IN-STREAM HABITAT COMPLEXING, 1997

- Pilot Testing -

NECHAKO FISHERIES CONSERVATION PROGRAM
Technical Report No. RM97-2

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ABSTRACT

The Nechako River In-Stream Habitat Complexing Project began in 1988 with pilot tests conducted to increase the complexity of juvenile chinook habitat prior to the implementation of the Long-Term Flow Regime of the Kemano Completion Project. Its immediate objectives were to design, test and monitor habitat complex structures specific to the Nechako River. This report documents the work done and the assessment of physical performance of Nechako River habitat complexes during the 1997/98 program year (April 1, 1997 to March 31, 1998).

Since 1988, the Nechako Fisheries Conservation Program (NFCP) pilot habitat complexing program has constructed and tested 14 different complex designs. Fifty-three (53) complexes were monitored in the Nechako River in 1997.

The habitat complexing project activities for 1997 were as follows:

- two emergent fry structures were constructed in the early spring (April 12 and 13) and two other constructed in 1996 were removed;
- twenty-one rail covers and seven nest boxes were installed on rails used to anchor structures to improve aesthetics (May 26 and 28 - Reach 2 and September 7 and 8 - Reach 4);
- rail debris catcher RM29.3RDC was added to the 1997 assessment after it was found to have accumulated debris;
- visual assessments and video documentations were performed three times during the spring and summer of 1997 under various flow conditions (167 m^3/s, 308 m^3/s, and 354 m^3/s); and,
- a physical assessment of habitat complex performance was performed during the fall which included video documentation (September 5 through 10).

Complexes which showed damage or displacement were:

- the brush pile;
- a floating crib;
- both pseudo beaver lodges;
- six rail-anchored sweepers;
- two hand-placed anchored sweepers;
- both emergent fry structures;
- six rail debris catchers; and ,
- the debris boom.

ABSTRACT (CONTINUED)

Twenty-five structures were earmarked for repair or removal:

Repair:

- rail-anchored sweepers (6)
- hand-placed anchored sweeper (1)
- pipe-pile debris catcher (1)
- rail debris catchers (7)

Removal:

- brush Pile (1)
- pseudo beaver lodge (1)
- rail-anchored sweepers (3)
- hand-placed anchored sweeper (1)
- rail debris catchers (2)
- emergent fry structures (2)

To date, the NFCP habitat complexing project has identified the following parameters as important for biological success in habitat complexing:

- shear velocity;
- cover area; and,
- substrate.

Additionally, it has been determined that adequate complex anchoring is crucial for the maintenance of structural integrity during fluctuating flows.

The rail-anchored sweepers, hand-placed anchored sweepers, and rail debris catchers have maintained velocity criteria. Some early structures altered velocities such that design criteria were no longer met.

INTRODUCTION

The Nechako Fisheries Conservation Program (NFCP) was established as a result of an agreement signed in 1987 by Alcan Aluminium Ltd., the Government of Canada, and the Province of British Columbia (Anon. 1987a). The goal of the NFCP is to ensure conservation of Nechako River chinook salmon populations and protection of migrating sockeye salmon populations. An integral component of the program is the testing and implementation of remedial measures including the modification of in-stream habitat and construction of habitat complexes.

This report documents the progress of work done on the habitat complexing project during the 1997 program year (April 1, 1997 to March 31, 1998). All field work for this project was performed between May and October. Therefore, the work is identified in this report as occurring in 1997.

This report focuses on the evaluation of the physical performance of habitat complexes constructed since the inception of the project in 1988 and on the modification of habitat complexes in 1997. The evaluation of the biological performance of habitat complexes in 1997 is reported elsewhere (Triton 1998a).

BACKGROUND

In August 1987, a working group of technical experts from the Department of Fisheries and Oceans (DFO), Alcan, and the Province of British Columbia was established to assess how to ensure the conservation and protection of the fisheries resource of the Nechako River. The working group recognized that changes in Nechako River flows following development of the Kemano Completion Project would influence the amount of cover habitat available to juvenile chinook that utilize the river. This fact prompted a recommendation to increase the complexity of juvenile chinook cover habitat in the Nechako River prior to the implementation of the Long-Term Flow Regime (Anon. 1987a) to replace what cover habitat might be lost due to the flow changes in the river. A preliminary assessment of the types of habitat utilized by Nechako River chinook was conducted in order to identify suitable habitat complexing designs for pilot testing. The NFCP pilot habitat complexing project was initiated in 1988 to test these habitat complexing techniques and to assess their use by Nechako River chinook.

After the 1988 pilot testing, the information on suitable designs was supplemented by a literature review of in-stream habitat complexing projects (Triton 1998b). It indicated that, although habitat complexes had been widely used to create fish habitat, most techniques had been directed to small streams supporting fish species other than chinook. In addition, quantitative assessments of the effectiveness of these techniques were limited. More potential remedial measures were researched and selected techniques appropriate to the Nechako River were pilot tested in 1989 and 1990 (Triton 1996a). Following this, a list of remedial measures was prepared, based on replicating what was found naturally in the Nechako River. In 1991, pilot testing of new complexes continued, along with the replicate construction of selected complexes (Triton 1996b). In 1992, modifications were performed on several complexes (Triton 1996c). From 1993 to 1995, no new habitat complexes were constructed, but monitoring continued and several complexes were modified or removed (Triton 1998c). In 1996, two new emergent fry structures (EFS) were constructed and the monitoring of all complexes continued (Triton 1998d). The emergent fry structures were essentially short-term habitats, and they were pilot tested to evaluate the appropriateness of their location. Long-term durability was not a consideration. In 1997, testing of emergent fry structures and monitoring continued, and the aesthetics of habitat complexes were improved. Appendix A provides the terms of reference for the pilot habitat complexing project, including the criteria used for site selection and structural design.

PROJECT IMPLEMENTATION

The 1997 habitat complexing project activities for 1997 were as follows:

- two emergent fry structures were constructed in the early spring (April 12 and 13) and two constructed in 1996 were removed;
- twenty-one rail covers and seven nest boxes were installed on rails used to anchor structures to improve aesthetics (May 26 and 28 - Reach 2 and September 7 and 8 - Reach 4);
- rail debris catcher RM29.3RDC was added to the 1997 assessment after it was found to have accumulated debris;

- visual assessments including video documentation were performed three times during the spring and summer of 1997 under various flow conditions (167 m^3/s, 308 m^3/s, and 354 m^3/s); and,
- a physical assessment of habitat complex performance was performed during the fall (September 5 through 10).

The purpose of the physical assessments was to identify any structural damage or instability incurred during cooling flows and over the winter period, and to evaluate how design criteria were met. Due to unexpected high water levels during 1997, structures were assessed at higher than normal flows of 81.8 m^3/s (2,887 cfs).

METHODS

Construction of Complexes

Construction and modifications to existing habitat complexes were completed with chain saws, power drills and oxyacetylene cutting torches. A work boat with a jet-converted outboard motor was used for the transport of personnel and miscellaneous materials. Materials transported to the sites included slabs and v-grooved logs used for rail covers, and banding material. Nest boxes were constructed in Fort Fraser and transported to the individual sites for installation.

The emergent fry structures installed in 1997 were constructed using methods similar as those used in 1996.

Construction Costs

In 1997 the approximate cost for the construction and modification of habitat complexes was $8,852 (Table 1). The estimated unit costs were $646 for each emergent fry structure, $300 for each V-groove rail cover, $210 for each slab rail cover, and $271 for each nest box. The estimated costs include all charges associated with labour, materials, equipment, and other disbursements.

Table 1
Summary of Habitat Complexing Construction Costs in 1997

Type of Habitat Complex	Quantity (Units)	Cost ($/Unit)*	Total Cost	Comments
Emergent Fry Structures	2	$646	$1,292	Two sites, with 10 individual structures per site.
V-Groove Rail Covers	14	$300	$4,195	
Slab Rail Covers	7	$210	$1,470	
Nest Boxes	7	$271	$1,895	
Total Construction Cost - 1997			$8,852	

* Cost estimates include fees and disbursements for each unit, excluding GST.
See Appendix D for drawings.

Physical Assessment

Visual assessments conducted in the spring and summer consisted of drifting by the habitat complexes in a boat while video taping and photographing each structure as well as commenting on physical parameters and structural performance.

The fall assessment consisted of inspections and of photographic and video documentation of all complexes remaining in the Nechako River since 1988. They were conducted from shore, by boat and by snorkeling. The following features were noted during the assessment of each habitat complex as applicable:

- water depths and velocities upstream and downstream (at 1/3 and 2/3 of the extension), at the inside and outside shear zones, and at a flow-through point within the complex;
- cover area;
- extension from margin;
- depth of cover;
- erosion/sedimentation;
- local substrate; damage;
- displacement; and,
- debris accumulation or loss.

Physical condition and stability were noted with reference to durability (structural integrity since the installation of the complex) and position in the river. Recommendations or comments were noted to modify or remove some complexes, and are presented in this report. This proposed work may be done in future years.

Velocity was measured at each complex with a Swoffer flow meter (model 2100). Due to equipment problems the flow meter was not available for all sites and velocities were then estimated by the floating chip method, which involves timing a floating chip over a measured distance. Water depths at all locations were measured with the flow meter rod. The dimensions of extension and principal cover area were measured with a survey tape. Cover areas were then calculated for each complex. The hydraulic characteristics of each complex were measured to determine compliance with design criteria. The amount of debris accumulation or loss was recorded to document the function of the habitat complex under prevailing Nechako River conditions. Substrate composition was noted as a relative ranking of material present.

A summary of all activities is presented in Table 2. Construction and modification details are presented in Appendix B and results of physical assessments are presented in Appendix C. Annotated lists of acronyms are also presented in Appendices B and C. Sketches and photos of the habitat complexes are presented in Appendices D and E, respectively.

RESULTS

1997 Habitat Complex Construction

Maps of the 1997 NFCP habitat complexing project study area and of the complex locations in Reaches 1 and 4, are presented in Figures 1 and 2, respectively.

Construction of Habitat Complexes

Emergent fry structures were installed in two locations in 1997. The first site was at km 20.6, in an area near high chinook spawning density. This site was close to the site used for testing the 1996 emergent fry structures. The second site was at km 38.5, in an area of low chinook spawning density. In 1996 the structures consisted of five individual trees per site. The 1997 structure design was more dense, with 10 trees per site. The design was changed to determine if the additional cover would increase fish use .

Modifications to Habitat Complexes

The British Columbia Utilities Commission hearings into the Kemano Completion Project identified aesthetics as one area of the habitat complexing project which had not been sufficiently addressed. During 1997, two methods of covering the rails used in the construction of rail debris catchers were pilot tested in an effort to improve the aesthetics of these complexes. In addition, nest boxes were installed on some complexes for the same purpose and also to provide habitat for cavity nesting waterfowl.

Installation of Rail Covers to Improve Aesthetics

Two methods were tested to give rails the appearance of natural logs standing upright in the river to blend the materials in with natural LWD captured by the debris catchers (See Appendix D for sketches).

The first method involved covering the rails with whole logs which had been cut in half and then had a V-groove removed from each half. The logs were then reassembled around the rails and held in place with a ratcheting strap until banding or bailing wire could be installed to hold the halves permanently together. To prevent the rail covers from floating off the top of the rail, a piece of redi rod was inserted through the log and through the lifting hole at the top of the rail. After installation of the V-groove logs, natural small woody debris were wedged between the log and the rail to prevent shifting of the log which might wear the redi rod or cause the banding to break.

The second method involved banding or wiring several sawmill slabs around the outside of the rails. Three (and in some cases four) slabs were used to cover each rail. The slabs were assembled around the rail, held together with a ratcheting strap, and then banded or wired together and a piece of redi rod was placed through the top to prevent the slabs from floating off the rail.

A total of 21 rail covers (14 V-groove and seven slab) was installed on nine active complexes and on a remaining rail from complex LM22.7RDC, which had been removed from assessment in 1993 (Table 2).

Table 2
Summary of Habitat Complexing Construction and Modification Activities, 1997

Type of Habitat Complex	Abbr.	Quantity Remaining 1996	Quantity Constructed 1997	Rail Covers Installed 1997	Nest Boxes Installed 1997	Quantity Added 1997	Quantity Removed 1997	Quantity Remaining 1997
STRUCTURES								
Debris Bundles								
Rootwad Sweepers	RS	1	-	-	-	-	-	1
Brush Pile	BP	1	-	-	-	-	-	1
Floating Cribs	FC	2	-	-	-	-	-	2
Pseudo Beaver Lodges	PBL	2	-	-	-	-	-	2
Rail-Anchored Sweepers	RAS	9	-	-	-	-	-	9
Hand-Placed Anchored Sweepers	HAS	7	-	-	-	-	-	7
Emergent Fry Structures	EFS	2	2	-	-	-	2	2
Debris Catchers								
Pipe-Pile Debris Catchers	PDC	2	-	-	-	-	-	2
Rail Debris Catchers	RDC	20	-	9	5	1	-	21
IN-STREAM MODIFICATIONS								
Side Channel	SC	1	-	-	-	-	-	1
Side Channel Debris Boom	DB	1	-	-	-	-	-	1
Point Bars	PB	3	-	-	-	-	-	3
Pocket Pools	PP	1	-	-	-	-	-	1
Totals		52	2	9	5	1	2	53

Notes:

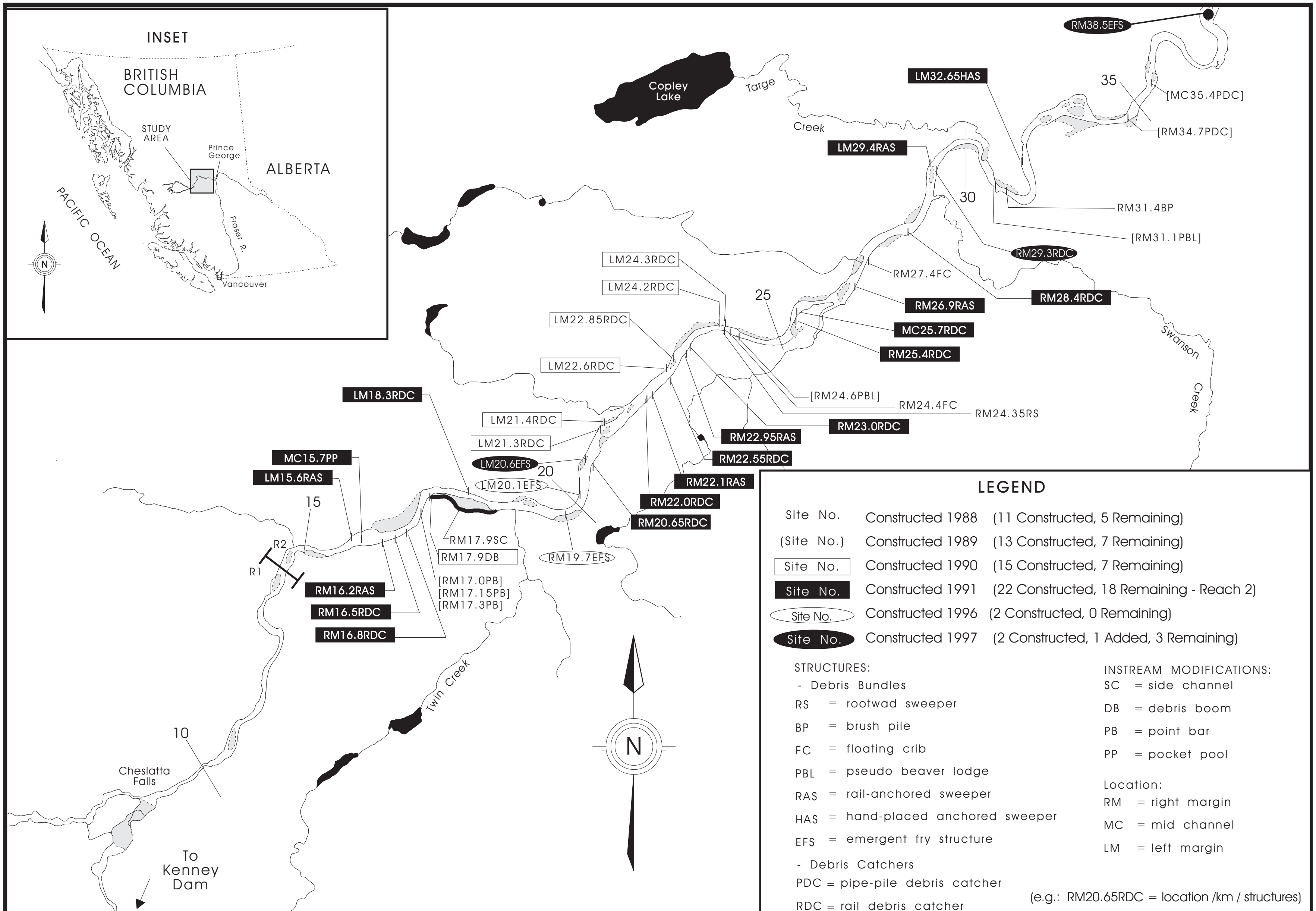
Constructed: 2 Emergent Fry Structures were constructed in 1997 (LM20.6EFS and RM38.5EFS).

Rail Covers Installed: 21 rail covers (14 V-groove and 7 slab) were installed on 9 active complexes (LM18.3RDC, RM20.65RDC, LM21.3RDC, LM21.4RDC, RM22.55RDC, LM22.6RDC, LM80.9RDC, RM86.35RDC, RM86.375RDC), and on the remaining rail from removed complex LM22.7RDC.

Nest Boxes Installed: seven nest boxes were installed on 5 active complexes (RM18.3RDC, LM21.3RDC, LM21.4RDC, RM22.55RDC, LM24.2RDC), on the remaing rail from removed complex LM22.7RDC, and on a rail supporting a dock at Irvine's Lodge.

Added: 1 Rail Debris Catcher (RM29.3RDC) was added to the 1997 assessment. It had been removed in 1993 due to complete loss of logs and debris but was found to have accumulated new debris in 1997.

Removed: 2 Emergent Fry Structures constructed in 1996 were removed from assessment in 1997 (RM19.7EFS and LM20.0EFS).

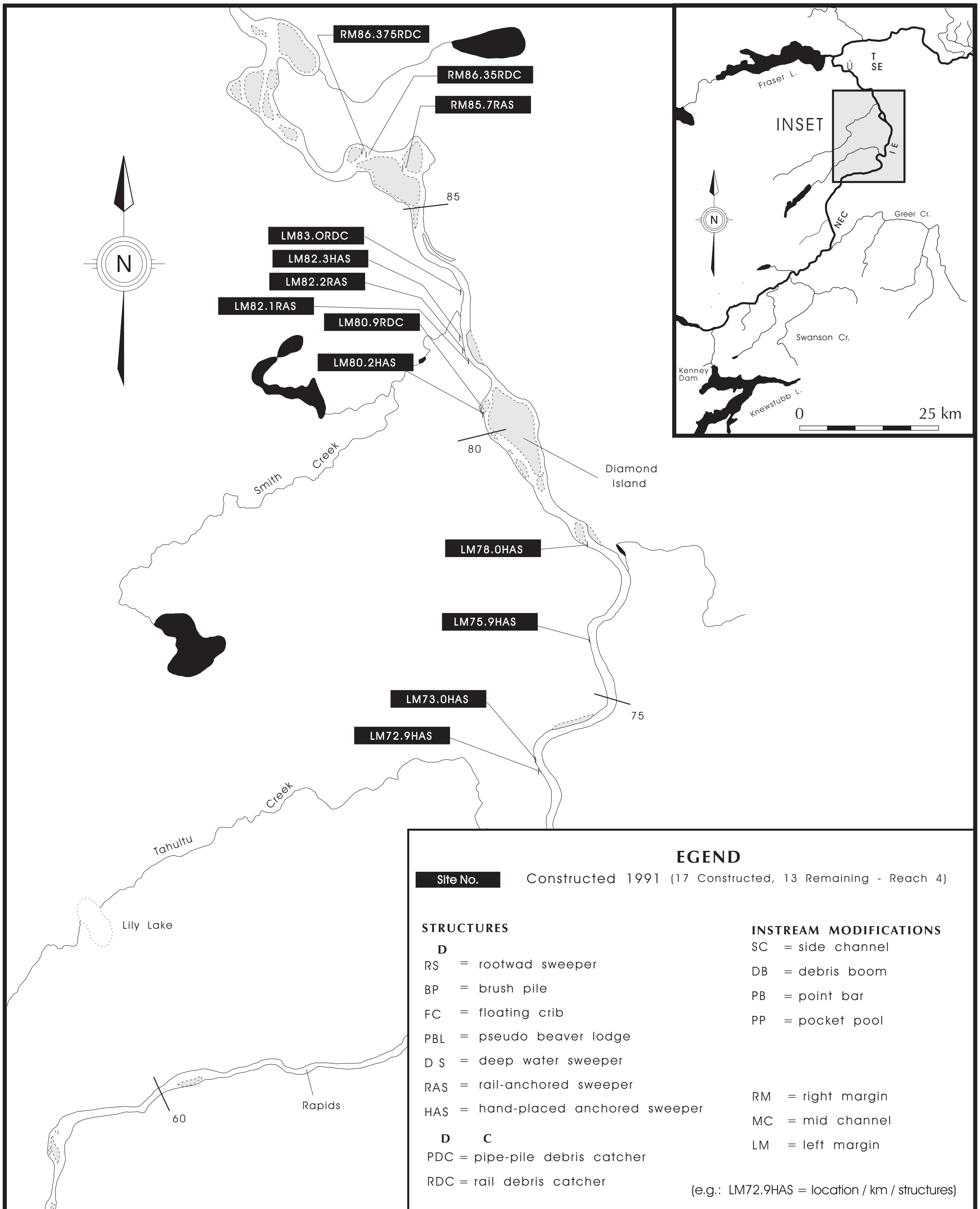


Nechako Fisheries Conservation Program

Map # RM97-2F1

0 5 km

FIGURE 1. NECHAKO RIVER MAINSTEM STUDY AREA 1997, REACH 1 & 2



Nechako Fisheries Conservation Program

Map # RM97-2F2

0 5 km

FIGURE 2. NECHAKO MAINSTEM STUDY AREA 1997, REACH

Installation of Nest Boxes

As part of the effort to improve the aesthetics of rail debris catchers, nest boxes for cavity nesting waterfowl were also installed on several structures. Nest boxes were constructed and installed based on plans from Ducks Unlimited Canada (Appendix D). The target species for nesting box utilization were buffleheads and goldeneye since neither of these species are known to prey on juvenile Chinook salmon. Entrances to the nest boxes were sized to minimize their use by mergansers which may prey on juvenile chinook salmon.

Seven nest boxes were installed on five active complexes, on a remaining rail from removed complex LM22.7RDC, and on a rail used to anchor a dock at Irvine's Lodge (Table 2).

Added Complex

One rail debris catcher (RM29.3RDC) was added to the 1997 assessment. It had been removed in 1993 due to complete loss of logs and debris but was found to have accumulated new debris in 1997. The complex will be monitored to determine its function as long as it retains debris.

Fall 1997 Physical Assessment

Physical assessments of all complexes were conducted between September 5 and 10, 1997. The average discharge in the Nechako River at this time was 81.8 m^3/s (2,887 cfs), which was above the high end of the criterion range of 56.6 m^3/s. Most depths were consequently above the minimum limit of 0.4 m. Velocities are affected by river discharge, structure size and condition. Despite the higher flows, approximately one third of velocity measurements were within the criterion range of 0.15 to 0.40 m/s, one third below and one third above it. Upstream velocities were generally within or above the criterion range, while flow-through and downstream velocities were generally below it. Most structures had a significant amount of debris cover, which reduced flows within and downstream of the structures. Outside and inside shear velocities were generally above the criterion range. Observations from those assessments and their associated recommendations are summarized below and in Table 3. Details are presented in Appendix C.

Structures

Debris Bundles

In 1997, 14 of the 24 debris bundles were damaged or displaced, with cover areas generally smaller than in 1996. All structures except the rootwad sweepers were impacted (Table 3). Most structures were displaced downstream and lost debris due to failure of a boom, anchor or stiffleg. Some structures had been partially defoliated and others had been stripped of almost all branches.

The two emergent fry structures sites constructed in 1996 were almost completely defoliated by the spring of 1997 and were removed from assessment. Because of high flows and ice conditions the two newly installed structures were reduced to bare trees and a few sparse branches. Anchoring systems for the majority of structures were adequate although some of the rebar anchors of 1996 structures had been lifted by the ice.

At the time of the complexes' physical assessment, flows in the Nechako River were at 81.8 m^3/s (2,887 cfs). The emergent fry structures were designed to function effectively at flows one third lower than this so the design criteria were not applied during the fall assessment. Their depths and velocities were measured immediately after their installation on April 12 and 13, 1997. The cover areas then varied between 2 and 3 m^2 each. Due to forced spills during the spring of 1997, additional velocity and depth measurements were not completed around these sites in 1997.

Repairs were recommended for seven debris bundles. Recommendations were made for the removal of eight debris bundles.

Seven structures were recommended for repair:

- six rail anchored sweepers; and,
- one hand-placed anchored sweeper.

Structures recommended for removal were:

- a brush pile;
- a pseudo beaver lodge;
- three rail anchored sweepers; and ,
- one hand-placed anchored sweeper,
- all of the remaining emergent fry structures.

Table 3: Summary of Fall 1997 Physical Assessment Observations

Type of Habitat Complex	Abbr.	Quantity Remaining 1997	Damage or Displacement in 1997	Cover Area (m^2)	Cover Area Change	Sedimentation or Erosion	Substrate (In order of predominance)	Comments	Recommendations
STRUCTURES									
Debris Bundles									
Rootwad Sweepers	RS	1	No	44	Reduced from 1996	No	Gravel, fines	Stable, loss of debris	None
Brush Pile	BP	1	Displaced to shore	1	Reduced from 1996	No	Fines, gravel	Cover consists of bare logs only	Remove from assessment due to lack of cover area.
Floating Cribs	FC	2	No/Displaced downsream due to failure of downstream stiffleg and upstream deadman anchor	65/70	Increased/Reduced slightly	No	Gravels, fines, cobbles	Shear zone depth and velocity still within criteria range despite displacement of 5 -10 m.	None
Pseudo Beaver Lodges	PBL	2	Displacement - RM24.6PBL/Frame collapse of RM31.1PBL in 1996 resulted in additional loss of debris in 1997.	18/0	Reduced from 1996	Some erosion along shoreline of RM24.6PBL	Gravels, cobbles, fines	Loss of debris at both structures.	Remove RM31.1PBL from assessment due to collapsed frame and loss of cover area.
Rail Anchored Sweepers	RAS	9	Detached from rails and displaced - RM22.1RAS, RM22.9RAS, RM26.9RAS, RM82.1RAS, LM82.2RAS and RM85.7RAS	0 - 6	Reduced from 1996	No	Gravel, cobble, with fines and boulders at some complexes.	Continued defoliation of all structures resulted in reduction in cover areas.	Remove 3 structures, repair or remove 6 remaining structures due to continued defoliation and failure to trap new debris.
Hand-Placed Anchored Sweepers	HAS	7	Shifted to shore - LM32.65HAS, Lost sweeper - LM80.2HAS	0 - 4	Reduced from 1996	No	Gravel, cobble, fines		Add downstream boom to LM32.65HAS to place into current. Remove LM80.2HAS due to complete loss of the structure
Emergent Fry Structures	EFS	2	No fall assessment due to high flows. In spring 1997, both structures were almost completely defoliated.	Not available	-	Not available	Not available	Some of the rebar anchors were lifted by ice.	None

Table 3: Summary of Fall 1997 Physical Assessment Observations

Type of Habitat Complex	Abbr.	Quantity Remaining 1997	Damage or Displacement in 1997	Cover Area (m^2)	Cover Area Change	Sedimentation or Erosion	Substrate (In order of predominance)	Comments	Recommendations
Debris Catchers									
Pipe-Pile Debris Catchers	PDC	2	No	21/220	Similar to 1996	Sedimentation downstream of larger complex	Gravel, fines, cobble	Outer piles tipped over on smaller complex from previous ice damage.	Remove failed piles on smaller complex RM34.7PDC because of navigational hazard and to restore stability to structure.
Rail Debris Catchers	RDC	21	Lifted rails from ice - RM29.3RDC, MC85.6RDC, shore boom broken - RM16.5RDC, RM16.8RDC, RM22.0RDC, rails tipped over - RM25.4RDC	0 - 100	Reduced from 1996	Sedimentation (11)/Erosion (12)	Gravel, cobble with fines present at most complexes.	Despite damage, most structures were stable and retained debris. Low velocities due to large cover areas and locations close to shore. Rail covers and nest boxes in good condition.	Repair 5 structures, remove 2 structures, reseed 1 structure and rebuild 1 structure closer to shore.
IN-STREAM MODIFICATIONS									
Side Channel	SC	1	No	12, 45 m^2 including natural cover	Increased from 1996	No	Gravel, fines, cobble	Flows blocked by beaver dams since 1989, resulting in no measured velocities.	None
Side Channel Debris Boom	DB	1	Offshore cable to deadman anchor snapped.	53	Reduced from 1996	Sedimentation downstream	Gravel, fines, cobble	Stable, despite loss of anchors.	None
Point Bars	PB	3	No	N/A	N/A	Erosion along shoreline - RM17.15PB/Sedimentation in backeddy of 2 structures.	Cobble, gravel, fines	Erosion probably due to high flows during 1997.	Monitor erosion at RM17.15PB.
Pocket Pools	PP	1	No	N/A	N/A	Sedimentation in pool	Boulder, cobble, gravel		None

Debris Catchers

The majority of the debris catchers lost debris in 1997. None of the pipe-pile debris catchers were damaged in 1997, but six of the rail debris catchers had their rails lifted by ice, had their rails tipped over, or had a shore boom broken.

All of the rails of RM25.4RDC were bent at various angles, and the structure lost all of its debris. Two structures had their rails lifted by ice movements (RM29.3RDC, MC85.6RDC). Three other structures (RM16.5RDC, RM16.8RDC, and RM22.0RDC) suffered damage to their shore booms, causing a loss of seeded material and failure to trap new debris. Sedimentation was found behind 12 sites, and erosion was observed at 11 sites. Large cover areas and positions in the river resulted in low velocities through some of the complexes , with flow passing outside of them.

Two pipe-piles that had failed on the small complex RM34.7PDC in 1995 were recommended for removal because of the potential navigational hazard they represented as they rested just below the water surface at low flows. Five rail debris catchers were recommended for repair, two were recommended for removal, one was recommended for reseeding and one was recommended to be rebuilt closer to shore.

In-Stream Modifications

Side Channel

As a result of continued flow blockage, all seven stations in the side channel had a velocity of zero. The cover area has increased from 34 m^2 in 1996 to approximately 45 m^2 in 1997 (natural cover included).

The debris boom had an estimated cover area of 53 m^2, down from its 1996 value of 62 m^2. In 1997, the offshore cable anchor snapped and significant sedimentation occurred downstream of the structure. However, the complex was stable and no displacement had occurred.

There was noticeable sedimentation downstream of two of the point bars. One of the point bars (RM17.15PB) was also significantly eroded downstream, along the shoreline. This erosion may have been due to unexpected high flows in 1997 and may therefore not be indicative of future flow or erosion patterns. The situation will be monitored closely, as if the erosion continues it may eventually allow water to pass by the inside of the point bar which would prevent the desired formation of a back eddy.

In 1997, no damage, erosion, or sedimentation was noted in the remaining pocket pool.

Fall 1997 Assessment of Spring Modifications

The fall physical assessment allowed for an early assessment of the modifications performed to improve aesthetics on habitat complexes in Reach 2. All rail covers installed in Reach 2 were still stable after the summer water temperature management period which saw flows in the Nechako River of up to 359 m^3/s (12,678 cfs). All these rail covers showed signs of wood expansion which caused tightening of the banding and bailing wire used to secure the covers.

All nest boxes installed during the spring in Reach 2 showed at least some signs of being used by birds. However two to three years are generally necessary to effectively determine nest box success, as nest boxes are generally ignored by buffleheads and goldeneye for one to two years after installation (Brad Arner, Ducks Unlimited, pers. comm.). The signs of use that were visible (feathers and debris inside the box) were possibly from non-target species such as kingfishers or swallows, which were often seen perched on the boxes during other ongoing monitoring projects. At one point one of the nest boxes was also observed to have several eggs inside it, but these eggs were not present one week later. It should also be noted that the nest boxes were not installed until after the typical nesting period for the target species.

OBSERVATIONS ON HABITAT COMPLEX PERFORMANCE

Some aspects of the structural performance of habitat complex designs used in the Nechako River are in their early stage. The majority of complex designs constructed in the early phases of this project have already been replaced with much more durable structures. These improvements in structure design reflect the effectiveness of physical performance monitoring, which allows the development of some understanding of the factors affecting complex durability and/

or performance. These observations can be used to further evaluate the criteria used in the design and location of the complexes. This section summarizes the condition of the complexes since their construction and the factors affecting biological and physical performance.

Structures

Debris Bundles

Rootwad Sweepers

The last remaining rootwad sweeper complex from the original four complexes constructed in 1988 had been modified in 1990 to reduce seeded material. Since then, this complex has remained stable, with no damage or displacement noted. No modification was recommended as it was performing satisfactorily.

Brush Pile

The brush pile complex installed in 1988 has remained stable. However, cover area has decreased from a high of 37 m^2 in the spring of 1991 to 1 m^2 in the fall of 1997. Due to its lack of cover area and the continued degradation of this complex the structure has been recommended for removal from further assessment.

Floating Cribs

The two floating cribs installed in 1988 have generally provided significant amounts of cover. In 1991, the smaller complex was moved further into the current in an effort to increase flow-through velocities. Anchoring was improved by securing the complex to two steel rails driven into the river bed. However, the failure of the rail in 1992 caused some displacement onto the shore and as a result, its downstream stiff-leg was damaged. The failure of the downstream stiff leg and the upstream shore anchor in 1997 caused the structure to move approximately 5 to 10 m downstream. Despite this, the structure generally provides adequate depth, cover area and velocity. The upstream floating crib was colonized by beavers in the fall of 1989 and has been left untouched since. In recent years, the cover areas of these complexes have varied but have always been within the criterion range.

Pseudo Beaver Lodges

The design of the pseudo beaver lodges was modified in the fall of 1989 to enhance stability. However three modified units continued to lose debris in 1991. An extra boom was added to one complex prior to reseeding to provide additional flotation and to assist in debris retention in the spring 1992. This modification appeared to help retain debris over the summer cooling flows, but this complex and two others were again damaged or displaced at higher flows. Due to continued debris loss, two pseudo beaver lodges were removed from further assessment in 1995.

In 1996, complex RM31.1PBL failed and in 1997 it completely collapsed and lost all cover area. It was recommended that this structure be removed from further assessment. There is currently only one structure remaining which offers cover area within the design criteria range. Due to debris retention problems it is not recommended that further units be constructed.

Rail-Anchored Sweepers

During the summer of 1991, 10 rail anchored sweepers were installed along the Nechako River. Three sweepers were repaired in 1992 as a result of damage incurred during the 1991 and 1992 summer cooling flows. In 1993, two sweepers were modified with the addition of downstream tree booms to improve debris capture. One of the rail-anchored sweepers was removed after having been repaired in 1992 as it had lost its shore anchor and debris for the second time. The downstream booms were not very effective as they became submerged under the load of debris at high flows. Between 1993 and 1996, five of the nine sweepers were damaged, either at the trees or at the anchor points. Several sweepers were stripped to bare logs. In 1996, sweeper RM22.1RAS had become detached from its rail. In 1997, six structures were damaged or displaced and all nine complexes were recommended for repair or removal.

As reported in Triton (1996c) the rail-anchored sweepers have required significant repairs during their rather short lives in the Nechako River. The short rails installed on these complexes allow less vertical movement of the sweeper as water levels rise, which may account for the lack of collected debris. Additionally, the single tree which serves to collect debris is susceptible to loss of branches due to stripping by ice and to damage under increased flows.

Hand-Placed Anchored Sweepers

As with rail-anchored sweepers, these complexes were not successful at capturing additional debris, and tended to be stripped, damaged or displaced during winter ice movement and high summer flows. Four of the structures have been removed since their installation in 1991. Downstream booms added to two complexes in 1993 did not prevent one unit from being stripped to a bare log. The second modified unit was significantly reduced in size between 1993 and 1995. As the booms are placed by hand only smaller logs can be used, and these are more susceptible to damage and stripping of branches.

During 1997, one hand-placed anchored sweeper was damaged and another displaced. These structures were recommended for removal and repair, respectively.

Emergent Fry Structures

Four sites were tested for the addition of emergent fry structures, two in 1996 and two more in 1997. The success of emergent fry structures tested in the Nechako River over the last two years has been mixed. The small trees used deteriorated rapidly (loss of needles and branches). The structures are completely submerged at high flows and therefore do not trap sufficient debris to be self maintaining. Chinook fry use of the structures was high, however, indicating that the structures met velocity and depth criteria sought by newly emergent chinook fry. Anchoring systems were also effective at maintaining the structures in position under a variety of flow conditions. The life span of the emergent fry structures appears to be only one year, which was expected as durability of the structures was not a design consideration.

Debris Catchers

Pipe-Pile Debris Catchers

Since their installation in 1989, the two pipe-pile debris catchers have been generally stable under variable flow conditions, despite pilings being bent or pulled from the river bed. Sedimentation was observed at both sites from 1993 to 1995, due to the large size of the complexes and low velocities. In 1995 and in 1996 the smaller complex lost a significant amount of debris, following the loss of its downstream piling. In 1997, it was recommended that pipe-piles from structure RM34.7PDC be removed as they pose a potential navigational hazard. These structures are otherwise stable and provide large cover areas.

Rail Debris Catchers

Seven large rail debris catchers were constructed in 1990. In 1991, an additional 16 smaller catchers were constructed to maintain more manageable debris piles. The large rail debris catchers have been generally quite durable. However, the smaller structures have required repairs and reseeding following summer cooling flows.

From 1993 to 1995, three rail debris catchers (two built in 1991 and one built in 1990) were removed from the assessments due to loss of logs and debris following summer cooling flows. Triton (1998c) suggested that the repeated damage to the newer complexes may be partially due to the down-scaling of complex size in 1991.

During 1997, six structures showed signs of damage and seven required repair. Two structures were recommended for removal. The 1997 aesthetics improvement modifications are in good condition after having withstood a summer of operation.

To match the durability of the older complexes, the log boom diameter of future complexes may have to be increased to prevent breakage at the anchor points. Stronger chain anchoring should also be considered rather than cable. The size of material used in the seeding of rail debris catchers may also play a significant role in the complex's ability to retain debris. For this reason it is recommended that seeded material be of sufficient size so that it spans the booms and can be held in place by the piles. The success of the larger pre-1991 structures may indicate that later structures were downsized too much, which reduced the structures' ability to trap new debris.

The site selection of debris catchers is also thought to play a significant role in the structures' ability to trap and hold LWD. Some structures have lost and trapped new debris on a regular basis during fluctuating flows while other structures have continuously failed to trap any significant new debris, and this despite no apparent damage. Other potential site selection problems include excessive velocities at high flows which may cause material to be broken into smaller pieces and thereby prevent debris retention. Structures may also fail to trap LWD due to the position of the thalweg at high flows, which may cause material to drift by either side of the structure.

In-Stream Modifications

Side Channel and Debris Boom

The original side channel built in 1988 with full spanning complexes and a debris boom had problems with excessive debris accumulation. As a result, the debris boom was moved upstream of the channel entrance in 1990 to prevent excessive loading within the channel. In addition, the full spanning habitat complexes in the side channel were removed and replaced with smaller single logs buried at intervals along the margins (Triton 1996a). Despite these modifications, low flows and subsequent construction of dams by beavers within the side channel have resulted in velocities well below criteria limits. No recommendations for improvements have been made as lack of adequate flow and continual beaver dam blockage has made the complex undesirable for long term use.

The debris boom installed upstream of the side channel in 1990 has been stable, successful at retaining debris, and no significant displacement has occurred, despite the shore deadman anchor having been unearthed in 1992, and the offshore anchor cable having snapped in 1997. The complex should however be monitored for displacement during subsequent visits due to the damage incurred.

Point Bars

The point bars were modified in 1991 to reduce their extension and to increase their elevation. This was done to encourage formation of a back eddy and to reduce erosion of the surface during overtopping of the complexes at high summer flows. A point bar at the shoreline had some erosion in 1997. However this erosion may have been due to the unusually high flow releases during 1997. Fines have deposited in the back eddy pools of these complexes indicating that downstream velocities are low. No recommendations for modifications were made although the one damaged point bar should be monitored closely to ensure that the erosion adjacent to the structure does not become excessive.

Pocket Pools

The two pocket pools constructed during the summer of 1991 were subject to either low velocities and sedimentation, or high velocities and channel scouring, depending on the location.

In 1994, due to significant erosion of the high velocity pocket pool, this complex was removed from further assessment. The remaining lower velocity complex continues to provide adequate cover area, although some erosion has resulted in cobbles and boulders being deposited within the pool.

Resistance to Winter Physical Conditions

During 1991, complexes were installed in Reach 4 of the Nechako River in an effort to expose them to more severe ice conditions. These complexes were assessed for winter resistance for the first time in 1992.

From 1993 to 1995, several rail-anchored sweepers and hand-placed anchored sweepers lost branches or were damaged. In 1993, two hand-placed anchored sweepers located in high velocity areas of Reach 4 were severely damaged by ice and were removed from biological and physical assessment. Rail-anchored sweepers located in Reach 2 experienced similar damage.

In addition, both pipe-pile debris catchers in Reach 2 had their pilings lifted from the river bed by the ice. If this trend continues, these structures may suffer the same problems as RM34.7PDC, and lose much or all of their debris. In 1997, at least 10 of the rails used in construction of rail debris catchers were slightly lifted by the ice during winter.

The emergent fry structures installed in 1996 were severely damaged by ice during the winter of 1996/97. Natural deterioration was also a factor in the damage incurred. This damage re-affirms the need for structures to be able to capture and maintain debris to be self-sustaining and durable.

Some sites in Reach 4 experience higher velocities and stage changes than in Reach 2, and these structures may also be damaged by summer cooling flows. It should be noted that in addition to more severe ice and high flow conditions, Reach 4 also experiences lower debris recruitment which limits the size of its structures compared to those of Reach 2.

Factors affecting Biological Performance

Visual observations confirm that the man made habitat structures are well used by juvenile chinook salmon during the spring rearing period. Large schools of chinook are often seen in the debris and the shear zones of various structures during biological assessments (Triton 1996d, e, f, g, and 1998a, e and f). Electrofishing results have shown that the man made structures are also used by overwintering chinook juveniles.

Physical factors affecting the observed density of chinook juveniles in habitat complexes during snorkel surveys have been analyzed since 1991 (Triton 1996d, e, f, g, and 1998a, e and f). Cover area is usually positively correlated with chinook abundance. Shear velocity and substrate (negatively correlated with fines) are also important. Complexes should therefore be located in areas of gravel and cobble to provide sufficient velocity to meet the design criteria, and should maintain adequate flow-through to minimize deposition of fines.

Site selection is essential to establish a complex which fulfills velocity design criteria over the full range of flows. The target fish species will also influence the cover area design range and the type of complex. For chinook salmon, habitat complexes which impede velocities should be avoided and should have appropriate cover density.

Since the beginning of this project, the rail-anchored sweepers, hand-placed anchored sweepers, and rail debris catchers have generally provided acceptable velocities and cover areas. These designs could be improved to also provide long term durability.

Factors Affecting Physical Performance

Durability of habitat complexes reflects the link between project cost-effectiveness and complex life span. Thus, complexes were fabricated from economical and weather resistant materials suitable for the application. Anchoring systems for habitat complexes must be secured adequately. The deadman and rail anchoring systems used in the NFCP habitat complexing project have been successful. The suggested method of attaching cable to anchors and LWD is the looping and threading method. Stapling of cable in previous years of the project proved to be unsuccessful. Anchoring systems must also be designed to function under variable and transient flow conditions. The adaptability of habitat complex anchoring systems to changing flow conditions and site-specific conditions is particularly important for maintaining position and stability following flow recession. Successful complexes move with fluctuating flows so the structure does not become submerged during high flows. Stripping or other damage to the structure is therefore less likely, and accumulated debris do not drift out of the complex.

SUMMARY

Since 1988, the NFCP pilot habitat complexing program has constructed and tested 14 different complex designs.

The 1997 habitat complexing project activities were as follows:

- twenty-one rail covers and seven nest boxes were installed on rails used to anchor structures to improve aesthetics (May 26 and 28 - Reach 2 and September 7 and 8 - Reach 4);
- two emergent fry structures were constructed in the early spring (April 12 and 13) and two others constructed in 1996 were removed;
- rail debris catcher RM29.3RDC was added to the 1997 assessment after it was found to have accumulated debris;
- visual assessments including video documentation were performed three times during the spring and summer of 1997 under various flow conditions (167 m^3/s, 308 m^3/s, and 354 m^3/s); and,
- a physical assessment of habitat complex performance was performed during the fall (September 5 through 10).

Fifty-three (53) complexes were monitored in the Nechako River in 1997 in the spring physical assessment. Complexes which experienced damage or displacement were:

- the brush pile;
- a floating crib;
- both pseudo beaver lodges;
- six rail-anchored sweepers;
- two hand-placed anchored sweepers;
- both emergent fry structures;
- six rail debris catchers; and,
- the debris boom.

Twenty-three structures were earmarked for repair or removal:

- Repair:
- Rail-anchored sweepers (6)
- Hand-placed anchored sweepers (1)
- Pipe-pile debris catcher (1)
- Rail debris catchers (7)

Removal:

- Brush Pile (1)
- Pseudo beaver lodge (1)
- Rail anchored sweepers (3)
- Hand-placed anchored sweepers (1)
- Rail debris catchers (2)

To date, the NFCP habitat complexing project has identified the following parameters as important for biological success in habitat complexing:

- shear velocity;
- cover area; and,
- substrate.

Additionally, it has been determined that adequate complex anchoring is crucial for the maintenance of structural integrity during fluctuating flows.

The rail anchored sweepers, hand-placed anchored sweepers, and rail debris catchers generally have provided acceptable velocities and cover areas.

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APPENDIX A
NFCP In-Stream Habitat Complexing Pilot Testing
Terms of Reference

1.0 INTRODUCTION

In August 1987, a working group of technical experts from the Department of Fisheries and Oceans (DFO), Alcan, and the Province of British Columbia was established to assess how to ensure the conservation and protection of the fisheries resource of the Nechako River. The working group recognized that changes in Nechako River flows following development of the Kemano Completion Project would influence the amount of cover habitat available to juvenile chinook in the river. This fact prompted a recommendation to increase the complexity of juvenile chinook cover habitat in the Nechako River prior to the implementation of the Long-Term Flow Regime (Anon. 1987a) to replace what cover habitat might be lost due to the flow change in the river. Although the KCP has been has been cancelled assessment of structural durability of habitat complexes has continued. A preliminary assessment of the types of habitat utilized by Nechako River chinook was conducted via snorkeling surveys in early 1988. Observations from these surveys were used to identify suitable habitat complexing designs for pilot testing. The design also benefited from the experience of NFCP Technical Committee members and from the results of previous studies on the Nechako River (Envirocon 1984a), which had developed basic criteria (e.g., depth, velocity, substrate). The NFCP pilot habitat complexing project was initiated in 1988 to test these habitat complexing techniques and to assess their use by Nechako River chinook.

2.0 OBJECTIVES

The objectives of the habitat complexing project are:

- to determine the hydraulic performance and durability of a variety of potential habitat complexes through a series of small scale pilot tests;
- to continue the physical assessment of previously constructed habitat complexes; and,
- to identify cost effective methods of achieving the habitat complexing goal set out in the Nechako River Working Group Report.

3.0 SCOPE

The scope of the NFCP habitat complexing project consisted of the following:

(1) Construction of a limited number of habitat complexes that have been demonstrated to work on other river systems for other species of salmon;

(2) Construction of a limited number of habitat complexes that could duplicate naturally occurring habitat on the Nechako River;

(3) Installation of these habitat complexes at accessible sites downstream of known spawning grounds; and

(4) Assessment of habitat complexes under varying flow and meteorological conditions to determine hydraulic performance and durability.

4.0 TYPES OF HABITAT COMPLEXES

The selection of the types of habitat complexes considered for installation in the Nechako River was based on a review of similar work on other river systems, on Nechako River conditions and on local availability of materials. Woody debris was identified as the preferred "cover habitat" (Triton 1998b and Lister 1994). Habitat complexes identified for pilot testing in the Nechako River were of two types: structures and in-stream modifications.

Structures consist of debris bundles and debris catchers placed along the river to provide additional cover habitat for rearing chinook juveniles. Debris bundles are trees or root masses cabled to anchors on the river bank. Debris catchers are structures placed at various locations along the stream margin to intercept and hold any large woody debris (LWD) floating downstream. These complexes trap the river's natural supply of debris to provide fish habitat.

In-stream modifications involve the excavation or placement of river bed materials to replicate existing natural morphological features found on the Nechako River.

Since 1988, 14 different habitat complex designs have been tested in the Nechako River. These designs are categorized below as either "structures" - (debris bundles or debris catchers), or "in-stream modifications".

STRUCTURES

Debris Bundles

1) Rootwad Sweepers (RS)
2) Brush Pile (BP)
3) Floating Cribs (FC)
4) Pseudo Beaver Lodges (PBL)
5) Deep Water Sweepers (DWS)
6) Rail-Anchored Sweepers (RAS)
7) Hand-Placed Anchored Sweepers (HAS)
8) Emergent Fry Structures (EFS)

Debris Catchers

1) Channel Jacks (CJ)
2) Pipe-Pile Debris Catchers (PDC)
3) Rail Debris Catchers (RDC)

IN-STREAM MODIFICATIONS

1) Excavation of a Side Channel, complexed with debris bundles and a Debris Boom (SC and DB).
2) Construction of Point Bars with back eddy pools on the Nechako River shoreline (PB).
3) Excavation of Pocket Pools from the Nechako River bed (PP)

Detailed descriptions of habitat complexes constructed from 1988 to 1990 are presented in Triton (1996a). Complexes constructed in 1991 and work performed in 1992 are described in detail in Triton (1996b) and Triton (1996c), respectively. Descriptions of the modifications made to the complexes from 1993 to 1995 are detailed in Triton (1998c) and the 1996 work is described in Triton (1998d).

5.0 SITE SELECTION AND DESIGN CRITERIA

Since 1988, the criteria utilized for site selection and for design of all habitat complexes were based on the following:

- a review of the general literature (Everest and Chapman 1972; Lister and Genoe 1970)
- chinook life history data collected during field studies on the Nechako River (Envirocon Ltd. 1984a and Russell *et al*. 1983).
- criteria developed by the Department of Fisheries and Oceans (Anon. 1987b) and Envirocon Ltd. (1984b), and
- Nechako River physical characteristics and natural habitats.

They are as follows:

Parameter	**Criterion Range**	**Preferred**
Velocity (m/s)	0.15 - 0.4	0.3
Depth (m)	not less than 0.4	0.75-1.0
Substrate	gravel to cobble	gravel to cobble
Extension (m)	site specific	5.0

Note that extension is defined as the perpendicular distance from the wetted edge to the outer edge of the structure.

Habitat complexes installed in the mainstem Nechako River from 1988 through 1990 were designed to operate at the Short-Term spring and summer rearing flows of 56.6 m^3/s (2,000 cfs), and at fall and winter flows of 31.1 m^3/s (1,100 cfs) (Anon. 1987a). By comparison, complexes installed in the mainstem Nechako River in 1991 were designed to operate at expected Long-Term rearing flows of 31.1 m^3/s (1,100 cfs) and were located so that they could also operate during lower water levels and river widths associated with proposed future Long-Term winter flows of 14.2 m^3/s (500 cfs). However, complexes were evaluated for design criteria fulfillment at approximate Nechako River high and low flows of 56.6 m^3/s (2,000 cfs) and 31.1 m^3/s (1,100 cfs).

The site selection and design criteria used in the construction of the side channel in the spring of 1988 were based on studies by DFO (Anon. 1987b) and Envirocon Ltd. (1984b) and are presented below.

Parameter	Criterion
Maximum Depth (m)	0.6
Average Cross-Sectional Velocity (m/s)	approx. 0.5
Side Channel Flow Range (m^3/s)	1 - 2
Nechako River Flow Range (m^3/s)	31.1 - 56.6

The construction of the side channel was such that depth and velocity at each complex in the side channel would be similar to the preferred depth and velocity criteria of complexes in the mainstem Nechako River. The criteria were developed for approximate Nechako River high and low flows of 56.6 m^3/s (2,000 cfs) and 31.1 m^3/s (1,100 cfs).

Side channel bank slopes were graded such that the right bank approximated the existing stable slope of 1.5H:1V and the left bank provided shallow habitat for newly emergent fry through a lower slope of 3.5H:1V.

The criteria for site selection and design of emergent fry structures were slightly modified in 1997 based on observations by the field crew and on a general literature review (Everest and Chapman 1972; Lister and Genoe 1970). These indicated that newly emergent fry occupy areas with depths less than 0.2 m and velocities of 0.0 to 0.15 m/s. As the fry develop, they move to areas of greater depth and velocity. The emergent fry structures were therefore placed in areas of reduced velocity and shallow depth to be effective for the earliest phase of juvenile chinook fry development. The emergent fry structures were designed and located to be wetted during the spring rearing period, and to be de-watered after the summer cooling flows to resist colonization by non target species. Pilot testing in 1996 indicated good use of emergent fry structures located in the proximity to known spawning grounds. Part of the 1997 test was to determine if fry recruitment to an area with a reduced spawner density could be encouraged with the placement of structures in that area.

It was expected that the installation of a given habitat complex would modify velocities at the site, but that the velocities throughout the complex would remain within the criteria range. Therefore, the criteria ranges apply to both the site selection and to the design of the habitat complexes.

APPENDIX B
1997 Summary of Habitat Complexing Construction, Modification and/or Rationale for Removal

APPENDIX B

1997 Summary of Habitat Complexing Construction, Modification and / or Rationale for Removal

Location (km)	Site Number	97	Nature of Modification	Modification and/or Removal Rationale
Reach 2				
15.6	LM15.6RAS		-	-
15.7	MC15.7PP		-	-
16.2	RM16.2RAS		-	-
16.5	RM16.5RDC		-	-
16.8	RM16.8RDC		-	-
17.0	RM17.0PB		-	-
17.15	RM17.15PB		-	-
17.3	RM17.3PB		-	-
17.9	RM17.9DB		-	-
17.9-18.6	RM17.9SC		-	-
18.3	LM18.3RDC	M	Rail covers installed, nest box installed.	To improve aesthetics of rail debris catchers.
19.7	RM19.7EFS	R	Removed from physical assessment.	Defoliated by ice conditions and high flows.
20	LM20.0EFS	R	Removed from physical assessment.	Defoliated by ice conditions and high flows.
20.6	LM20.6EFS	C	-	-
20.65	RM20.65RDC	M	Rail covers installed	To improve aesthetics of rail debris catchers.
21.3	LM21.3RDC	M	Rail covers installed, nest box installed.	To improve aesthetics of rail debris catchers.
21.4	LM21.4RDC	M	Rail covers installed, nest box installed.	To improve aesthetics of rail debris catchers.
22.0	RM22.0RDC		-	-
22.1	RM22.1RAS		-	-
22.55	RM22.55RDC	M	Rail covers installed, nest box installed.	To improve aesthetics of rail debris catchers.
22.6	LM22.6RDC	M	Rail covers installed	To improve aesthetics of rail debris catchers.
22.85	LM22.85RDC		-	-
22.95	RM22.95RAS		-	-
23.0	RM23.0RDC		-	-
24.2	LM24.2RDC	M	Nest box installed.	To improve aesthetics of rail debris catchers.
24.3	LM24.3RDC		-	-
24.35	RM24.35RS		-	-
24.4	RM24.4FC		-	-
24.6	RM24.6PBL		-	-
25.4	RM25.4RDC		-	-
25.7	MC25.7RDC		-	-
26.9	RM26.9RAS		-	-
27.4	RM27.4FC		-	-
28.4	RM28.4RDC		-	-
29.3	RM29.3RDC	A	Complex removed in 1993 added to 1997 assessment.	Complex captured new debris.
29.4	LM29.4RAS		-	-
31.1	RM31.1PBL		-	-
31.4	RM31.4BP		-	-
32.65	LM32.65HAS		-	-
34.7	RM34.7PDC		-	-
35.4	MC35.4PDC		-	-
38.5	RM38.5EFS	C	-	-

APPENDIX B (continued)

1997 Summary of Habitat Complexing Construction, Modification and / or Rationale for Removal

Location (km)	Site Number	97	Nature of Modification	Modification and/or Removal Rationale
Reach 4				
72.9	LM72.9HAS		-	-
73.0	LM73.0HAS		-	-
75.9	LM75.9HAS		-	-
78.0	LM78.0HAS		-	-
80.2	LM80.2HAS		-	-
80.9	LM80.9RDC	M	Rail covers installed	To improve aesthetics of rail debris catchers.
82.1	LM82.1RAS		-	-
82.2	LM82.2RAS		-	-
82.3	LM82.3HAS		-	-
83.0	LM83.0RDC		-	-
85.7	RM85.7RAS		-	-
86.35	RM86.35RDC	M	Rail covers installed	To improve aesthetics of rail debris catchers.
86.375	RM86.375RDC	M	Rail covers installed	To improve aesthetics of rail debris catchers.

Where,

RS = rootwad sweeper
BP = brush pile
FC = floating crib
PBL = pseudo beaver lodge
RAS = rail-anchored sweeper
HAS = hand-placed anchored sweeper
EFS = emergent fry structure
PDC = pipe-pile debris catcher
RDC = rail debris catcher
SC= side channel
DB = debris boom
PB = point bar
PP = pocket pool

C= constructed
M = modified
R = removed
A = added

APPENDIX C
1997 Physical Assessments of Habitat Complexes

Appendix C. Fall 1997 Physical Assessment of Habitat Complexes

Fall 1997 Habitat Complex Assessment (Sept 5 - 10, 1997): Discharge = 82.6 m³/s (2917 cfs)

		Depth							Velocity						
Location (km)	Site Number	u/s 1/3 ext. (m)	u/s 2/3 ext. (m)	Outside Shear (m)	d/s 2/3 ext. (m)	d/s 1/3 ext. (m)	Through (m)	Inside Shear (m)	u/s 1/3 ext. (m/s)	u/s 2/3 ext. (m/s)	Outside Shear (m/s)	d/s 2/3 ext. (m/s)	d/s 1/3 ext. (m/s)	Through (m/s)	Inside Shear (m/s)
Reach 2															
15.6	LM15.6RAS	0.37	0.63	0.94	0.3	0.2	0.33	0.1	0.31	0.57	0.75	0.09	0.1	0.31	0.05
15.7	MC15.7PP	0.37	0.32	1.01	0.27	0.35	N/A	N/A	0.18	0.31	0.04	0.1	0.22	N/A	N/A
16.2	RM16.2RAS	0.8	0.96	0.98	0.79	0.54	N/A	0.2	0.6	0.98	0.94	0.76	0.48	N/A	0.17
16.5	RM16.5RDC	0.49	0.84	1.4	0.79	0.47	N/A	N/A	0.4	0.45	1.26	0.2	0.96	N/A	N/A
16.8	RM16.8RDC	0.81	0.89	1.25	1.06	0.93	0.85	0.78	0.26	0.48	0.94	0.32	0.02	0.22	0.56
17	RM17.0PB	-	-	1.12	-	-	-	-	-	-	0.69	-	-	-	-
17.15	RM17.15PB	-	-	0.83	-	-	-	-	-	-	0.63	-	-	-	-
17.3	RM17.3PB	-	-	0.93	-	-	-	-	-	-	0.51	-	-	-	-
17.9	RM17.9DB	0.53	0.51	0.59	0.47	0.41	0.4	N/A	0.14	0.4	0.55	0	0.15	0.14	N/A
17.9	RM17.9SC	-	-	-	-	-	0.77	-	-	-	-	-	-	0	-
18.3	LM18.3RDC	0.27	1.17	1.86	1.54	0.47	0.29	N/A	0.28	0.48	1.21	0	0	0.26	N/A
20.65	RM20.65RDC	0.57	0.85	2	1.14	0.54	0.72	N/A	0.2	0.3	0.8	0.1	0	0.3	N/A
21.3	LM21.3RDC	0.6	0.95	1.55	1.03	0.46	0.5	N/A	0.3	0.4	0.8	0	0	0.3	N/A
21.4	LM21.4RDC	1.5	1.5	2.3	1.6	0.6	1.3	1.25	0.3	0.4	1	0.1	0.4	0.3	0.4
22	RM22.0RDC	0.77	0.95	1.15	0.85	0.69	0.67	0.53	0.4	0.5	1	0.3	0.3	0.5	0.6
22.1	RM22.1RAS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22.55	RM22.55RDC	0.56	0.95	1.6	0.87	0.65	0.5	N/A	0.2	0.3	0.9	0	0	0.05	N/A
22.6	LM22.6RDC	0.8	1.2	1.55	1	0.64	0.97	N/A	0	0.3	0.6	0	0	0.2	N/A
22.85	LM22.85RDC	0.87	1.02	1.45	0.94	0.51	0.55	0.38	0.3	0.5	0.7	0	0.1	0.2	0.4
22.95	RM22.95RAS	0.46	0.56	0.83	0.49	0.37	0.48	N/A	0	0.2	0.3	0.2	0.1	0.2	N/A
23	RM23.0RDC	1.08	1.3	1.6	1.2	1.07	1.2	0.69	0.3	0.5	0.9	0.05	0.1	0.2	0.4
24.2	LM24.2RDC	0.47	1.02	1.27	1.07	0.71	0.24	N/A	0	0.3	0.7	0	0.05	0.1	N/A
24.3	LM24.3RDC	0.95	1.05	1.23	1.13	0.89	0.79	0.88	0.2	0.3	0.4	0.05	0.05	0.1	0.2
24.35	RM24.35RS	0.53	0.59	0.98	0.74	0.49	0.4	N/A	0	0.1	0.3	0.05	0.05	0.1	N/A
24.4	RM24.4FC	0.31	0.57	0.79	0.73	0.56	N/A	N/A	0	0.15	0.3	0	0	0	N/A
24.6	RM24.6PBL	0.54	0.69	1	0.44	0.25	N/A	N/A	0	0.2	0.4	0	0	0	N/A
25.4	RM25.4RDC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
25.7	MC25.7RDC	0.88	0.75	0.83	0.55	0.56	0.6	0.77	0.3	0.3	0.8	0.02	0.02	0.1	0.7
26.9	RM26.9RAS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
27.4	RM27.4FC	0.43	0.44	0.55	0.4	0.28	0.4	N/A	0.1	0.2	0.4	0	0	0.05	N/A
28.4	RM28.4RDC	0.6	1	1.35	0.88	0.69	0.34	N/A	0.1	0.3	0.6	0	0	0.2	N/A
29.3	RM29.3RDC	1.03	1	1.3	1.19	0.74	1	1.01	0.2	0.2	0.5	0	0	0.05	0.3
29.4	LM29.4RAS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
31.1	RM31.1PBL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
31.4	RM31.4BP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32.65	LM32.65HAS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
34.7	RM34.7PDC	0.6	0.85	1.3	0.67	0.32	0.52	N/A	0.1	0.2	0.5	0.1	0.1	0.2	N/A
35.4	MC35.4PDC	1	1	1.4	0.52	0.6	N/A	1.4	0.2	0.2	0.3	0	0	0	0.4

Appendix C. Fall 1997 Physical Assessment of Habitat Complexes

Fall 1997 Habitat Complex Assessment (Sept 5 - 10, 1997): Discharge = 82.6 m³/s (2917 cfs)

		Depth							Velocity						
Location (km)	Site Number	u/s 1/3 ext. (m)	u/s 2/3 ext. (m)	Outside Shear (m)	d/s 2/3 ext. (m)	d/s 1/3 ext. (m)	Through (m)	Inside Shear (m)	u/s 1/3 ext. (m/s)	u/s 2/3 ext. (m/s)	Outside Shear (m/s)	d/s 2/3 ext. (m/s)	d/s 1/3 ext. (m/s)	Through (m/s)	Inside Shear (m/s)
Reach 4															
72.9	LM72.9HAS	0.52	0.69	0.94	0.6	0.4	0.4	N/A	0.05	0.2	0.6	0.3	0.1	0.3	N/A
73	LM73.0HAS	0.29	0.47	0.72	0.47	0.29	0.2	N/A	0.1	0.15	0.4	0.1	0	0.1	N/A
75.9	LM75.9HAS	0.24	0.4	0.65	0.53	0.32	0.5	N/A	0	0	0.3	0.15	0.02	0.15	N/A
78	LM78.0HAS	0.42	0.76	0.84	0.62	0.43	N/A	N/A	0	0	0.3	0	0	0	N/A
80.2	LM80.2HAS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
80.9	LM80.9RDC	0.91	0.93	1.09	0.98	0.87	0.9	1.18	0.5	0.6	1	0.2	0.5	0.5	0.6
82.1	LM82.1RAS	0.87	1.13	1.07	0.83	0.54	0.72		0.4	0.6	1	0.5	0.3	0.6	N/A
82.2	LM82.2RAS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
82.3	LM82.3HAS	0.57	0.88	1.29	0.63	0.54	0.5	N/A	0.1	0.2	0.3	0.2	0.1	0.2	N/A
83	LM83.0RDC	0.6	0.8	1.2	0.89	0.6	1	0.8	1	1	1.5	0.8	0.8	1	1
85.7	RM85.7RAS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
86.35	RM86.35RDC	1	1.4	2	1.9	1.4	1	N/A	0.2	0.3	0.8	0.4	0.3	0.4	N/A
86.375	RM86.375RDC	1	1.2	1.9	1.8	1.6	1.4	0.6	0.3	0.4	0.9	0.1	0.3	0.4	0.3

Spring 1997 Emergent Fry Structure Assessment (April 12 and 13, 1997): Discharge = 59.8 m³/s (2110 cfs)

		Depth @ Distance from Shore							Velocity @ Distance from Shore						
Location	Site	1.0 m (m)	1.5 m (m)	2.0 m (m)	2.5 m (m)	3.0 m (m)	3.5 m (m)	4.0 m (m)	1.0 m (m/s)	1.5 m (m/s)	2.0 m (m/s)	2.5 m (m/s)	3.0 m (m/s)	3.5 m (m/s)	4.0 m (m/s)
Emergent Fry Structures															
20.6	LM20.6EFS	0.15	0.18	0.22	0.25	0.27	0.28	0.32	0.06	0.08	0.10	0.11	0.09	0.08	0.15
38.5	RM38.5EFS	0.06	0.10	0.12	0.17	0.22	0.24	0.27	0.03	0.09	0.06	0.12	0.11	0.13	0.15

Where,
RM = right margin
MC = mid-channel
LM = left margin

RS = rootwad sweeper
BP = brush pile
FC = floating crib
PBL = pseudo beaver lodge
RAS = rail-anchored sweeper
HAS = hand-placed anchored sweeper
EFS = Emergent Fry Structure

PDC = pipe-pile debris catcher
RDC = rail debris catcher
SC= side channel
DB = debris boom
PB = point bar
PP = pocket pool

u/s = upstream
d/s = downstream
N/A - not available

Appendix C. Fall 1997 Physical Assessment of Habitat Complexes

Fall 1997 Habitat Complex Assessment (Sept 5 - 10, 1997): Discharge = 82.6 m³/s (2917 cfs)

Location (km)	Site Number	Cover Area (m²)	Ext. from Margin (m)	Dist. from Shore	Cover to Bottom?	Debris Entrapment (yes, no, lost)	Sedimentation	Erosion (Scour)	Substrate B	C	G	F
Reach 2												
15.6	LM15.6RAS	6	8.5	1.5	Y	L	N	N		1	2	
15.7	MC15.7PP	N/A	N/A	N/A	N/A	N/A	Y (Fines in pool)	N	1	2	3	
16.2	RM16.2RAS	0	7.2	0.5	N	N	N	N	3	1	2	
16.5	RM16.5RDC	2	8.6	0	Y	N	N	N	3	1	2	
16.8	RM16.8RDC	8	8	5	Y	Y	N	Y - outside shear zone		1	2	3
17	RM17.0PB	N/A	8	N/A	N/A	N/A	Y - near shore in Eddy	N		1	2	3
17.15	RM17.15PB	N/A	12.5	N/A	N/A	N/A	Y - d/s middle of PB	Y - along shoreline		1	2	3
17.3	RM17.3PB	N/A	7.5	N/A	N/A	N/A	N	N		1	2	3
17.9	RM17.9DB	53	10	0	Y	Y	Y - d/s behind complex	N		3	1	2
17.9	RM17.9SC	45	-	-	-	N	N	N		3	1	2
18.3	LM18.3RDC	99	12	0	Y	Y	N	Y - outside shear zone	3	1	2	
20.65	RM20.65RDC	86	7	0	Y	Y	N	Y - outside shear zone		2	1	3
21.3	LM21.3RDC	64	9	0	Y	Y	Y - d/s behind complex	Y - outside shear zone		3	1	2
21.4	LM21.4RDC	37	16	7	Y	N	Y - d/s of inside shear	Y - inside and outside shear		1	2	3
22	RM22.0RDC	15	9	3.5	Y	L	N	Y - inside shear		1	2	3
22.1	RM22.1RAS	0	0	0	N	L	N	N	3	1	2	
22.55	RM22.55RDC	50	10	0	Y	Y	Y - d/s behind complex	N		3	1	2
22.6	LM22.6RDC	95	9.5	0	Y	N	N	N		2	1	3
22.85	LM22.85RDC	27	11	3	Y	Y	Y - d/s behind complex	N		2	1	3
22.95	RM22.95RAS	3	3	0	Y	L	N	N		3	1	2
23	RM23.0RDC	40	15	7	Y	Y	Y - d/s behind complex	N		1	2	3
24.2	LM24.2RDC	100	9.5	0	Y	Y	Y - d/s behind complex	N		2	1	3
24.3	LM24.3RDC	18	16	10	Y	Y	N	N		1	2	3
24.35	RM24.35RS	44	11	0	Y	N	N	N		3	1	2
24.4	RM24.4FC	65	6	0	Y	N	N	N		3	1	2
24.6	RM24.6PBL	18	4	0	Y	L	N	Y - along shoreline		2	1	3
25.4	RM25.4RDC	0	0	0	N	L	N	Y - everywhere	3	1	2	
25.7	MC25.7RDC	16	12	8	Y	N	Y - d/s behind complex	Y - outside shear zone		2	1	3
26.9	RM26.9RAS	0	0	0	N	L	N	N		2	1	3
27.4	RM27.4FC	70	7	0	Y	Y	N	N		2	1	3
28.4	RM28.4RDC	77	11	0	Y	Y	Y - d/s behind complex	N		2	1	3
29.3	RM29.3RDC	50	20	13	Y	Y	Y - d/s behind complex	Y - outside shear zone		1	2	3
29.4	LM29.4RAS	0	0	0	N	L	N	N		2	1	3
31.1	RM31.1PBL	0	0	0	N	L	N	N		2	1	3
31.4	RM31.4BP	1	1	0	N	L	N	N			2	1
32.65	LM32.65HAS	1	2	0	Y	L	N	N		2	1	3
34.7	RM34.7PDC	21	7	0	Y	L	N	N		3	1	2
35.4	MC35.4PDC	220	40	30	Y	Y	Y - d/s behind complex	N		3	1	2

Appendix C. Fall 1997 Physical Assessment of Habitat Complexes

Fall 1997 Habitat Complex Assessment (Sept 5 - 10, 1997): Discharge = 82.6 m³/s (2917 cfs)

Location (km)	Site Number	Cover Area (m²)	Ext. from Margin (m)	Dist. from Shore	Cover to Bottom?	Debris Entrapment (yes, no, lost)	Sedimentation	Erosion (Scour)	Substrate B	C	G	F
Reach 4												
72.9	LM72.9HAS	2	3	0	Y	L	N	N	3	2	1	
73	LM73.0HAS	1	2	0	Y	L	N	N		2	1	3
75.9	LM75.9HAS	4	3.2	0	Y	L	N	N		1	2	3
78	LM78.0HAS	3	2.4	0	Y	L	N	N		2	1	3
80.2	LM80.2HAS	0	0	0	Y	L	N	N			1	2
80.9	LM80.9RDC	5	14.5	8	Y	N	N	Y - inside shear zone		3	1	2
82.1	LM82.1RAS	3	5.5	0	N	N	N	N		2	1	3
82.2	LM82.2RAS	0	0	0	N	L	N	N		2	1	3
82.3	LM82.3HAS	2	3	0	Y	L	N	N		2	1	3
83	LM83.0RDC	5	14	8	Y	N	N	Y - all around complex		1	2	3
85.7	RM85.7RAS	0	0	0	N	L	N	N		3	1	2
86.35	RM86.35RDC	6	10	0	Y	N	Y - d/s of complex	Y - between inner rails			1	2
86.375	RM86.375RDC	10	14	3	Y	Y	Y - 10 meters d/s of complex	Y - d/s of complex for 8 meters		3	1	2

Where,

RM = right margin
MC = mid-channel
LM = left margin

RS = rootwad sweeper
BP = brush pile
FC = floating crib
PBL = pseudo beaver lodge
RAS = rail-anchored sweeper
HAS = hand-placed anchored sweeper
EFS = Emergent Fry Structures

PDC = pipe-pile debris catcher
RDC = rail debris catcher
SC= side channel
DB = debris boom
PB = point bar
PP = pocket pool

u/s = upstream
d/s = downstream
N/A - not available

B = boulder
C = cobble
G = gravel
F = fines

Appendix C. Rationale of Recommendations for Habitat Complexes

Based on Fall 1997 Habitat Complex Assessment (Sept 5 - 10, 1997): Discharge = 82.6 m^3/s (2917 cfs)

Location (km)	Site Number	Damage / Displacement	Debris Accumulation/Loss	Recommendation/Comments
Reach 2				
15.6	LM15.6RAS	Sweeper being defoliated	Loss of previously captured LWD, current debris pile very sparse	Sweeper being defoliated. Re seed with LWD, replace or remove.
15.7	MC15.7PP	-	-	Leave in present form.
16.2	RM16.2RAS	Sweeper almost completely defoliated.	-	Sweeper consists of bare log with sparse branches. Re seed with LWD, replace or remove.
16.5	RM16.5RDC	Shore boom broken; some lifting of rails by ice.	-	No complex cover. Repair shore boom and re seed with LWD
16.8	RM16.8RDC	Shore boom submerged failing to hold trapped debris. Some lifting of rails by ice.	Some new debris collection on two outer rails.	Repair shore boom and re seed with LWD
17.0	RM17.0PB	-	-	Leave in present form.
17.15	RM17.15PB	Erosion of bank along shoreline on d/s side of Point bar.	-	Monitor erosion along shoreline.
17.3	RM17.3PB	-	-	Leave in present form.
17.9	RM17.9DB	Outside cable attachment to deadman snapped	-	Significant sedimentation d/s of complex. Leave in present form.
17.9	RM17.9SC	Beaver dam blocks 99% of flow through channel.	-	Leave in present form.
18.3	LM18.3RDC	-	Some new debris collection.	Leave in present form.
20.65	RM20.65RDC	-	Significant new debris collection. Large debris pile forming on shore.	Leave in present form.
21.3	LM21.3RDC	-	Significant new debris collection.	Leave in present form.
21.4	LM21.4RDC	-	-	Some scour on inside and outside shear zones. Leave in present form.
22.0	RM22.0RDC	Inside shore debris boom broken.	Major loss of accumulated debris	Repair shore boom and re seed with LWD
22.1	RM22.1RAS	Sweeper completely gone, rails remaining.	-	Remove rails. Navigational hazard.
22.55	RM22.55RDC	-	Some new debris collection.	Leave in present form.
22.6	LM22.6RDC	-	-	Leave in present form.
22.85	LM22.85RDC	-	Some new debris collection.	Leave in present form.
22.95	RM22.95RAS	Attachment to outer rail broken	Sweeper mostly defoliated. Sparse debris remaining.	Replace sweeper and add d/s shore boom, or remove rails.
23.0	RM23.0RDC	-	Some new debris collection.	Leave in present form.

Appendix C. Rationale of Recommendations for Habitat Complexes

Based on Fall 1997 Habitat Complex Assessment (Sept 5 - 10, 1997): Discharge = 82.6 m³/s (2917 cfs)

Location (km)	Site Number	Damage / Displacement	Debris Accumulation/Loss	Recommendation/Comments
24.2	LM24.2RDC	-	Some new debris collection.	Leave in present form.
24.3	LM24.3RDC	-	Some new debris collection.	Leave in present form.
24.35	RM24.35RS	-	Some loss of accumulated debris.	Leave in present form.
24.4	RM24.4FC	-	-	Leave in present form.
24.6	RM24.6PBL	Debris pile shifted d/s 5-10 meters	Some loss of accumulated debris	Leave in present form.
25.4	RM25.4RDC	All three rails severely tipped over	Complete loss of all debris	Remove navigational hazard
25.7	MC25.7RDC	-	-	Leave in present form.
26.9	RM26.9RAS	D/s shore boom broken	Loss of accumulated debris	Rebuild sweeper with d/s shore boom or remove remaining rail.
27.4	RM27.4FC	D/s stiff leg broken, u/s deadman broken complex shifted d/s 5-10 meters	-	Shifting of complex has changed shear zone depth from 2.0 to 0.55 meters
28.4	RM28.4RDC	-	-	Leave in present form.
29.3	RM29.3RDC	Lifting of rails by ice	Significant new debris collection	Leave in present form.
29.4	LM29.4RAS	-	Almost all of remaining sweeper defoliated	Remove last signs of complex.
31.1	RM31.1PBL	Frame broken, boom logs hanging d/s in a row.	All debris lost except frame booms	Remove last signs of complex.
31.4	RM31.4BP	Remaining debris shifted onto shore	-	Remove last signs of complex.
32.65	LM32.65HAS	Sweeper being shifted onto shore	Most of remaining sweeper defoliated	Add d/s shore boom to create debris capture.
34.7	RM34.7PDC	Outer two pipes are tipped over	-	Remove tipped over pipes from river attempt to stabilize debris pile
35.4	MC35.4PDC	-	Some new debris collection.	Significant sedimentation occurring d/s of complex. Leave in present form.
Reach 4				
72.9	LM72.9HAS	Sweeper being defoliated	-	Leave in present form.
73.0	LM73.0HAS	Sweeper being defoliated	-	Leave in present form.
75.9	LM75.9HAS	Sweeper being defoliated	-	Leave in present form.
78.0	LM78.0HAS	Sweeper being defoliated	-	Leave in present form.
80.2	LM80.2HAS	Sweeper is gone	-	Remove from assessment
80.9	LM80.9RDC	-	Lack of debris collection. Major debris pile on shore behind complex	Complex fails to capture debris. Re seed with new LWD.
82.1	LM82.1RAS	D/s debris boom broken	Sweeper being defoliated	Sweeper being defoiliated. Re seed with LWD, replace or remove.
82.2	LM82.2RAS	Shore attachment to stump broken. Outer rail remains below surface.	Complete loss of sweeper and debris	Remove outer rail which is 20 cm. below surface. Navigational hazard
82.3	LM82.3HAS	Sweeper being defoliated	-	-

Appendix C. Rationale of Recommendations for Habitat Complexes

Based on Fall 1997 Habitat Complex Assessment (Sept 5 - 10, 1997): Discharge = 82.6 m^3/s (2917 cfs)

Location (km)	Site Number	Damage / Displacement	Debris Accumulation/Loss	Recommendation/Comments
83.0	LM83.0RDC	-	-	Rebuild complex closer to shore. Navigational hazard; fails to trap debris.
85.6	MC85.6RDC	Some lifting of rails due to ice.	Almost no debris remaining, no complex cover only bare logs.	Remove rails due to navigational hazard.
85.7	RM85.7RAS	Sweeper is gone	Complete loss of sweeper and debris	All debris washed away. Re seed with LWD, replace or remove rails.
86.35	RM86.35RDC	Inside shore boom submerged, some lifting of rails by ice.	Lost almost all debris, due to submerged shore boom.	Repair shore boom and re seed with LWD
86.375	RM86.375RDC	Inside shore boom gone. Some lifting of rails by ice.	Some debris entrapment on two outer rails.	Repair shore boom and re seed with LWD

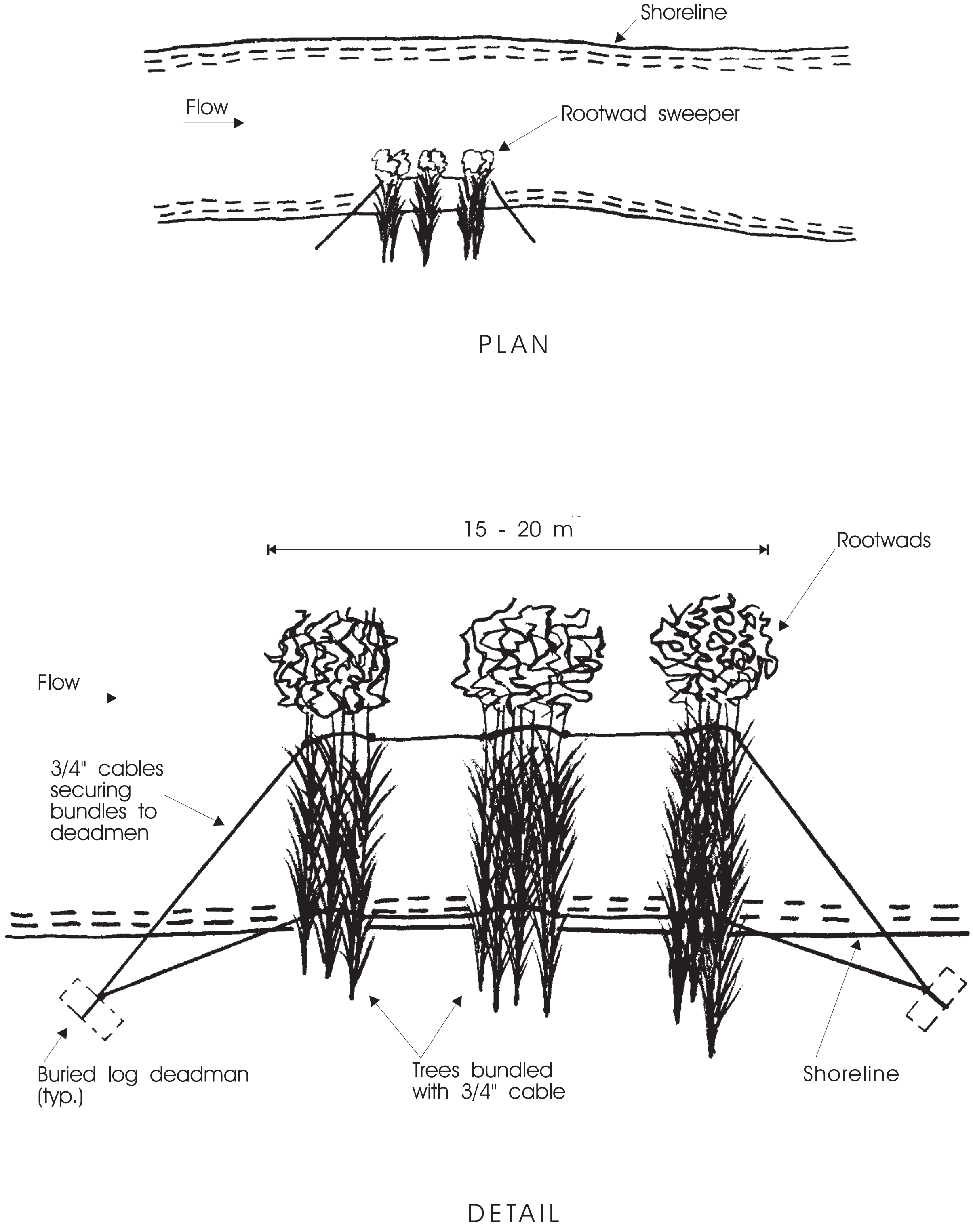
Where,
RM = right margin
MC = mid-channel
LM = left margin

RS = rootwad sweeper
BP = brush pile
FC = floating crib
PBL = pseudo beaver lodge
RAS = rail-anchored sweeper
HAS = hand-placed anchored sweeper
EFS = Emergent Fry Structures

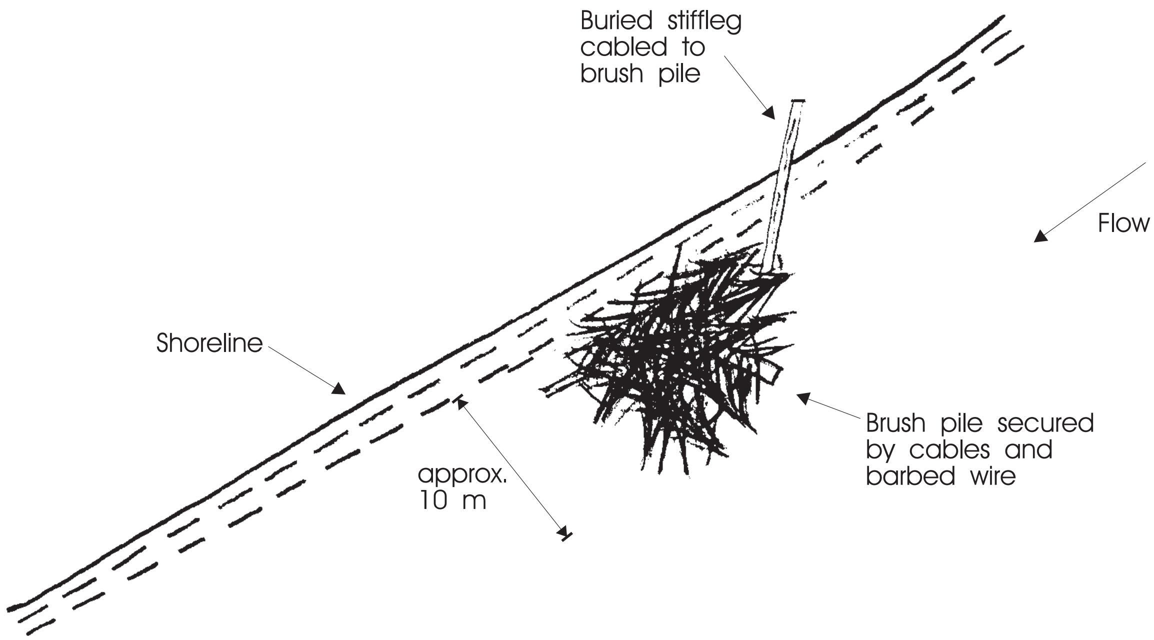
PDC = pipe-pile debris catcher
RDC = rail debris catcher
SC= side channel
DB = debris boom
PB = point bar
PP = pocket pool

u/s = upstream
d/s = downstream
N/A - not available

APPENDIX D
1997 Sketches of Habitat Complexes (As Built)

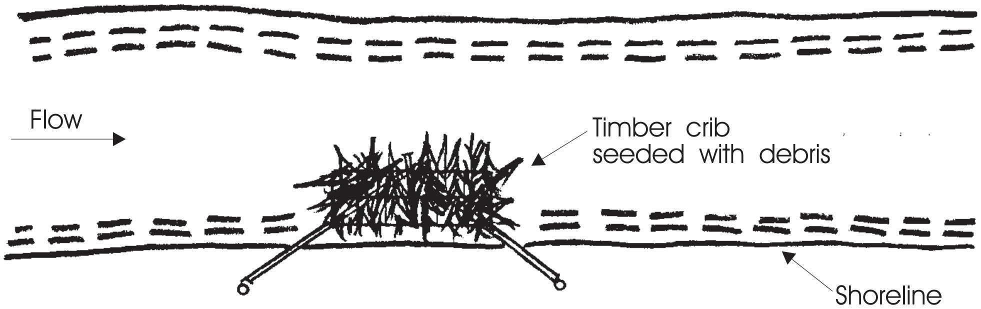


Nechako Fisheries Conservation Program	Drawing # RM972-1a	Not To Scale
FIGURE 1. ROOT WAD SWEEPER (1988)		

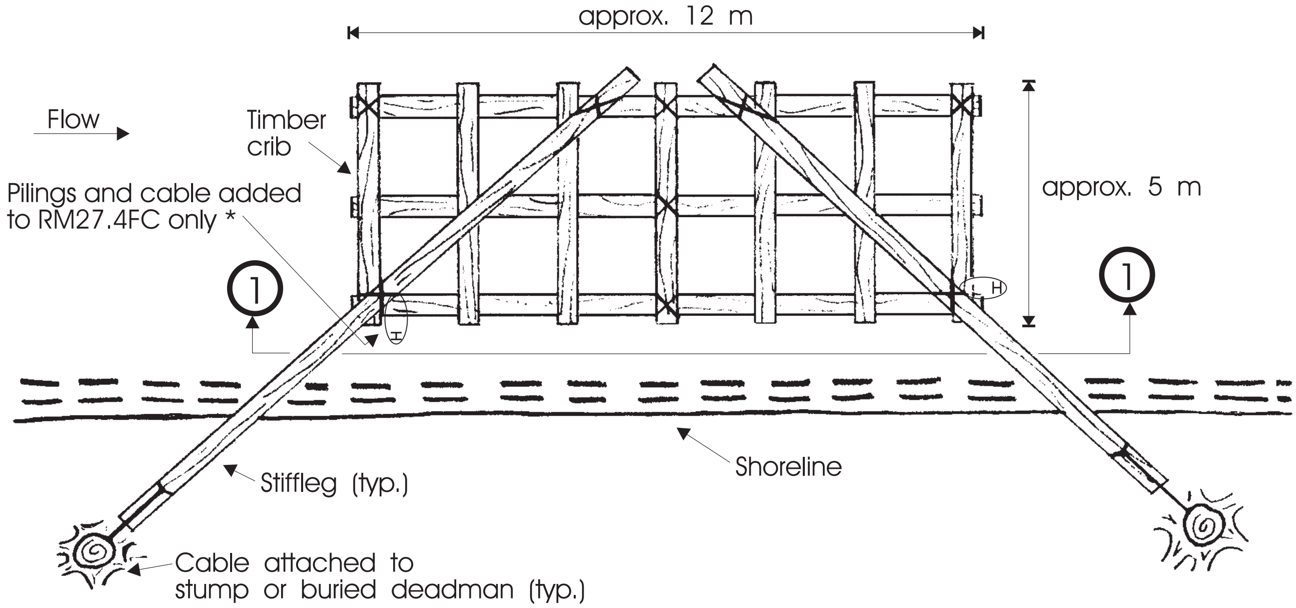


PLAN

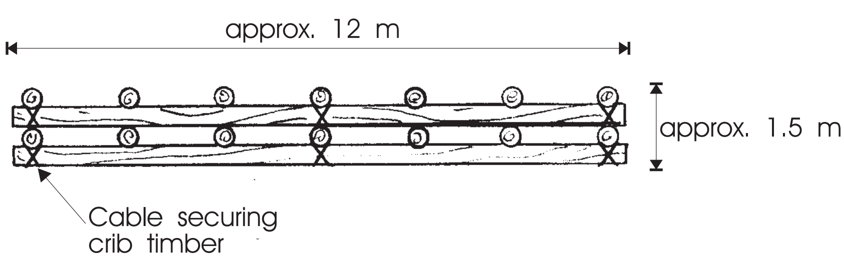
Nechako Fisheries Conservation Program	Drawing # RM972-2a	Not To Scale
FIGURE 2. MAINSTEM BRUSH PILE (1988)		



PLAN



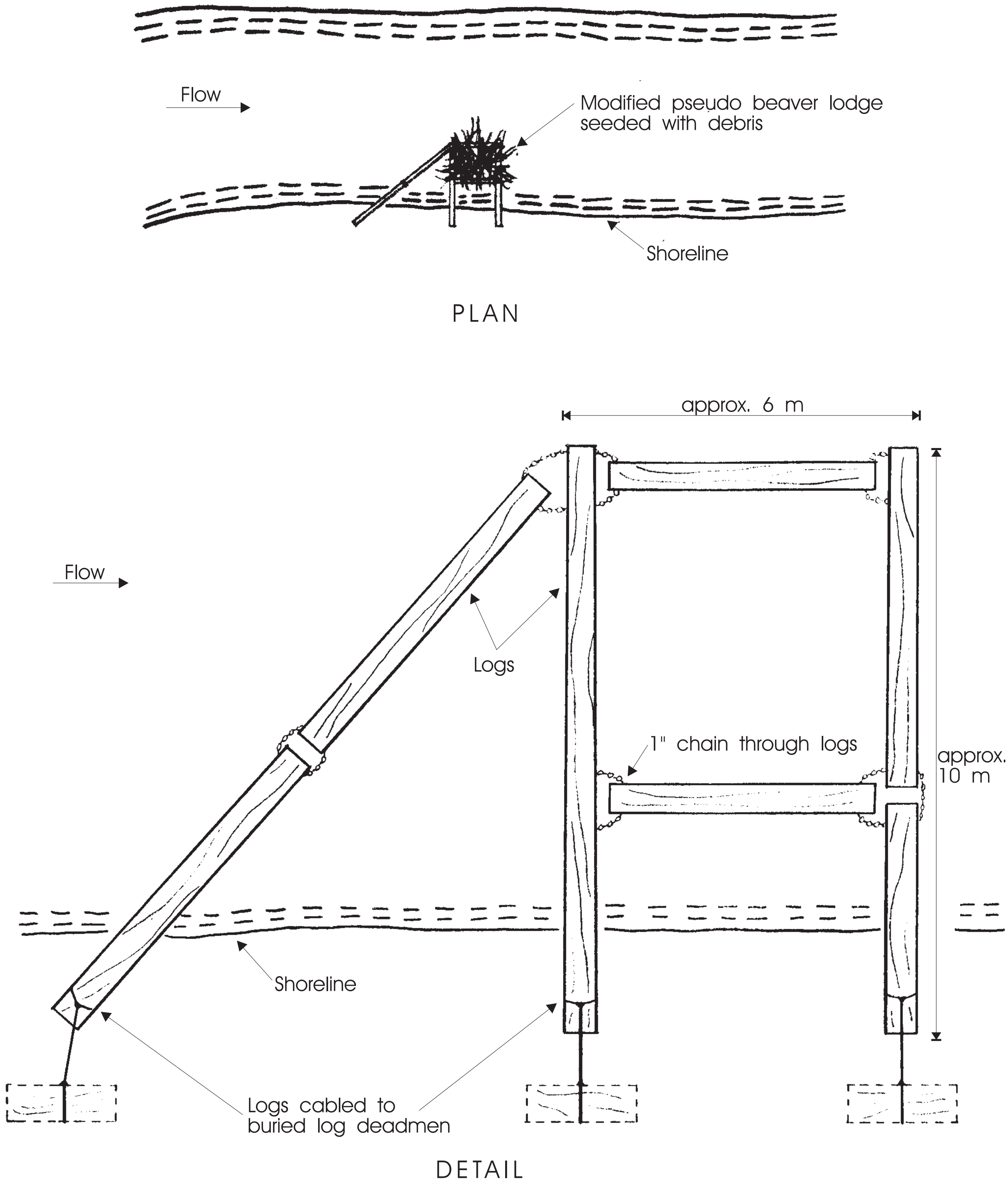
DETAIL



SECTION 1

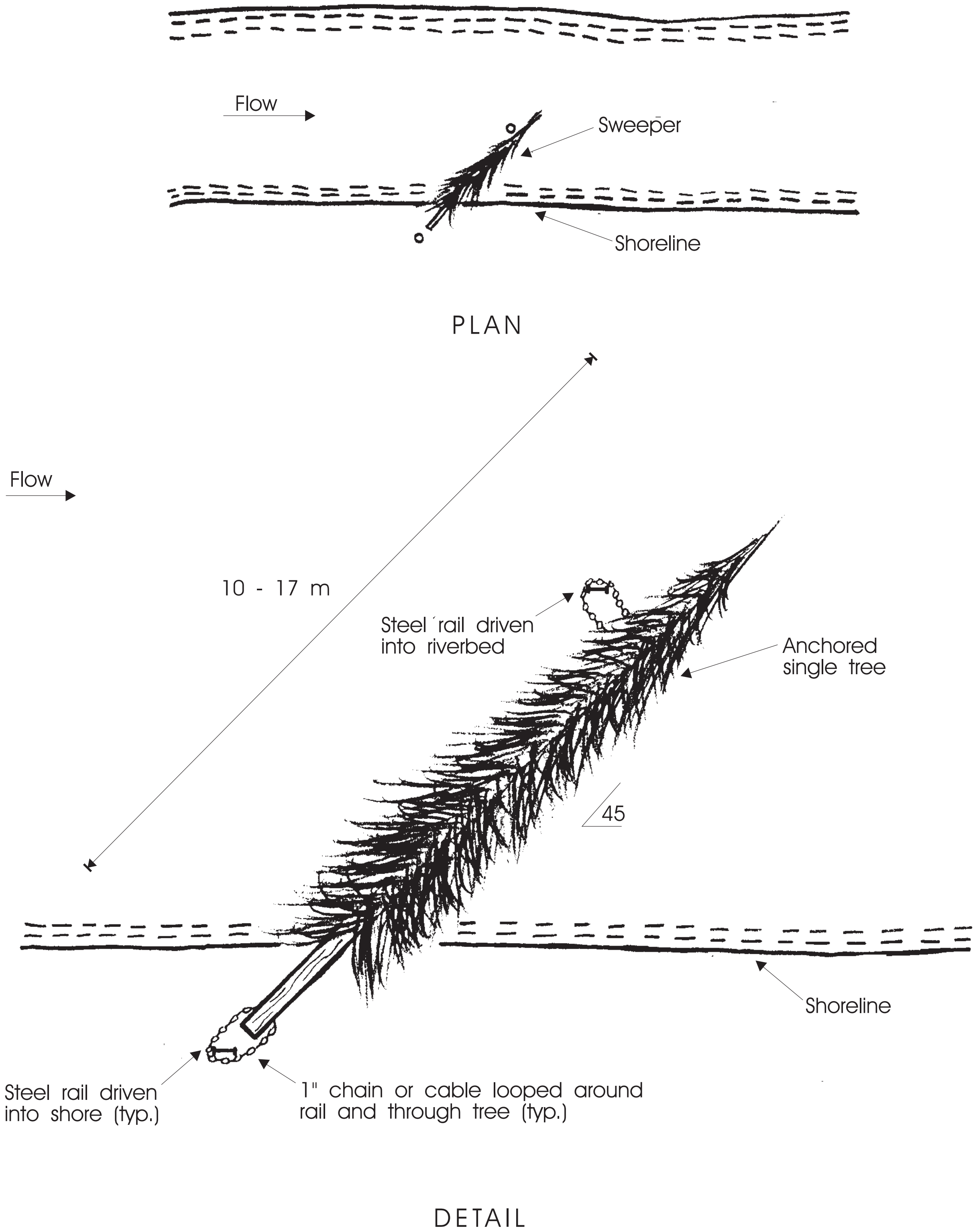
* RM27.4FC was modified in Spring 1991. Structure was removed offshore to increase flow-through velocities and two rails were installed to secure the structure in place offshore.

Nechako Fisheries Conservation Program	Drawing # RM972-3a	Not To Scale
FIGURE 3. FLOATING CRIB (1988)		

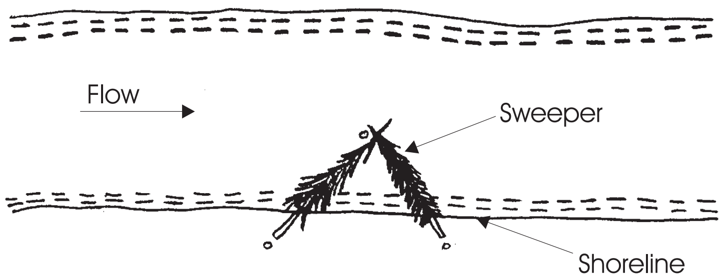


Nechako Fisheries Conservation Program	Drawing # RM972-4a	Not To Scale

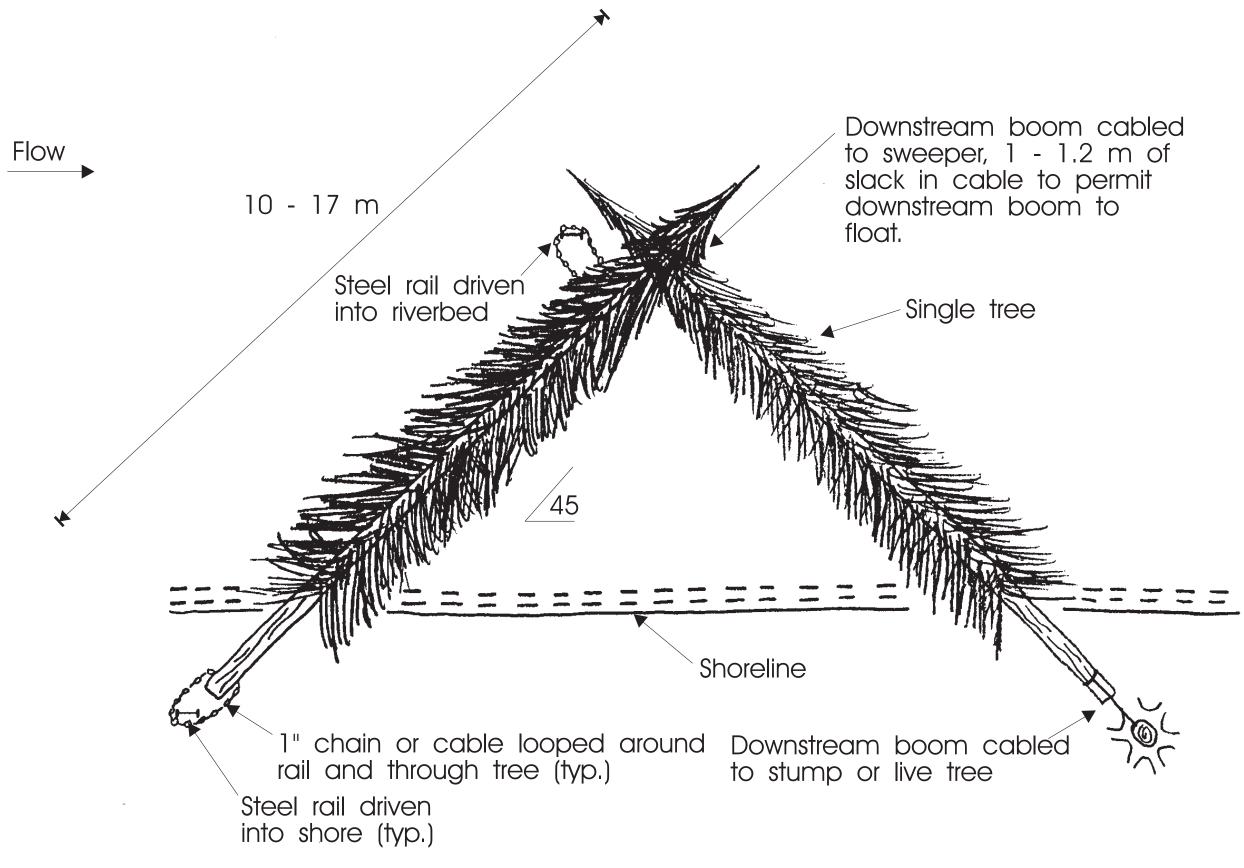
FIGURE 4. PSEUDO BEAVER LODGE (FALL 1989)



Nechako Fisheries Conservation Program	Drawing # RM972-5a	Not To Scale
FIGURE 5. RAIL-ANCHORED SWEEPER (1991)		



PLAN



DETAIL

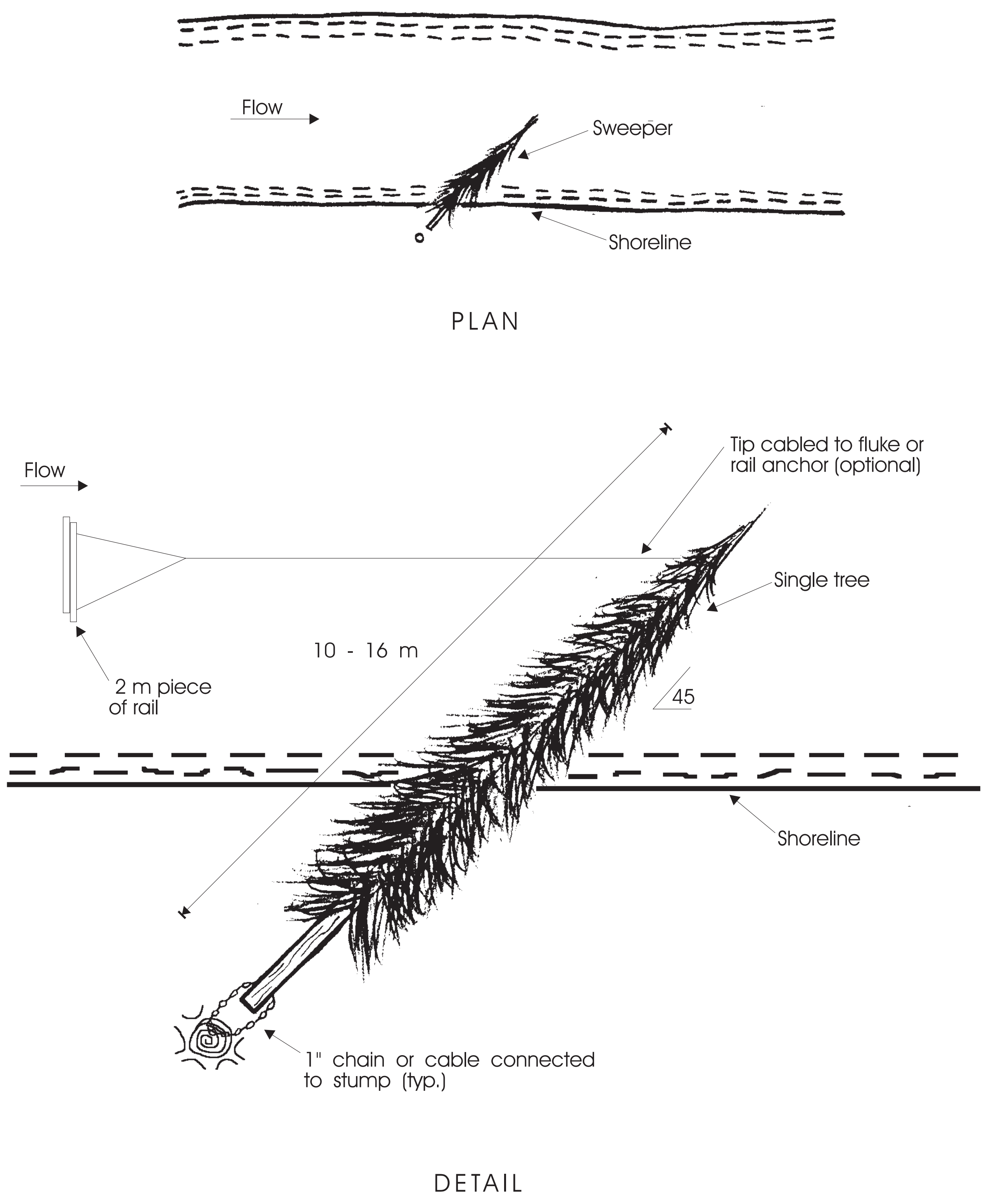
Note: Tree added to two existing rail-anchored sweepers (LM82.1RAS and RM85.7RAS) in 1993 as a downstream boom to improve debris capture.

Nechako Fisheries Conservation Program

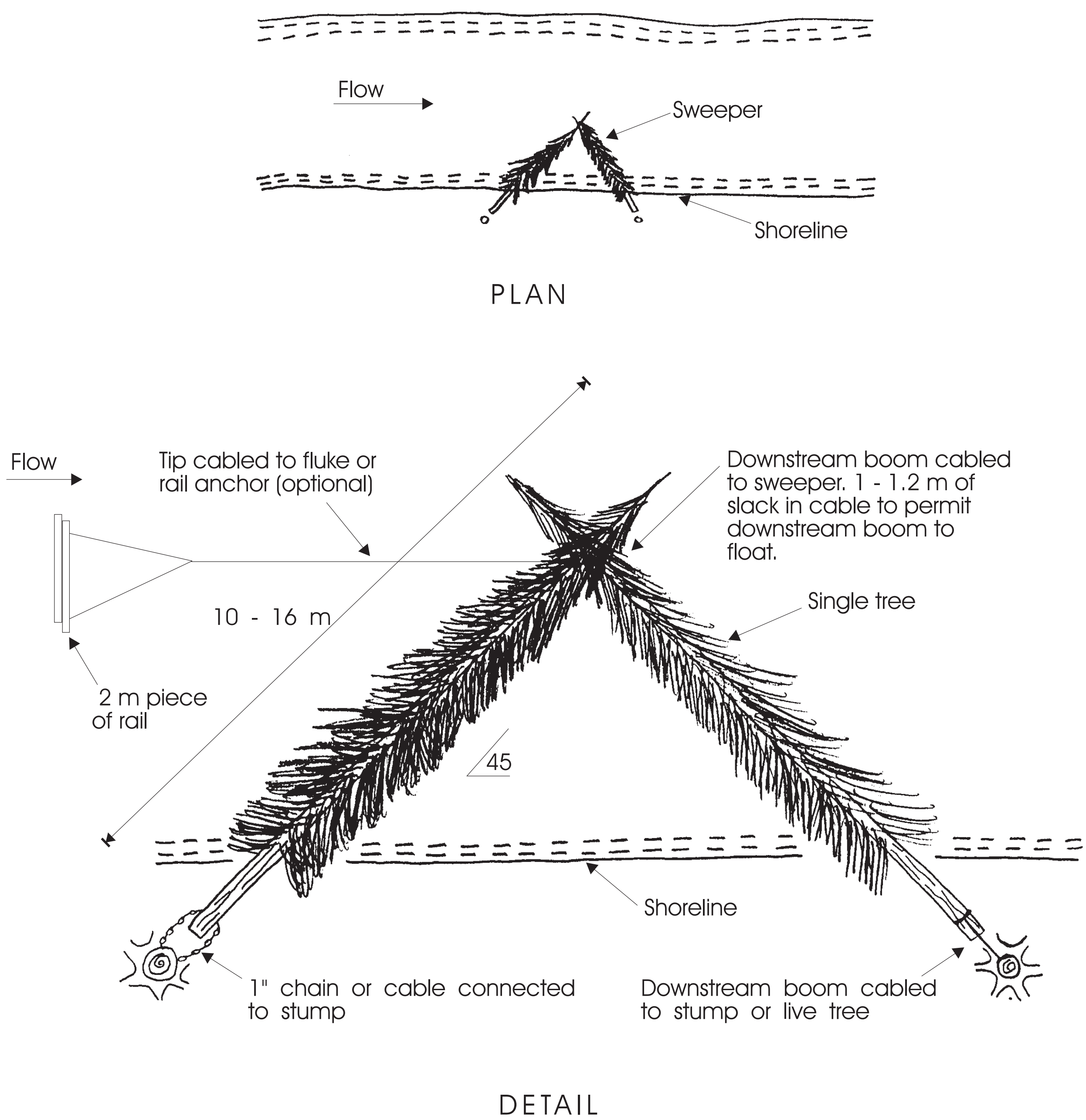
Drawing # RM972-6a

Not To Scale

FIGURE 6. MODIFIED RAIL-ANCHORED SWEEPER (1993)

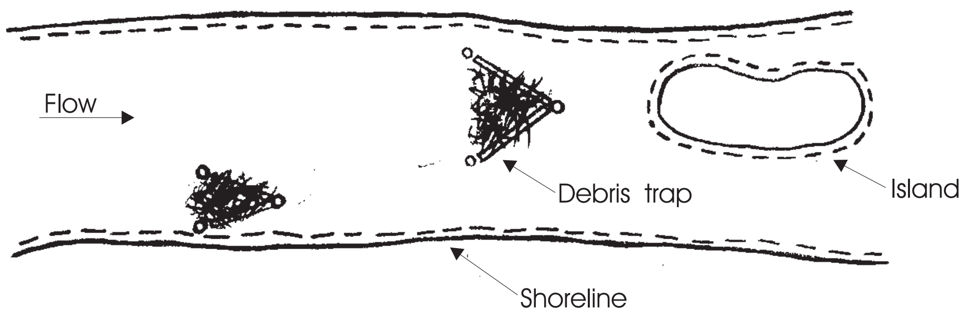


Nechako Fisheries Conservation Program	Drawing # RM972-7a	Not To Scale
FIGURE 7. HAND-PLACED ANCHORED SWEEPER (1991)		

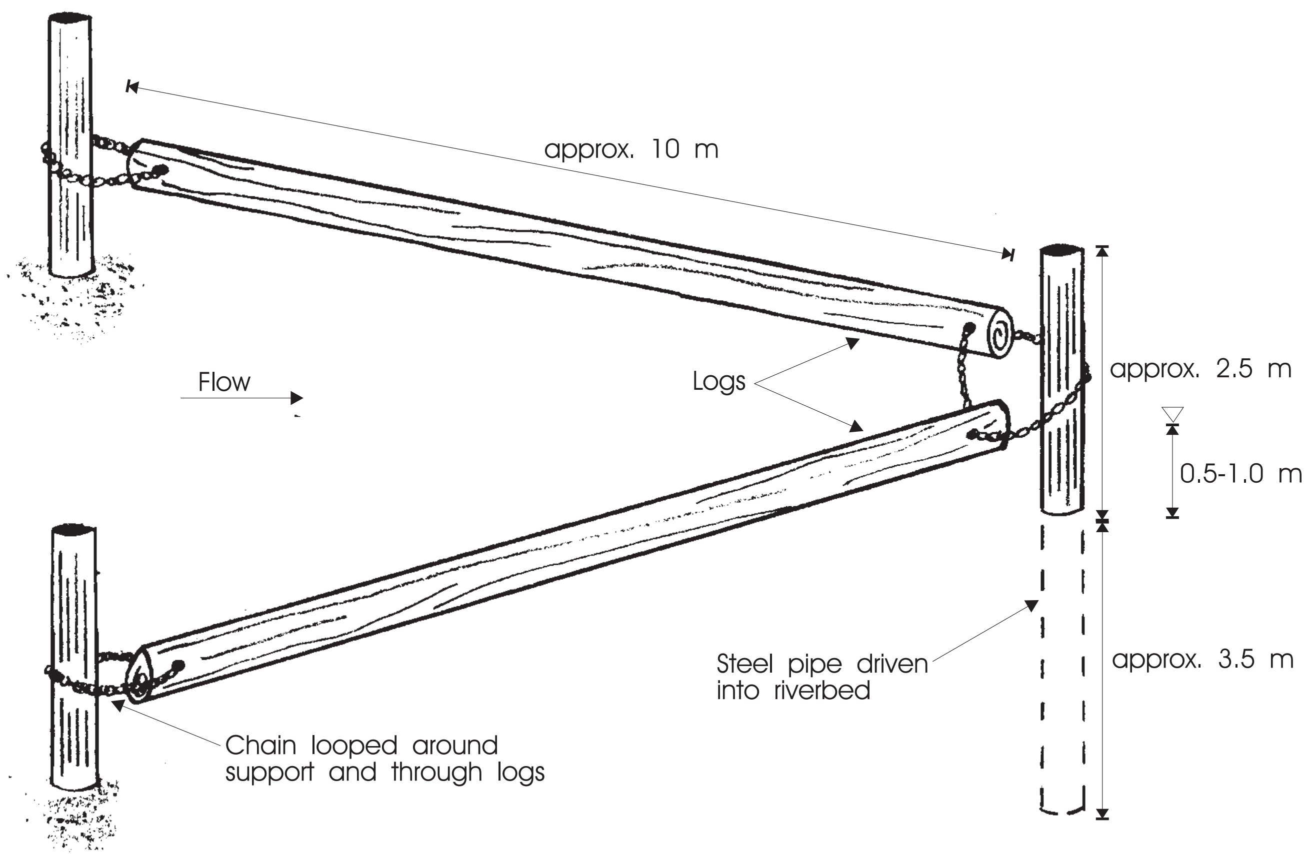


Note: Tree added to two existing hand-placed anchored sweepers (LM72.9HAS and LM75.9HAS) in 1993 as a downstream boom to improve debris capture.

Nechako Fisheries Conservation Program	Drawing # RM972-8a	Not To Scale
FIGURE 8. MODIFIED HAND-PLACED ANCHORED SWEEPER (1993)		

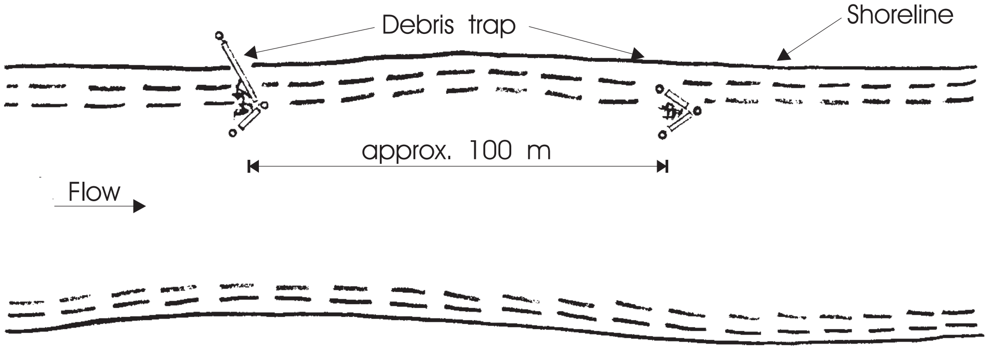


PLAN

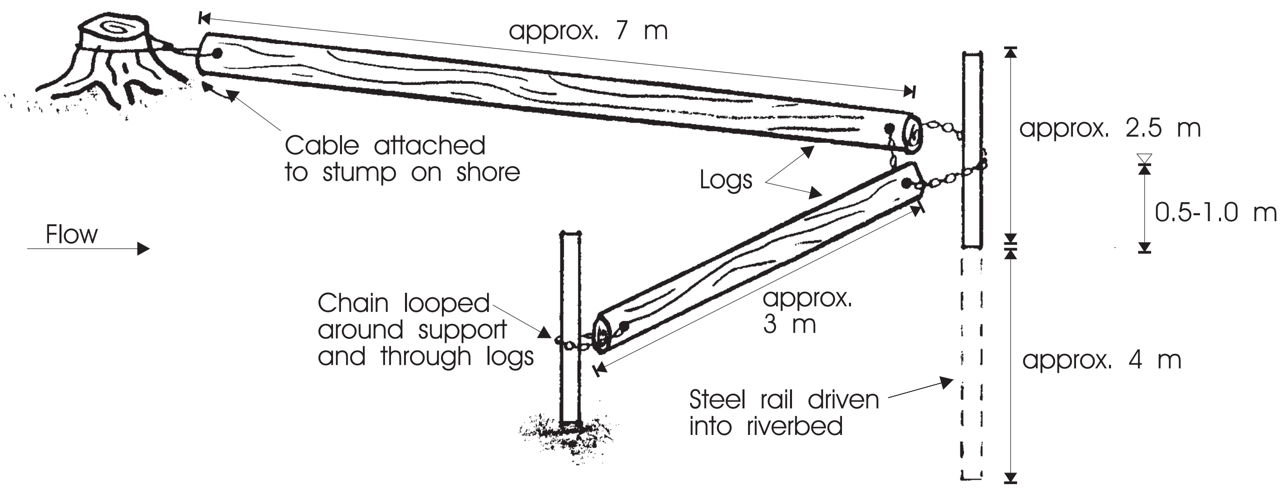


DETAIL

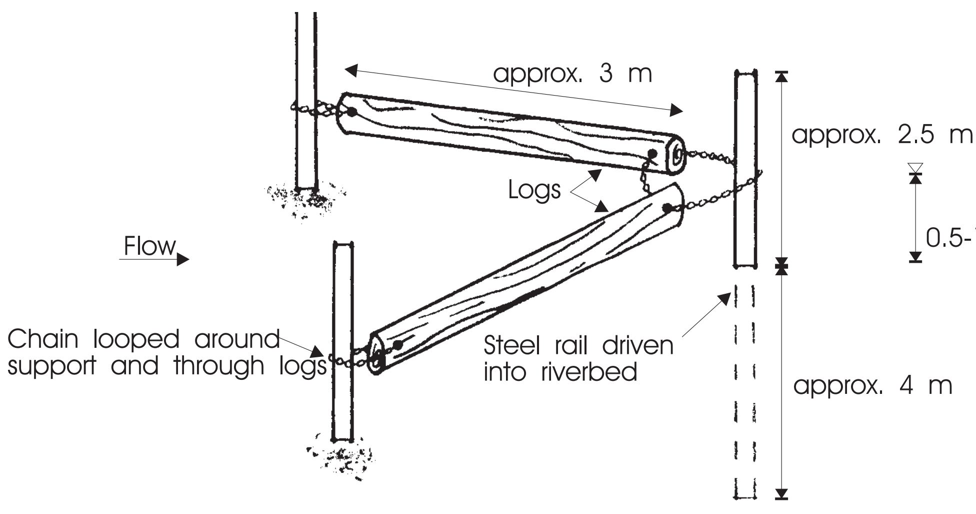
Nechako Fisheries Conservation Program	Drawing # RM972-9a	Not To Scale
FIGURE 9. PIPE PILE DEBRIS CATCHER (1989)		



PLAN

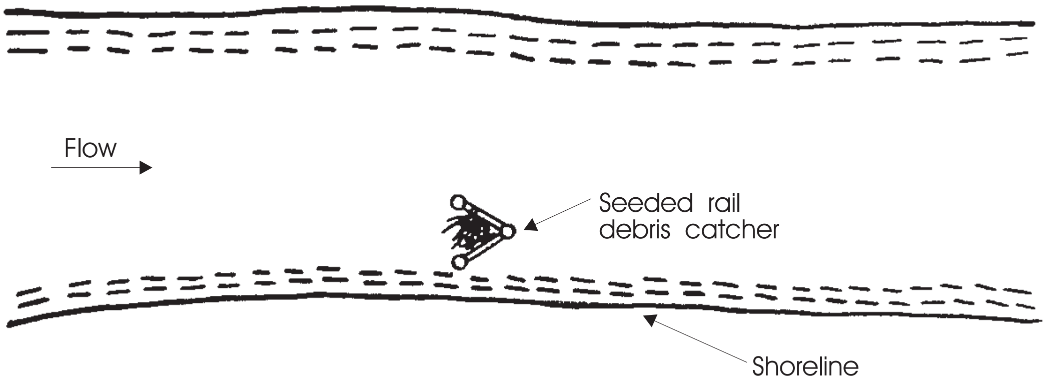


DETAIL - SHORE TYPE

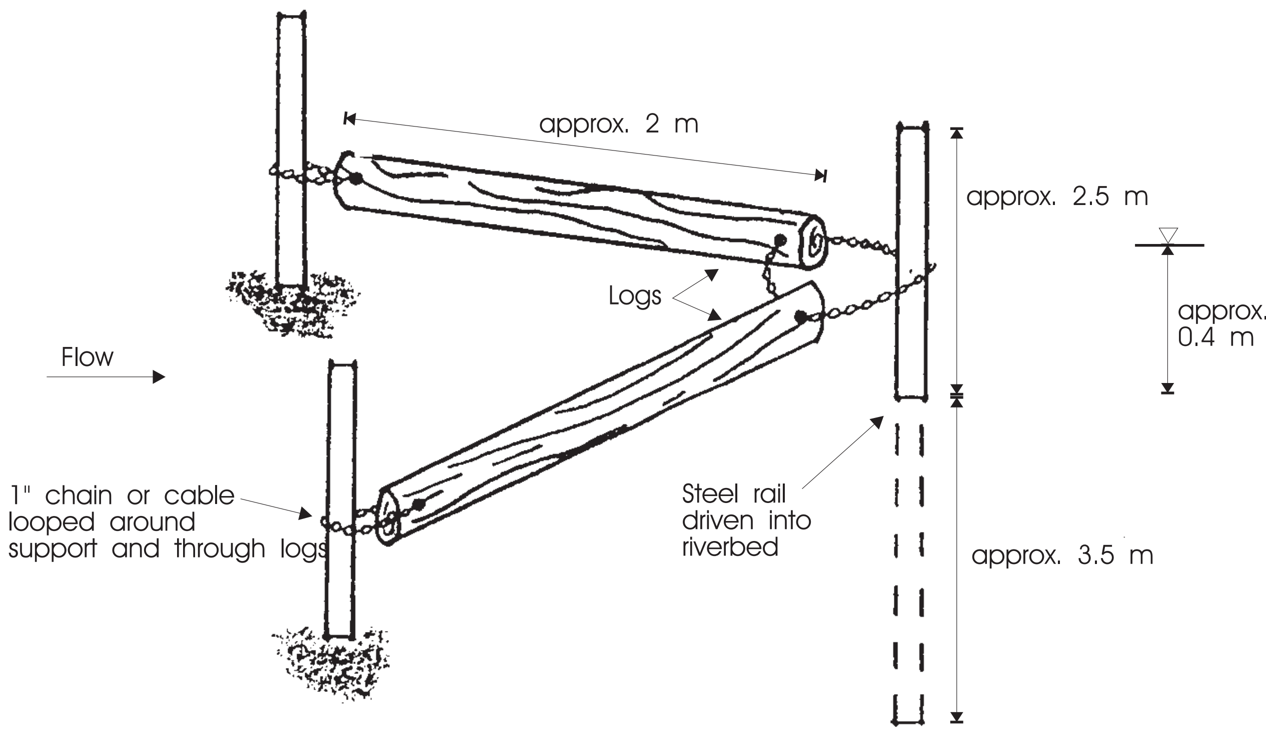


DETAIL - STANDARD TYPE

Nechako Fisheries Conservation Program	Drawing # RM97210a	Not To Scale
FIGURE 10. RAIL DEBRIS CATCHER (1990)		



PLAN

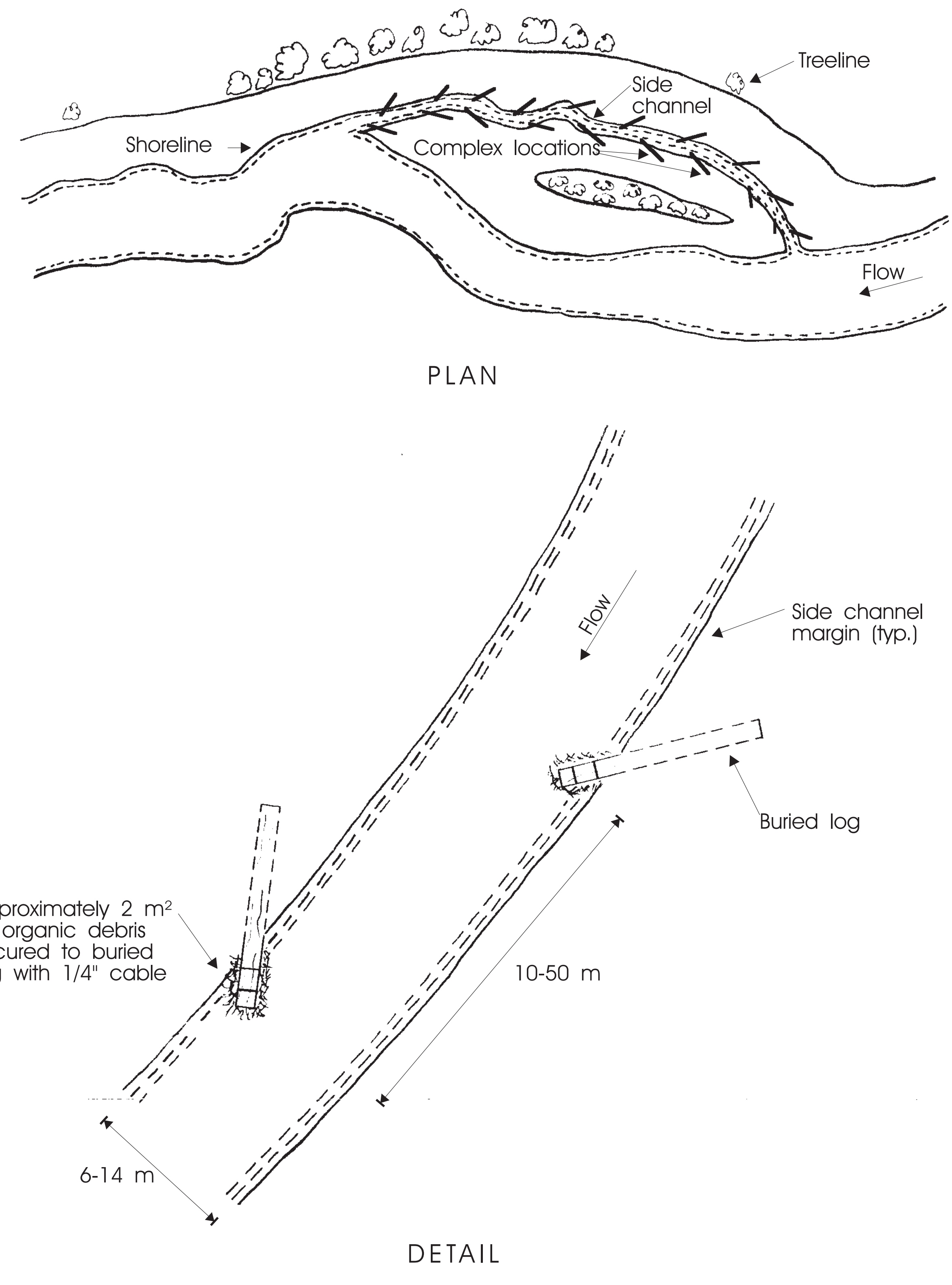


DETAIL

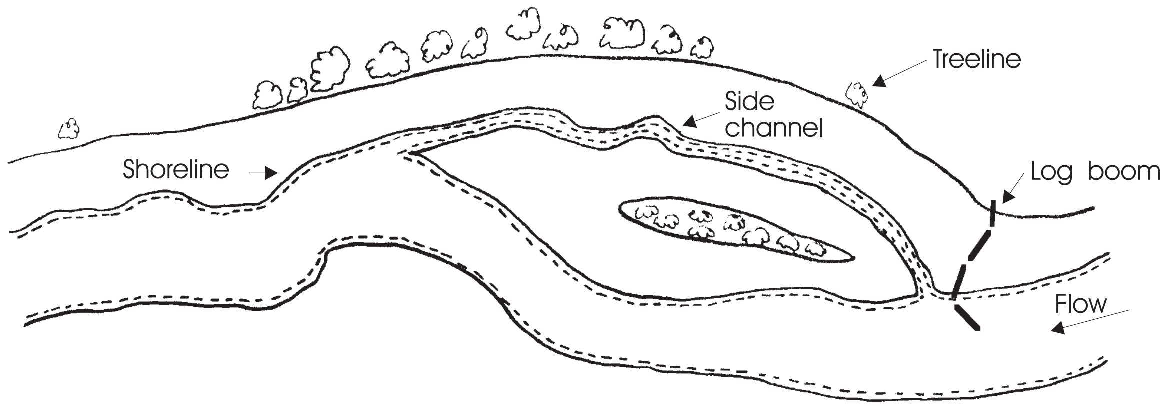
Nechako Fisheries Conservation Program	Drawing # RM97211a

FIGURE 11. RAIL DEBRIS CATCHER (1991)

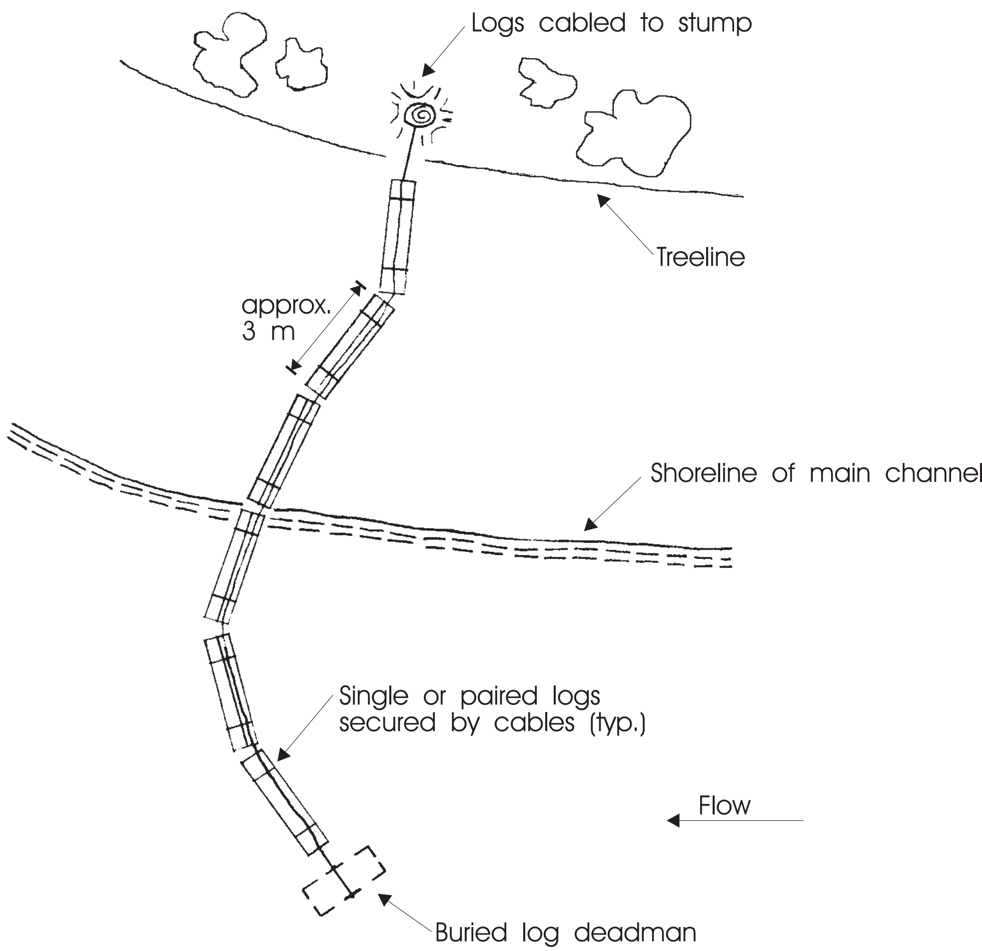
Not To Scale



Nechako Fisheries Conservation Program	Drawing # RM97212a	Not To Scale
FIGURE 12. SIDE CHANNEL COMPLEX (1990)		

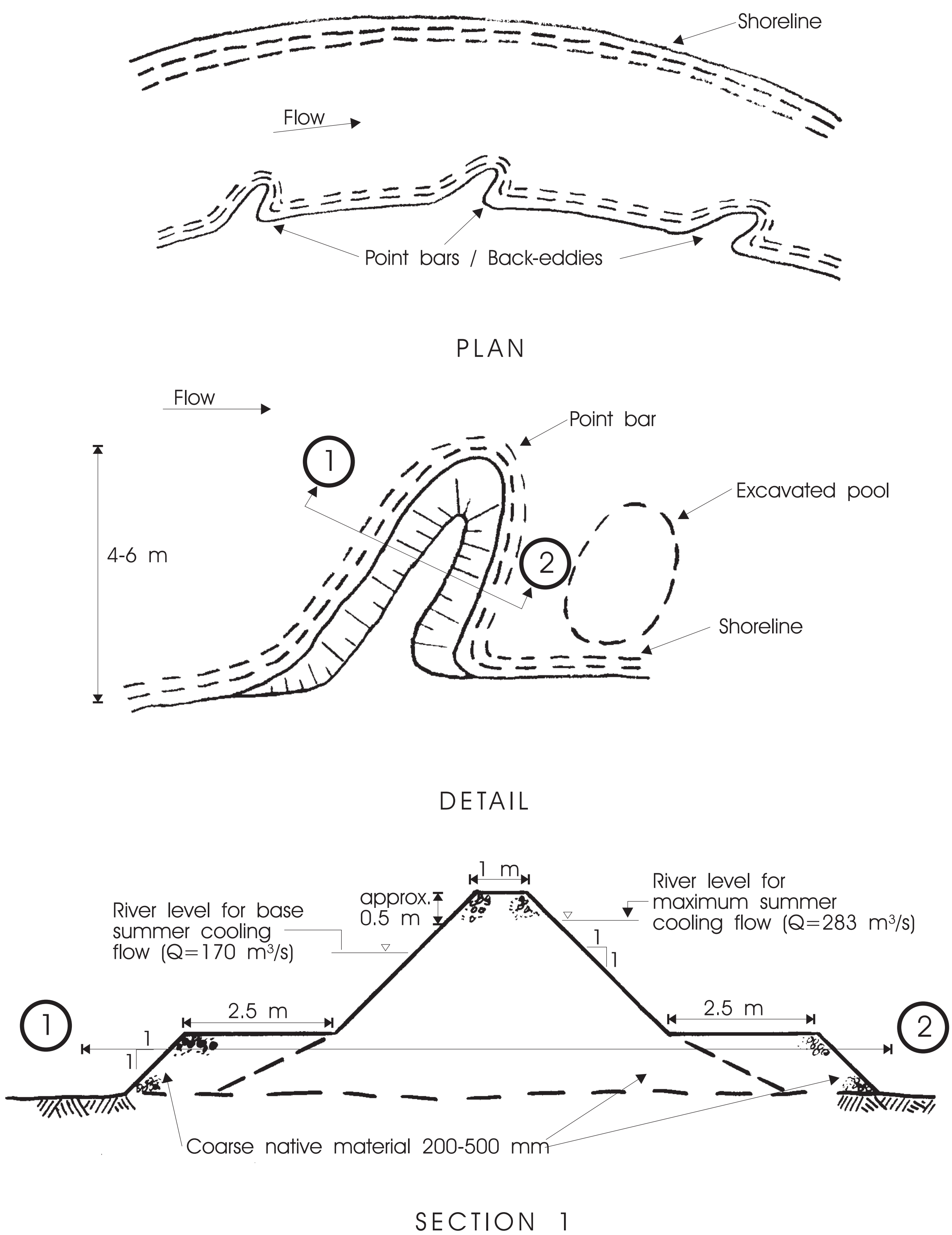


PLAN

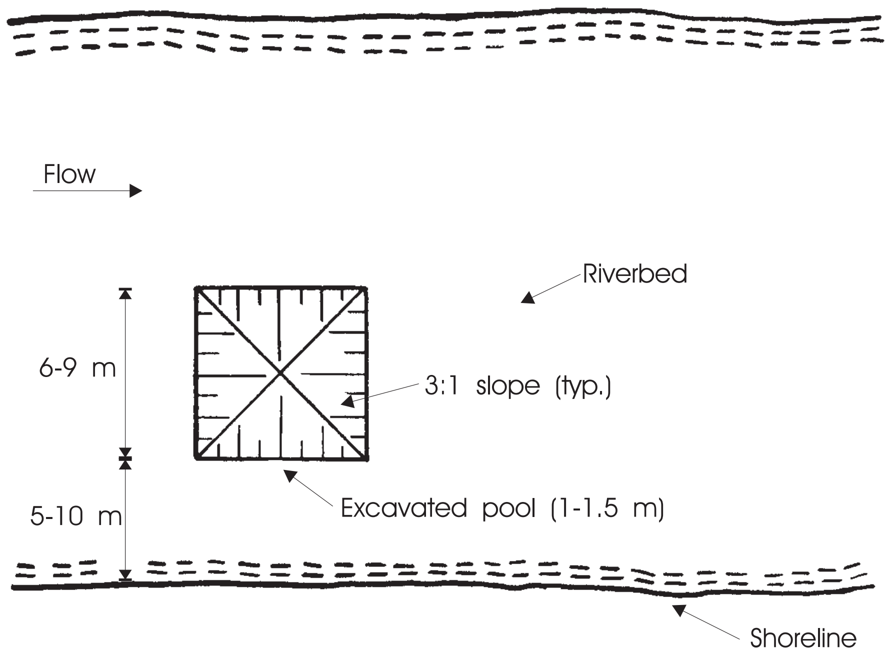


DETAIL

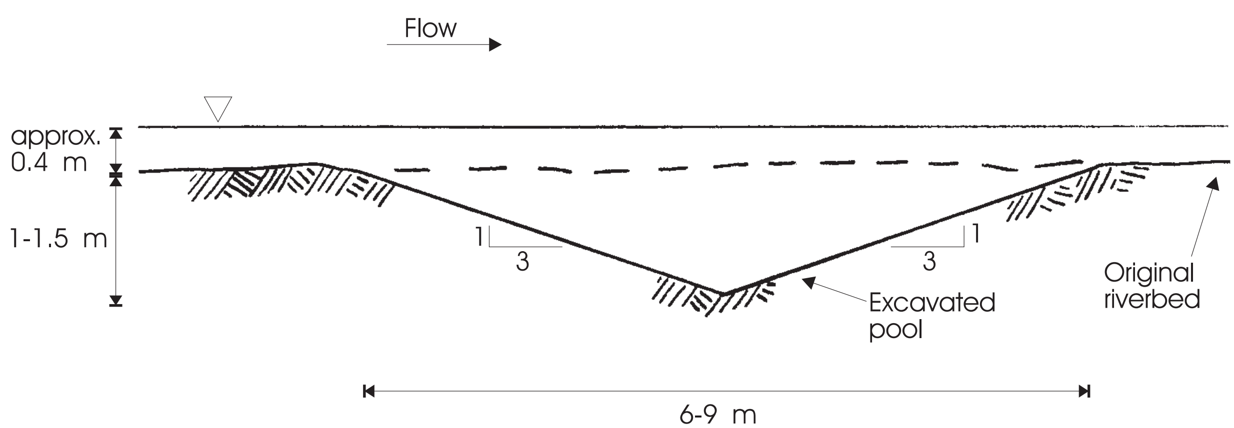
Nechako Fisheries Conservation Program	Drawing # RM97213a	Not To Scale
FIGURE 13. SIDE CHANNEL DEBRIS BOOM (1990)		



Nechako Fisheries Conservation Program	Drawing # RM97214a	Not To Scale
FIGURE 14. MODIFIED POINT BAR (1991)		

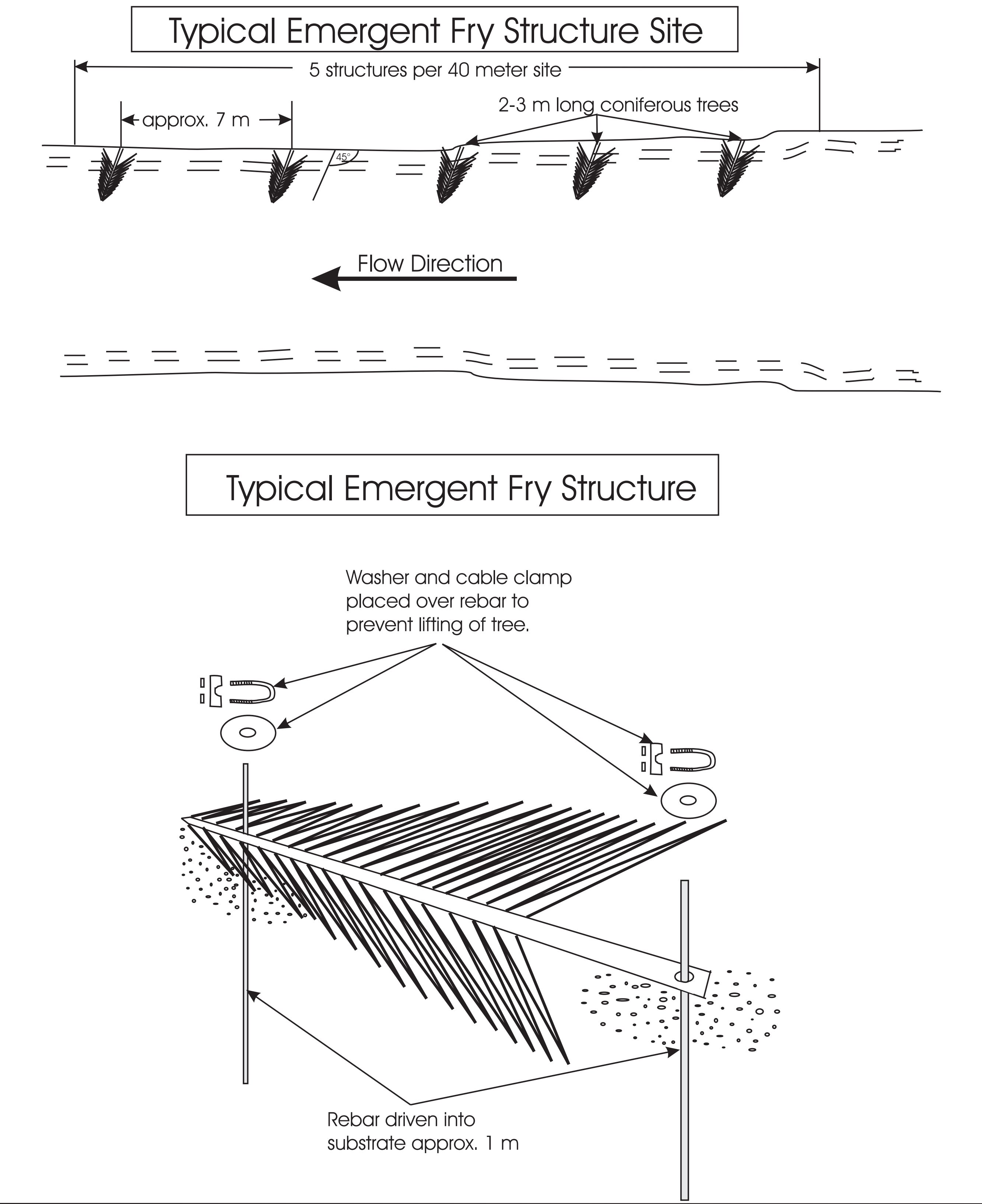


PLAN

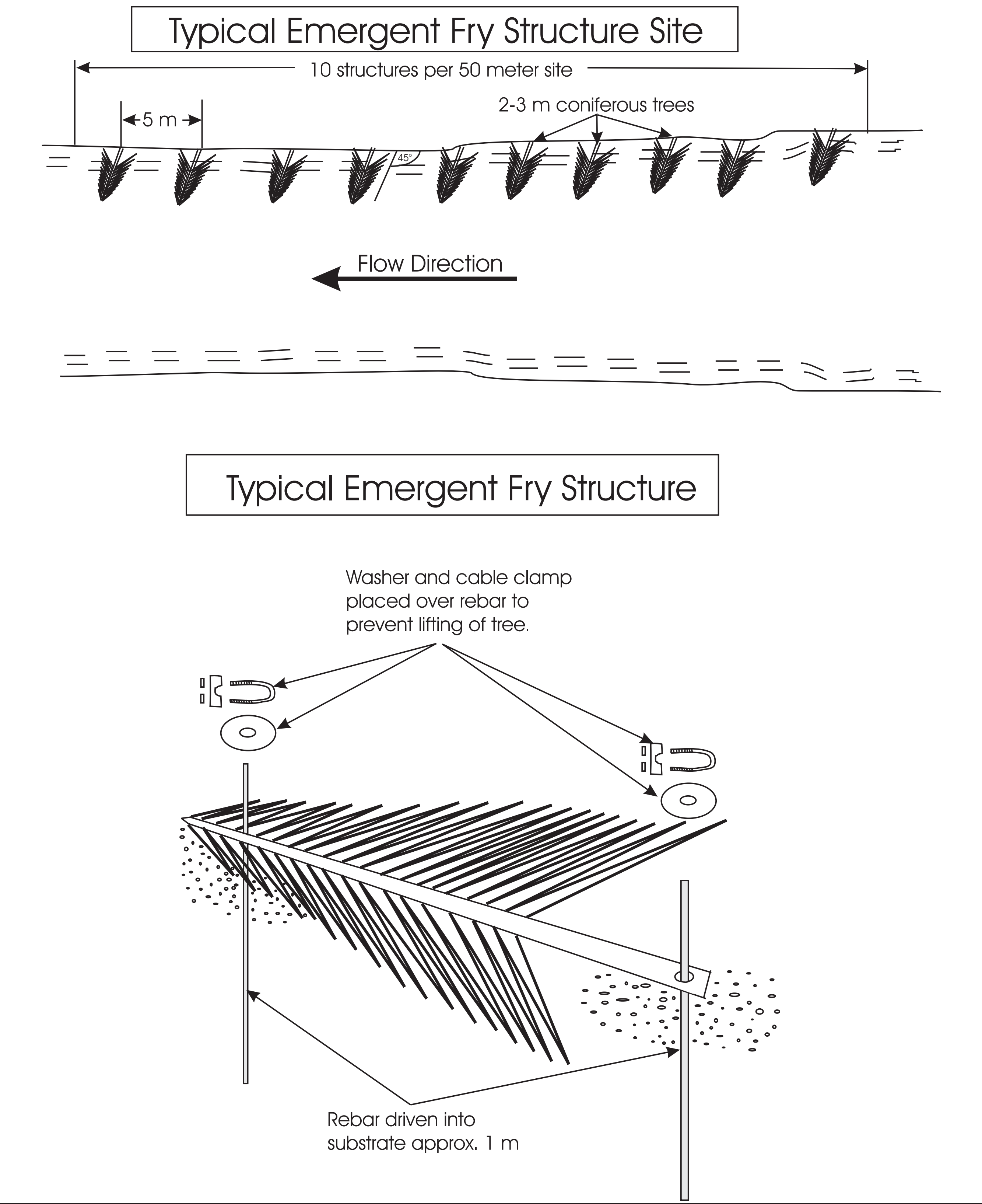


DETAIL

Nechako Fisheries Conservation Program	Drawing # RM97215a	Not To Scale
FIGURE 15. POCKET POOL 1991		

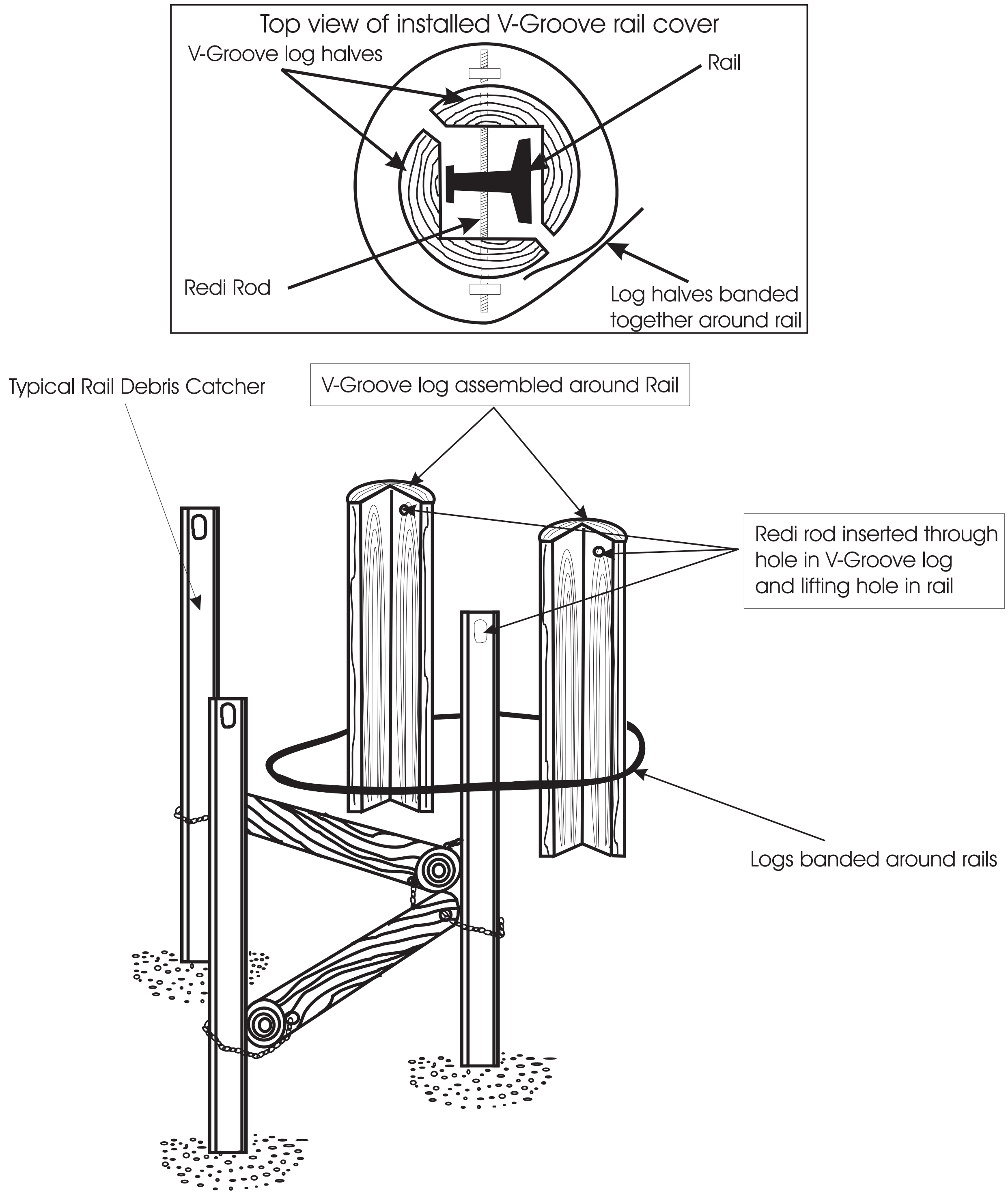


Nechako Fisheries Conservation Program	Drawing # RM97216a	Not To Scale
FIGURE 16. EMERGENT FRY STRUCTURES (1996)		

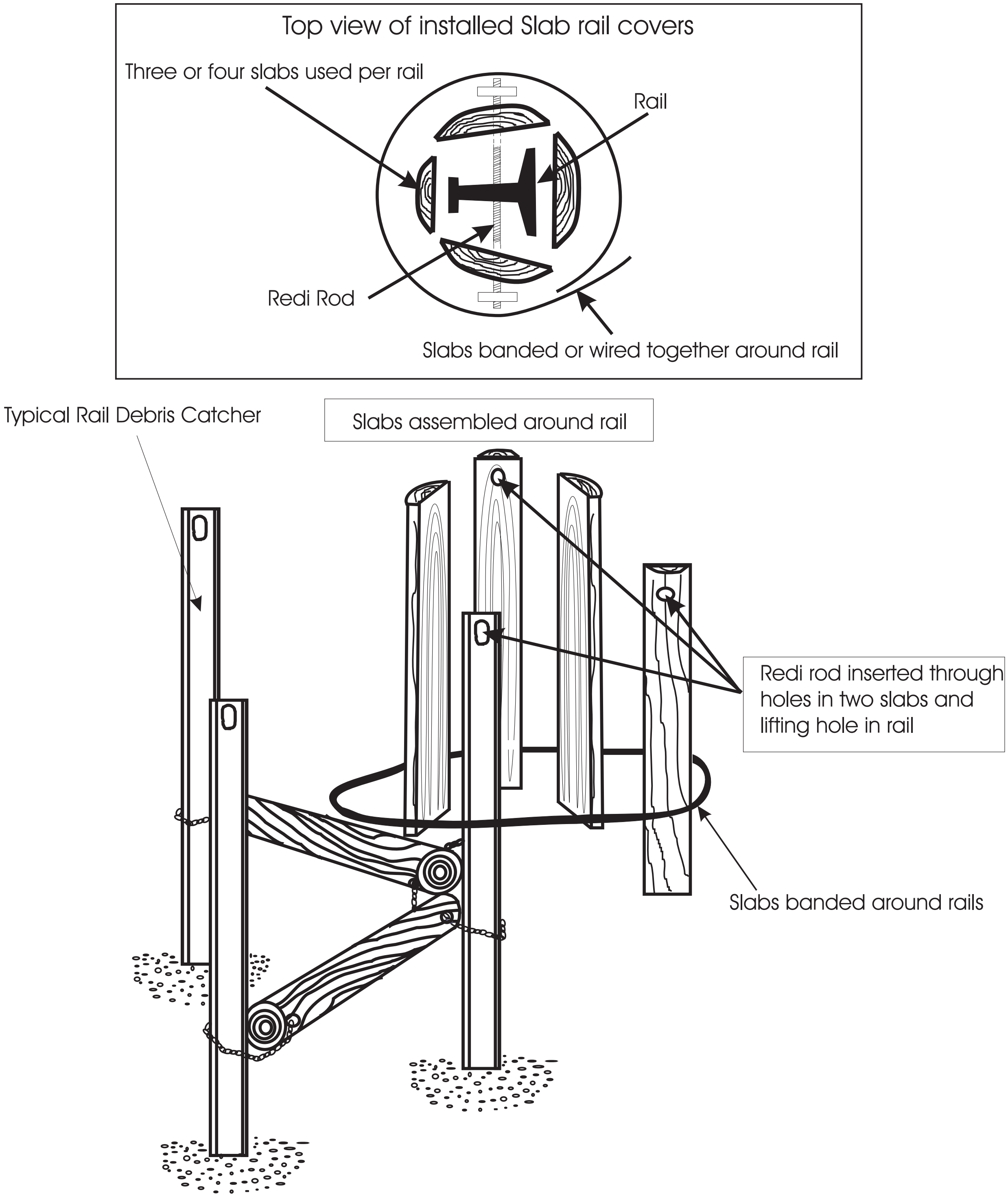


Nechako Fisheries Conservation Program | Drawing # RM97217a | Not To Scale

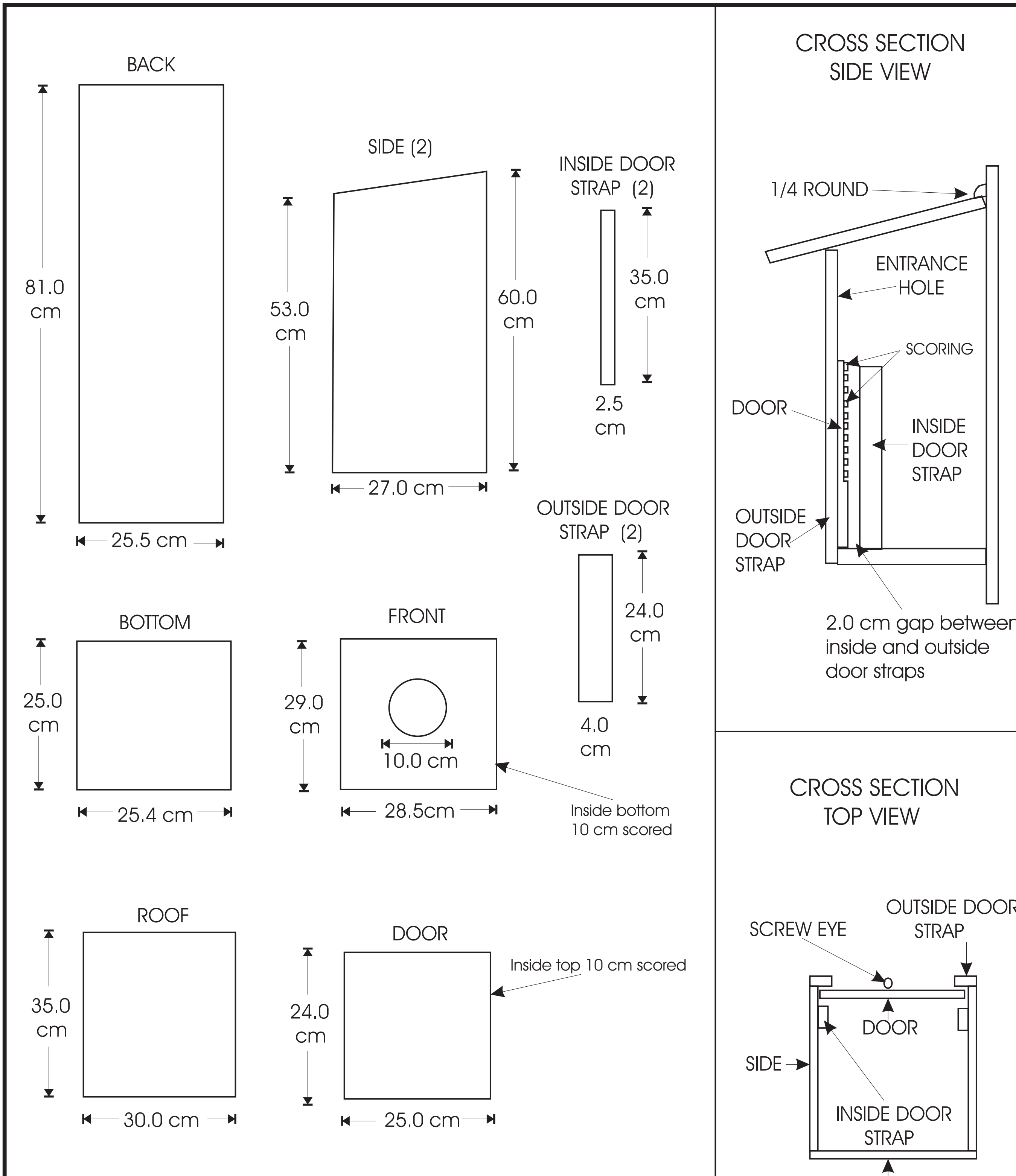
FIGURE 17. EMERGENT FRY STRUCTURES (1997)



Nechako Fisheries Conservation Program	Drawing # RM97218a	Not To Scale
FIGURE 18. V-GROOVE RAIL COVERS (1997)		



Nechako Fisheries Conservation Program	Drawing # RM97219a	Not To Scale
FIGURE 19. SLAB RAIL COVERS (1997)		



NOTE: - use 5/8" plywood
- nail and glue all joints

Nechako Fisheries Conservation Program	Drawing # RM97220a	Not To Scale

FIGURE 20. NEST BOX DESIGN (DUCKS UNLIMITED CANADA - 1997)

APPENDIX E
1997 Habitat Complex Physical Assessment Photos

Sept.9,1997–LM 15.6 Rail Anchored Sweeper (82.6m^3/s)
Constructed in 1991, this structure has captured a small amount of debris, and remained relatively stable although some material was lost in 1997.

Sept. 9, 1997 - MC15.7 Pocket Pool (82.6m^3/s)
Constructed in 1991, the pocket pool consists of a 1 meter deep depression, excavated into the substrate in an area of shallow water, and has remained relatively stable.

Sept. 9, 1997–RM16.2 Rail Anchored Sweeper (82.6m^3/s)
Constructed in 1991, this structure has failed to capture new debris, and has slowly been reduced in size due to defoiliation of the sweeper.

Sept. 9, 1997 - RM16.5 Rail Debris Catcher (82.6m^3/s)
Constructed in 1991, the structures shore debris boom was broken causing the structure to lose most of the debris, and preventing the capture of new material.

Sept. 9, 1997 - RM16.8 Rail Debris Catcher (82.6m^3/s)
Constructed in 1991, failure of the shore debris boom has also caused this structure to lose most of the debris and prevents the structure from capturing new material.

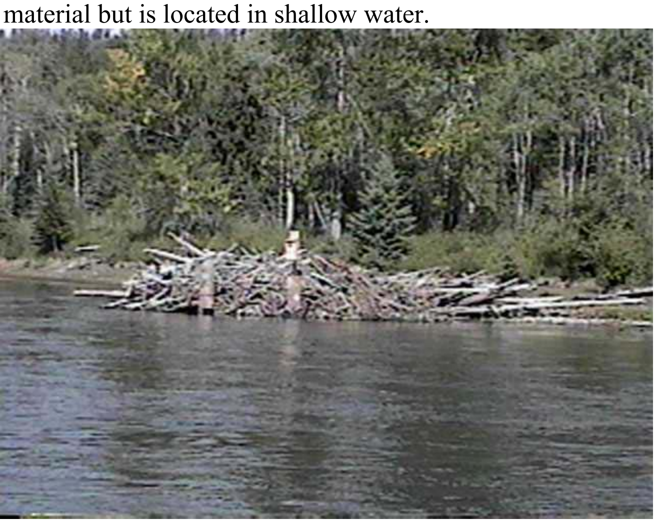
Sept. 9, 1997 - RM17.0 Point Bar (82.6m^3/s)
Constructed in 1989, and modified in 1991, this point bar has remained stable.

Sept. 9, 1997 - RM17.15 Point Bar (82.6m^3/s)
Constructed in 1989 and modified in 1991, this point bar has remained stable.

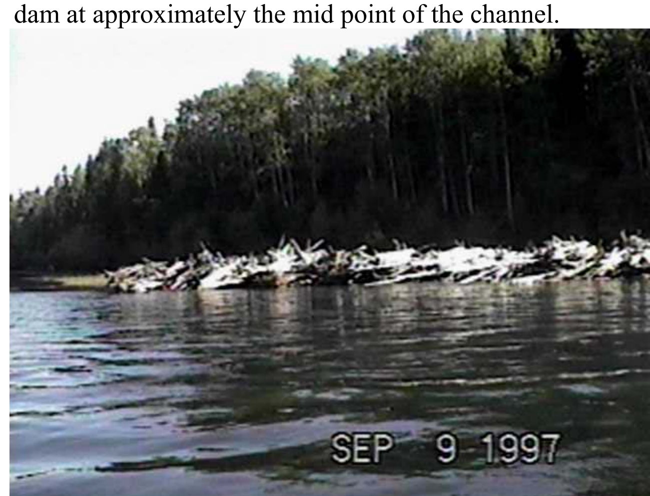
Sept. 9, 1997 – RM17.3 Point Bar (82.6m^3/s)
Constructed in 1989, and modified in 1991, this point bar has remained stable

Sept. 9, 1997 – LM17.9 Debris Boom (82.6m^3/s)
Constructed in 1990, this structure prevents excess material from entering the side channel and causing a blockage of flow. It has trapped a large amount of material but is located in shallow water.

Sept. 9, 1997 - RM17.9 Side Channel (82.6m^3/s)
Constructed in 1988 and modified in 1990 to remove material that was reducing velocities, the side channel currently has extremely low velocities due to a beaver dam at approximately the mid point of the channel.



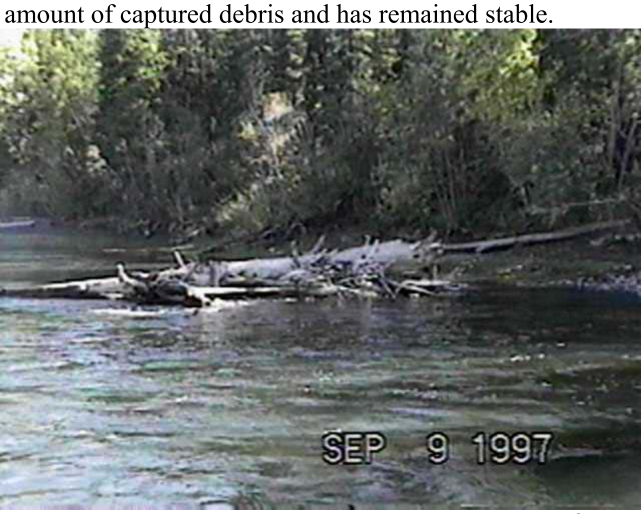
Sept. 9, 1997 – LM18.3 Rail Debris Catcher (82.6m^3/s)
Constructed in 1991, this structure trapped a large amount of debris, and was colonized by beavers immediately after construction, and has remained stable since that time.



Sept. 9, 1997 - RM20.65 Rail Debris Catcher (82.6m^3/s)
Constructed in 1991, this structure trapped a large amount of debris within the wetted area, and on shore immediately after construction. It has remained stable since that time.

Sept. 9, 1997 - LM21.3 Rail Debris Catcher (82.6m^3/s) Constructed in 1990 this structure had preliminary debris retention problems, but after three modifications and reseeding efforts the structure has slowly increased the amount of captured debris and has remained stable.

Sept. 9, 1997 – LM21.4 Rail Debris Catcher (82.6m^3/s Constructed in 1990, this structure trapped a large amount of debris after construction and was colonized by beavers in 1996.



Sept. 9, 1997 – RM22.0 Rail Debris Catcher (82.6m^3/s) Constructed in 1991, this structure trapped a large amount of debris after construction. Damage to the shore debris boom caused the loss of some material but the structure has remained stable.

Sept. 9, 1997-RM22.1 Rail Anchored Sweeper (82.6m^3/s) Constructed in 1991, the sweeper has been broken away from the rails. The rails, which are submerged at high flows are failing to capture woody debris.

Sept. 9, 1997 - RM 22.55 Rail Debris Catcher (82.6m^3/s) Constructed in 1991, this structure captured a large amount of material after construction and has remained stable.

Sept. 9, 1997 - LM22.6 Rail Debris Catcher (82.6m^3/s) Constructed in 1990, this structure captured a large amount of material after construction and was colonized by beavers. The structure has remained stable.

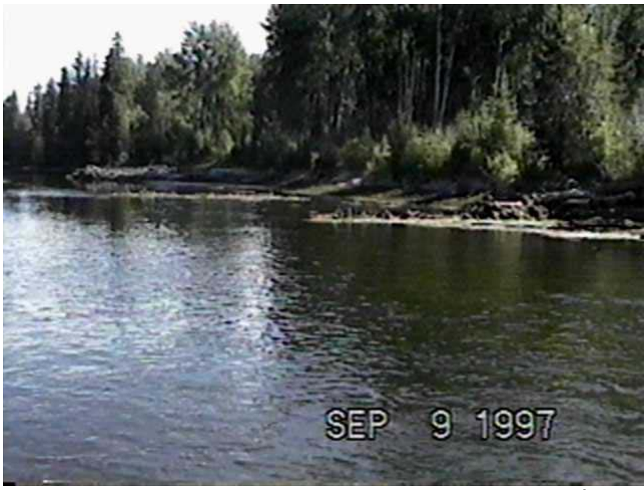
Sept. 9, 1997 - LM 22.85 Rail Debris Catcher (82.6m^3/s) Constructed in 1990, this structure has slowly accumulated woody debris and continues to remain stable.

Sept.9,1997-RM22.95 Rail Anchored Sweeper(82.6m^3/s) Constructed in 1991 this structure is almost completely submerged at high flows and fails to trap woody debris. It has slowly deteriorated in size over time due to defoiliation.

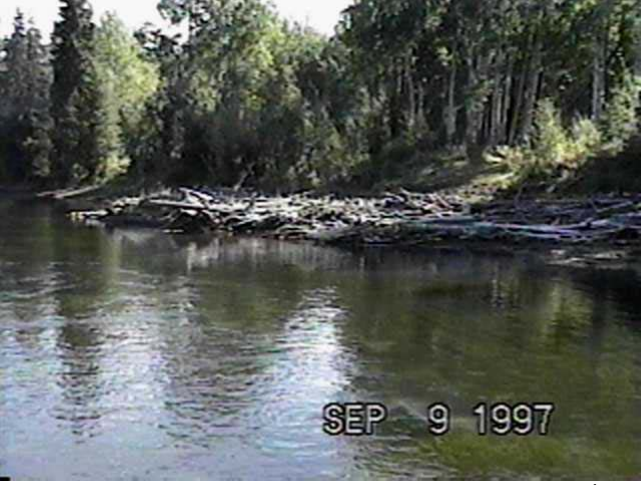
Sept. 9, 1997 - RM23.0 Rail Debris Catcher (82.6m^3/s) Constructed in 1991, this structure trapped a large amount of material after construction, and has remained stable.

Sept. 9, 1997 - LM24.2 Rail Debris Catcher (82.6m^3/s) Constructed in 1990, this structure captured a large amount of material after construction and was colonized by beavers several years later. Since that time it has remained stable.

Sept. 9, 1997 - LM24.3 Rail Debris Catcher (82.6m^3/s) Constructed in 1990, this structure originally did not trap much woody debris, but over time has accumulated material and has remained stable.



Sept. 9, 1997 - RM24.35 Rootwad Sweepers (82.6m^3/s) Constructed in 1988, this structure was thinned in 1990 and 1991 in an effort to increase flow through velocities, and has remained relatively stable.



Sept. 9, 1997 - RM24.4 Floating Crib (82.6m^3/s) Constructed in 1988, this structure has trapped some material on shore, and was colonized by beavers after construction. However beavers have not utilized the structure for several years.

Sept. 9, 1997 - RM24.6 Pseudo Beaver Lodge (82.6m^3/s) Constructed in 1989, this structure had some success with debris entrapment. It is currently maintaining a small pile of woody debris.

Sept. 9, 1997 - RM28.4 Pseudo Beaver Lodge (82.6m^3/s) Constructed 1989, this structure fails to trap woody debris despite several efforts at modification and is only creating a very small area of cover. Most debris is on the shore.

Sept. 9, 1997 - RM25.4 Rail debris Catcher (82.6m^3/s) Constructed in 1991, this structure captured a large amount of debris after construction. However, scour and high velocities combined to destabilize the rails over time causing the structure to lose most of the woody debris.

Sept. 9, 1997 - MC25.7 Rail debris Catcher (82.6m^3/s) Constructed in 1991, this structure has accumulated a small amount of material, and has remained relatively stable over time.

Sept. 9, 1997-RM26.9 Rail Anchored Sweeper (82.6m^3/s) Constructed in 1991, and modified in 1993, the failure of the modified shore anchor caused the loss of captured material at this complex reducing the structure to a single log attached to a rail.

Sept. 10, 1997 - RM27.4 Floating Crib (82.6m^3/s) Constructed in 1989, and modified in 1991 with additional rail anchors for stability, the failure of the rail anchors, and downstream boom, caused the structure to shift downstream partially on to the shore.

Sept. 10, 1997 - RM28.4 Rail Debris Catcher (82.6m^3/s) Constructed in 1991, this structure trapped a large amount of debris, and was colonized by beavers after construction, and has remained stable.

Sept. 10, 1997 – RM3.1 Pseudo Beaver Lodge (82.6m^3/s) Constructed 1989, this structure fails to trap woody debris despite several efforts at modification, and is creating almost no cover as the structure has been reduced to bare logs.

Sept. 10, 1997 – RM31.4 Brushpile (82.6m^3/s) Constructed in 1988, this structure has not trapped new debris, and the slow loss of and deterioration of seeded material have slowly reduced the size of the structure.

Sept. 10, 1997-RM34.7 Pipe Pile Debris Catcher (82.6m^3/s) Constructed in 1989, this structure captured a large amount of material after construction, but failure of the outer pipe pile caused a significant reduction in the size of the structure.

Sept. 10,1997 -MC35.4 Pipe-Pile Debris Catcher (82.6m^3/s) Constructed in 1989, this structure captured a large amount of material after construction. It was colonized by beavers several years later and has remained stable.

Sept. 8, 1997–LM73..9 Hand Anchored Sweeper (82.6m^3/s) Constructed in 1991, and modified in 1993 with the addition of a downstream boom, this structure generally fails to trap large woody debris and has deteriorated over time and been reduced in size.

Sept. 8, 1997–LM74.0 Hand Anchored Sweeper (82.6m^3/s) Constructed in 1991, this structure generally fails to trap large woody debris, and has deteriorated over time, and been reduced in size.

Sept. 8, 1997–LM75..9 Hand Anchored Sweeper (82.6m^3/s) Constructed in 1991, and modified in 1993 with the addition of a downstream boom, this structure generally fails to trap large woody debris and has deteriorated over time and been reduced in size.

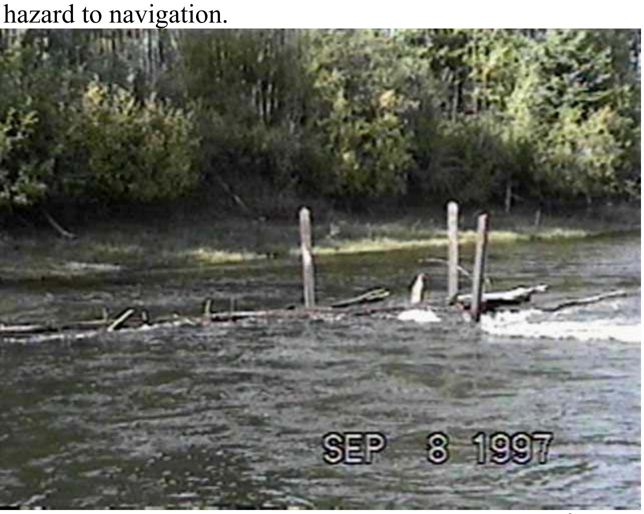
Sept. 8,1997–LM78.0 Hand Anchored Sweeper (82.6m^3/s) Constructed in 1991, this structure generally fails to trap large woody debris, and has deteriorated over time, and been reduced in size.

Sept. 8, 1997 – LM80.9 Rail debris Catcher (82.6m^3/s) Constructed in 1991, and modified in 1997 with the addition of rail covers, this structure has generally failed to trap new debris and was slowly being reduced in size.

Sept. 8,1997–LM82.1 Rail Anchored Sweeper (82.6m^3/s) Constructed in 1991, and modified in 1993 with the addition of a downstream boom, this structure generally fails to trap large woody debris, and has deteriorated over time, and been reduced in size.

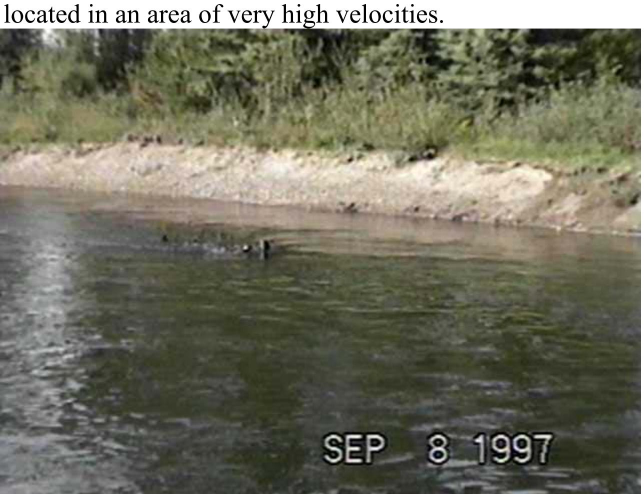
Sept. 8, 1997 – LM82.2 Rail Anchored Sweeper (82.6m^3/s)
Constructed in 1991, this structure generally failed to trap large woody debris, and the entire sweeper was lost in 1997. The rail has been marked to avoid becoming a hazard to navigation.

Sept.8, 1997 – LM82.3 Hand Anchored Sweeper (82.6m^3/s)
Constructed in 1991,, this structure generally fails to trap large woody debris, and has deteriorated over time, and been reduced in size.



Sept. 8, 1997 – LM 83.0 Rail Debris Catcher (82.6m^3/s)
Constructed in 1991 and modified in 1992 with an additional debris boom from the rails to the shore, this structure generally fails to trap woody debris, and is located in an area of very high velocities.

Sept. 8, 1997 – LM 83.0 Rail Debris Catcher (82.6m^3/s)
Constructed in 1991 and modified in 1992, this structure generally fails to trap woody debris, and has slowly been reduced in size over time.



Sept. 8, 1997-LM85.7 Rail Anchored Sweeper (82.6m^3/s)
Constructed in 1991, and modified in 1992 and 1993, this structure generally failed to trap large woody debris and the entire sweeper was lost in 1997. The rail has been marked to avoid becoming a hazard to navigation.

Sept. 8, 1997 – RM86.35 Rail debris Catcher (82.6m^3/s)
Constructed in 1991, this structure captured large amounts of material after construction. The shore debris boom was damaged and much of the captured material was lost. The structure now maintains minimal debris.

Sept. 8, 1997 – RM86.375 Rail Debris Catcher (82.6m^3/s)
Constructed in 1991, this structure captured a large amount of debris after construction, and subsequently lost some material, but has remained stable and maintains a moderate sized debris pile.

Sept. 9, 1997 – RM17.9 Side Channel (82.6m^3/s)
This beaver dam located at approximately the mid point of the side channel effectively blocks the majority of the flow and reduces velocities in the channel to near zero.

Sept. 8, 1997 –Rail Covers
Rail covers were designed and tested in 1997 to improve the esthetics of habitat complexes by giving the rails the appearance of a natural log. V-Groove and slab rail covers were installed on 10 and 6 rails respectively.

Sept. 8, 1997 – Slab Rail Covers
Four slabs were fastened around the rail with banding, or multiple wraps of galvanized fencing wire, and were bolted through the top of the rail to prevent lifting.

Sept. 8, 1997 – V-Groove Rail Covers
To install V-groove rail covers the two halves of the logs were fastened around the rail with banding wire and were bolted through the top of the rail to prevent lifting.

Sept. 9, 1997 – Typical Nesting Box
Nesting boxes were installed on 7 rails in 1997 in an effort to improve esthetics and provide habitat for cavity nesting waterfowl such as Buffleheads and Goldeneye.