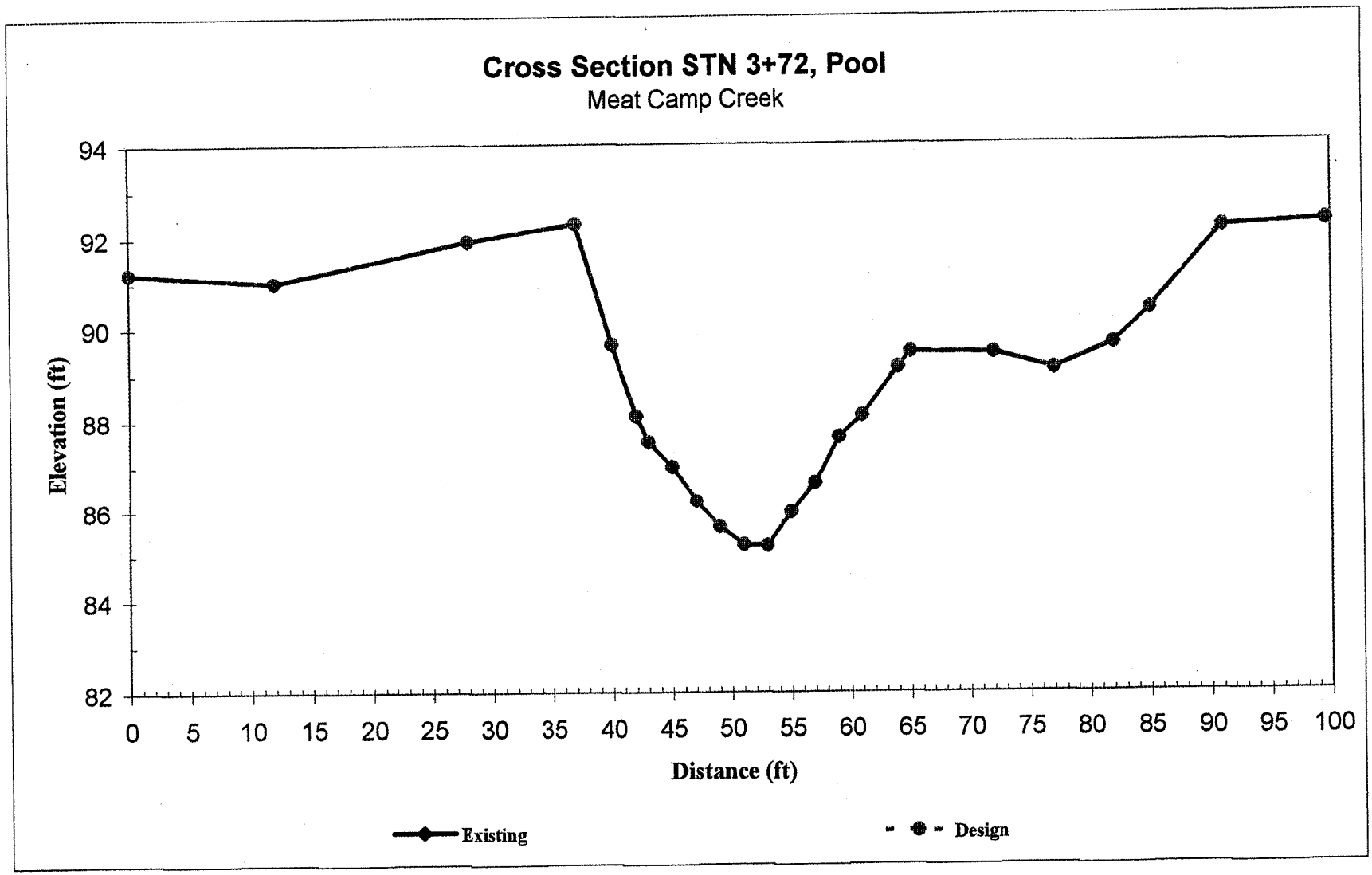
2+06	Feature	Type	Wfpa	LBKF	RBKF	ELEVbkf	Wbkf	Dbkf	W/D	Abkf	Dmax	ER
Existing	Riffle	C3	100	14.8	43.4	92.14	28.6	1.5	18.5	44.2	3.7	3.5
Design	Riffle	E3c	100	16.9	43.5	91.06	26.6	1.7	15.5	45.4	3.3	3.8



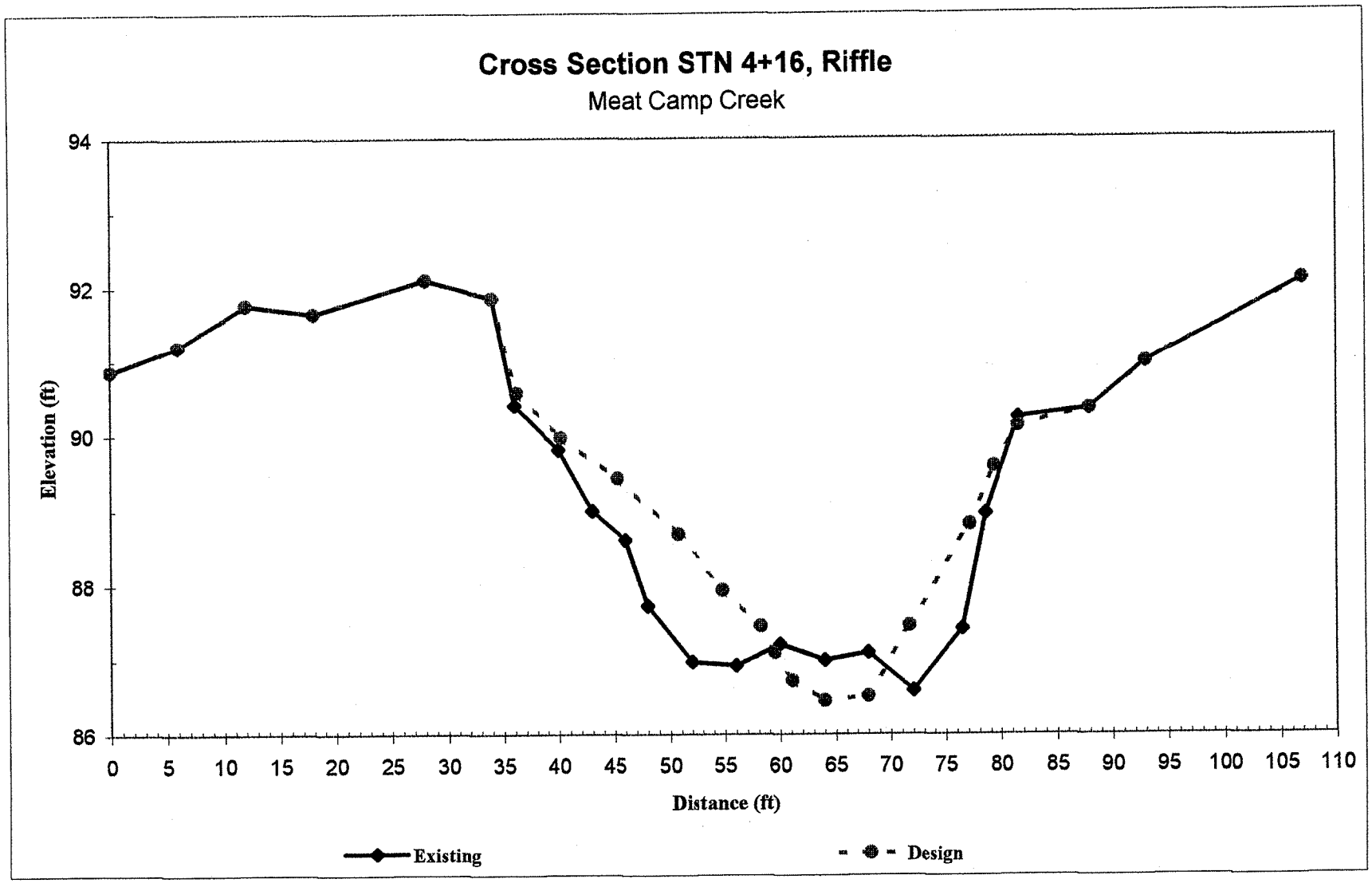
3+33	Feature	Type	Wfpa	LBKF	RBKF	ELEVbkf	Wbkf	Dbkf	W/D	Abkf	Dmax	ER
Existing	Riffle	C3	100	28.9	77.2	90.59	48.30	1.56	30.91	75.47	3.00	2.07
Design	Run	C3	100	32.8	61	89.76	28.20	1.44	19.57	40.64	2.87	3.55

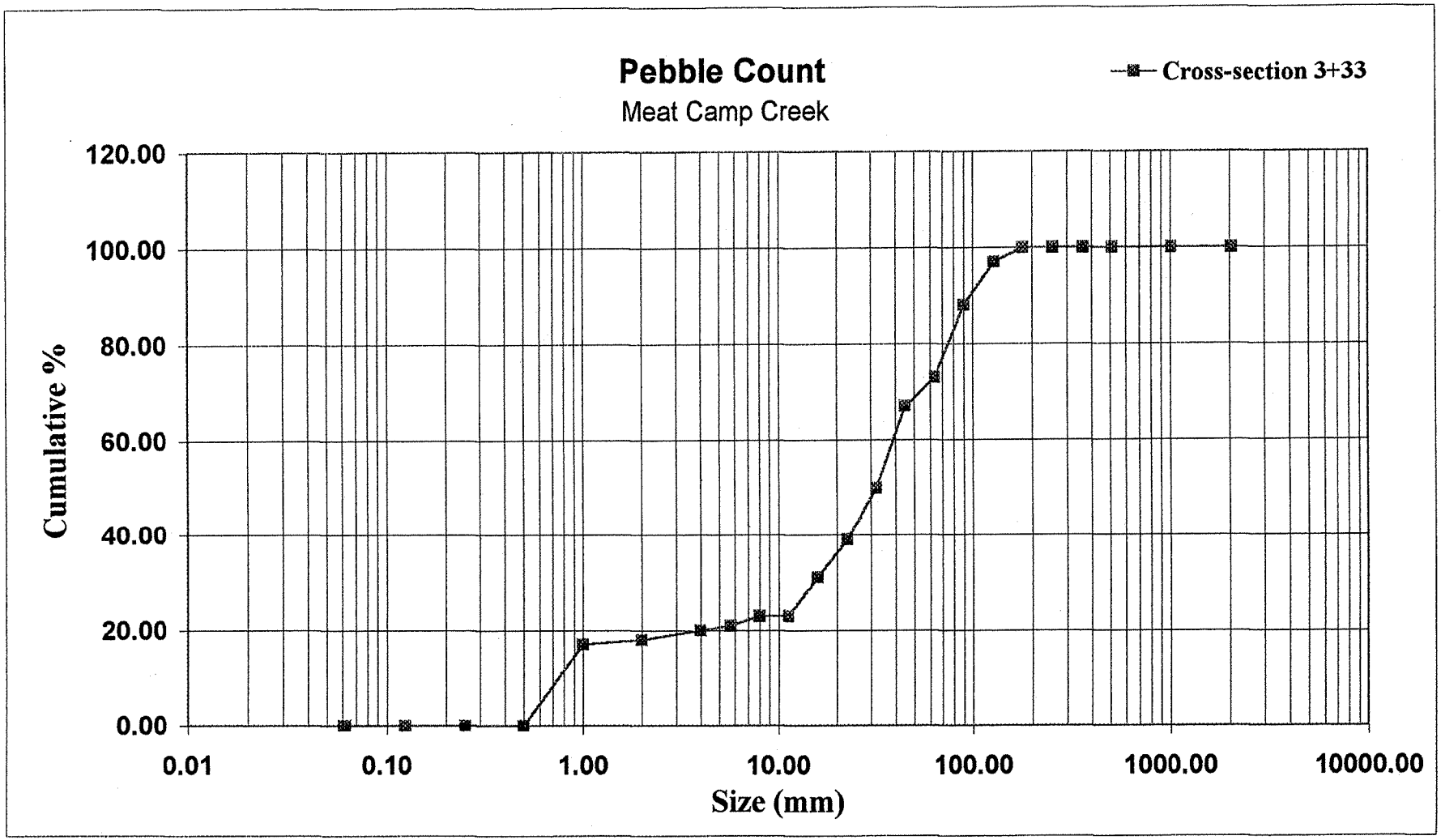


3+72	Feature	Type	Wfpa	LBKF	RBKF	ELEVbkf	Wbkf	Dbkf	W/D	Abkf	Dmax	ER
Existing	Pool	C3	54	42	61	88.1	19.00	1.63	11.64	31.01	2.89	2.84
Design	Pool	C3	100	42	61	88.1	19.00	1.63	11.64	31.01	2.89	5.26



4+16	Feature	Type	Wfpa	LBKF	RBKF	ELEVbkf	Wbkf	Dbkf	W/D	Abkf	Dmax	ER
Existing	Riffle	B3	70	43	78.6	89	35.6	1.67	21.33	59.40	2.41	1.97
Design	Riffle	E3c	100	45.3	79.4	89,43	34.1	1.29	26.46	43.94	2.98	2.93





X-SECTION

Particle Sizes (mm):

D16	18
D35	45
D50	110
D84	112
D95	115

Stream Reach Data

Stream Name: **Meat Camp Creek** Date: 8/31/00

Basin Name: **NEW** Drainage AREA: 3580 Ac. 5.59 MI^2

Location: D. Miller, Baxter, Winebarger, Proffit, B. Miller site along Meat Camp Cr.
Below SR 1339 bridge downstream along SR 1335 for a distance of approx. 700'

Observers: J. Mickey, M. Martinez

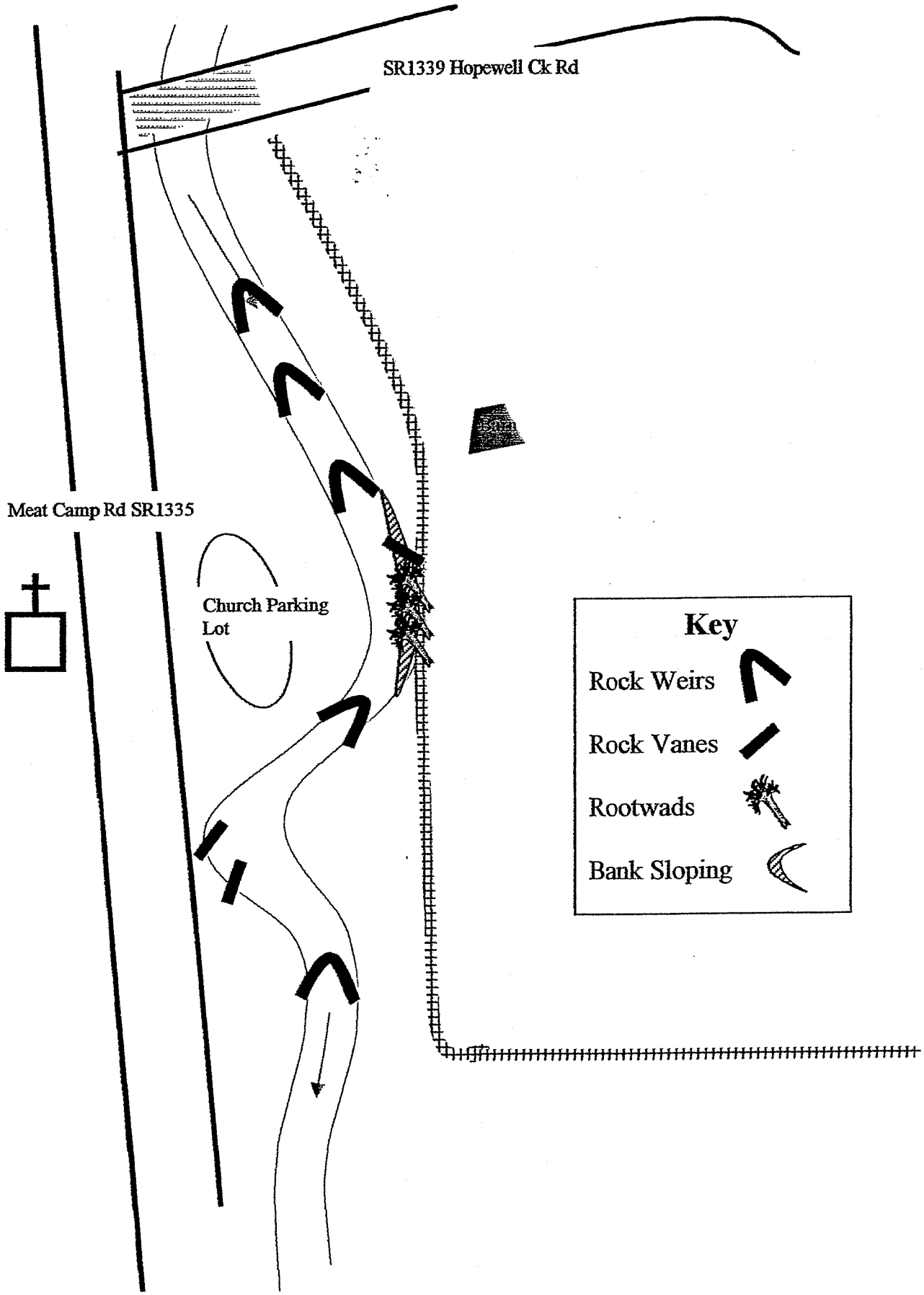
	X-S 2+06 Riffle	Reach Design
Bankfull WIDTH (W_{bkf}):	28.6	25-48
Mean DEPTH (D_{bkf}):	2.38	1.5-3
Bankfull X-sectional AREA (A_{bkf}):	68.01	31-46
Width / Depth RATIO (W_{bkf}/d_{bkf}):	12.03	12 - 26
Maximum DEPTH (d_{mbkf}):	3.67	2.5 -3.5
WIDTH of Flood-Prone Area (W_{fpa}):	100+	100
Entrenchment Ratio (ER):	3.5	3 - 5
Channel Materials D50:	110mm D95:115mm	110 mm
Water Surface SLOPE (S):	0.01 (0.00977)	0.01
Channel SINUOSITY (K):	1.1 (1.0977)	1.1
STREAM TYPE:	C3b	C3b

Notes:
At this location the stream appears to be in a transistion from class B3 to class C3.
Channel sinuosity is low (classification A range: <1.2) because the stream has been channelized due to past land use practices (agriculture, grist mills, road construction). The stream should have more sinuosity based on width of valley floor and Valley Type VIII. Reconstruction of a more sinuous channel at this site is not possible due to the existance of SR 1135 along the right bank and barn, pasture, and steep slopes along the left bank (facing downstream).

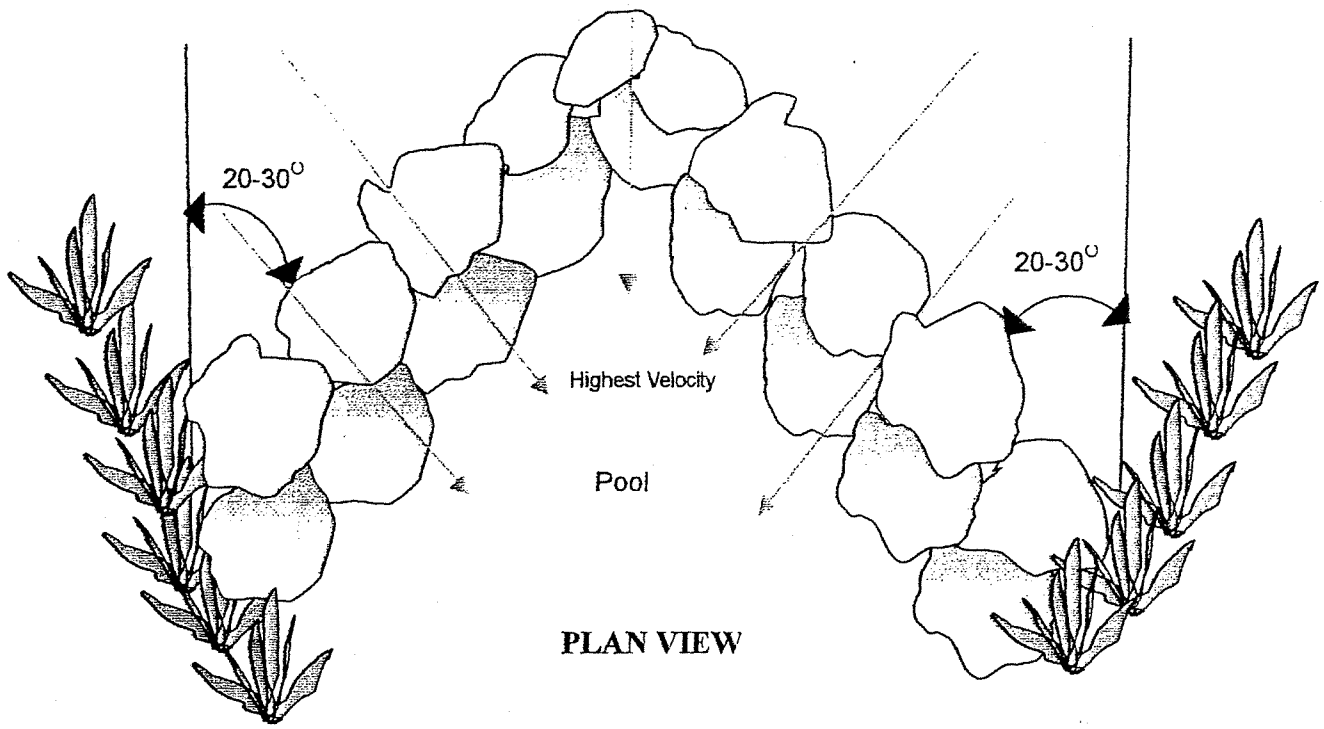
Appendix 3

Plan view of Stream Structures
Structures (rock weirs, rock vanes, root wads)
Typical Bank Profile

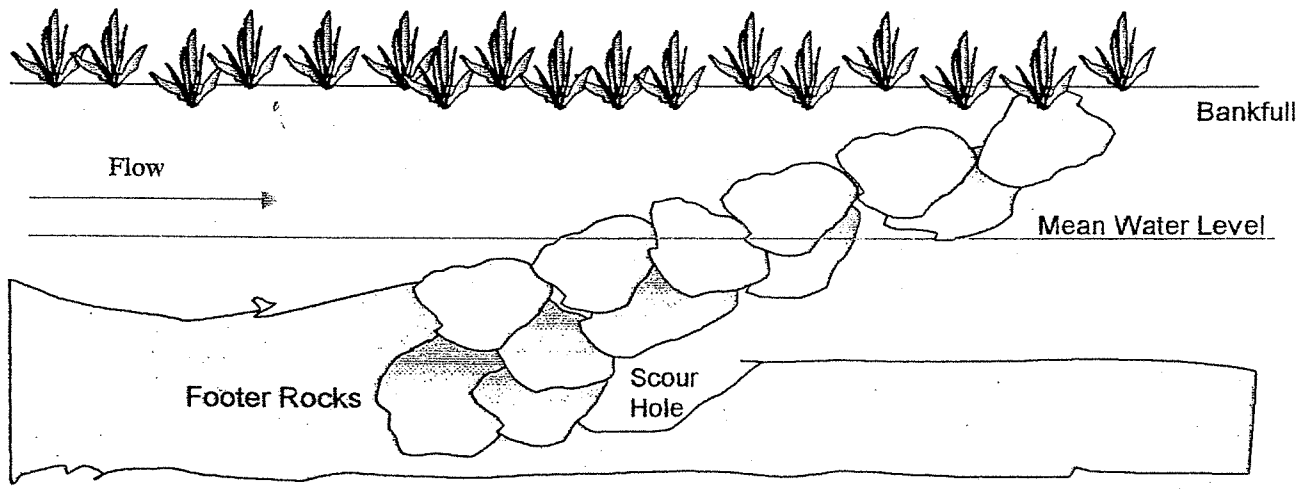
MILLER CONCEPTUAL RESTORATION PLAN



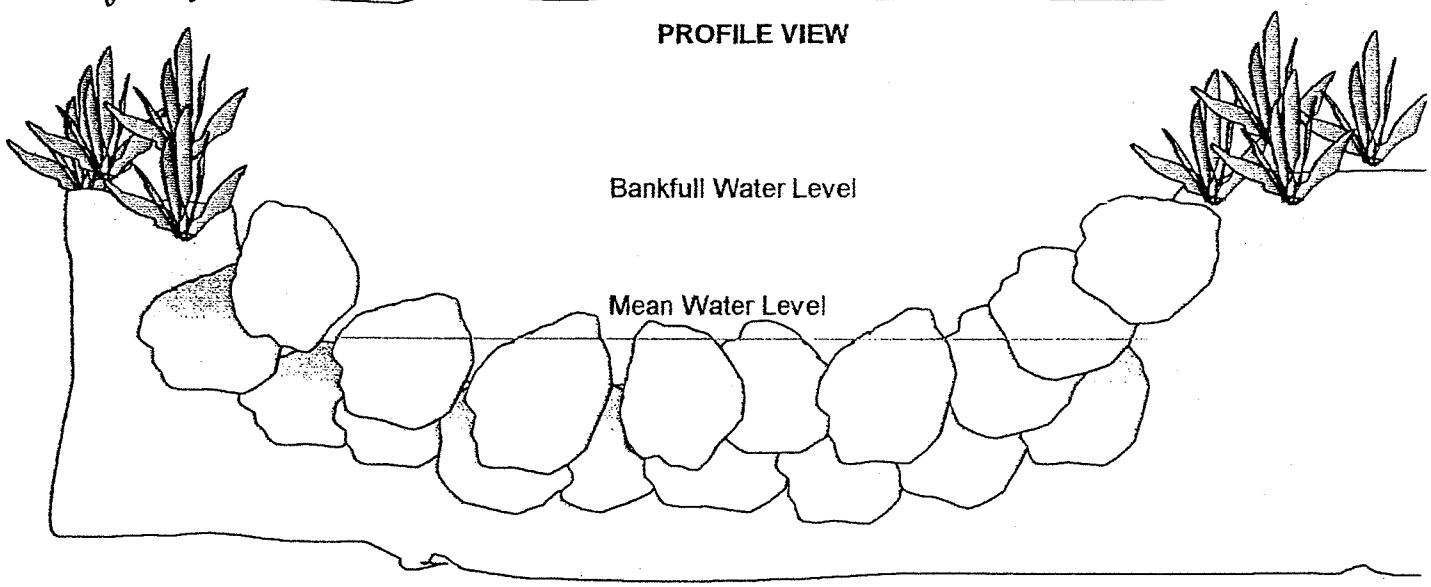
Cross Vane Rock Weir showing plan, profile, and cross section views



PLAN VIEW

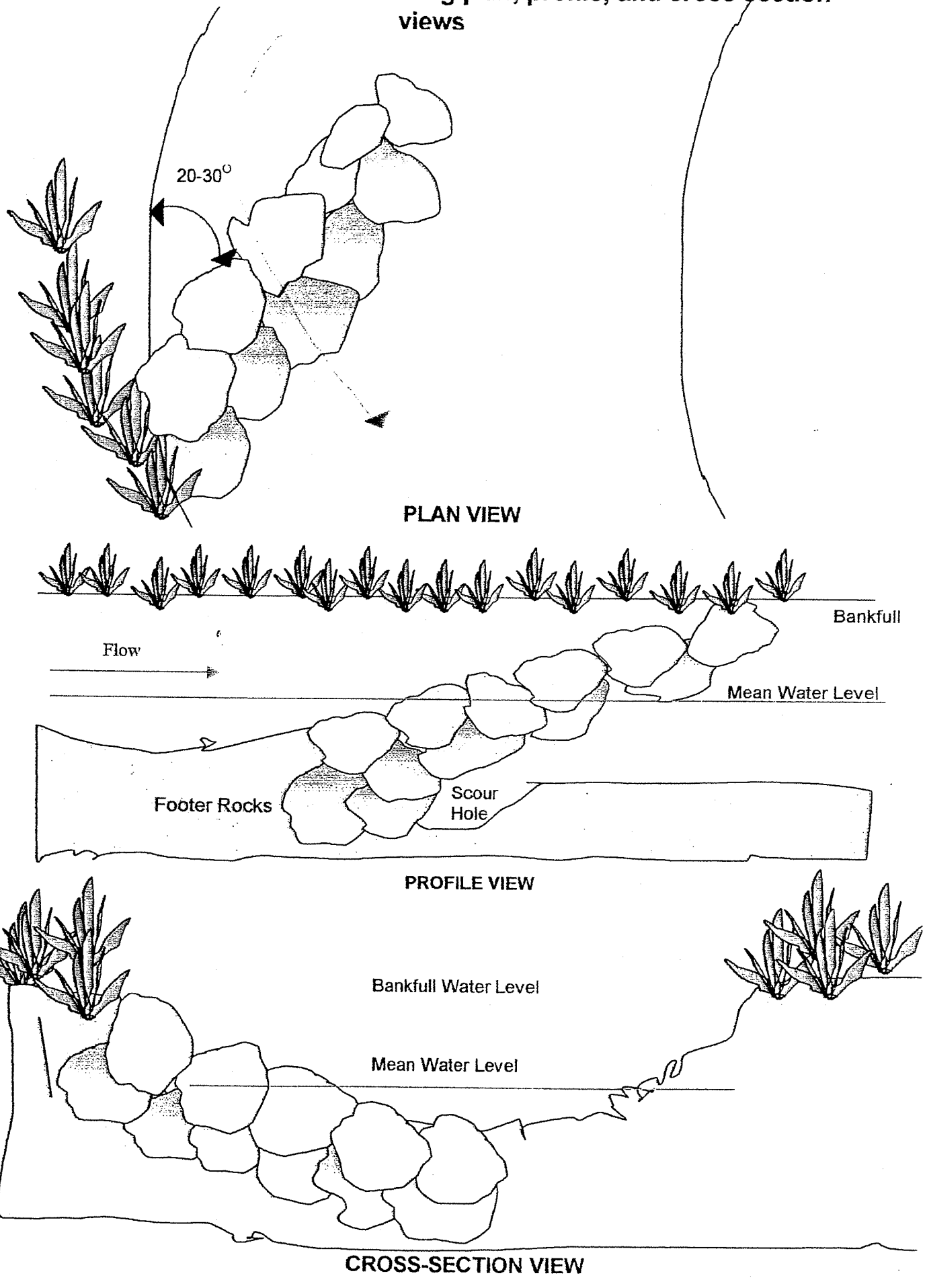


PROFILE VIEW



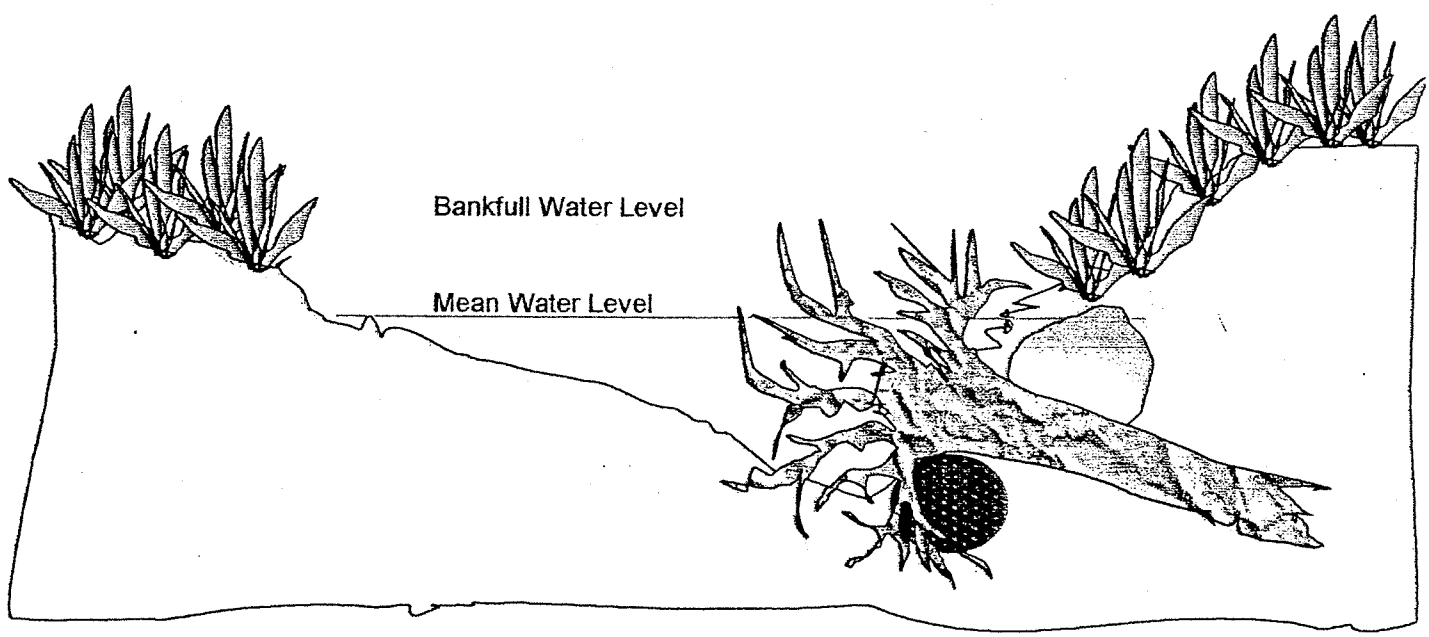
CROSS-SECTION VIEW

ROCK VANE STRUCTURE showing plan, profile, and cross section views



ROOT WAD STRUCTURE showing plan and cross section views

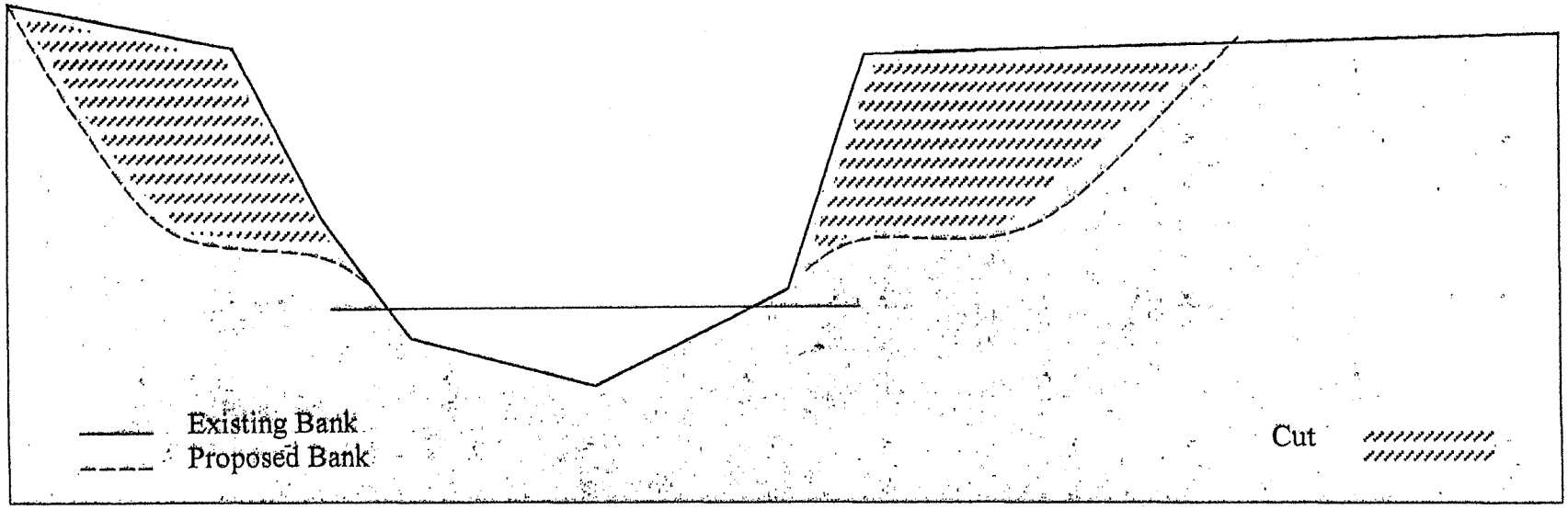
PLAN VIEW

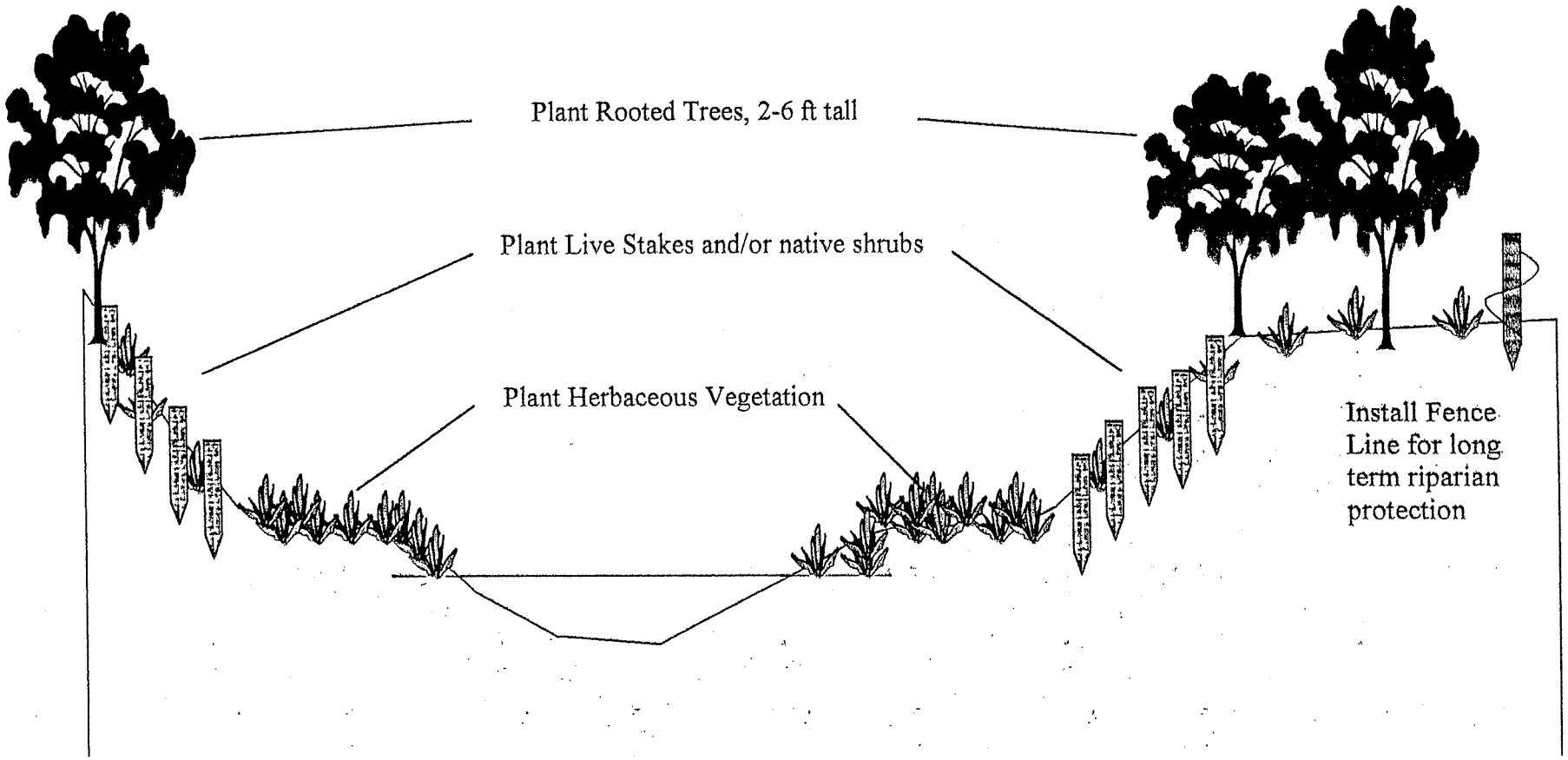


CROSS-SECTION VIEW

TYPICAL BANK GRADING

for low stress areas





Appendix 4

Vegetation

Riparian Seeding and Planting Guidelines
For NCWRC Mitigation Program

These guidelines will provide the methods to be used for reestablishing riparian vegetation at NCWRC mitigation sites. They will include seedbed preparation, nutrient enhancement, temporary seeding, permanent seeding, and erosion control. Methodology for planting sod mats, live stakes, and trees will also be presented.

Herbaceous Vegetation

Sod mats

Prior to sloping stream banks within easement areas the sod on these banks will be removed. Mats should be deep enough to contain a majority of the roots. These mats should be stockpiled for later use. After banks are sloped the mats should be placed from the bankfull elevation down to the normal water line or onto the interberm feature. Mats should be laid as close to one another as possible and pushed into the under laying soil. Openings between mats should be filled with soil and seeded with temporary seed mix. Mats should be fertilized at a rate of 25 lbs. per 1000 sq. ft. and watered using a pump or by dipping water out of the creek with a clean track-hoe bucket

Seed

Seedbed Preparation: On sites where equipment can be operated safely the seedbed shall be adequately loosened and smoothed. This may require disking and dragging. On sites where equipment cannot operated safely, the seedbed shall be prepared by hand scarifying to provide a roughened surface so that seed will stay in place. If seeding is done immediately following construction, seedbed preparation may be required only on areas where heavy equipment has caused compaction of the ground.

Fertilizing: Evenly distribute lime and fertilizer over the area to be seeded using a tractor mounted fertilizer spreader or with a hand held fertilizer spreader. Uniformly mix lime and fertilizer into the top 3 inches of the soil using a drag or hand rake. Where surface materials are predominately gravel and/or cobble, no incorporation is required. Apply lime and fertilizer according to soil test or at the following rates.

	Per 1000 sq. ft.	Per Acre
Lime	100 lbs.	2 ton
18-46-00 Fertilizer*	12 lbs.	500 lbs.

*(half of fertilizer will be applied in fall at planting and other half in spring)

Seeding:

Temporary seeding – Use where needed for erosion control, when permanent vegetation cannot be established due to planting season and where temporary ground cover is needed to allow native or woody vegetation to become established. Apply the following vegetation at the listed rates.

Fall, Winter, and Spring Seeding

	Per 1000 sq. ft.	Per Acre
Japanese Millet	½ lb.	20 lbs.
Winter Wheat	1 lbs.	40 lbs.

Summer Seeding

	Per 1000 sq. ft.	Per Acre
Sudangrass	1 lb.	40 lbs.
Browntop Millet	1 lb.	40 lbs.

Permanent Seeding – Use in combination with woody plantings on the up-slope side of the riparian area and down to the bankfull elevation. This mixture can be planted at any time but will do best in spring or late fall. Spring planted seed should be treated with a cold wet chill process to maximize germination. Fall plantings should be planted with a lightly sown cool season annual to hold soil and does not need to be chilled. Seeding should be done evenly over the area using a mechanical or hand seeder. A drag should be used to cover the seed with no more than ½ inch of soil. Where a drag can not safely be utilized the seed should be covered by hand raking.

All seasons: WNC Riparian Diversity Mix (as described on the attached sheet)
¼ lb. per 1000 sq. ft. and 10 lbs. per Acre

Erosion Control: All seeded areas, areas disturbed by heavy equipment, or other areas disturbed by mitigation activities should be protected from erosion by installation of erosion control blankets or matting. The area 6.5 feet above the bankfull elevation should be stabilized using either a coir fiber mat or coir/straw blanket. A 4 ft. wide jute blanket should be installed up-slope of the 6.5 ft. strip. All of these materials should be installed and stapled according to the attached diagram and instruction. Staples should be installed on a 2 ft. spacing.

Woody Vegetation

Live stakes (unrooted material)

Live stake material should be dormant and gathered locally or purchased from a reputable commercial supplier. Stakes should be ½ to 3 inches in diameter and living based on the presence of young buds and green bark. Stakes should be kept cool and moist to improve survival and to maintain dormancy. Stakes should be driven into the ground using a rubber hammer or by creating a hole and slipping the stake into it. The ground around the stake should be firmed against the stake after planting. Stakes should be placed so that 75% of the stake is below the ground and 2 or 3 buds are above ground. Stakes should be planted on a 2 – 3 foot spacing and at a density of 160 – 360 stakes per 1000 sq. ft.

Bare rooted or potted stock

Care and handling: Desirable trees and shrubs on the construction site should be dug and stored. These plants should be stored in a cool moist environment or heeled in. Roots of bareroot

stock should be kept moist during planting operations. Bareroot material should only be planted during Winter and early Spring. Container or potted stock shall be kept moist at all times. Do not let roots freeze or dry out prior to planting.

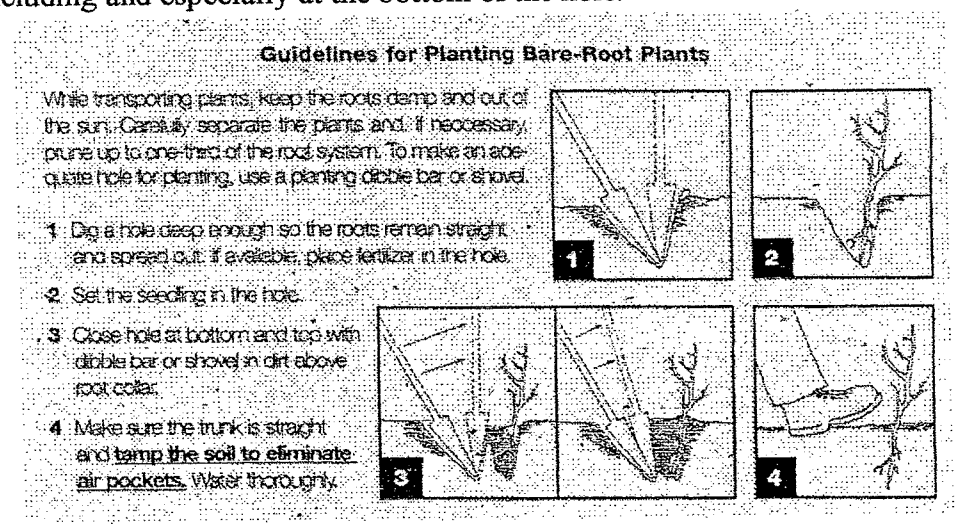
Site Preparation: The soil in the area of tree planting should be loosened to a depth of at least 1 foot. This is only necessary on hard compacted soil.

Planting:

On site material - Transplants should be replanted to the same depth they were originally growing.

Potted stock - Planting should be done mechanically or by hand using a shovel. The planting trench or hole must be deep enough and wide enough to permit roots to spread out and down without J-rooting. Potted stock should be planted in a hole 2-3 times the diameter of the root ball and at the same depth as the root ball. When setting plants, be certain to plant them high. Locate the root ball on solid soil and not loose backfill. Wire baskets do not need to be completely removed from large field grown trees. Be sure to remove plastic liners or synthetic burlap materials. Construct an earthen dam 4-6 inches high around the drip zone area of the plant after planting. This will allow for self watering and runoff will be minimized.

Bare rooted stock - Bare rooted material can be planted using a hoedad or a dibble bar (see diagram below). Planting slits for bare rooted material should be 6-8 inches in diameter and should be at least 8-12 inches deep. Damaged roots should be trimmed. Plants should be placed with the root collar slightly below the soil surface. Holes and slits should be closed completely, including and especially at the bottom of the hole.



Spacing of rooted Woody Vegetation – the following guidelines should be used for spacing rooted woody vegetation.

Type	spacing	# per 1000 sq. ft.
Shrubs, less than 10 ft. in height	3 – 6 ft.	27 - 111
Shrubs and Trees, 10 -25 ft. in height	6 – 8 ft.	15 - 27
Trees greater than 25 ft. in height	8 – 15 ft.	4 – 15

Plant List

Herbaceous, permanent seed mixture labeled "WNC Riparian Diversity Mix"

%	Common Name	Botanical Name
5.00%	Sensetive Fern	Onoclea sensibillis
2.50%	Joe Pye Weed	Eupatorium fistulosa
2.50%	Swamp Milkweed	Asclepias incarnata
2.50%	Eastern Gamagrass	Tripascum dactyloides
5.00%	Green Bulrush	Scirpus atrovirens
5.00%	Hop Sedge	Carex lupilina
10.00%	Rice Cut Grass	Leersia oryzoides
2.50%	Soft Rush	Juncus effusus
2.50%	Softstem Bulrush	Scirpus validus
2.50%	Three Square Spikerush	Scirpus americanus
10.00%	Va Wild rye	Elymus virginicus
10.00%	Woolgrass	Scirpus cypemus
2.50%	Deertongue	Panicum clandestinum
5.00%	Button Bush	Cephalanthus occidentalis
5.00%	Elderberry	Sambucus canadensis
2.50%	Red Chokeberry	Aronia arbutifolia
5.00%	Silky Dogwood	Comus amomuin
2.50%	Winterberry	Ilex verticillata
2.50%	Black Gum	Nyssa sylvatica
2.50%	Green Ash	Fraxinus pennsylvanica
2.50%	Red Maple	Acer rubrum
2.50%	Pin Oak	Quercus palustris
2.50%	Wild Black Cherry	Prunus serotina
2.50%	Silver Maple	Acer saccharium

This mixture was taken from the list of plants that begins on the following page. It was created from a database compiled by TVA and distributed on CD format as a product called "Banks & Buffers" (Tennessee Valley Authority. 1996. Banks & Buffers, A guide to selecting native plants for streambanks and shorelines; Riparian Plant Selector, Version 1.0; Environmental Research Center and Clean Water Initiative, Muscle Shoals, AL.). As more information becomes available we will add to this list in an effort to encompass as many riparian species native to Western North Carolina as possible.

Shrub and tree species listed on the following pages will be planted at mitigation sites as either live stakes, potted stock, balled stock or bare root stock. These plantings will take place in the winter or early spring. Spacing suggestions should be used as guidelines, but can be varied depending on species requirements and landscape objectives. For example species that are commonly found growing in clumped distributions should be planted that way. It is desirable for the final distribution of trees and shrubs to have a more natural, random appearance. In order to accomplish this exact spacing should be avoided and mixing of various species should be done.

Plants native to the riparian and wetland areas of Western North Carolina

Type	Common Name	Scientific Name	Flooding	Light	Wetland	pH	wildlife val.	region
1	American Pillwort	Pilularia americana	Reg	sun	obli	0-7	birds	all
1	Cinnamon Fern	Osmunda cinnamomea	Irreg to reg	Part to shade	Fac.wet	0-7	birds	all
1	Netted Chain Fern	Woodwardia areolata	seas to reg	all	obli	less	birds	all
1	Royal Fern	Osmunda regalis	seas to reg	Part to shade	obli	0-7	birds, sm	all
1	Sensitive Fern	Onoclea sensibilis	Irreg to reg	all	facu	0-7	birds	all
2	American Lotus	Nelumbo lutea	reg to perm	sun	oblig	0-7	birds,SM	all
2	American Pondweed	Potamogeton nodosus	perm	sun	oblig	7	birds,SM	all
2	Arrowhead	Sagittaria latifolia	seas-perm	sun to shade	oblig	all	B, Sm	all
2	Broad-leaf Cattail	Typha latifolia	seas-perm	sun	oblig	all	B, Sm	all
2	Cardinal Flower	Lobelia cardinalis	irreg-seas	sun	fac.wet	0-7	B, Sm	all
2	Hollow Joe-pye-weed	Eupatoriadelphus fistulosus	irreg-seas	sun	facu	0-7	birds	all
2	Narrow-leaf Cattail	Typha angustifolia	seas-perm	sun	oblig	all	B, Sm	all
2	Pickerelweed.	Pontederia cordata	seas-perm	sun-part.sh	oblig	0-7	B, Sm	all
2	Spotted Touch-me-not	Impatiens capensis	irreg-seas	part.sh	fac.wet	0-7	B, Sm	all
2	Swamp Milkweed	Asclepias incarnata	irreg-reg	sun-part.sh	oblig	0-7	B, Sm	all
2	Swamp Rose Mallow	Hibiscus moscheutos	seas-reg	sun-part.sh	oblig	0-7	B, Sm	all
2	Virginia Blueflag	Iris virginica	seas-perm	sun	oblig	0-7	birds	all
2	Water Plantain	Alisma subcordatum	seas-perm	sun	oblig	0-7	B, Sm	all
2	Waterwillow	Justicia americana	reg-perm	sun-part.sh	oblig	0-7	B, Sm	all
2	White Waterlily	Nymphaea odorata	reg-perm	sun-part.sh	oblig	0-7	B, Sm	all
2	Yellow Cowlily	Nuphar luteum	reg-perm	sun-part.sh	oblig	0-7	B, Sm	all
3	Creeping Spikerush	Eleocharis palustris	seas-perm	sun-part.	oblig.	0-7	B,Sm	all
3	Green Bulrush	Scirpus atrovi	seas-reg	sun	oblig.	0-7	B,Sm	all
3	Hop Sedge	Carex lupulina	seas-reg	sun-part.	oblig.	0-7	B,Sm	all
3	Rice Cutgrass	Leersia oryzoides	reg-perm	sun	oblig.	0-7	B,Sm	all
3	River Cane	Arundinaria gigantea	irreg-seas	sun-part.	fac.wet	0-7	B,Sm	all
3	River Oats	Chasmanthium latifolium	irreg-seas	part.-shade	facu	0-7	B,Sm	all
3	Slender Spikerush	Eleocharis acicularis	seas-perm	sun	oblig.	0-7	B,Sm	all
3	Soft Rush	Juncus effusus	seas-perm	sun-part.	fac.wet	0-7	B,Sm	all
3	Softstem Bulrush	Scirpus validus	seas-perm	sun	oblig.	0-7	B,Sm	all
3	Square-stem Spikerush	Eleocharis quadrangulata	seas-perm	sun	oblig.	0-7	B,Sm	all
3	Three-square Bulrush	Scirpus americanus	seas-perm	sun	oblig.	0-7	B,Sm	all
3	Virginia Wildrye	Elymus virginicus	irreg-seas	part.-shade	facu	0-7	B,Sm,Lm	all
3	Woolgrass	Scirpus cyperinus	seas-reg	sun	oblig.	0-7	B,Sm	all
	Bluet	Houstonia serpyllifolia						
4	Bushy St. Johnswort	Hypericum densiflorum	irreg-seas	sun-part	fac.wet	0-7	birds	all
4	Buttonbush	Cephalanthus occidentalis	seas-perm	sun-part	oblig	all	B,Sm,Lm	all
4	Wild Hydrangea	Hydrangea arborescens	irreg	part.-shade	fac.upl	0-7	B,Sm	all
4	Yellowroot	Xanthorhiza simplicissima	irreg-seas	part.-shade	fac.wet	0-7	birds	all
5	American Witch-hazel	Hamamelis virginiana	irreg	part	fac upl	0-7	B,Sm,Lm	all
5	Brookside Alder	Alnus serrulata	irreg-reg	sun	fac wet	0-7	birds	all
5	Carolina Buckthorn	Rhamnus caroliniana	irreg	part	fac upl	all	B,Sm	all
5	Carolina Willow	Salix caroliniana	seas-reg	sun-part.	oblig	0-7	B,Sm,Lm	all
5	Common Pawpaw	Asiminia triloba	irreg-seas	part.-shade	facu	0-7	Sm	all
5	Elderberry	Sambucus canadensis	irreg-seas	sun-part.	fac wet	0-7	B,Sm,Lm	all
5	Red Chokeberry	Aronia arbutifolia	irreg-seas	sun-part.	fac wet	0-7	B,Sm,Lm	all
5	Silky Dogwood	Cornus amomuin	irreg-seas	sun-part.	fac wet	all	B,Sm	all
5	Silky Willow	Salix sericea	irreg-reg	sun-part.	oblig	0-7	B,Sm,Lm	all

5	Spicebush	Lindera benzoin	irreg-seas	part.-shade	fac wet	0-7	birds	all
5	Winterberry	Ilex verticillata	irreg-reg	part.-shade	fac wet	0-7	B,Sm	all
5	Sweet Azalea	Rhododendron arborescens	irreg	part	fac wet	acid	B,Lm	F,H,Lt
5	Rhododendron	Rhododendron catawbiense						
6	American Hornbeam	Carpinus caroliniana	irreg-seas	all	facu	acid	B,Sm	all
6	Eastern Hornbeam	Ostrya virginiana	irreg	part.-shade	fac. Upl	0-7	B,Sm	all
7	Baldcypress	Taxodium distichum	all	sun - part	oblig	0-7	birds	all
7	Black Walnut	Juglans nigra	irreg	sun - part	fac upl	0-7	Sm	all
7	Black Willow	Salix nigra	seas perm	sun	oblig	0-7	B,Sm,Lm	all
7	Blackgurn	Nyssa sylvatica	irreg-reg	all	oblig-fac	0-7	B,Sm,Lm	all
7	Boxelder	Acer negundo	irreg	all	fac wet	0-7	birds	all
7	Eastern Cottonwood	Populus deltoides	irreg-seas	sun	facu	0-7	birds	all
7	Green Ash	Fraxinus pennsylvanica	irreg-reg	all	fac wet	0-7	B,Sm	all
7	Honeylocust	Gleditsia triacanthos	irreg-seas	sun	facu	0-7	B,Sm,Lm	all
7	Persimmon	Diospyros virginiana	irreg-seas	sun - part	facu	0-7	B,Sm,Lm	all
7	Red Maple	Acer rubrum	irreg-reg	all	obli-fac	0-7	B,Sm,Lm	all
7	Red Mulberry	Morus rubra	irreg-seas	part - shade	facu	0-7	B,Sm	all
7	River Birch	Betula nigra	irreg - seas	sun	fac wet	0-7	birds	all
7	Silver Maple	Acer saccharinum	irreg	all	fac wet	0-7	birds	all
7	Sweetgum	Liquidambar styraciflua	irreg - reg	sun	facu	0-7	B,Sm	all
7	Sycamore	Platanus occidentalis	irreg - seas	sun - part	fac wet	0-7	B,Sm	all
7	American Basswood	Tilia americana	irreg	all	fac upl	0-7	B,Sm	Ho,F,Lt
7	Eastern Hemlock	Tsuga canadensis						

Plant Type	
Fern or fern allies	1
Em, float, or wetl herb	2
Grass, sedge, or rush	3
Small Shrub	4
Large Shrub	5
Small Tree	6
Large Tree	7

Appendix 5

Livestock Exclusion

L RESOURCES CONSERVATION SERVICE

Watauga County (Boone) Field Office (828) 264-3543

CONTRACT SUPPORT DOCUMENT

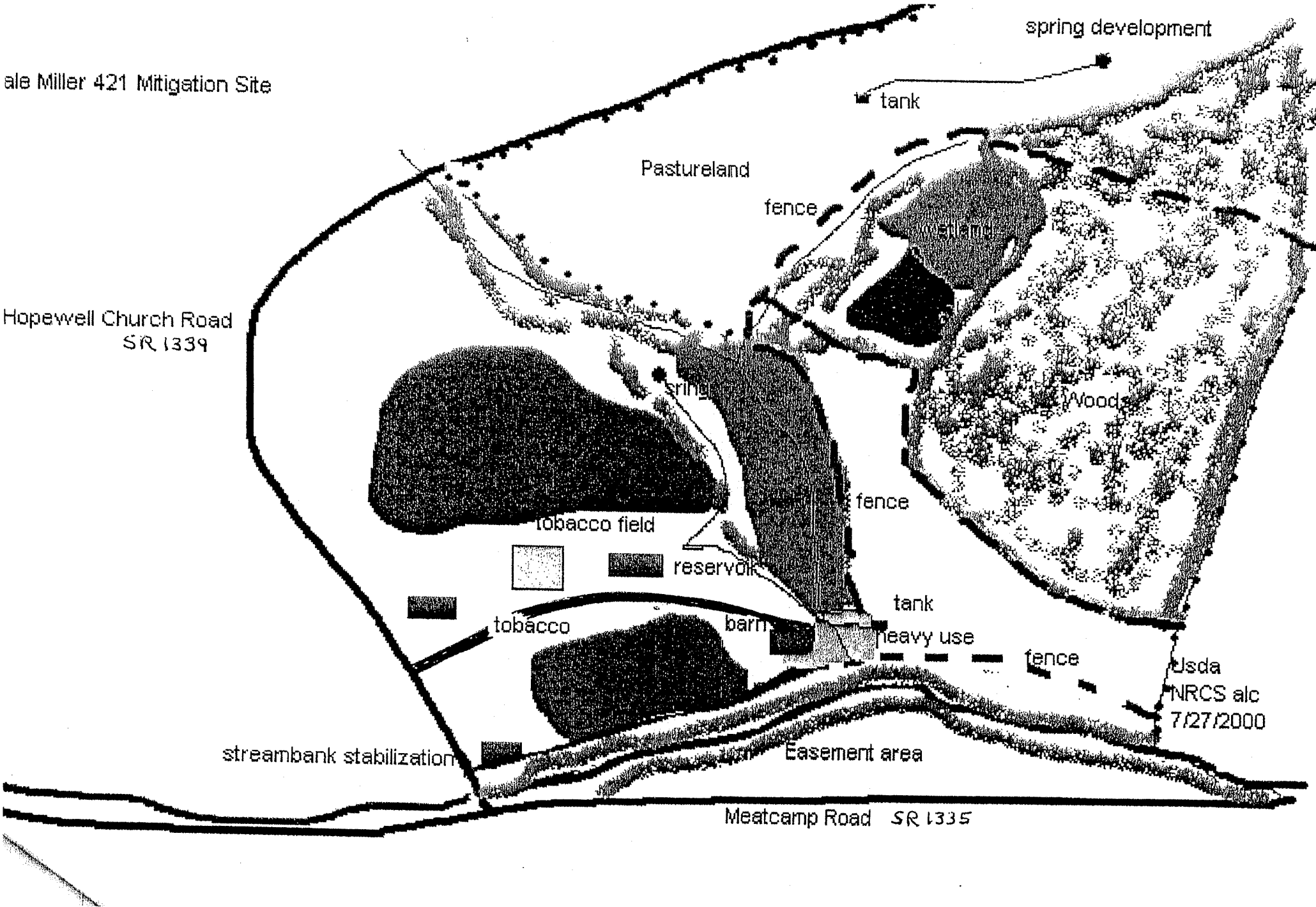
NO.: TOTAL ACRES: 5.0

Miller, Dale	Watauga County	NC

ITEM NO	FIELD	PLANNED CONSERVATION TREATMENT	EST. AMOUNT (UNITS)	COST / UNIT	COST SHARE %	ESTIMATED COST-SHARE BY YEAR 2001	2002	2003
1	1, 2	Tract 2687						
		TROUGH OR TANK (614)						
1a		PIPE-water supply/fittings, <=2"	350.0 LinFt	$ 1.50	100AA	$ 525		
1b		TANK-permanent watering	1.0 Each	$ 533.00	100AM	$ 533		
2	1	Tract 2687						
		SPRING DEVELOPMENT (574)						
2a		EXCAVATION-spring development	4.0 Hr	$ 50.00	100AA	$ 200		
2b		PIPE-water supply/fittings, <=2"	20.0 LinFt	$ 1.50	100AA	$ 30		
2c		STONE-gravel	3.0 Ton	$ 14.40	100AA	$ 43		
3	1, 3	Tract 2687						
		HEAVY USE AREA PROTECTION (561)						
3a		FILTER CLOTH-geotextile fabric	553.0 SqYd	$ 2.00	100AA	$ 1,106		
3b		GRADING-light, 1" to 3" avg	0.1 Acre	$ 500.00	100AA	$ 50		
3c		STONE-gravel	150.0 Ton	$ 14.40	100AA	$ 2,160		
3d		36" CSP asphalt coated	80.0 Lft	$ 46.65	100AA	$ 3,732		
4	1, 3	Tract 2687						
		FENCE (382)						
		FENCE-perm, non-electric	900.0 LinFt	$ 1.50	100AA	$ 1,350		
Total Cost-Share by Calendar Year:						$ 9,729		

SUMMARY	PROGRAM	CONTRACT NO.	TOTAL	2001	2002	2003
Total Cost-Share by Fiscal Year:	421		$ 9,729			
Total Contract Cost-Share:	421		$ 9,729			

NOTES: A. All items numbered under "ITEM NO." must be carried out as part of this contract to prevent violation.
B. When established, the conservation practices listed as "PLANNED CONSERVATION TREATMENT" must be maintained by the participant at no cost to the government.


ale Miller 421 Mitigation Site
spring development
tank
Pastureland
fence
stand
Hopewell Church Road
SR 1339
spring
Woods
fence
tobacco field
reservoir
tank
tobacco
barn
heavy use
fence
Usda
NRCS alc
7/27/2000
streambank stabilization
Easement area
Meatcamp Road SR 1335

Appendix 6

Monitoring

Mitigation Site Monitoring Protocol for the NCWRC/NCDOT Mitigation Program

In 1998 the North Carolina Wildlife Resources Commission (WRC) and the North Carolina Department of Transportation (DOT) began working together to accomplish stream mitigation requirements associated with U.S. Army Corps of Engineers (COE) 404 permits for various state highway projects. Stream restoration is being undertaken at several sites within the state to fulfill these mitigation requirements. This work involves making improvements to stream reaches so that the stream channel is more stable and provides better fish and wildlife habitat. Restoration work will provide long-term improvements to these sites because they are being placed in conservation easements and maintained by DOT (short-term) and WRC (long-term). In order to assess the accomplishment of these objectives this monitoring protocol has been developed and will be employed at each site.

Environmental components monitored in this program will be those that allow an evaluation of channel stability and improvements to fish habitat. Specifically we will evaluate channel stability, erosion control, shading, seeding, woody vegetation plantings and at some sites, the response of fish and invertebrate populations. This will be accomplished using photo reference sites, measurements of air and water temperature, measurements of stream shading, stream dimension and profile, survival of planted vegetation, and direct sampling of important populations.

Photo Reference Sites

Photographs used to evaluate reference sites will be made pre-, during, and post-construction. Reference sites should be photographed twice a year for at least 5 years following construction. Reference photos should be taken in winter and summer at approximately the same date and under similar weather conditions. After construction has taken place, reference sites should be permanently marked with stakes, above the bankfull elevation. Detailed notes and a map describing the location of reference points should be made

Longitudinal reference photos: The stream will be photographed beginning at one end of the site and moving to the other end with photographs taken at delineated locations. Reference photo locations should be marked and described for future reference. Points should be close enough together to get an over all view of the reach. The angle of the shot will depend on what angle provides the best view and should be noted and continued in future shots. Reference points should not be changed unless absolutely necessary. When reference photos have to be moved the new position should be as close as possible to the old with changes noted. The new position should be used in all future photos.

Lateral reference photos: Reference photo transects should be established based on criteria which is described in the initial monitoring data summary and followed in subsequent data collections. Most often these may be the reference cross-sections. Permanent photo points should be demarcated using wooden stakes and duplicated each year. Photographs will be taken of both banks at each transect. The transect line will be centered in the photographs of the bank. Photographers should make an effort to consistently maintain the same area in each photo over

time. Photos of areas that have been treated differently should also be included; for example two different types of erosion control material used. This will allow for future comparisons.

Success Criteria: Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures. Longitudinal photos should indicate the absences of developing bars within the channel or an excessive increase in channel depth. Lateral photos should not indicate excessive erosion or continuing degradation of the bank over time. A series of photos over time should indicate successional maturation of riparian vegetation. Vegetative succession should include initial herbaceous growth, followed by increasing densities of woody vegetation and then ultimately a mature overstory with herbaceous understory.

Channel Stability

Cross-sections: At least 4 permanent cross-sections will be established, measured and plotted to indicate how the banks and channel were modified. These cross-sections may be at the same location as ones taken to develop construction plans or they may be different. New cross-sections should be developed to monitor structures or features that may have an increased risk of failure. Each cross-section should be marked on both banks to establish the exact transect location. A common benchmark should be used for cross-sections and consistently used to facilitate easy comparison of year to year data. Data should be taken at a scale that allows the evaluation of bank and channel changes. Photos of each cross-section should be made. Data should be collected once a year for the first 5 years and then as needed after this to evaluate stability of the bank and channel.

Longitudinal Profile: A longitudinal profile will be developed for each site prior to construction. This profile will be duplicated each year and the year to year data compared. The beginning and end of each profile should be well demarcated and the length should be at least 20 bankfull widths.

Pebble Counts: An evaluation of bed material changes will be made by doing a pebble count along at least two of the reference cross-sections. A 100 particle sample will be collected at each cross-section. Particles will be randomly selected according to standard procedures. Particle size distributions will be compared to initial pebble counts and to year to year samples.

Success Criteria: Judgements of success or failure of restoration activities using this data will be subjective. There should be minimal changes in as built cross-sections and longitudinal profiles. If changes do take place they will be evaluated to determine if they represent a movement toward a more unstable condition (down-cutting, deposition, erosion) or are minor changes that represent an increase in stability (settling, vegetative changes, decrease in width/depth ratio). Unstable conditions that require remediation will indicate failure of restoration activities. Pebble count data should indicate a reduction in fine bed material if the project is successful.

Vegetative Cover

One objective of the mitigation program is to increase the quantity of shade, through vegetative cover of the stream. This will be accomplished by planting herbaceous and woody vegetation along the riparian zone. As this vegetation grows and matures the stream should become more

and more shaded, the air temperature along the stream corridor should become more stable and water temperatures should not rise in the affected reach. We will evaluate project impacts to these environmental variables by monitoring air and water temperature and shade.

Shading: Improvements to shading of the stream will be evaluated by monitoring the change in light penetration over time. Light penetration will be measured along each reference cross-section. A light meter will be used to measure the light at the ground or water surface, and at 1 meter above the ground and water surface along the cross-section. Measurements will be taken along the left bank at a point outside of the conservation easement, at the top of the stream bank, and in mid-channel. On channels greater than 10 feet in width, measurements will also be taken at the waters edge. The right-bank will be used when the left-bank has not been altered. Individuals collecting this data should wear light colored clothing and hold the light meter horizontal and perpendicular to the ground. The sun should be at the 12:00 position from the meter with the collecting individual at the 6:00 position. The date, time of day and weather conditions should be duplicated in samples taken year to year. Any factors, other than vegetative shading, that might affect measurements should be noted and controlled year to year.

Temperature: The ability of planted vegetation to thermally stabilize mitigation site riparian zones will be evaluated by monitoring both water temperature and air temperature. Temperature will be sampled using StowAway® XTI recording thermometers made by Onset Computer Corporation. These thermometers will be placed upstream and downstream of the site reach and will record water temperature every hour. They will be deployed by the 1st of August each year to record the water temperature during August and September. Streams in Western North Carolina usually are the warmest during these months and begin to cool by the end of September. Water temperature will be recorded prior to construction and each year during the 5 year monitoring period. Shading effects on air temperature will be evaluated by recording air temperature along each reference cross-section. Air temperature will be recorded at each location that light penetration is measured and each measurement will be taken at 1 meter above the ground or water surface. Temperature stability will be measured using StowAway® recorders to measure air temperature in the shade at hourly intervals for seven consecutive days. This temperature stability measurement will be done along one of the randomly selected reference cross-sections, at points outside of the easement and within the easement (at the top of the stream bank).

Success Criteria: Comparisons of air temperature and shading should indicate a lower temperature and increased shading within the easement area when compared to points outside of the easement. Water temperature should decrease, or at least be constant, as it moves through the mitigation site. This difference may not be found until riparian vegetation grows to the point that it is shading the stream. Temperature stability data should indicate that the riparian zone has a less variable temperature regime than a site outside of the vegetated buffer. Reference data from existing riparian zones in excellent condition, needs to be developed to provide targets for shading and thermal buffering of restored sites.

Plant Survival

Survival of vegetation will be evaluated using survival plots or direct counts. Coverage by the cover crop will be evaluated at regular intervals the first 2 months following construction.