PRESCRIPTIONS TO PROTECT, ENHANCE, AND/OR RESTORE ELEVEN SMALL TRIBUTARIES AND BACKWATERS ALONG THE LOWER HORSEFLY RIVER

DRAFT FINAL REPORT

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TABLE OF CONTENTS

PRESCRIPTIONS TO PROTECT, ENHANCE, AND/OR RESTORE ELEVEN SMALL TRIBUTARIES AND BACKWATERS ALONG THE LOWER HORSEFLY RIVER

INTRODUCTION

At least four species of salmon and trout use the quality spawning gravels along the Black Creek area of the Horsefly River. Fry and juveniles of at least three of these species seek out nearby small creeks and quiet backwaters for protection and early development. Eleven such rearing sites just downriver of the spawning gravels were identified as having juvenile habitat potential. Several streams contained, coho and rainbow juveniles and are suspected to support chinook juveniles as well.

These tributaries and backwaters are located along the left bank of the river between Tisdall and Woodjam creeks. Three are on the Black Creek Ranch properties, which are now owned by The Land Conservancy (TLC) and managed by the Ministry of Environment Lands and Parks (MELP), and the remaining creeks and backwaters are on private ranch land. Some are diversion ditches, some are parts of remnant old river channels (oxbow lakes), some are year around creeks, and some are seasonal creeks.

Due to impacts from agriculture over many decades (grazing and hay production), most of these waters fall short of their productive potential. Too assess their conditions (riparian/stream) and to provide prescriptions for protection, enhancement and/or restoration, R.L. Case and Associates was contracted by the Department of Fisheries and Oceans (DFO) to conduct this study.

PROJECT OBJECTIVES

- Assess riparian/stream condition in the context of riverine ecosystem processes and potential natural vegetation

- Assess riparian/stream conditions in the context of past and current agricultural operations (hay cropping and livestock grazing).

- Prescribe experimental and common protection/restoration measures for degraded riparian stream habitats, in the context of an active ranching operation.

ECOLOGIAL CONTEXT AND GENERAL APPROACHES

The Horsefly River between Tisdall and Woodjam Creeks flows (meanders) through a low gradient broad floodplain dominated by meadow type vegetation and deep fine-grained soils. Valley bottom widths vary between 600 and 1000 meters with most areas having a history of cultivation for hay production and seasonal grazing. Sections of the project creeks and backwaters are located in these fields with variable bands of native deciduous riparian vegetation (some bands are thin and/or non-existent). Some riparian buffers have been cropped and/or are grazed to the stream bank, and some experience cattle at times in the creeks for part of the year.

River Dynamics and Backwater Habitats

River meanders on the Tisdall Creek to Woodjam Creek floodplain are tortuous (highly sinuous, with loops nearly cutting back upon themselves) and actively moving laterally, toe slope to toe slope over time (decades and centuries). Lateral movement is estimated to be between 10 and 100 cm a year depending upon type of root reinforcement by bank vegetation, soil grain size, and the sharpness of a river bend. Eventually meander loops cut back upon themselves, creating meander loop cutoffs. Several remnant cutoff channels in varying stages of succession occur on the project area and a few are subjects for prescription.

When young, cutoffs are active and connected to the river. With time and normal siltation/sedimentation processes, they become isolated from the main river, with normal riverbank sedimentation eventually cutting off the access. Over long periods of time without through-flow cutoff lakes and ponds fill in with silt and become a part of a diverse surface topography. Although these cutoffs when young and connected to the river can be valuable as refuge and rearing habitat for several fish species. They are also valuable to waterfowl and numerous wildlife species in all their stages.

Four ponds and small lakes (old cutoffs) between Tisdall and Woodjam creeks have been identified as having juvenile fish habitat potential. Three are in moderately advanced stages of filling in with silt and are now disconnected from the river during the lowest flows. They may isolate and/or strand fish for parts of the year.

On an experimental basis, reconnecting these ponds to the river (excavating part of the old connector channel) is a part of these prescriptions. However, these habitats should first be assessed for their biological integrity and current or potential usage by salmonids, before adopting these connector channel prescriptions. It should be recognized that due to normal siltation processes, they may only be viable for a few decades before the quality of the habitat is lost.

In three different locations excavating a short channel (100m) has been proposed in order to reconnect a potential habitat to the river system. This will provide new opportunities for young fish seeking refuge and areas for rearing. The highest banks usually indicate the outside of an old meander turn. The oldest tallest willows are often found here. Abruptly next to these banks is also where the deepest water occurs. River channels are typically deepest along the outside of a turn directly below the outside bank.

Potential Natural Vegetation

The project area falls within the SBSdw1 biogeoclimatic subzone. Natural vegetation on the floodplain and along the lower reaches of creeks and backwaters in the project area are most closely associated with site series 7, 8, and 9 (Steen and Coupe 1997). Due to a high water table and long periods of flooding in the spring, only species with a high flood tolerance occupy the lowest areas of the floodplain. Woody vegetation in these areas is mostly restricted to willows (approximately 5 species), red osier dogwood, black twinberry, prickly rose, and others. The occasional spruce or cottonwood would be found where soils were better drained during the time of their establishment. These lowest lying areas are in general meadow communities typically dominated by willows and sedge. Templates for these communities can be found along lowest reaches of sites 10 and 12 and at other nearby low lying locations which have not been logged or farmed.

Where coarse grained alluvial materials have been deposited by a tributary creek (an alluvial fan) or where hillslope soils (glacial till) mix with active floodplain soils, alders, cottonwood, aspen, spruce, birch, currants, and hawthorne can often be found, in particular along the stream environments. Intact portions of the perennial streams at Sites #3 and #9 provide good templates for early riparian recovery and restoration along gravel bottom creeks.

Man set fires and wildfires in the late 1800's and early 1900's burned off many of the older forests surrounding the Horsefly River Black Creek and Woodjam Creek area. Consequently, lower slope and valley bottom forests are mostly dominated by young stands of early successional species (i.e., aspen, birch, pine, cottonwood, and willows). The potential natural vegetation, along lower reaches, which have been converted to fields (toeslopes and higher terraces), is distinctly deciduous dominated. Hybrid white spruce is a scattered component slowly seeding in under this deciduous canopy.

A good choice for riparian plantings along these streams is cottonwood and willows. They are easy to collect and grow from cuttings and once the methods and their ecology is understood anyone (landowners) can participate successfully. Cottonwood can be shrub-like when young and when mature it is a good source of large woody debris and litter (for

both streams and wildlife). It is fast growing and rapidly recycles with benefits to many levels of the food chain community. Large branches, which fall, can provide browsing protection for shoots and seedlings. It is a good source of material for channel and habitat structuring. Alder is another good choice along small streams, although it does not grow from cuttings. It must be transplanted as a nursery grown seedling, as a rooted shoot, or as an uprooted tree or shrub.

Field assessments for this project were done in the fall when the grasses were high and riparian leaves had fallen. Shoots of woody starts (condition and abundance) were in part obscured by this condition. Willows etc. could have been hidden and not noticed. For these reasons it is recommended that a spring assessment confirm these prescriptions. The tall grass is a good indicator of low grazing pressure along some creeks.

Riparian Stream Protection with Tree Carcasses

To avoid costly fencing and fence maintenance, a system of using dead trees as barriers is proposed for creek protection in some locations with low browsing pressure. Sound deciduous tree carcasses (i.e., aspen, cottonwood, alder), normally piled, pushed to the margins of a field, and/or burned during land clearing, can be utilized by placing structures over the vulnerable sections of creeks. Vulnerable sections of creek often include those sections immediately up stream and down stream of a road (equipment/cattle) crossing.

Sound dead trees (or live trees) with a stout open branching structure (aspen, cottonwood) can be carefully placed along each side or overtop of a small creek (spruce, also a possibility, are in general too thick with branches, too light restrictive, and not readily available). These structures could provide 2 to 4 meters of riparian protection on each side of the creek. Carcass placement should not be treated as disposal area or a place to pile debris, but it should be planned with structures spread out in an open arrangement as if naturally fallen. Initially tree placement should be supervised until best methods and outcomes are acheived.

The open branching will allow cuttings and seedlings to be planted inside of the arms of the woody skeleton both before and after placement. Abundant sunlight needs to be available to the light demanding pioneer species (willows, cottonwood, alder, aspen, etc.). Carcasses placed along the creek would also serve as a ladder to support vertical development. Carcasses would provide some shade and cover to the stream, be a future source of wood for the channel, as well as food and habitat for the valuable instream/streambank insect communities. Eventually the cuttings and seedlings growing between the arms would reach beyond browsing height and contribute to stream habitat protection. Once the concept is understood, landowners could add tree and or large shrub

carcasses as the need arises. Sites could also serve as a useful place to put by products from adjacent land clearing operations.

Landowner Participation

A high priority to insure a successful restoration plan on private land is cooperation and participation by the landowners. A good restoration plan requires control of livestock. Fortunately in this situation cattle are on the open range during summer months and in general only concentrated on floodplain fields and raparian areas in early spring or fall. However, cooperation from ranchers can help protect fish and facilitate a restoration plan. For example, salting locations, distribution of animals, selection of winter feeding sites, movement of animals, watering locations and design, and/or general timing of operations can be planned to protect restoration sites and high value streams. The woody tree type barriers (an alternative to fencing along small creeks) from time to time may need repair (additions), if they are inadequate or broken down by time, snow, or animals. Livestock adaptations to the new watering sites will need monitoring and possibly short fences or barriers to direct their movements. Salt could be placed near the fishless ponds and away from the vulnerable sites.

For this project it is proposed that landowners be offered opportunities to participate on the restoration projects that are planned for their lands (i.e., hoe work, culvert work, planting, fencing, monitoring, etc.). Access to tree and shrub carcasses also needs to be negotiated with the landowner if the source is on their land or with MOF if the source is on crown land.

A demonstration workshop aimed at the ranching community might be of value if this project is successful. Juvenile fish and the ecology of small streams and backwaters could be discussed, as well as this tree carcass protection scheme. Willow and cottonwood planting (cuttings) could also be demonstrated. Livestock control for the protection of small streams without excessive fencing is a big challenge.

Culverts and Stream Crossings

Stream crossings for cattle and equipment should utilize culverts. Log culverts are inexpensive and fish friendly and with the right materials can last more than 20 years. Small galvanized open bottom culverts (Mini Span I from Armtec) cost around $1500 each (not including the cost of delivery and placement). Small Pipe Arch culverts with a flat bottom approximating channel widths of around 1.5m cost upwards of $400 each not including delivery and placement. They can be sunk in the channel bed to produce a natural bottom.

In this project culverts (mini-bridges) are proposed to be built out of old bridge timbers. This would interfere least with the natural stream bottom environment. It is suggested that well weathered treated old bridge timbers and posts (locally available at a good price) could be utilized to construct mini-bridge-like log culverts. Treated 8" x 21" timbers would double as stringers and decking and sill logs would be cut from 14" treated posts. Tables for determining stringer sizes vs. span length can be interpolated from The Forest Road Engineering Guidebook (Province of BC 1995). In any case work windows and design and construction of culverts (pipe or log) at fish streams need to conform to the specifications and methods prescribed in the two Forest Practices Code Guidebooks, the one above and Stream Crossings for Fish Streams (Province of BC 2000).

In two locations a ford is proposed for gravel bottom stream crossings. One is a cattle crossing which can be well armored and the other is a road which should be closed (locked gate) except for emergency access (see Site #3 discussion). The approaches, steambed, and sloping banks should be well armored with coarsely screened gravel, including some planting.

In 3 other locations crossings are proposed to be de-activated by planting trees and shrubs among the branches of a tree carcass which would be laid over the crossing (with landowners approval).

During removal or replacement of a culvert measures to reduce sediment include installing an appropriately sized pump to divert the flow around the operation. Following construction fill slopes should be planted with cuttings and seeded with the following riparian seed mixture:

Custom Seed Mix - Richardson Seed, Burnaby provided by Polster Environmental.

4.95% Creeping Red Fescue
7.85% Osprey Hard Fescue
29.25% Hycrest Crested Wheat
2.37% Alma Timothy
19.58% Soder Streambank Wheatgrass
10.97% Perennial Ryegrass
18.95% Rangelander Alfalfa
6.06% Alsike Clover

PRESCRIPTIONS

Sites # 1 and #2 - These tributaries were judged to be pristine and not needing either assessments or prescriptions. Both flow through natural vegetation in their downstream reaches. They were not field assessed in this project.

Site #3

This site is on TLC properties and not subject to future livestock grazing. The assessed reaches of the creek flow at around a 2-5% gradient with gravels extending to the mouth. Riparian cover approaches a closed canopy in most locations and is dominated mainly by willows and alder (<8 meters tall, see Site #3 photos).

In general the creek and riparian areas are in good condition. Remnant trails from past livestock watering and crossing are evident at a few openings in the canopy about 200m from the mouth. In this area the streambed and habitats have been somewhat altered by trampling (see photos). With the elimination of livestock, abundant seed, and restoration measures in this location the stream should readly recover. This low gradient small graveled well vegetated year-round creek is very valuable for fish.

Fields used for hay cropping encroach upon the riparian band for approximately 35 meters in this open canopy location (see Site #3 map). The riparian buffer zone here is narrowest for this stream (in general 15 meters). At one spot at this location the creek is next to the field (no woody bank vegetation for 15 meters), and the bank is unstable. Willow, cottonwood, and alder should be planted in 2 rows 1 and 3 meters back from the bank. Seedlings of aspen, birch, spruce, and rose should be randomly planted (2m spacing) to extend the riparian buffer to 20 meters. Cuttings can be taken from plants growing in the area and then planted in hand scarified patches (30cm). Plantings should be coordinated with the restoration work prescribed for the adjacent field (see MELP).

At 305 meters along the creek, a road, which accessed the fields, crosses the creek. The future use and status of this road needs to be determined so that a fish friendly culvert or de-activation can be planned. To keep all options open while saving on costs, it is recommended that a locked gate at the upper end of the TLC properties close access to this road. The crossing should be left passable but the approaches, banks and bed should be well armored with a pre-screened gravel/cobble.

Site #4

While the overview map (1:20,000 scale) and initial field survey indicated one watercourse, further field surveys found that this tributary has been highly altered (see Site #4 photos and map). A series of seeps drain the hillslope above the large field and ditch #1 was constructed to intercept this water and to divert it from saturating the field.

It connects to half moon oxbow (see map). The ditch is a meter deep or more along most of its extent. It flows at a low gradient (<1%), and is well vegetated by willows in its upper third, sparsely vegetated in its middle third, and has no woody vegetation for the final 200 meters (see photo # 2). The ditch/stream is relatively homogenous in terms of plant, channel, and habitat diversity. It needs some work (plantings and woody debris).

Ditch #2 (see Site #4 map) crosses the slope on a contour a few hundred meters above the toe of the slope (ditch #1). This ditch was built to drain the upper slope seepage in the upriver direction, where it would connect to the river above the head of the dike. Some water is captured this way.

There is no logical way to reestablish a natural drainage that would have potential for fish at Site #4. Prior to being converted to a field, this was probably a big wetland fed by the series of seeps coming off the slope. To reestablish a natural ecosystem here would require undoing the ditches so that hillslope water could follow its natural course. The ditches would have to be filled in, and/or breached along its length. The following proposal should be considered. Breach the top ditch #2 in numerous locations so that natural slope drainage can be restored. This would provide additional water to ditch #1, thereby making it more viable as a potential fish stream. In addition this would add more fresh water to half moon oxbow, which is proposed to be reconnected to the river where the dike is to be breached (see map and Site #5 prescription).

MELP has planting prescriptions for this large field. Prescriptions provide for willow, dogwood, and cottonwood cuttings (spruce on the berms) along the banks of the ditches, wet depressions, old remnant channels, and the oxbow. Ditch #1 should be given a high priority in this scenario. One short (50 meters) shallow area of the ditch should be excavated to insure its flow. Measures to help rehabilitate half moon oxbow include the increased supply of water added by breaching ditch #2 and a reconnection to the river described in the Site #5 prescription. The following questions should be answered before committing to this ditch and oxbow. Does the oxbow have potential to support fish? Does it get too warm or is it oxygen poor? What will change when the dike is breached?

Site #5

This site centers around breaching the dike at its lowest end, an outlet pipe draining the large field, and a 20m long outlet channel to the river. It is on TLC property, which has been designated a wildlife management area. The pipe goes through a wide section of the dike near the lower end of the oxbow. The outlet channel has been scoured by high flows exiting from the pipe. The dike is proposed for breaching (MELP contract) near this location, i.e. 50 meters up river where the amount of earth to be moved is much less. It is suggested that the dike be breached at 4 locations each 20m wide as indicated on the map. The intent is to reconnect the river to its floodplain. The willow clumps growing on the

dike should be excavated at each location (for replanting at restoration sites) before the dike is breached.

In addition to removing the dike at site #5, the excavator should dig a channel approximately 2 meters wide by 1.5 meters deep connecting the outlet channel to the tail of the oxbow and therefore the long drainage ditch (to be naturalized) at Site #4. This short 100 meter long channel connection would create 1.6 kilometers of new off channel fish habitat (experimental). The excavated soil from digging the channel (and breaching the dike) should be randomly piled to create a variety of high microsites adjacent to the ditch.

The excavated live willow clumps should be replanted in holes along the connector ditch and/or backchannel to the river. Cottonwood, willow, and red osier dogwood cuttings should be planted in the bare soils exposed by the excavator and elsewhere along the channel to the river.

Cuttings can be gathered nearby (excellent source between the dike and the river) and placed 1 to 2 meters apart. In addition cuttings should be planted in scarified patches. This could be coordinated with MELP plans for plowing and planting along the oxbow and in particular surrounding the cottonwood carcasses 200 meters up from the oxbow tail.

A wire fence runs along the boundary between TLC property and the adjacent Kroener property adjacent. The fence needs repair and redesigning at both ends (see photo). This should exclude livestock from the cattle trails accessing the new wildlife management area.

Site #6

Site #6 is a backwater. It is part of a complex low lying field containing 5 small ponds of varying age, size, and depth (site #8 is one of these). They are remnant pieces of an old river channel. The annual silting process has filled in sections while leaving several ponds isolated. The main Site #6 backwater pond is 65 meters across at its widest point. It is well connected to the river by a deep channel 5 meters across (see photos). Woody vegetation (willow, birch, dogwood, rose, and others) populate the highest of its banks, although active land clearing is a threat to its integrity. The property owner (rancher) should be persuaded to retain a buffer of vegetation along the edges of these ponds. He should be coached into seeing that a few shrubs and trees along the margins of the fields, streams, and ponds has a positive benefit to his fields as well as for birds, fish, and wildlife.

Approximately 100 meters to the west is another much smaller and shallower (30cm) pond, which is connected to the larger pond for a few months in the spring. It may be causing the stranding of fish when flood waters recede. If its biological integrity (for salmonids) is judged to be adequate and a cost benefit ratio is positive, the small pond should be reconnected to the river. An excavator should dig a small channel (≈2m x 1.5m) close to the row of willows (original channel), between the two ponds (see Site #6 map and photos). Spoils from the excavation should be randomly piled in high microsites along the connector channel.

Habitat complexity at these two ponds can be improved by placing half a dozen or so tree carcasses extending out into the ponds (i.e., butts on the bank as if naturally fallen). Placement should mainly be along the highest banks with the deepest water. To keep the tree carcasses from floating away during high water, they should be anchored to rebar stakes near the butt end. Drive 2 1.5m x 1 inch diameter rebar stakes 7/8 ths of its length into the ground on each side of the stem. A 3/8ths-inch cable can be drapped over the stem and fastened to rebar with cable clamps. Trees with root wads would be best although difficult to transport. Uprooting and transport can be done by the excavator, if a source is nearby. Another possibility is to fall green trees and use a skidder to transport to the site.

Willow and cottonwood cuttings and dogwood and twinberry seedlings should be planted in hand scarified patches along the higher banks (mostly willow). Cottonwood is in a marginal environment due to the long seasons of saturated soil. They should be planted only on the highest ground. Birch seedlings and a few spruce can also be tried on the highest microsites. Only willows will survive in the wettest areas, but not in the horsetail dominated stands.

Site #7 – Following a detailed field inspection this tributary was judged to be too short, seasonal, and not a true tributary or backwater of significance.

Site #8

Like tributary # 6, this is also an isolated pond and potential backwater area, which could be rehabilitated and reconnected to the river to provide new rearing habitat. The pond is 110 meters long and shallow. The ancient channel which connected the pond to the river has filled in with silt, not that long ago. If the large pond is judged to have biological integrity necessary for salmonids, it could be reconnected to the river. A 2m wide by 1.5m deep channel should be dug. It would need to be 80 meters long and it should be located abruptly next to the existing willow populated bank (see Site #8 photos and map).

At approximately 60 meters from the river backwater, a channel crossing for cattle and equipment would be needed. Since this is standing water only and to be cost efficient the soundest and largest of the culverts removed from Sites #9, #10, and #11 could be used to provide the crossing. Tree carcasses would need to be placed over the channel at each end of the culvert. Carcasses could be willow trees taken from the adjacent brush piles or standing aspen. They would need to extend to where the existing brush piles start. This will guide the animals to cross at the crossing while protecting seedlings and the banks of the new channel. The willow carcasses that have been piled should be spread out along and over the new channel. Cuttings should be planted before and after distributing the carcasses.

In addition, half a dozen tree carcasses (cottonwood, aspen) could be placed at the highest banks around the pond to add habitat complexity. They should be cabled as described for Site#6. This should mainly be at the area with the deepest coolest water and habitat potential. The carcasses should be anchored as described above and then the high banks should be planted with the same flood tolerant species. Cottonwood and birch may not survive since this is an area of extended flooding and a high water table.

To keep cows out of the new channel and to discourage them from drinking from the tributary at Site #9, a watering ramp to the river should be built as shown on the map. The ramp width should be 4 meters and gently sloped back. The bed of the ramp should be protected by placing Tensar Geogrid under 10 to 12 inches of screened gravel. A fact sheet outlining the use of geogrid in cattle watering applications is contained in Brown (1992). Fish populations in the mainstem river are not as vulnerable to bank disturbance as the tiny creeks and freshly dug connector channels, which would contain rearing salmonids. Riverbank shrubs removed during ramp excavation should be transplanted to the nearest restoration site, as specified by the supervisor.

Site #9

This one to two meter wide stream probably flows year round. Its gradient ranges between 2 and 11% with gravel substrates beginning at about 160 m. Unlike the flat wetter sites (#4, #5, #6, and #8) the terrain here is gently sloping (an alluvial fan) starting at about 60 meters from the confluence. Soils are better drained and capable of supporting a greater variety of riparian species including aspen, alder, birch, cottonwood, and spruce, as well as twinberry, dogwood, rose, willows, and raspberry. All were observed in the first 200 meters with alder and birch dominating the overstory after about 40 meters (see Site #9 photos and map).

At 18 meters 2-20cm culverts (15cm outlet drop) provide a crossing for cattle and equipment. They should be replaced with a log culvert built out of the treated bridge

timbers. Willow or small tree carcasses (from brush piles or nearby land clearing operation) should be placed at both ends of the culvert and at the exposed bank areas immediately below and above this crossing. With protection, the existing low profile shrubs should develop height and provide increasing riparian amenities. Cuttings and seedlings can be planted in hand scarified patches before and after the placement of the carcasses, as required. If access to the river is provided (watering ramps at Sites #8 and #10) pressure by livestock on the stream should be mostly eliminated.
Above 40 meters and to about 240 meters the stream is well vegetated with early successional species (described above) and cattle impact appears minor to non-existent. This is a good template for riparian restoration off the wet floodplain (i.e., good overstory/understory mix and with an ongoing supply of appropriately sized coarse woody debris).

At 287 meters there is another culvert (400mm, 50cm drop), which should be replaced by a log culvert as before. Immediately up stream of the crossing is a heavily impacted area with exposed unstable soils. It should be a high priority for planting and protection. Cuttings of willow and cottonwood should be mixed among seedlings of alder, birch, and aspen. After planting, tree carcasses should be placed on top as a protection barrier to horses and cattle. Plants will also use the structure as a ladder to gain height.

At 325 begins an 11% gradient where the creek has been channelized. The left bank is somewhat unstable (i.e. without woody roots) for approximately 75 meters. Willows and cottonwood cuttings should be planted in hand scarified patches 1-2 meters apart and 1 and 3 meter back from the bank. Brush or small tree carcasses should be placed along the bank to protect and support the cuttings

At 425 meters the creek enters a little disturbed area containing a good mix of young and older deciduous vegetation (i.e., cottonwood, birch, aspen, and alder).

At 460 meters there is another crossing (see Site #9 photos). It is proposed that this crossing be planted and abandon with tree carcasses used as protection. Beyond here no restoration or protection measures are needed.

Site #10

This is another perennial creek, which was surveyed for approximately 560 meters. It has two branches besides the main stem (see Site #10 map). The lower third of the surveyed creek flows through a low gradient sedge and willow meadow of which two-thirds has been impacted by cows (see photos). The middle third flows through a stable diversion ditch, which needs some repair, protection, and plantings. The upper third is in good condition and well protected by willows, alders, and other shrubs. Branch #1 is in the

meadow/swamp, with half of its length needing some protection. Branch #2 is in the upper terrain and protected by alder and other shrubs (see site map).

In the low gradient meadow section of the creek the channel which has not been trampled is narrow, deep, and undercut. The trampled sections of the main stem and branch #1 should be planted with willow cuttings taken from the nearby meadow willows. The cuttings and channel should be protected with small tree and large shrub carcasses placed over the channel. The 25cm culvert should be replaced with a log culvert. The dead wood carcasses should butt up against the culvert as a barrier to the cows utilizing the crossing.

Two watering ramps (as described in site #8 prescription) to the river should be constructed (see map). One on each side of the tributary should give good water access. Construct water ramps using geogrid and gravel as described above. The up stream ramp should be placed closer to site #9 tributary. Riverbank shrubs should be carefully removed during excavation so as to be transplanted to a nearby restoration site.

The middle section of site #10 tributary, the well established diversion ditch, needs some berm repair in at least one location. Cuttings of willow and cottonwood and seedlings of alder and spruce should be planted along this ditch. Numerous willow shoots already exist and they will likely expand when given protection.

The upper third of this tributary and the upper left branch are in good condition. Stream substrates are gravel and the riparian width is up to 10 meters. Alder is dominate and woody debris is abundant. Other observed species include willows, birch, dogwood, rose, black twinberry, and a few spruce. A good example of how carcasses of small trees and large shrubs provide browsing protection and support for the growth of shoots and seedlings can be seen along this upper reach (below the crossings).

Carcasses and plantings of willow and cottonwood should be placed at the impacted sections below and above the road crossing (several meters each side). The culvert at the main road crossing should be replaced with a log culvert. The upper left branch culvert does not need to be replaced as it is near the upper limit of the channel.

Site #11

This is a year around tributary, which flows by Charlie Kroeners house and through the corrals. It is his source of water as well as a source of water for animals in the corral and during winter feeding in the field. This stream receives considerable grazing pressure although probably not until the fall following hay-harvesting operations. Because of substantial livestock pressure during winter it is probably not suited for the tree carcass

barrier scheme. Stream gradients vary between 2 and 7.5%. Sandy gravel substrates give way to increasing cobbles and small boulders across its length. Trampled banks occur where cattle access or cross the creek. Channel width varies between 1 and 3 meters. Numerous banks along this stream have exposed soils, are sloping back, and are loose from trampling. They are unstable (relative, see photos). Large amounts of transported gravel sediments threaten to plug the channel in the low gradient sections. With protection and planting the stream banks and bed should slowly stabilize allowing sediment transport and down cutting to occur.

A narrow band of willows (less than 5 meters wide total) characterize Site #11 riparian buffer (see photos). Some alder and a few young cottonwoods also occur. Low profile heavily browsed shoots of several shrub species were observed. In the absence of pressure these shoots should grow in stature with increasing riparian function.

It is proposed that the high value year around creek be excluded from cattle access by constructing a riparian exclosure fence. The fence should be set back 7 meters on each side of the creek (see Site #11 map). A gated 20m stream crossing for cattle should be provided below the road but closer to the river. This would provide Charlie with management options and control between the left and right fields. Charlie Kroener should be involved in the fencing design as he may have some requests and good ideas. A variety of fencing techniques and considerations are presented in Brown (1996). Areas within the riparian fence should be planted with the indicated species (see Table 1)

The 50cm culvert at the road crossing has a 20cm drop at the outlet. It should be replaced with a mini-bridge type log culvert. The wooden bridge just above the corrals should also be replaced with a log culvert (it is collapsing). It is proposed that the crossing at 360m be de-activated and planted if the Kroeners are agreeable.

The corral beginning at 290m needs to be rebuilt and set back from the creek. Regulations specify that livestock kept in a confined area (corral) may not have access to a water course (B.C. Reg. 131/92 – O.C. 557/92 Part 9 Section 28 of Agricultural Waste Control Regulation). A flow-through watering trough or a float controlled watering trough should be planned for the corral set back. The creek can supply gravity feed water, and the outlet pipe should drain into a rock pit. Charlie Kroener should have input into the design of the corral and alternate watering system. Ideas for alternate watering systems are presented in Brown (1990).

Two-meter high eroding banks above Charlie Kroeners house needs protection. The bank can be protected by diverting the flow with armoring along the bank using log and tree revetments (see photo).

A watering ramp (described above) should be built to the river at the lower edge of this field (see map).

Site #12

This tributary has two main branches. It is complicated by 5 channel diversions, a small artificial dam (barrier to migration), logged riparian areas, 3 swamps, a small lake, and livestock grazing (see Site #12 photos). Juvenile coho were identified in lower reaches of this creek. Fish (kokanee or rainbows?) have been reported by local residents as jumping and using the small lake in the headwaters of the left branch.

The gradient of the left branching tributary at site #12 ranges between 0 and 3%. Channel width varies between 0.5 and 1.5 meters. This stream flows through 2 swamps and is close to a natural physical condition for about 40% of its length (1km). The sons of the landowner believe that fish at one time used the creek to migrate to the lake. It apparently dries up during some years.

The first reach, immediately above its confluence with the river is a low gradient meadow type of channel (sedges, willows). It has been ditched for approximately 140m of its length (240m). Livestock traffic crosses a 25m section to access an adjacent cleared field. They have broken down and disrupted both beds and banks along this section. At about 240m the ditch enters an intact sedge and willow swamp. Juveniles were observed in this reach. The stream emerges on the upper side of the willow swamp at about 380 meters.

The stream in this reach should be left in its ditched channel. A cattle/machine crossing (fish friendly log culvert as described before) should be established at the high traffic area (see map). The channel immediately above and below the culvert should be protected with willow tree carcasses beginning at each end of the culvert. Willow cuttings should be planted between the branches and along all exposed and damaged banks. A watering ramp should be constructed at the riverbank (see map and prescription for Site #8).

The next section of the stream (other side of the swamp) flows through a highly disturbed area for about 224 meters (to the main road crossing). The first 100m is a ditch with no cover and in poor condition. This ditch should be abandoned and the creek put back to its natural channel. Above the diversion the stream is dammed by a 2m high earthen dam. This is a barrier to fish migration. The impoundment is 60 meters long. The right bank supports 15 young spruce trees and several shrub species. The left bank is heavily grazed disturbed and generally lacks vegetation. Riparian buffer is sorely lacking along this 224 meter reach.

The dam should be removed and a permanent riparian exclosure fence should be established 5 meters back from the channel, extending to the road (see map and photos). This area could be used as an experimental recovery area where processes could be observed by the landowners live beside the area. Tree carcasses would not be needed for protection within the fence, although pieces of dead wood would be a benefit to the

recovering system. Willows, cottonwood, birch, alder, and spruce should be planted along both banks. A culvert for crossing should be considered just below the riparian exclosure fence. This should be a log culvert. Fill slopes of the existing culvert at the main road should be planted with willows and seeded with the riparian seed mix (mentioned above).

Hopefully the young boys would take interest in this project. They could be coached and offered an opportunity to participate. They could be taught how to gather and plant cuttings and seedlings. They could help decide on the planting scenario and be in charge of monitoring. They could be encouraged to be stewards of this entire site #12 tributary system. Maybe a small contract would be appropriate. See discussion under project monitoring.

The stream above the road flows through a relatively intact riparian area. Alder, willows, cottonwood, spruce, and birch were observed. The riparian width varied from 3 to 20 meters along both banks. At 200 meters above the road a diversion ditch ends. It flows along the edge of a willow/sedge swamp for about 200 meters (see map and photos). The diversion should be blocked so that the creek can reestablish its natural channel through the willows.

The left bank of the lake has been cleared for pasture and hay. The berm established at the lake edge should be planted with cottonwood, spruce, and willow at 3-4 meter spacing (see photo).

Inlet channels to the lake are intact and typical of a meadow system. Sedges dominate the channel banks, which are undercut and overhanging. Field surveys indicated marginal fish habitat and no spawning gravels above the lake.

Site #12A

The right branch of the tributary at site #12 begins 18m up from the proposed crossing in the first reach (see map). The gradient and width are between 0 and 3% and 1 meter respectively. It is relatively intact through the sedge and willow meadow swamp and to the beginning of a grove of spruce at 75m, except for the last 20 meter section, which needs planting and protection (see map and photos). The stream flowing through the spruce grove sees cattle traffic and also needs protection (carcasses).

After emerging from the spruce grove the small stream flows through a logged off low gradient and/or swampy area (about 200 meters) extending to the main road. Numerous small logs left from logging are scattered about this area. These could be easily winched over to the creek channel (where appropriate) to provide coarse woody debris and riparian

protection. Just above mid way through this section, the stream has been diverted to flow for 30m along the edge of a landing. This section of stream should be left in its new location to avoid more disturbance and possible major rerouting. Willow cottonwood and spruce should be planted on high spots along the channel 5 to 10 meters each side (where needed) throughout this section. Fill slopes over the culvert at the main road crossing should be planted with willows and seeded with the riparian seed mix.

Above the road the small creek increases in gradient (6%) and it enters an area with an overstory (aspen, spruce). Alder are present along the creek increasing in density in a short distance. A second channel to the east of the main channel above the road has been diverted from its course to join the main channel. This has to do with the owners well (diversion of swamp water). It also provides more flow to the tiny main channel. Cuttings should be planted along this diversion.

Site #14

This is a back channel fed by three diversion ditches (see map). The ditches serve to drain wet soils in an area used for hay production. Small fish were observed along one of the main ditches. The ditch is about 1.5 meters deep (channel bottom to top of bank), the gradient is less than 1%, and the wetted width varied around 1 meter. The left ditch has a right fork at about 150m. It is 330 meters in length. The fork contributes about 30% to the flow. During the survey, fish were observed above the fork but not in the fork (see map). Cattle do not appear to be using the ditch for water, as there is an easy watering spot along the river. Plant willows, twinberry, and dogwood along the banks of the these ditches. Debris added to generate channel complexity would need to be cabled down.

The main channel is also a deeply dug ditch (1.5m) for about 120 meters, until it reaches a fence and the beginning of a swamp (the source, which extends to a large area on the upper side of the road). Willows populate the right bank of the main channel ditch and provide shade. The left bank is a field. This bank and ditch should also be planted with indicated species (Table I)

Fish habitat in these excavated channels is very homogeneous. The section of ditch with field on both sides should be planted with willows.

SELECTION, HARVESTING, AND PLANTING OF CUTTINGS

For the most part, small to medium size shrub type willows and rhizomatous or creeping-type willows should be used within the channel banks and at the stream wetted edge. These species for our site include Mackenzie willow, sitka willow, and Pacific willow. They are found at point bars and on the low areas on the inside of meander turns.

Wetland willows, which are growing in standing water or saturated conditions for long periods should be selected for planting along and in the depressions of old river channels, the ancient oxbow depressions, and in swampy areas. Species with a tall and wide canopy provide more shade and should be selected for planting in dryer locations. Species with a flexible stem should be selected for planting on the channel banks particularly when the bank is on the outside of a turn. An entire section can be planted with the same species. Plant shorter shrubby species at mid bank and in front of the tree form species. They provide protection for the tree willows. Technical data related to harvesting and planting of willow and cottonwood cuttings is contained in USDA (1993).

When harvesting select disease and insect free wood that is not split and at least 2 years old. Diameter should generally be ¾ inch or larger. The best wood is 4 to 5 years old and smooth barked not deeply furrowed. Rhizomatous sandbar type willows rarely reach ¾ inch in size. Larger diameter cuttings have more energy reserves. Highest survival rates occur with cuttings 2 to 3 inches (USDA 1993). Cuttings as large as 8 inches have been tested with excellent success.

Use sharp lopping shears to make clean cuts. No more than a third of any individual plant should be removed. Cut off the apical bud plus several inches of the cutting (horizontal on the top cut) before planting. This is the flowering part of the stem, which will consume much energy, which needs to go to forming roots. Trim off the side branches and cut the base at a 45^{o} angle. With the base at 45^{o} and the top horizontal the top and bottom of the cutting is easily recognized. All cuttings should be soaked for a minimum of 24 hours prior to planting, it initiates root growth processes. Only the bottom third of the cutting needs to be placed in water.

When planting use a long heavy bar or bar and hammer to make a deep pilot hole. Select the lower wetter spots. Shrub form willows can be 1 meter or less apart but the tree form willows should be 2 or more meters apart. Be careful to get good soil stem contact. Avoid damaging the buds when inserting the cutting. Use additional soil to drop down the hole and carefully tamp the soil as you fill the hole.

PROJECT MONITORING

Restoration projects should be monitored for their effectiveness and to learn. Did the tree carcass barrier system protect the creeks. How long did it last? How many repairs did it need? How successful was the planting of trees and shrubs in the different ecological settings. Which species were most and least successful? Did the seedlings, to support their growth, use the tree carcasses? Did the backwater connectors work? Are the new backwater habitats being utilized? Will the new habitats be cooler have more complex habitat? Will the creeks support more fish? Will cattle stay out of the creeks? Will species intolerant of an extreme flooding regime survive in the flood zone and in which situations? Will breaching the dike create new habitats and diversify the floodplain.

Will the watering ramps support livestock and be stable. Will naturalizing the manmade ditches with debris and the planting of shrubs and trees provide functional habitat? Will the creeks run cooler in the warm months? Will the cattle crossings and culverts be stable and accommodate high flows? Answers to these questions will help us improve riparian prescriptions and develop more effective work procedures. Unfortunately some answers won't come for decades.

A photo point monitoring system is a good method for recording riparian response to protection and planting. Forty-five photos have been selected for a photo point monitoring system. It is suggested that these photos be retaken in the spring before the grasses hide the new shoots, at least during the first few years. In addition to the photo record, representative seedlings should be tagged and monitored for performance (i.e. height and crown growth), at least for the first three years and less frequent thereafter. Numerous comments can be incorporated into a monitoring form such as browsing damage, peak flow damage, plant color, apparent vigor, whether under a canopy or not (how much), soil texture (silt or gravel) soil saturation (wet or drained), and location relative to the river flood zone. A simple monitoring form should also record condition of the watering ramps, condition of the carcasses used as barriers, were fish observed. Ecologist/biologist types should develop this form.

It is suggested that Charlie and George Kroener be offered a 3 year experimental contract to do the monitoring. The main purpose would be to encourage landowner interest in the project and to promote education. The form could be simple and filled out once a year. A biologist or technician could be present for the first monitoring. The contract could include minor repairs. The McKone boys could do the monitoring of site #12 particularly the area inside of the exclosure (even if it is token). Planting (and harvesting) of cuttings could be demonstrated and encouraged. Were fish observed? Maintaining the carcass barrier system could be encouraged. The contract could be redesigned and renewed if appropriate after the 3 years.

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TABLES

MAPS

PHOTOS