RIPARIAN VEGETATION MONITORING PROGRAM 1993

NECHAKO FISHERIES CONSERVATION PROGRAM
Technical Report No. RM93-7

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ABSTRACT

As part of the deliberations of the Nechako River Working Group (NRWG, 1987), a program of measures was recommended to ensure that chinook salmon stocks in the Nechako River would be conserved following the change from short term to long term flows associated with the Kemano Completion Project. The program of measures included recommendations for increasing bank stability and controlling sediment sources that may affect water quality, either through the use of engineering or bioengineering techniques.

Bioengineering techniques have been used throughout Europe and North America to stabilize eroding banks. The Nechako Fisheries Conservation Program (NFCP) completed a literature review of these techniques to identify appropriate treatments to be used along the Nechako River and tributaries (Triton 1993a). Results of this literature review provided recommendations for treatments applicable for pilot testing along the Nechako River.

In the spring of 1991, pilot revegetation projects were initiated at two test sites in the upper Nechako River watershed, one along the Nechako mainstem and one in Greer Creek (a tributary to the upper Nechako River). The purpose of this work was to determine the applicability of bioengineering techniques to stabilize streambanks and thereby reduce sediment input to the Nechako River. Bioengineering methods used in the first year of the project included spiling, brush mattressing, contour wattling, seeding and placement of rooted and unrooted cuttings as well as various types of revetments designed to protect the toe of banks from fluvial erosion.

Monitoring of the revegetation sites was carried out in 1991, 1992 and 1993. The monitoring was terminated in 1993 after plants failed to propagate at the large Nechako site and a rainstorm had caused the relocation of Greer Creek away from that test site.

Site conditions such as soil conditions, slope, inundation of the lower slope, mass wasting and limited rainfall may have hampered the success of establishing vegetation at the Nechako River test bank. Although the brush mattress and shoreline fascines remained stable, neither vegetative treatments nor natural vegetation grew well at that test site.

Aside from major changes in the stream channel at the Greer Creek test bank, vegetation originating from the spiling showed good signs of propagation. Over 70% (29 m of 39 m) of the spiling was buried during the June flood. However, opportunistic site visits conducted post 1993 indicated that willow shoots, originating from the spiling, continued to grow with vigor.

The conclusions of the three year pilot study were:

1. Thinleaf alder (*Alnus tenuifolia*) does not appear to propagate well from cuttings and is likely best established by seeding. Willow cuttings provide the highest opportunity of success for use in future revegetation efforts. Suitable supplies of donor stocks are present in the Nechako area.

2. Establishment of rooted or unrooted cuttings will likely require watering for at least the first growing season, unless they are placed in areas where the cuttings can reach water. The use of longer cuttings may improve success rate. Alternative species, such as wild rose, could provide some opportunity for future revegetation projects at dry sites.

3. Structural techniques such as wattling, brush mattresses and spiling can be successfully employed in the Nechako area although considerable vegetative material and manpower is required. Smaller tributary banks are likely more suited to these techniques with assistance from land owners or community groups.

4. The use of bioengineering techniques for large Nechako banks could possibly be combined with engineering techniques along these areas. The feasibility and cost effectiveness of using hard engineering works to reduce erosion at these sites is unknown at this time.

INTRODUCTION

As part of the deliberations of the Nechako River Working Group, a program of measures was recommended to ensure that chinook salmon stocks in the Nechako River would be conserved following the change from short term to long term flows associated with the Kemano Completion Project. The program of measures included recommendations for increasing bank stability and controlling sediment sources that may affect water quality, either through the use of hard engineering or bioengineering techniques.

The benefits of a healthy riparian zone extend beyond reducing bank erosion and decreasing sediment input into a stream. Riparian vegetation also provides valuable overhead cover and shade for rearing juvenile and adult salmonids, augments nutrient input into streams via increased deposition of organic matter and provides habitat for invertebrates used as food by juvenile and adult fish.

In 1990, the NFCP conducted a literature review of bioengineering applications to identify prescriptions that could be used along the Nechako River. Possible treatments included techniques such as live fencing (spiling), placement of bundles of shrubs such as willow (wattling) and planting of rooted and unrooted cuttings . The results from this literature review can be found in the NFCP Report RM 90.3.1 (Triton 1993a)

Based on the results of this literature review, a pilot bank stabilization project was initiated in the spring of 1991. Its objectives were to:

1. Stabilize each bank against erosion by using revegetative techniques to protect the toe of selected banks along the Nechako River and Greer Creek; and
2. Test and compare the effectiveness and success of the establishment of various types of revegetative bank stabilization techniques.

Monitoring of the revegetative works was carried out from 1991 through 1993. Installation methods and results of previous studies are documented in NFCP reports RM91-7, Riparian Vegetation Pilot Testing, and RM92-7, 1992 Bank Stabilization Monitoring Program (Triton 1996b, Triton 1996c). This report summarizes the results of the pilot test over the monitoring period.

STUDY AREA

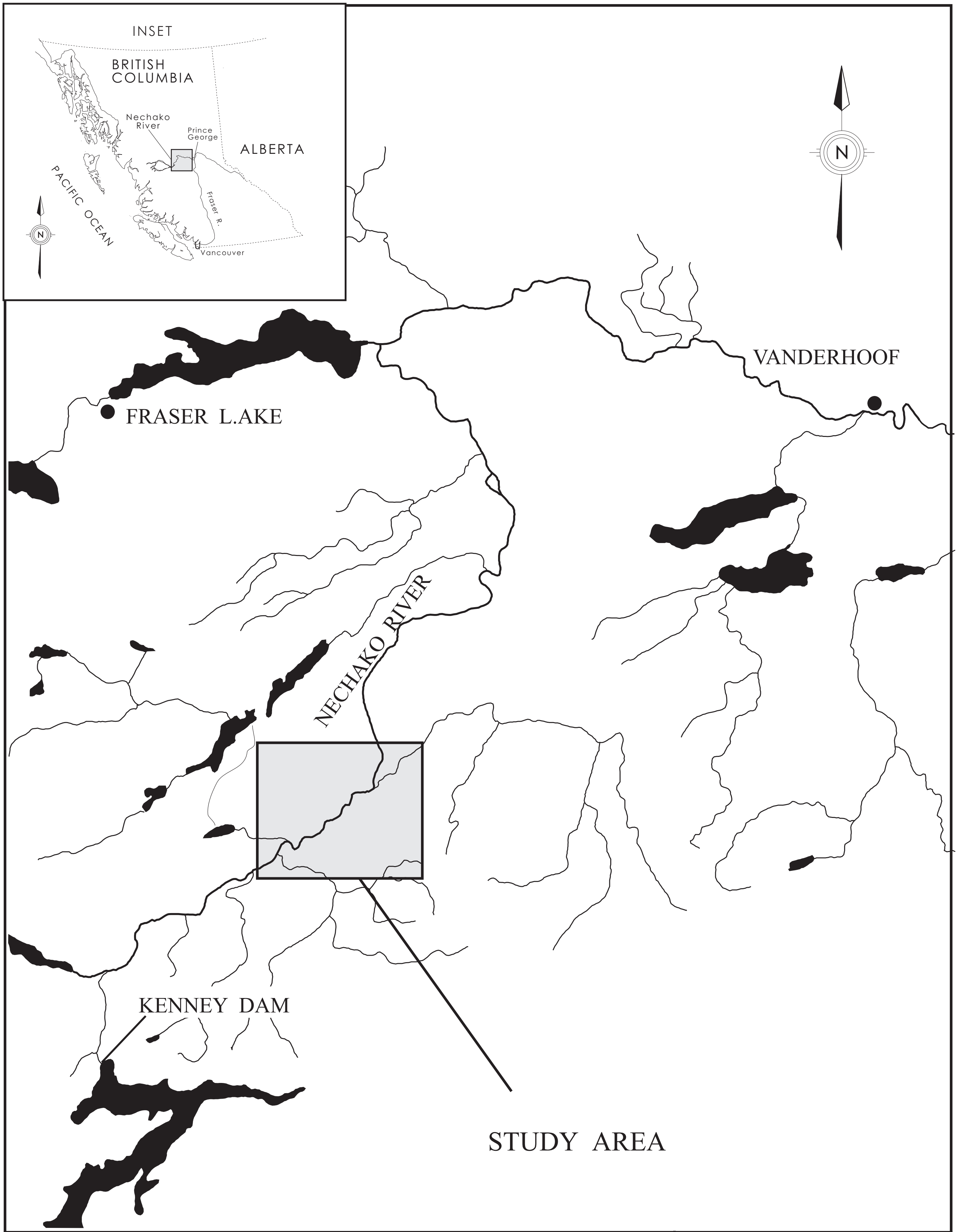
The Nechako River flows generally northwest from Cheslatta Falls to its confluence with the Fraser River at Prince George (Figure 1). The upper Nechako River study area is located within one of three dry subzones of the Sub-Boreal Spruce Biogeoclimatic zone (SBS). Typically the SBS is characterized by seasonal extremes of temperatures: severe, snowy winters, relatively warm, moist, and short summers, and moderate annual precipitation (Meidinger and Pojar 1991). Average annual temperatures are below 0°C for 4-5 months and above 10°C for 2-5 months. Mean annual precipitation ranges from 440-990 mm of which 20-25% is snow. Two test sites were chosen for initiating the pilot program; one site was along the Nechako River approximately 30 km downstream of Kenney Dam; the other, at Greer Creek, which is one of the larger creeks draining into the upper Nechako River (Figure 2).

The selection of the test banks at each site was based on six criteria:

1. Erosion problem had to be representative of other locations in the Nechako system;
2. Sites should not be exposed to high water velocity or excessive water depth;
3. Bank material had to be comprised mainly of sand-silt / clay (i.e., the type of soil identified as having the most potential to damage spawning habitat);
4. Desirable plant material had to be available at or close to the construction site;
5. Sites preferably had to have a southwestern or south-eastern exposure to optimize available sunlight and soil temperatures; and
6. Test sites had to be accessible by boat and / or machinery necessary to construct as well as monitor and maintain the revegetated area.

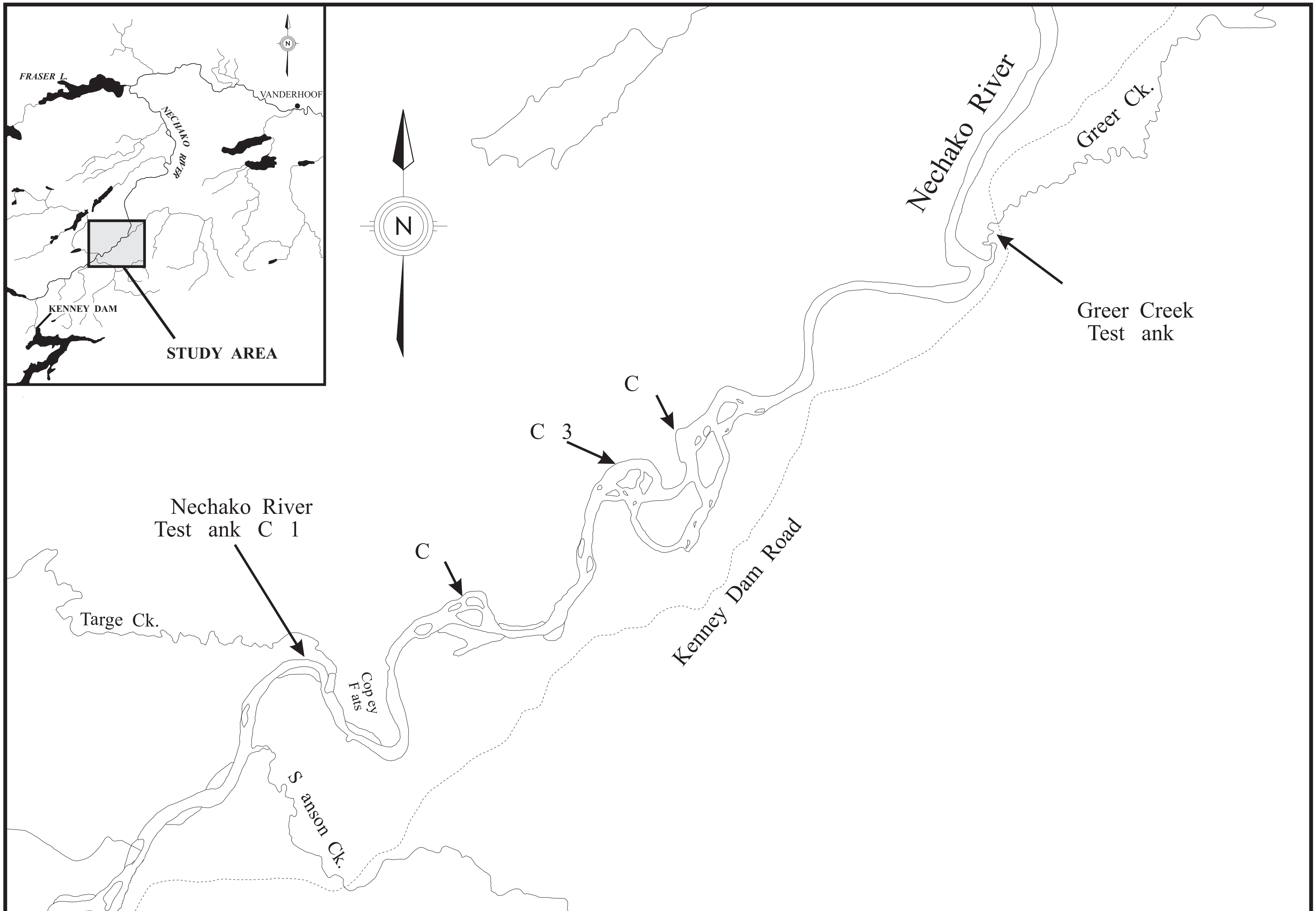
Greer Creek

Greer Creek has a number of eroding banks comprised of silt / clay soils. Several sites were examined for their suitability for testing of erosion control techniques. The site eventually selected was 100 m south of the Greer Creek Bridge, on the west side of the Kenney Dam road (Figure 2). This site provided good access and had a variety of desired shrub species readily available. These



Nechako Fisheries Conservation Program | Map # RM93-7-1 | Scale 0 20 KM

FIGURE 1. Nechako River Study Area



Nechako Fisheries Conservation Program	Map # RM93-7-

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FIGURE . THE LOCATIONS OF TEST ANKS FOR THE REVEGETATION PILOT PRO ECT species included Thinleaf alder (*Alnus tenuifolia*), Pacific willow (*Salix lucidia lasiandra*) and Bebbs willow (*Salix bebbiana*). It was noted that numerous alders were growing at the edge of the stream and on bank slopes, in close association with Bebbs willow. Pacific willow was more evident at the top of banks and along old flood channels.

Nechako River

A number of candidate sites were identified on the Nechako River. However, large stage changes associated with differences in winter flow conditions (approximately 32 m^3/s) and cooling flows ranging from 170 to 283 m^3/s for protection of upstream migrating sockeye provided challenges in finding suitable sites. Since bioengineering techniques are identified as being most suitable to control erosion on small streams or on non-critical eroding sections of large streams (Bowie 1982, Keown et al. 1977, Klingeman and Bradley 1976, Mills and Tress 1988, Schiechtl 1980), a site which could expect the least impact from increased water currents was selected for test purposes. Four clay banks (CB-1 to CB-4) located 30, 33.5, 36.5 and 38.5 km downstream of the Kenney Dam were considered as potential test sites (Figure 2). A fifth site, across the Nechako River from Targe Creek (30.5 km downstream from Kenney Dam) was also considered. Stream flow conditions at the Targe bank and especially at CB-4 were deemed too severe to attempt revegetation during this pilot project. Of the remaining sites, CB-1 was selected because of its proximity to suitable plant material (Copley Flats at the mouth of Targe Creek) and ease of access. At winter flow levels, the shelf which exists at the base of CB-1 could facilitate the planting of shrubs and / or seeds.

METHODS

Selecting of Appropriate Revegetation Techniques

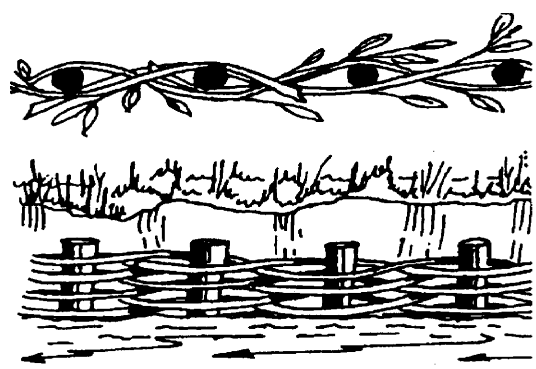
Upon completion of the literature review and onsite observations of implemented revegetation projects within British Columbia, a number of applicable techniques were identified which could be tested during the Nechako River revegetation pilot project. These techniques are briefly described below but detailed descriptions are available in the NFCP Report No. RM 90.3.1 (Triton 1993a).

Greer Creek

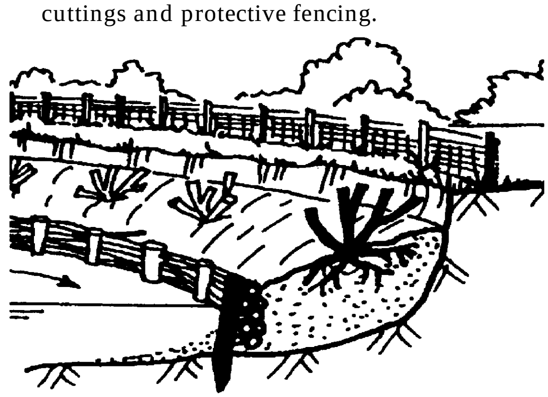
A technique known as spiling was chosen for use at Greer Creek since this method incorporated structural integrity plus vegetative growth to protect the base (the toe) of a streambank against fluvial erosion. This was appropriate for Greer Creek since this stream experiences a strong freshet each spring and the test bank, like many other banks on Greer Creek, was sloughing badly due to erosion at its toe. Spiling involves the positioning of a series of stout, live posts which are driven approximately half their length into the ground at the base of an eroding bank. These posts are then interwoven with slender branches, also called weathies (the British variation), to create a fence-like structure between the stream and the eroding bank (Figure 3). The area between the spiling and the bank is then backfilled with soil collapsed from the bank and seeded to stimulate growth. Spiling provides a rigid structure that has the potential to become rooted while preventing erosion from fluvial action as vegetation becomes established.

Figure 3
Examples of Spiling (Lewis and Williams 1984)

A. Top view (above) and side view (below) of spiling.



B. Spiling used in conjunction with placement of live cuttings and protective fencing.



Nechako River

Bank erosion at the toe of the Nechako site is mainly caused by wave wash from boat wakes and discharge variation associated with summer cooling flows on the Nechako River. Upslope erosion results from wind erosion, rilling due to rain events and, occasionally, slope failure. Initiating plant growth was considered a more important factor than creating a barrier against erosion at the Nechako site. Revegetative techniques selected for this site primarily involved testing several methods of propagation in combination with bioengineering structures to reduce erosion. Propagation techniques involved planting unrooted and rooted live cuttings, as well as seeding with appropriate grass mixes in an effort to provide quick stabilization. Bioengineering structures tested at the site included a brush mattress and contour wattling. Both of these structures utilize unrooted live materials to create rigid structures. Wattles in particular were directed at stabilizing the toe of the bank while vegetation becomes established.

Unrooted Cuttings

Placement of unrooted cuttings is a relatively simple procedure, provided that some precautions are enforced. These include:

1. Collecting cuttings when donor plants are dormant;
2. Ensuring cuttings are not allowed to dehydrate before placement; and
3. Ensuring that no more than 20% of a cutting is left above ground after planting.

The simplicity of the procedure for placement of unrooted cuttings allows for a relatively inexpensive method of revegetating large areas such as the Nechako River test bank.

Rooted Cuttings

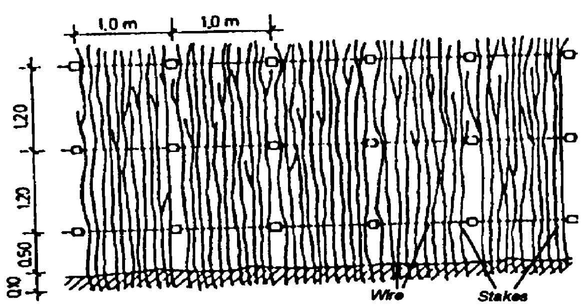
Rooted cuttings differ from unrooted cuttings by having an established root network prior to planting. This necessitates more planning than unrooted cuttings, since the rooted cuttings must be grown prior to being used and coldframe facilities are required to grow rooted cuttings from live cuttings. However the establishment of roots under enhanced conditions may provide an increase in survival rates which compensates for the increased effort.

Brush Mattresses

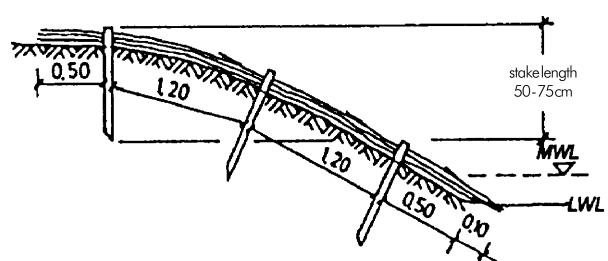
Like cuttings, a brush mattress relies on the propagative properties and ensuing vegetative growth and root development of the species used to provide protection against erosion. Unlike cuttings, brush mattresses do provide some protection from overland erosion from rain and wind and can also protect the toe of a bank from fluvial erosion due to waves or water current. If the base of the mattress is properly secured prior to the establishment of vegetation, it provides a rigid barrier to help reduce erosion. Brush mattressing involves the placement of branches greater than 1.5 m long to form a layer of closely spaced parallel branches which lie flat on a stream-bank. The mattress is held flat to the ground surface by crosswires or crossbraces which are staked into place (Figure 4).

Figure 4
Brush Mattress Construction

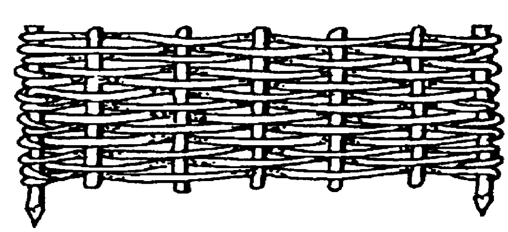
A. Top view of a brush mattress (Schiechtl 1980).



B. Side view of a brush mattress (Schiechtl 1980).



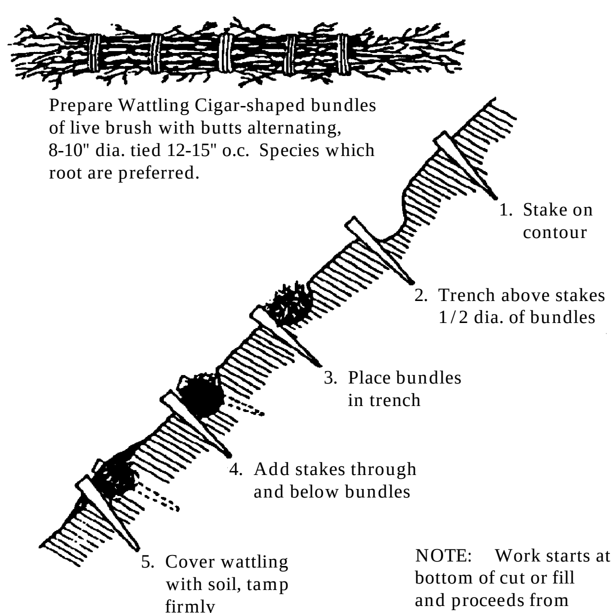
C. A hurdle of woven hardwood (Lewis and Williams 1984).



Wattles

Numerous variations of the term wattle exist, including fascine (German) and faggot (British). However, all refer to the bunching of slender branches from shrubs to create bundles 2 to 3 m long and 20 to 40 cm thick. (Figure 5) The wattle can be employed to protect the toe of a bank by intercepting waves washing against the bank or reducing water velocity next to a bank (faggoting). Wattles are also useful for securing other revegetation structures, such as the toe of a brush mattress (fascines). Finally, placing wattles in a series of parallel shallow trenches, following the profile of the bank, is known as contour wattling and is particularly useful for stabilizing soils on steep slopes.

Figure 5
Preparation and Installation of Wattles
(Gray and Leiser 1982)



Implementation of Revegetative Techniques

The Riparian Vegetation Pilot testing program was initiated in March of 1991 with an initial field visit conducted to choose appropriate sites for testing. In addition, cuttings were collected for rooting in coldframes at Deadman Creek. Technical expertise for the initial implementation stage was provided by Pat Mathew of the Shuswap Nation Fisheries Commission (SNFC). Installation of various revegetative techniques and bioengineering structures took place between April and June of 1991.

Greer Creek

Construction of the spiling began on April 9 and was completed by April 11, 1991. The structure ranged in height from 0.7 to 1 m above the water level. The total length of the spiling constructed was approximately 50 meters.

Retrieving plant material proved to be the most time consuming activity at this site. Materials were readily available but the cutting of posts and weathies (long slender branches) to weave between the posts was slower than expected. Alders were more extensively used for live posts than either Bebbs or Pacific willow posts, since alders of appropriate size were most readily available. Bebbs willow posts were the least abundant and Pacific willow posts were also hard to acquire since many of the plants available were overmature and rotting in the center. Posts had an average length of 2 m and ranged in width from 8 to 15 cm.

A fence post auger was initially used to drill holes in which the live posts were placed but the posts could not be situated deep enough into the soil before the sides of the holes collapsed. Eventually, a fence post pounder was used for this task. The pounder proved to be a faster method although just as strenuous as the auger. The distance between posts ranged from 0.7 to 1.1 m and each post was driven a minimum of 50% of its total length into the ground, although many were deeper than this. Frozen soil beneath the surface of the ground at some sections of the work site prevented posts from being placed in preferred locations along the bank, specifically the toe of the bank, since neither drilling nor pounding could penetrate the frozen layer of ground.

Weathies were comprised primarily of alder and Bebbs willow. Longer branches were more suitable since they encompassed more posts, making the structure stronger. Once the weaving of weathies between posts was completed, the bank was collapsed behind the spiling, and soil was backfilled to the top of the weaving (Photo 1).

In anticipation of increased flow during spring freshet, a short 5 m section of spiling was also positioned at the head end of the main spiling, close to the creek margin. This was done to provide additional protection and pre-

Photo 1

vent undermining at the upstream end of the main structure since it was expected that the upstream end of the spiling would bear the brunt of increased water current. Two small spruce tree revetments, anchored by 1/4" cable to a nearby cottonwood, were woven into this short section of spiling (Photo 2).

After the freshet subsided, the area behind the spiling was backfilled and seeded with an evenly proportioned mix of Creeping Red Fescue (*Festuca rubra*), Alsike clover (*Trifolium hybridium*) and annual Rye grass (*Lolium multiflorum*). A starter fertilizer, 34-0-0 (+11), was spread with the seed to help establish growth.

Photo 2

Nechako River

Details on planting at the Nechako River test bank can be found in NFCP Report RM 91-7 (Triton 1996b). The first step towards revegetating the Nechako bank occurred in mid-March with the collection of cuttings for rooting. Construction of bioengineering structures and planting of unrooted cuttings took place between April 12 and April 15, 1991. Water flows in the upper Nechako River were approximately 71 m^3/s and increased slowly during revegetation activities. Variations of the revegetation techniques proposed were used along the Nechako test bank, since wave action, particularly from boat traffic, was a primary cause of erosion at the toe of this bank. Hence, methods specific to breaking the force of waves and preventing toe erosion were also employed in conjunction with the proposed revegetation techniques.

Revegetation of the Nechako test bank began with the placement of 135 alder and 270 willow unrooted cuttings. These cuttings averaged 20 cm long by 2 cm in diameter. Each cutting was kept moist and dipped in Stim Root No. 3 rooting hormone prior to placement. Approximately 2 cm of each cutting was exposed above ground level. Two areas, each with different densities of unrooted cuttings, were planted on the test bank (Fig-

ure 6). A 30 m^2 area, Plot 1 (along 9 m of shore), was planted with 4 cuttings / m^2 while a second 200 m^2 section, Plot 2, was planted at a density of approximately 1 cutting / m^2, along 25 m of shore. The two sites were 30 m apart. Both sites were comprised of sand / clay soils and planting conditions ranged from moist to muddy. Plot 2 already had some small shrubs and grasses growing on it, whereas Plot 1 was devoid of vegetation.

Cuttings were collected from the Greer Creek site in mid March for transfer to Deadman Creek coldframe facilities where they were grown into rooted cuttings. In addition, another 150 alder and 200 Bebbs willow cuttings were collected from Copley Flats (near the mouth of Targe Creek) during revegetation of the Nechako test bank in mid-April. This was done at a later date to ensure adequate numbers of rooted cuttings would be available for planting, since fungus problems had previously destroyed 70% of the Bebbs willow cuttings taken earlier from the Greer Creek site. The coldframe greenhouses to propagate rooted cuttings were of simple design. The greenhouse consisted of a low wood frame with an opaque lid which enclosed a growing medium of peatmoss and perlite. A self-modulating heating coil maintained desired soil temperature. Rooted cuttings were grown in greenhouses for several weeks until roots developed, at which time they were ready to be transported and planted in the selected sites. Three people were able to collect over 500 cuttings in less than half a day, including packaging the cuttings into a transportable cooler (Photo 3). Rooted cuttings were ready for transport back to the Nechako River by mid-May, and placement began at the Nechako test bank on May 30. The area planted with rooted cuttings extended approximately 150 m downstream from the upstream end of the clay bank (Photo 4). The rooted cuttings were placed in upper, middle and lower zones of the test bank, ranging from the river edge to as high as 15 m above the water level. In areas where unrooted cuttings had been previously planted, rooted cuttings were planted at higher elevations on the bank (Figure 6).

A brush mattress, 10 m wide and extending 6 m up the bank, was constructed between Plot 1 and Plot 2 (Photo 5). The mattress was mainly comprised of young alders and Bebbs willow branches. Attempts to press the mattress flat against the bank using 1 m stakes and bailing wire as cross braces failed since the wire kept breaking. Instead, trembling aspen (*Populus tremuloides*) poles were positioned as cross braces and anchored with stakes and wire. The toe of the brush mattress was secured and protected against water current with two layers of wat-

Photo 3

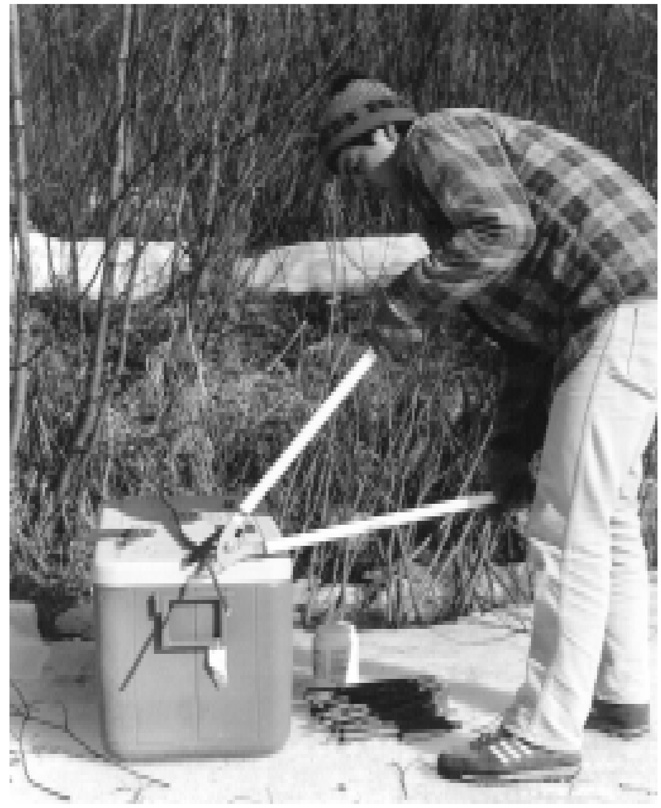
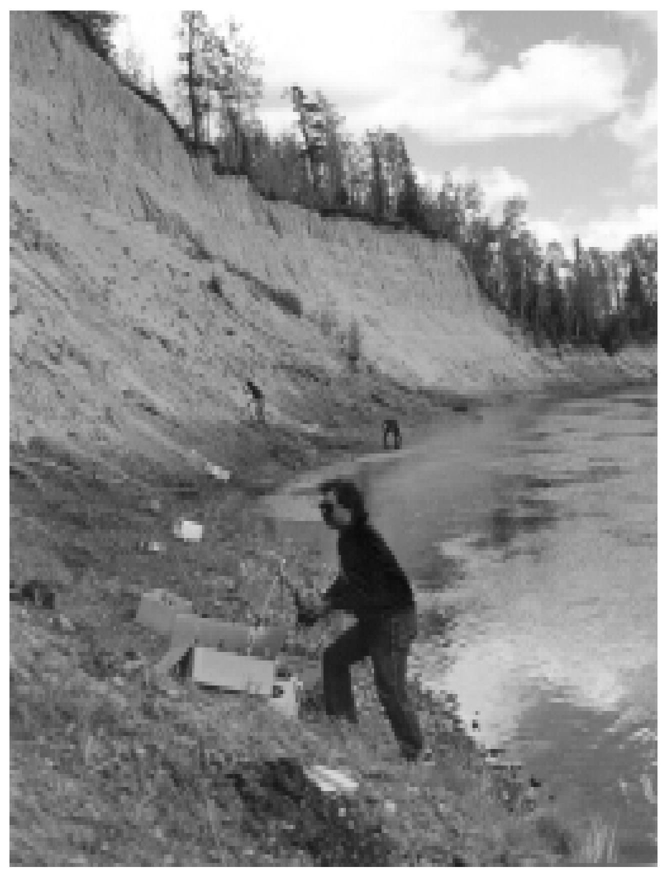


Photo 4



tles comprised of Pacific willow, Bebbs willow and alder branches. The wattles were staked into the substrate and then covered with soil from above the bank. A row of coniferous branches were placed under each layer of wattles, to act as buffers against wave wash to prevent soil erosion at the toe of the mattress. The brush mattress was then partially covered with soil.

Various types of wattles were tested to compare their effectiveness in reducing wave-caused erosion at the toe of the Nechako test bank along treated and untreated stream sections. These methods included:

1. Wattles staked parallel to the flow of the river, in the water but at the base of the bank below a 10 m section of Plot 2;
2. Wattles, staked as in method 1, in conjunction with small coniferous tree revetments placed below a second 10 m section of Plot 2;
3. Two rows of wattles; staked as in method 1, in conjunction with coniferous tree revetments, placed along 10 m of unprotected bank downstream of the brush mattress; and
4. Two rows of wattles; staked as in method 1, with a row of coniferous branches held in place under the wattles, placed along 10 m of unprotected bank downstream of the brush mattress and at the base of the brush mattress.

Photo 5

Upstream of, and adjacent to, the brush mattress, a small section of contour wattling was constructed (Photo 6). A total of four wattles were placed in four separate trenches which ranged from 1 m to 5 m up from the stream edge. Each wattle was secured with 1 m stakes driven into the bank. An area of bank, approximately 15 m^2, was planted in this fashion.

Photo 6

As in the Greer Creek site, the Nechako bank was seeded with Creeping Red Fescue, Alsike Clover and Annual Rye Grass after completion of all other revegetation activities.

Monitoring

Monitoring of the two test sites in 1991 occurred twice after the initial work was completed, in late May and again in late August. In 1992 monitoring took place in May and November and the 1993 monitoring was only conducted in November. Maintenance and additional monitoring of the sites were made opportunistically by crews working on other projects within the study area. During these times, the sites were often video taped and photographed.

Photographic Monitoring

Photographs were taken of each test bank during the scheduled monitoring trips each year. Supplemental photographs were taken of the sites on an opportunistic basis, particularly at Greer Creek, which underwent severe changes in channel course after the occurrence of a flood event in June 1993. As well, video documentation was taken at the sites to aid documenting growth rates and establishment of cuttings and resistance to erosion and relative water levels, particularly at Greer Creek. Table 1 indicates the dates that videographic documentation of each test bank was recorded. Photographic documentation also aided in the assessment of structural integrity of bioengineering techniques installed at the Nechako test bank and at the Greer Creek site. Photographs were also taken at control sites which were established in proximity to the test sites and were used as a comparison of erosion activity among treated and untreated areas.

Surveys of Vegetative Growth at Test Banks

Vegetative growth was evaluated by measuring the lengths of a randomly selected sample of stems and branches of vegetation from each bioengineering technique. The survival of rooted and unrooted cuttings was determined by counting the number of cuttings which demonstrated signs of growth and comparing this to the number of planted cuttings. Survival of grasses used in revegetation techniques was difficult to quantify and grass was simply noted as present or absent in seeded areas.

RESULTS

Vegetation

Greer Creek Test Bank

Monitoring conducted from 1991 to 1993 indicated good growth in the spiling used to stabilize the Greer Creek site. In addition, herbaceous species planted in the backfilled area behind the spiling grew throughout the monitoring period.

Willow shoots at the Greer Creek test bank showed some signs of grazing but this grazing did not appear to adversely affect growth of the spiling since the average shoot length increased from 0.65 m to 1.00 m between 1992 and 1993. By the project end, weathies (interwoven branches) remained the only source of shoots in the spiling. Upright posts which had exhibited signs of growth in 1991 and 1992 had stopped growing by 1993.

Table 1
Dates of Videographic Documentation at Greer Creek and Nechako River Test Banks

Greek Creek Revegetation Site	Nechako River Test Bank
April 15, 1991	April 16, 1991
April 26, 1991	April 27, 1991
May 9, 1991	May 14, 1991
May 10, 1991	May 31, 1991
May 12, 1991	June 10, 1991
May 23, 1991	July 13, 1991
May 31, 1991	August 14, 1991
June 10, 1991	October 17, 1991
July 11, 1991	April 13, 1992
August 26, 1991	May 12, 1992
September 22, 1991	June 16, 1992
October 8, 1991	July 12, 1992
March 9, 1992	October 6, 1992
April 7, 1992	May 23, 1993
May 7, 1992	June 15, 1993
June 14, 1992	
July 12, 1992	
October 6, 1992	
April 17, 1993	
May 8, 1993	
May 12, 1993	
May 23, 1993	
June 15, 1993	
June 21, 1993	
June 30, 1993	
July 6, 1993	
August 20, 1993	

Nechako River Test Bank

Naturally occurring vegetation provided the most foliage along the length of the Nechako River test bank. Herbaceous species, which were planted as seed during the initial revegetation project, continued to grow along the shallow slope near the upstream end of the test bank. Although these species supplemented naturally occurring vegetation at the site, they were almost entirely absent along the steeper sections of the test slope farther downstream.

Four techniques were used to establish shrub species: unrooted cuttings, rooted cuttings, wattles and a brush mattress. Despite some initial growth in the first two years of the project, none of the vegetative material employed in these techniques demonstrated good continued growth. By November 1993, new shoots were sparse and in many instances the shrubs had died, particularly along sections of the test bank, which were inundated by water during spring freshet and / or summer cooling flows. Shrubs contained within the brush mattress and wattles did exhibit signs of growth but this growth was minimal. The net increase in shoot length was only 7 cm for the brush mattress. The average length of shoots in the wattles actually decreased by 2 cm.

There were signs of grazing on planted shrubs along the Nechako River test bank, which may in part have accounted for the apparent reduced growth observed for the wattles and the brush mattress.

Although shoots from unrooted cuttings and rooted cuttings had better growth than those in the brush mattress or in wattles, the number of live plants for both techniques was minimal with only 5 observations for unrooted cuttings and 1 observation for rooted cuttings by 1993. Of an original 400 unrooted cuttings, only 3 had survived into the third year, or approximately 0.8% of the total number planted. Similarly only 7 of the original 400 rooted cuttings were alive in November 1993.

Structural Integrity of Vegetative Structures

Greer Creek Test Bank

The spiling at the Greer Creek test bank, although still intact, had begun to unravel at its downstream end by the end of the monitoring program. This unraveling was initially observed in 1992 but was more pronounced in May 1993 (Photo 7). A rain-generated flood event, which occurred during the week of June 28, 1993, resulted in a complete change in channel morphology at the Greer Creek revegetation site (Figure 7). The discharge for Greer Creek during this flood was approximately twice that estimated during freshet conditions in May 1993. And, although no gauging station exists for Greer Creek, comparison to recorded freshet values and conversations with local landowners suggested it was an extreme event. As a result of the June 1993 flood, the first 30 meters of spiling were almost completely buried by sediment (Photo 8). The next 10 m of spiling were partially buried, while the remaining 10 m of spiling were still totally exposed.

The change in channel course isolated the spiling away from the new stream channel so that the spiling, which was adjacent Greer Creek, was left 25 m west of the active channel. An estimated 30 m^3 of material was de-

Photo 7

The toe o the Nechako River Test ank as protected y various methods indicated y etters as o o s

A. One ro o   att es staked para e to the   o o the river

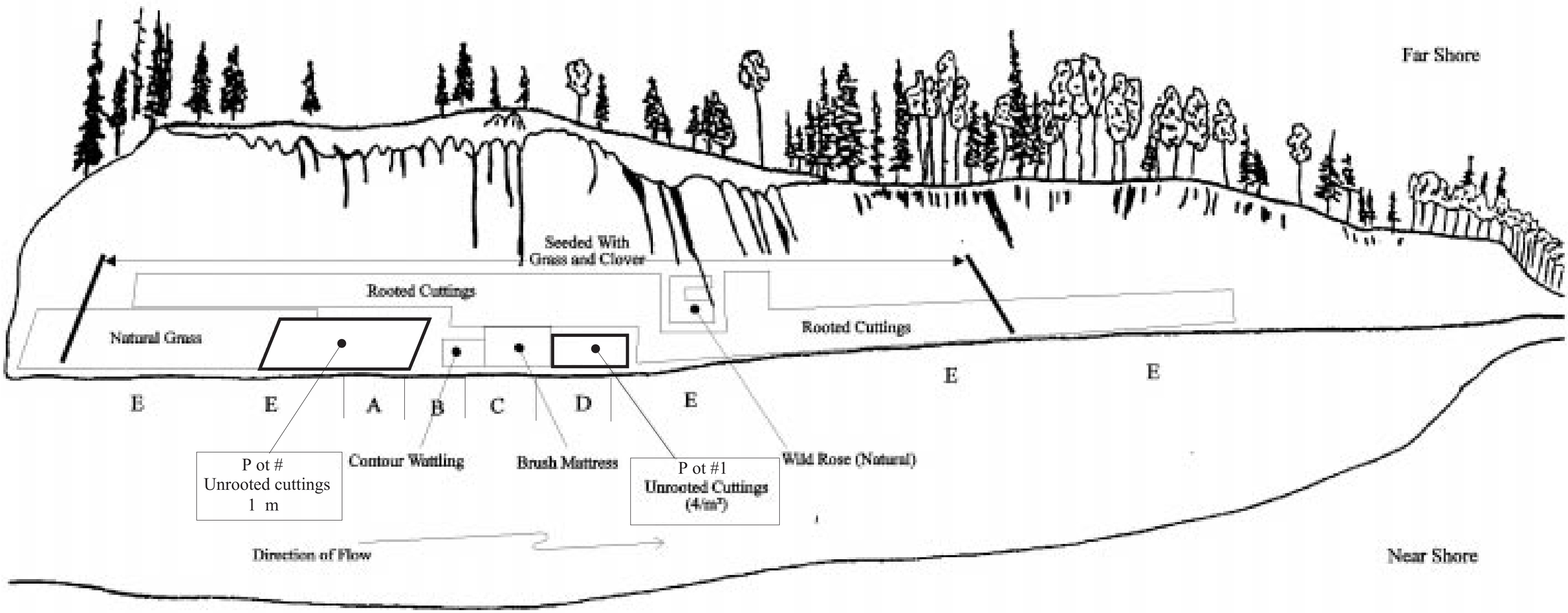
.   att es staked as in A   ut in con uction ith coni erous tree revetments

C. T o ro s o   att es as in A   ut a so securing a coni erous ranch ayer

D.   att es staked as C ut in coni erous tree revetments

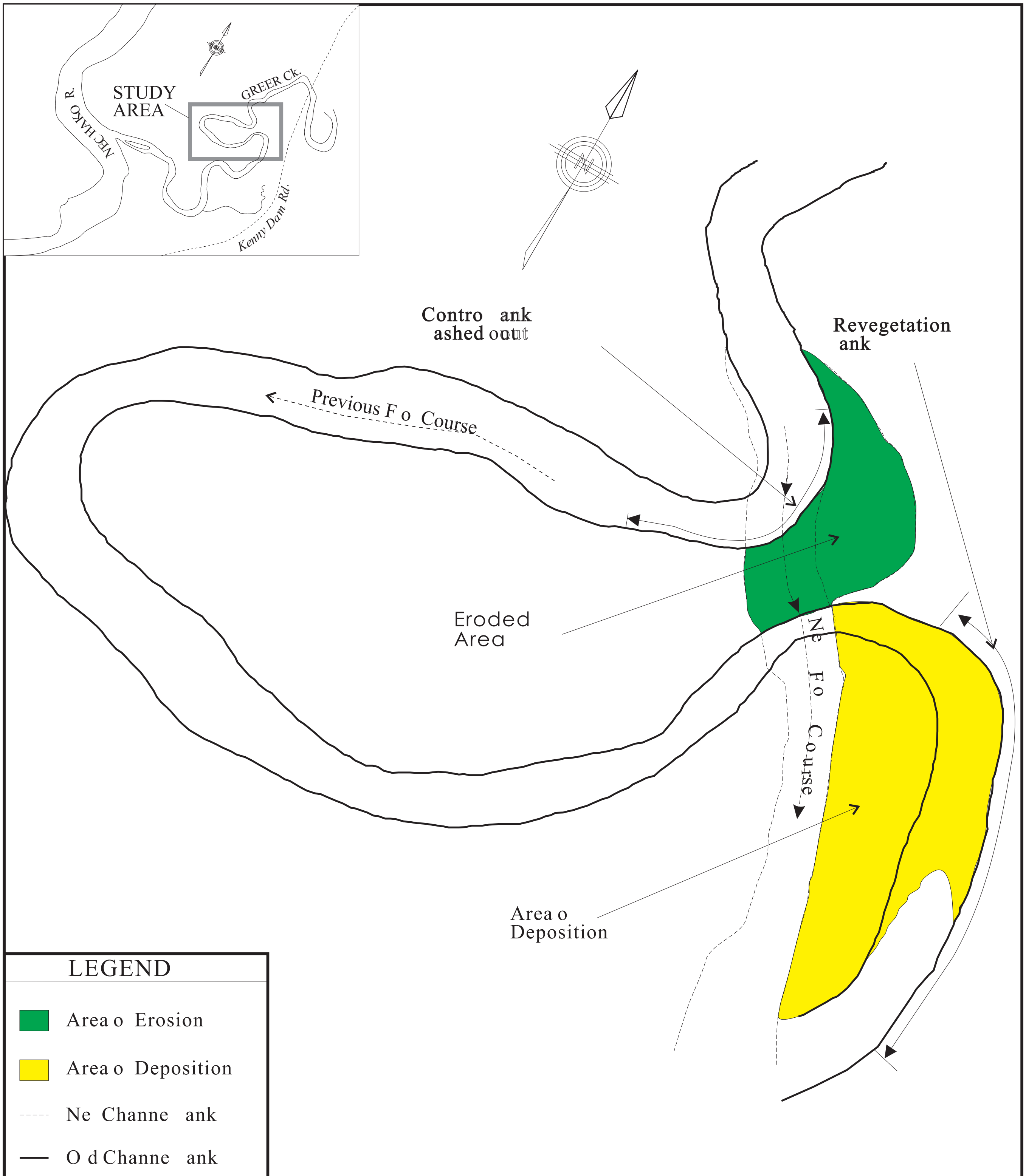
E. No protection at the toe o the ank.

Note   Grass seeding over apped areas revegetated y other means inc uding areas a ready having some gro ing grass.



Nechako Fisheries Conservation Program	Map# RM93-7-	Not to Sca e

Figure . Schematic Diagram o the Nechako River Test ank Sho ing Spatia Arrangement o Various Revegetation Techni ues



Nechako Fisheries Conservation Program	Map # RM93-7-7
URE T S	

Photo 8

devoid of needles. The contour wattling showed signs of degradation as wattles were becoming exposed. This suggests that the wattles were not sufficiently buried when initially placed or that they had become exposed by erosion. The short sections of wattling covered by contour wattling, one wattle long by three wattles high, may also have adversely affected this section's stability. Longer sections of contour wattling may be less prone to exposure or downslope movement (Gray and Leiser 1982). Regardless of the cause, exposure of wattles tends to reduce their effectiveness in stabilizing soils and can also lead to dehydration of vegetative material in the wattles, particularly roots, which will impact upon vegetative growth and vigor. Wind erosion, prevalent on these types of banks, may have been responsible for the exposure of the material.

posited between the spiling and the new river channel (Photo 9). The final assessment, conducted in November 1993, assessed vegetative growth over the project period. However, the isolation of the site due to the channel shift resulted in termination of the pilot test and no assessments other than opportunistic ones were made of the growth of the planted materials.

Nechako River Test Bank

The bioengineering techniques employed at the Nechako test bank to protect against erosion did withstand the effects of freshets and winter conditions during the monitoring period. However, high mortality of plants meant that degradation due to weather and flow conditions had begun at this site.

The brush mattress at the Nechako River test bank remained in place over the monitoring period but experienced limited growth. Similarly, shoreline fascines at the base and upstream of the brush mattress were intact and there were no signs of displacement ,which may have been expected due to winter ice or spring and summer high water conditions. The coniferous branch layers affixed to the toe of the brush mattress and to the toe of the slope immediately downstream of the brush mattress were still in place, although their effectiveness was likely reduced due to the loss of needles. Similarly, the coniferous tree revetments were in place but were also

DISCUSSION

Aside from major changes in the stream channel at the Greer Creek test bank, vegetation originating from the spiling continued to grow well. Although over 70% (29 m of 39 m) of the spiling was buried during the June flood, at least 10 of the 29 m of buried spiling may still grow, since tops of willows are exposed and appear to have grown after the flood. Opportunistic site visits conducted post 1993 indicate that willow shoots originating from the spilling are continuing to grow with vigor. (NFCP data on file.) Although the channel shift terminated the pilot test prematurely, the results of the three seasons of monitoring suggest that bioengineering techniques could be a suitable erosion control treatment for this type of streambank. Growth of vegetation, particularly willow, was robust and there is a ready supply of local materials. This type of revegetative treatment can be done with minimal or no machine activity and hence results in little disturbance. However, because of the

Photo 9

dependent upon a stable growing medium and some method of shoreline protection (the toe) is consequently required when revegetation projects are initiated. Without shore protection, the bank may be easily destabilized before introduced vegetation can take root, resulting in a loss of plant material and continued erosion.

Cuttings (rooted and unrooted) and grass seeding are best used when integrated with some other structural revegetation method which ensures a stable growing medium. The high water period associated with the summer cooling flows coincides with the normal growth season and is an atypical situation which may cause stress to juveniles during initial growth periods after planting. This submergence likely retards growth when growth and nutrient storage should be occurring. This retarded growth may in turn affect the winter hardiness of cuttings and increase overwinter mortality. Furthermore, if suitable growth does not occur during the summer months, the ability for such vegetation to initiate growth the following spring may be impaired. Several other factors likely affected the survival rates of vegetation on the Nechako River test bank. Dry site conditions above the high water mark and slope instability probably affected the cutting techniques on the Nechako River bank. A regimented watering regime during the first year after planting may have helped the establishment of vegetation.

Unrooted cuttings demonstrated good initial growth rates but were unable to maintain their growth over the monitoring period. The use of longer cuttings may provide additional energy reserves from which cuttings can draw to establish root networks in dry conditions. In addition, the use of longer cuttings may provide the opportunity to place stems deeper into soils and reach subsurface water sources inaccessible to shorter cuttings.

nature of the work the labour component is very high. Collection of suitable materials was the most time consuming process during construction. Once materials were collected, time was required to construct the spiling, and additional time was also required to backfill after freshets and seed the test area. It was estimated that three person hours were required to construct each meter of spiling. Construction time could be reduced on a larger scale project with persons dedicated to individual tasks, such as material collection and construction. Stream stewardship initiatives and aid from local rod and gun clubs or land owners, to provide additional volunteer labour, may provide the most ideal opportunities to use this type of application for bank stabilization.

Site conditions at the Nechako River test bank (soil conditions, degree of slope, inundation of the lower slope, mass wasting, wind erosion and limited rainfall) may have limited the success of establishing vegetation along the bank. Repeated submergence of vegetation at the toe of Nechako River bank and an unstable growing medium are also possible detriments to establishing vegetation in this area. Neither vegetative treatments nor natural vegetation grew well at the Nechako River test bank.

It appears that protection of the toe of the bank reduces bank recession, when compared to banks where no protection exists. The success of establishing vegetation is

During the first year, cuttings may have shown a significant amount of shoot growth with little supporting root growth. Polster (1998a) recommended using cuttings up to 1.5 meters in length and inserting cuttings 3/4 of their length into the substrate.

Rooted cuttings were also unsuccessful at the Nechako test bank and this is likely due to similar factors as unrooted cuttings. Stress caused by transportation and inadequate acclimatization of rooted cuttings prior to planting may also have contributed to a reduction in growth rates. Methods to increase first and second year survival of rooted cuttings, such as periodic irrigation and/or fertilization, may increase cost effectiveness of rooted cuttings in the long term. However, the additional effort involved in collecting, transporting, rooting and planting of rooted cuttings makes rooted cuttings less cost effective to install.

Alder cuttings, used during revegetation applications on the Nechako test bank, did not propagate well even in the first year of the program. However, this should not preclude the use of alder species for revegetation projects. Alder is associated with nitrogen fixing bacteria and has been used to provide nitrogen and enhance site nutrient status. This, in turn, can provide suitable micro sites for conifer growth (Polster 1998a). Alder may be particularly useful at the test sites on the Nechako river due to poor, dry soil conditions. As a deciduous plant, alders also allow soils to warm in the early spring, while providing shade later in the season to reduce transpiration losses. In addition, a variety of plants species should be employed in any revegetation project in order to encourage the development of a diverse riparian zone which can benefit the entire ecosystem. Red alder seed has been successfully mixed with grass and legume seed and applied to landslides in the Clayqout sound area of British Columbia (Polster 1998b). Polster (1987c and 1988d) also used Sitka alder seeded on steep rock cuts in the Rogers Pass area of the province. Alder species are likely best used as a secondary species in conjunction with other bioengineering structures that can stabilize the toe of the bank and allow the establishment of seeded material.

Structural bioengineering techniques used on the Nechako test bank, although structurally sound, did not generate continued growth through the monitoring period. The brush mattress and wattles may have been affected in ways similar to cuttings. Poor site conditions and fluctuating water levels during the summer cooling flows may have prevented suitable root development in these bioengineering structures. A watering regime during initial growth periods may also aid the development of these types of structures. Due to the large scale of stabilizing mainstem clay banks, rigid structural techniques would also need to be combined with cuttings and seeding in order to be cost effective. Structural revegetation techniques ensure a stable growing medium on slopes during the propagation of cheaper techniques such as cuttings and seeding. The presence of wild rose on the face (mid-slope region) of one section of the Nechako site suggests that this species could act as the intermediary plant between the toe and the crest of a large bank. The establishment of the native rose may have been facilitated by the increase in bank roughness and seed trapping ability associated with the bioengineering works. Rose hips are easily collected for seed stock, and could possibly be supplied for application by broadcast or hydro seeding methods.

If revegetation is to be employed for the type of bank found along the Nechako (with slope stability problems), it may need to be combined with hard engineering techniques. The large scale of eroding banks along the Nechako River, combined with manpower costs associated with structural bioengineering techniques, reduces the cost effectiveness of such structures. The feasibility and cost effectiveness of using hard engineering works to reduce erosion at these sites is unknown at this time.

CONCLUSIONS

1. Thinleaf alder (*Alnus tenuifolia*), does not appear to propagate well from cuttings and is likely best established by seeding. Willow cuttings provide the highest opportunity of success for use on future revegetation efforts. Suitable supplies of donor stock are present in the Nechako area.
2. Establishment of rooted or unrooted cuttings, unless placed in areas where the cuttings can reach water, will likely require watering for at least the first growing season. The use of longer cuttings may improve the success rate of establishment. Alternative species such as wild rose could provide some opportunity for future revegetation projects at dry sites.
3. Structural techniques such as wattling, brush mattresses and spiling can be successfully employed in the Nechako area although considerable vegetative material and manpower is re-

quired. Smaller tributary banks are likely more suited to these techniques, with assistance from land owners or community groups.

4. Use of bioengineering techniques for large Nechako banks could possibly be combined with hard engineering techniques along these areas. The feasibility and cost effectiveness of using hard engineering works to reduce erosion at these sites is unknown at this time.

REFERENCES

Bowie, A. J. 1982. Investigations of vegetation for stabilizing eroding streamlines. Trans. of the ASAE, 25 6: 1601 - 1606, 1611.

Keown, M. P., N. R. Oswalt, E. B. Perry and E. A. Dardeneau, Jr. 1977. Literature survey and preliminary evaluation of streambank protection methods. Tech Rep. H-77-9. U. S. Army Engineer Waterways Experiment Station. Vicksburg, Miss. 261 pp.

Klingeman, P. C. and J. B. Bradley. 1976. Willamette River basin streambank stabilization by natural means. Prep. for U. S. Dept. of the Army, Portland District, Corps of engineers by: Water Resources Institute, Oregon State University, Corvalis, Oregon. 233 pp.

Gray, H.L. and A.T. Leiser. 1982. Bio technical Slope protection and erosion control. Van Nostrand Reinhold Company Ltd. New York, N.Y.

Mills, G. S. and J. A. Tress. 1988. Terrestrial ecology lower Colorado River bankline modifications. Prep. for the Bureau of Reclamation, lower Colorado River regional office, Boulder City, Nevada. by: SWCA, Inc. Environmental Consultants, Tuscon Arizona. 179 pp.

Meidinger, D. and Pojar, J.. 1991. Ecosystems of British Columbia.

Polster Environemntal Services, 1998a. Soil Bioengineering for Forest Land Reclamation and Stabilization. Prepared for British Columbia Ministryo of Forests Resource Tenure and Engineering Branch Engineering Section. 81 pp.

Polster Environemntal Services, 1998b. Landslide and gully restoration Lost Shoe / Thunderous, Little Toquart, Muriel Ridge, Catface and Shark Creek Watershed Restoration Program. Unpublished report prepared for International Forest Products Limited, Tofino, B.C. Vols. 1 to 3.

Polster Environemntal Services, 1987c. Rogers Pass Project 1986: Environmental Supervision, Monitoring and Reclamation Program. Unpublished report prepared for CP Rail, Special Projects. Calgary, Alberta.

Polster Environemntal Services, 1988d. Rogers Pass Project 1987: Environmental Supervision, Monitoring and Reclamation Program. Unpublished report prepared for CP Rail, Special Projects. Calgary, Alberta.

Schiechtl, H. 1980. Bioengineering for land reclamation and conservation. University of Alberta Press. Edmonton, Alta.

Summary Report of the Nechako River Working Group, 1987 Settlement Agreement, appended to the 1987/88 Nechako Fisheries Conservation Program Annual Report, 1988.

Triton Environmental Consultants Ltd. 1993a. A literature review of riparian revegetation techniques. Nechako Fisheries Conservation Program Report No. RM 90-3.1.

Triton Environmental Consultants Ltd. 1996b. Riparian vegetation pilot testing. Nechako Fisheries Conservation Program Report No. RM 91-7.

Triton Environmental Consultants Ltd. 1996c. Riparian vegetation pilot testing. Nechako Fisheries Conservation Program Report No. RM92-7.