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REPORT ON

ADDENDUM TO SUNCOR STEEPBANK MINE ENVIRONMENTAL IMPACT ASSESSMENT: SPRING 1996 FISHERIES INVESTIGATIONS

Submitted to:

Suncor Inc., Oil Sands Group
Fort McMurray, Alberta

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1.0 INTRODUCTION

This report is an addendum to the aquatic baseline report prepared by Golder Associates Ltd. (Golder) for Suncor Inc., Oil Sands Group (Suncor) as part of the Steepbank Mine Environmental Impact Assessment (EIA) (Golder 1996a; 1996b). Supplemental field sampling in the spring of 1996 was conducted to provide further information on habitat quality and quantity and fish use of Shipyard Lake and three small Athabasca River tributaries: Leggett Creek, Wood Creek and the unnamed tributary (referred to as Unnamed Creek) that drains into Shipyard Lake and forms the outlet to Shipyard Lake. Fish use of Horseshoe Lake was also investigated.

1.1 Study Area

The location of the study area within Alberta is shown in Figure 1.1-1. The local study area for the Steepbank Mine aquatic baseline study includes 25 km of the Athabasca River extending from Willow Island to Saline Lake; the lower portion of the Steepbank River within the proposed mine area; Unnamed, Leggett, Wood and McLean Creeks and Shipyard Lake (Figure 1.1-2).

1.2 Objectives

The objectives of this study were as follows:

- to document the habitat quality and quantity in Unnamed Creek, Shipyard Lake, Leggett Creek and Wood Creek;
- to document fish utilization and access to these habitats, particularly with respect to sport fish usage; and,
- to document fish presence and utilization of Horseshoe Lake.

2.0 METHODS

Habitat mapping and fish inventories were conducted in the spring of 1996 from 9 to 22 May. Sampling sites are shown in Figure 2.0-1: the types of sampling conducted at each station are presented in Table 2.0-1. Station numbers follow the same format as Golder (1996a) and are a continuation of station numbers used in the 1995 sampling program. Geographic Positioning System (GPS) techniques were used to record the position of all sampling locations, areas of significant habitats and concentrations of fish.

2.1 Fish Habitat

Habitat conditions within the entire extent of Shipyard Lake and Unnamed, Leggett and Wood Creeks were documented from a helicopter using a SONY video camera. Representative habitat types within the upper, middle and lower reaches of the creeks were identified during the overflight. Detailed habitat mapping was conducted for 100 m segments at each of the representative areas in the creeks. Measurements of channel width, wetted width, water depth, velocity, stream discharge, substrate composition, cover availability, bank stability and bank vegetation were conducted at transects within each of these 100 m segments.

Habitat mapping was carried out using the Stream Habitat Classification and Rating System set out in Golder Technical Procedure (TP) 8.5-0 (Appendix I). The stream habitat mapping system is based on individual channel units (i.e., riffle/run/pool) in combination with depth, velocity and substrate characteristics to provide a subjective quality rating for each unit in relation to various fish life stages (i.e., spawning, rearing, feeding, overwintering).

2.2 Fish Inventory

In association with habitat mapping, fish were inventoried in Unnamed, Leggett and Wood Creek using a backpack electrofisher (Smith Root Type VII backpack electrofisher), Gee minnow traps and gill nets depending on the habitat types present (see Figure 2.0-1 and Table 2.0-1). In addition, the lower reaches of the creeks were examined to determine if fish passage was possible, and potential

use as a spawning stream by fish stocks from the Athabasca River. Fish inventories were conducted in Shipyard Lake and Horseshoe Lake using gill nets and minnow traps.

All captured individuals of all fish species were identified and enumerated. Common and scientific names of the fish species encountered are shown in Table 2.2-1. Fork length and weight of large fish species were measured and a sub-sample of forage fish species was measured for fork length. The life history stage, sex, state of maturity and any evidence of external pathology were recorded. All fish inventories were conducted following Golder TP 8.1-0 (Appendix II).

Kick sampling was conducted in Unnamed, Leggett and Wood Creeks in areas of potential spawning habitat, to check for the presence of eggs and thus determine if any spring spawning species had used these areas.

3.0 RESULTS

3.1 Habitat

Habitat maps of the 100 m segments examined in the lower, middle and upper portions of each of the three creeks are presented in Figures 3.1-1 to 3.1-9. Table 3.1-1 presents the measured discharges for each of these segments and Table 3.1-2 presents the mean channel widths, mean wetted widths and the calculated areas for the three streams.

3.1.1 Habitat Description

Unnamed Creek and Shipyard Lake

Fish habitat at the mouth of Unnamed Creek, which drains Shipyard Lake wetlands was examined in spring, 1995 (Golder 1996a). No water was present in this creek in the spring of 1995, and substrate at the mouth of the creek was dominated by fines. Thus, during the spring spawning season in 1995, fish passage into this creek and into Shipyard Lake was not possible. Unnamed Creek was examined again in May, 1996. At this time, water levels were higher and flow was present in the lower reaches of Unnamed Creek (Photograph 1). A discharge of 0.50 m3/s was measured at a location 75 m upstream of the confluence with the Athabasca River (Table 3.1-1). The average channel width was 6.1 m and the average wetted width was 4.7 m. The available habitat in the lower segment of the creek was composed entirely of R3 (low quality) run habitat with sand/silt substrate. Woody debris and partial beaver dams provided some instream cover (Figure 3.1-1). The stream banks were clay/silt with some grass cover and do not provide much overhanging cover. Three small drainages enter Unnamed Creek from the east about 0.85 km, 0.9 km and 2.0 km upstream from the confluence with the Athabasca River. The creek was passable to large fish species from the Athabasca River for approximately 2 km, to a point where there is a large beaver dam that extends across the channel (Photograph 2). Upstream of the beaver dam is an extensive flooded area.

The middle segment of Unnamed Creek was located upstream of Shipyard Lake (Figure 2.0-1). Unnamed Creek is the primary inflow to the Shipyard Lake wetlands. The discharge in this segment was measured to be 0.09 m^3/s, considerable less than for the lower segment downstream of Shipyard

Lake. The creek channel is much smaller at this location, having a channel width of 1.8 m and a wetted width of 1.3 m (Photograph 3). Available habitats in this segment show considerably greater complexity than the lower segment, being composed of riffle, run, pool, snye and backwater habitats (Figure 3.1-2). Run habitats comprised 70% of the area examined and all run habitats were low quality R3 runs. Riffle areas were present but were infrequent, comprising 20% of available habitats. One pool was present and at the time of the survey had a maximum depth of 0.9 m and was classified as a medium quality pool (P2). All habitat areas had substrate composed entirely of silt, limiting the suitability of this segment for some fish species and life stages. Some instream debris is present providing limited instream cover. The lower 60 m of this creek segment consists of a confined channel while the upper 40 m consists of an unconfined channel, created by an old beaver dam in combination with a bog area.

The upper segment of Unnamed Creek was located in the upper reaches of the drainage. Further upstream of this segment there were only bog areas with no defined channel. The upper segment had a discharge of 0.10 m^3/s, similar to the middle segment. The average channel width was recorded as 1.5 m and the average wetted width as 1.0 m, indicating that the creek channel in the upper portion of the drainage is similar to, but slightly smaller than, the middle segment (Table 3.1-2). The overall stream gradient was higher in the upper segment than in the middle segment and riffle habitats were comparatively more frequent, comprising 80% of the available habitats (Figure 3.1-3) (Photograph 4). One class R3 run was present, representing 15% of the available habitat area, as was one low quality pool area (P3). Substrate particle sizes were coarser than in downstream areas with cobbles, gravels and boulders present in the swifter riffle areas. The lower velocity run and pool areas had substrates composed entirely of fines. The large substrate particles provided good instream cover and velocity breaks. Overhead cover was limited to small areas with floating debris but overhanging vegetation provided good stream shading. Several beaver dams were present in this segment causing ponding and potentially affecting fish passage.

Shipyard Lake is a shallow wetland located on the Athabasca River floodplain, that is considered to approximate a slough/marsh type of wetland (Photograph 5). Shipyard Lake is fed by two small catchment basins, the largest of which is the portion of Unnamed Creek included in this study. Shipyard Lake drains to the Athabasca River via the lower portion of Unnamed Creek. The lake consists of an open water area surrounded by a perimeter mat of floating aquatic vegetation. Emergent

vegetation, consisting primarily of cattail (Typha latifolia), occurs at the interface of the open water and floating vegetation. Transects conducted across the lake indicate water depths in the open water area ranging from 1.5 to 2.3 m. Submergent macrophytes were present but were not well developed during the spring. The types of habitat present in Shipyard Lake would provide spawning and rearing areas for sport species such as northern pike and yellow perch which utilize still water areas with aquatic vegetation for spawning.

Leggett Creek

The lower study segment on Leggett Creek shown in Photograph 6, was located upstream of the creek mouth. At the time of the study the discharge was measured as 0.28 m^3/s in this segment. The segment was divided by a beaver dam (Figure 3.1-4). The creek was fairly wide in the lower segment with an average channel width of 8.5 m and the average wetted width of 5.6 m. Upstream of the dam the creek channel was widest, with medium quality pool (P2) and run (R2) habitats present. The maximum depth of the pool was 1.0 m. Below the dam the creek channel was narrower, and other than one riffle section was composed of low quality run habitat (R3). Overall, the available habitats consisted of 58% run, 24% riffle and 18% pool. The substrate was composed primarily of fines. There is good overhead cover available from instream debris, and to a lesser extent from undercut banks and overhanging vegetation.

The stream discharge in the middle segment of Leggett Creek was 0.27 m^3/s, similar to the lower segment. The size of the channel was determined to be much smaller than the lower portion of the creek, having an average channel width of 2.5 m and an average wetted width of 2.3 m. The middle segment of Leggett Creek was a moderately high gradient section and was composed primarily (85%) of riffle habitat (Figure 3.1-5) (Photograph 7). The remaining available habitat was low quality class R3 run habitat. The maximum water depth in this segment was 0.7 m. Due to the predominance of swift flowing riffle areas the stream substrate was dominated by cobble and gravel particle sizes. There was much debris in the stream providing overhead cover for fish.

The upper segment of Leggett Creek is also a moderately high gradient channel (Photograph 8). At the time of the survey the discharge was measured to be 0.28 m^3/s, which is very similar to the discharges in the lower and middle segments. The average channel width was 3.1 m and the average

wetted width was 2.2 m. This segment was composed of 60% riffle habitat, 30% run habitat and 10% pool habitat (Figure 3.1-6). Both R2 and R3 run habitats were present, as was moderate quality pool habitat (P2). Maximum pool depth was 0.8 m and water depths in run areas ranged from 0.3 to 0.9 m. Channel complexity was high with several back water areas and much instream debris providing overhead cover. The stream substrate was composed of fines in lower velocity pool and R3 areas, with coarser particle sizes (gravel/cobble) as well as silt in the riffle areas. There were several log jams and beaver dams present which may reduce the potential for fish passage.

Wood Creek

The study segment on lower Wood Creek was located at the creek mouth. It had an average channel width of 6.3 m and an average wetted width of 4.8 m. The discharge at the time of the survey was measured as 0.57 m^3/s. It is a moderately high gradient section with the available habitats consisting of 74% riffle habitat and 26% run habitat (Figure 3.1-7). All of the run habitats were low quality R3 runs. The substrate was dominated by cobbles and gravels with some bedrock intrusions, although the substrate particles were somewhat imbedded in fines. Numerous riffles and shallow runs were present: water depths ranged from 0.2 to only 0.5 m. Overhead cover was abundant, due to instream debris, overhanging vegetation and undercut banks (Photograph 9). Undercutting of the banks has created instability along much of the shore.

The middle study segment on Wood Creek had an average channel width of 5.6 m and an average wetted width of 4.8 m. The stream discharge was measured to be 0.54 m^3/s, similar to that of the lower segment. It was a moderately high gradient section being composed of 70% riffle habitat and 30% run habitat (Figure 3.1-8). A portion of the riffle areas consisted of boulder garden habitat that provided a high degree of instream cover and velocity breaks, making these riffle areas more suitable for most fish species and life stages (Photograph 10). The available run habitats were all low quality class R3. Substrate in the riffle areas was dominated by cobbles, gravels and boulders. In the lower velocity R3 areas the substrate was dominated by fines, although some boulders were also present. Water depths ranged from 0.3 to 0.7 m. Undercut banks, debris and overhanging vegetation were present providing a moderate amount of overhead cover.

Upper Wood Creek was observed to be predominately flooded as a result of beaver dams. The study segment on upper Wood Creek was located immediately below a beaver dam. The discharge in upper Wood Creek was determined to be 0.50 m^3/s, which is similar to both the middle and lower segments. Compared to the upper portions of Unnamed Creek and Leggett Creek, Wood Creek is a decidedly larger stream, both in wetted width and volume of flow (Photograph 11). The average channel width was determined to be 4.5 m and the average wetted width was 4.1 m. The available habitats in the study segment were composed of 67% runs and 33% riffles (Figure 3.1-9). The run habitats were primarily class R3 although one moderate quality R2 run was present. There was considerable sedimentation of the channel, probably a result of a logging road crossing upstream of the segment. As a result, the substrate was dominated by fines with coarser substrate particles (cobble) present only in the centre of the channel in the riffle areas. With R2 habitat present, water depths ranged from 0.3 m to as high as 1.0 m. There is a fair amount of overhead cover present, mostly due to instream debris, with some overhanging vegetation and undercut bank present.

Horseshoe Lake

Horseshoe Lake is a shallow, eutrophic lake with abundant emergent vegetation (Photograph 12). It is connected to the Athabasca River through two channels at the north end of the lake (Figure 2.0-1). In spring 1996, water was present only in the east channel.

3.1.2 Habitat Quantity

Estimates of habitat quantity (habitat area) for Unnamed, Leggett and Wood Creeks are shown in Table 3.1-2. A Geographic Information System (GIS) was used to determine the stream lengths from NTS 1:50,000 scale maps. Stream widths were determined from field measurements of channel widths at the upper, middle and lower reaches of the streams.

The area of Shipyard Lake was calculated by Golder (1996b) to be approximately 151 ha (128 ha wetland shrub, 23 ha open water).

3.2 Fish Inventory

The total number of fish captured by all methods during the spring of 1996 is presented in Table 3.2-1. Overall, for the locations where fish were captured, the catch was dominated by forage fish species. Three species of sport fish were captured in the study area: northern pike were collected from Shipyard Lake, mountain whitefish were collected from the lower section of Wood Creek and yellow perch were captured at the mouth of the channel draining Horseshoe Lake and the lower section of Unnamed Creek (outlet of Shipyard Lake). No fish were captured in the middle and upper reaches of Unnamed, Wood or Leggett creeks. Sport species were located in the lower reaches of Wood and Unnamed Creeks, as well as in Shipyard Lake and the channel draining Horseshoe Lake.

Backpack electrofishing results are shown in Table 3.2-2. In the upper reaches of the creeks electrofishing effectiveness was reduced due to low conductivity and deep pools near beaver dams. Hence, minnow traps and gill nets were also used to sample fish in these areas (Tables 3.2-3 and 3.2-4). Minnow traps and gill nets were also used to survey fish in Shipyard and Horseshoe Lakes (Table 3.2-3 and 3.2-4). Detailed descriptions of the fish fauna of individual watercourses and lakes are provided below.

Unnamed Creek and Shipyard Lake

A fish inventory of the lower reaches of Unnamed Creek was conducted on 9 May using a backpack electrofisher. Four yellow perch were captured at a partially washed out beaver dam about 350 m upstream of the creek mouth. These individuals were small, but could possibly have been mature. The single yellow perch captured in the creek that drains Horseshoe Lake (see below) was approximately the same size, and was found to be a ripe male. Other fish species captured in the lower reaches of Unnamed Creek include spottail shiner, lake chub, trout perch, brook stickleback and emerald shiner.

A fish survey of Shipyard Lake was conducted on 15 and 16 May 1996 using minnow traps and gill nets. No fish were caught in minnow traps (Table 3.2-3). However, five spent (i.e., recently spawned) northern pike (4 males, 1 female) were captured with gill nets (Table 3.2-4), indicating the use of Shipyard Lake as spawning habitat for this species. It is unlikely that these fish are long-term

residents of Shipyard Lake. The general characteristics of this lake (i.e., relatively shallow, eutrophic) indicate that it may not always support an overwintering population of fish. Winter anoxic conditions have been documented in other shallow eutrophic wetlands in the area (R.L.&L. 1989).

Shipyard Lake would provide excellent spawning habitat for northern pike from the Athabasca River, if fish access was not precluded by beaver dams. It is possible that the origin of the northern pike collected from Shipyard Lake was the Athabasca River. The northern pike could have entered the wetland to spawn, and possibly became trapped as a result of construction of a beaver dam. The possibility also exist that Shipyard Lake supports a small, resident population of northern pike.

No fish of any species were captured in the middle and upper portions of Unnamed Creek. No spawning areas were located during the kick sampling surveys. Due to the small size of the stream channel upstream of Shipyard Lake and the presence of beaver dams which would likely affect fish passage, it is probable that fish use of this drainage is limited to Shipyard Lake and the portion of Unnamed Creek between the lake and the Athabasca River.

Leggett Creek

Fish were found to be present only in the lower study segment on Leggett Creek. The catch consisted entirely of forage species, including lake chub, emerald shiner and pearl dace. As with Unnamed Creek, the middle and upper portions of this drainage consist of a small creek channel with beaver activity, instream debris and low discharge levels limiting fish passage. No spawning areas were found in any of the study segments.

Wood Creek

Wood Creek is the largest of the three streams included in this study, having a larger channel and higher discharge throughout the drainage when compared to Unnamed and Leggett Creeks. However, fish were found to be present only in the lower study segment on Wood Creek. Three immature mountain whitefish were captured in the lower segment near the confluence with the Athabasca River, indicating that the lower portion of the creek is being utilized to a limited extent as a rearing area for

this species. Other fish captured in Wood Creek were forage species, and included spoonhead sculpin, longnose sucker and brook stickleback.

Horseshoe Lake

The fish species captured in Horseshoe Lake included spottail shiner, lake chub and trout-perch. A single ripe male yellow perch was captured near the mouth of the creek which drains Horseshoe Lake to the Athabasca River.

3.3 Summary and Concluding Discussion

Shipyard Lake was found to be utilized in the spring of 1996 by spawning northern pike. It is not presently clear if this is a resident population, or if these fish originated from the Athabasca River prior to 1996. In either case, it is likely that northern pike from the Athabasca River utilize this lake for spawning when flow and passage conditions in Unnamed Creek allow them access to the lake. Spawning habitat for this species is limited in the mainstem Athabasca River, and northern pike would be expected to use any suitable water bodies, tributaries or side channels in the Athabasca River floodplain when accessible. The presence of yellow perch in Unnamed Creek downstream of the lake suggests that this species may also use this drainage for spawning activity when conditions permit. Lower Unnamed Creek probably receives use by fish from the Athabasca River when the discharge is sufficient; however, habitat conditions would limit the suitability of this channel primarily to forage fish species.

However, as a result of concern for the northern pike habitat in Shipyard Lake, as well as other issues related to potential effects on wetland, the waste dump that was proposed to encroach on part of Shipyard Lake has been relocated. Studies are presently underway to ensure drainage plans for the mine will not result in significant changes to the hydrology and water quality of the wetland.

The upper portion of Unnamed Creek upstream of Shipyard Lake is too small with too low a flow volume to provide significant habitat for sport fish species. Numerous obstructions such as instream debris and beaver dams would limit or eliminate fish movements within the drainage. It is not likely that the middle or upper portions of Unnamed Creek could support a sustainable resident fish

population or would be used as spawning habitat for fish stocks from the mainstem Athabasca River. Conditions in much of Leggett Creek would be similarly restrictive, although the channel size and flow volume is somewhat larger than the middle and upper portions of Unnamed Creek. Lower Leggett Creek would provide some habitat for fish species, particularly as it is accessible from the Athabasca River. Habitat conditions in this segment would, however, have to be considered suitable for forage fish with limited utility for sport species.

Wood Creek is the largest of the three streams examined, having a larger channel and higher flow volume throughout the drainage. It has potential as a spawning tributary for Athabasca River fish stocks but is likely too small to sustain resident populations of sport fish species. Numerous obstructions to fish passage are likely the reason that no fish were recorded in the middle or upper study segments and would preclude the use of these sections for spawning fish originating from the Athabasca River. The lower portion of the creek in the vicinity of the creek mouth was determined to be used by rearing mountain whitefish. Mine development plans would not preclude the continued use of this habitat by rearing mountain whitefish.

The information (both qualitative and quantitative) collected during this survey regarding the habitats present in Unnamed and Leggett Creeks will be employed to design watercourses of comparable or superior value to fish during the mine reclamation phase. It is very likely that one watercourse may be created that would support fish at least during the open-water season, whereas the habitats that would be lost during mine development (i.e., the middle and upper reaches of Unnamed and Leggett Creeks) presently do not provide suitable fish habitat.

4.0 CLOSURE

We trust that this report presents the information that you require. Should any portion of the report require clarification, please do not hesitate to contact the undersigned.

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5.0 REFERENCES

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Table 2.0-1

Summary of Additional Sampling Stations within Steepbank Mine Study Area

STATION ID	STATION WATERCOURSE	STATION TYPE	STATION DESCRIPTION	SEASON SAMPLED	FISH INVENTORY	HABITAT MEASUREMEN
AF068	UNNAMED CREEK	SECTION	LOWER SECTION	P	BP	
AF069	UNNAMED CREEK	TRANSECT	LOWER SECTION	P		X
AF070	HORSESHOE LAKE	POINT	NORTHWEST SECTION OF LAKE	P	MT	
AF071	HORSESHOE LAKE	POINT	ACROSS NORTHWEST ARM OF LAKE	P	GN	
AF072	HORSESHOE LAKE	POINT	ACROSS SOUTHWEST ARM OF LAKE	P	MT	
AF073	HORSESHOE LAKE	POINT	ACROSS SOUTHEAST ARM OF LAKE	P	GN	
AF074	HORSESHOE LAKE	SECTION	DRAINAGE OUTLET FROM LAKE -- NORTHEAST	P	BP	
AF075	UNNAMED CREEK	POINT	UPPER SECTION	P	MT	
AF076	UNNAMED CREEK	TRANSECT	UPPER SECTION	P		X
AF077	UNNAMED CREEK	POINT	MIDDLE SECTION	P	MT, SN	
AF078	UNNAMED CREEK	TRANSECT	MIDDLE SECTION	P		X
AF079	UNNAMED CREEK	SECTION	MIDDLE SECTION	P	BP	
AF080	LEGGETT CREEK	POINT	UPPER SECTION	P	MT	
AF081	LEGGETT CREEK	TRANSECT	UPPER SECTION	P		X
AF082	LEGGETT CREEK	POINT	MIDDLE SECTION	P	GN	
AF083	LEGGETT CREEK	TRANSECT	UPPER SECTION	P	BP	
AF084	LEGGETT CREEK	TRANSECT	MIDDLE SECTION	P		X
AF085	WOOD CREEK	POINT	UPPER SECTION	P	MT	
AF086	WOOD CREEK	TRANSECT	UPPER SECTION	P		X
AF087	WOOD CREEK	TRANSECT	UPPER SECTION	P	SN	
AF088	WOOD CREEK	POINT	MIDDLE SECTION	P	MT	
AF089	WOOD CREEK	TRANSECT	MIDDLE SECTION	P		X
AF090	WOOD CREEK	TRANSECT	MIDDLE SECTION	P	BP	
AF091	SHIPYARD LAKE	POINT	MIDDLE SECTION	P	GN	
AF092	SHIPYARD LAKE	POINT	ACROSS NORTH ARM OF LAKE	P	GN	
AF093	SHIPYARD LAKE	POINT	SOUTHEAST SECTION OF LAKE	P	GN	

KEY

SEASON
P = Spring
U = Summer
F = Fall

FISH INVENTORY METHODS
BP = Backpack Electrofisher
EF = Boat Electrofisher
GN = Gill Net
KS = Kick Sampling
MT = Minnow Trap
PE = Post-emergent Fry Drift Trap
SN = Beach Seine
SL = Set Line

Table 2.0-1

Summary of Additional Sampling Stations within Steepbank Mine Study Area

STATION ID	STATION WATERCOURSE	STATION TYPE	STATION DESCRIPTION	SEASON SAMPLED	FISH INVENTORY	HABITAT MEASUREMEN
AF094	SHIPYARD LAKE	POINT	SOUTHWEST SECTION OF LAKE	P	GN	
AF095	SHIPYARD LAKE	POINT	WEST SIDE OF LAKE	P	MT	
AF096	SHIPYARD LAKE	POINT	EAST SIDE OF LAKE	P	MT	
AF111	LEGGETT CREEK	POINT	LOWER SECTION	P	MT	
AF112	LEGGETT CREEK	TRANSECT	LOWER SECTION	P		X
AF113	LEGGETT CREEK	TRANSECT	LOWER SECTION	P	BP	
AF114	WOOD CREEK	POINT	LOWER SECTION	P	MT	
AF115	WOOD CREEK	TRANSECT	LOWER SECTION	P		X
AF116	WOOD CREEK	TRANSECT	LOWER SECTION	P	BP	

KEY

SEASON
P = Spring
U = Summer
F = Fall

FISH INVENTORY METHODS
BP = Backpack Electrofisher
EF = Boat Electrofisher
GN = Gill Net
KS = Kick Sampling
MT = Minnow Trap
PE = Post-emergent Fry Drift Trap
SN = Beach Seine
SL = Set Line

Table 2.2-1

Fish Species Names and Codes

SPECIES COMMON NAME	SCIENTIFIC NAME	CODE
Brook Stickleback	*Culaea inconstans*	BRST
Emerald Shiner	*Notropis atherinoides*	EMSH
Lake Chub	*Couesius plumbeus*	LKCH
Longnose Sucker	*Catostomus catostomus*	LNSC
Mountain Whitefish	*Prosopium williamsoni*	MNWH
Northern Pike	*Esox lucius*	NRPK
Pearl Dace	*Semotilus margarita*	PRDC
Spoonhead Sculpin	*Cottus ricei*	SPSC
Spottail Shiner	*Notropis hudsonius*	SPSH
Trout Perch	*Percopsis omiscomaycus*	TRPR
Yellow Perch	*Perca flavescens*	YLPR
Unidentified		UNID

Table 3.1-1

Stream Discharge Measurements, 1996

WATERCOURSE	SECTION	FLOW m3/s
Unnamed Creek	Lower	0.50
	Middle	0.09
	Upper	0.10
Leggett Creek	Lower	0.28
	Middle	0.27
	Upper	0.28
Wood Creek	Lower	0.57
	Middle	0.54
	Upper	0.50

Table 3.1-2

Habitat Area (Hectares) for Unnamed Creek, Leggett Creek and Wood Creek, 1996

WATER COURSE	SECTION	AVERAGE WETTED WIDTH (m)	AVERAGE CHANNEL WIDTH (m)	STREAM LENGTH (m)	AREA[1] (Hectares)
Unnamed Creek	Lower	4.7	6.2	2800	1.7
	Middle	1.3	1.8	7100	1.2
	Upper	1.1	1.6		
	AVERAGE	1.2	1.7		
Leggett Creek	Lower	5.7	8.6	5800	2.8
	Middle	2.4	2.6		
	Upper	2.2	3.1		
	AVERAGE	3.4	4.8		
Wood Creek	Lower	4.8	6.4	12800	7.2
	Middle	4.8	5.7		
	Upper	4.1	4.6		
	AVERAGE	4.6	5.6		

[1]Area is calculated from stream length and average channel width.

Table 3.2-1

Total Number of Fish Captured using Gill Nets, Minnow Traps, and Backpack Electrofishing, 1996

Species	Horseshoe Lake	Shipyard Lake	Unnamed Creek			Wood Creek			Leggett Creek		
			Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Brook Stickleback	-	-	5	-	-	1	-	-	-	-	-
Emerald Shiner	-	-	2	-	-	-	-	-	2	-	-
Lake Chub	3	-	9	-	-	-	-	-	11	-	-
Longnose Sucker	-	-	-	-	-	2	-	-	-	-	-
Mountain Whitefish	-	-	-	-	-	3[c]	-	-	-	-	-
Northern Pike	-	5[a]	-	-	-	-	-	-	-	-	-
Pearl Dace	-	-	-	-	-	-	-	-	2	-	-
Spoonhead Sculpin	-	-	-	-	-	4	-	-	-	-	-
Spottail Shiner	5	-	14	-	-	-	-	-	-	-	-
Trout-Perch	1	-	4	-	-	-	-	-	-	-	-
Unknown	2	-	-	-	-	-	-	-	4	-	-
Yellow Perch	1[a]	-	4[b]	-	-	-	-	-	-	-	-

[a] adult
[b] immature or adult
[c] immature

Table 3.2-2

Total Catch and Catch-Per-Unit-Effort for Fish Captured by Backpack Electroshocking, 1996

STATION	WATER COURSE	TIME SAMPLED (SEC)	BROOK STICKLEBACK	SPOONHEAD SCULPIN	LONGNOSE SUCKER	MOUNTAIN WHITEFISH	EMERALD SHINER	LAKE CHUB	PEARL DACE	YELLOW PERCH	TROUT PERCH	SPOTTAIL SHINER	TOTAL
AF068	LOWER UNNAMED CREEK	1707	4 (0.0023)	-	2 (0.0012)	-	2 (0.0012)	9 (0.0053)	-	4 (0.0023)	3 (0.0018)	9 (0.0053)	33
AF074	OUTLET OF HORSESHOE LAKE	938	-	-	-	-	-	3 (0.0032)	-	1 (0.0012)	1 (0.0012)	2 (0.0096)	7
AF113	LOWER LEGGETT CREEK	924	-	-	-	-	2 (0.0022)	11 (0.012)	2 (0.0022)	-	-	-	15
AF116	LOWER WOOD CREEK	1222	1 (0.0008)	3 (0.0025)	1 (0.0008)	1 (0.0008)	-	-	-	-	-	-	6
	TOTAL	4791	5	3	3	1	4	23	2	5	4	11	61

Table 3.2-3

Total Catch and Catch-Per-Unit-Effort
for Fish Captured by Minnow Traps, 1996

Station	Watercourse	Time Sampled (hours)	Spoonhead Sculpin
AF070	Horseshoe Lake	20.92	-
AF072	Horseshoe Lake	20.42	-
AF075	Unnamed Creek (upper)	3.75	-
AF077	Unnamed Creek (middle)	5.42	-
AF080	Leggett Creek (upper)	4.08	-
AF085	Wood Creek (upper)	4.58	-
AF088	Wood Creek (middle)	4.83	-
AF095	Shipyard Lake	24.7	-
AF096	Shipyard Lake	23.25	-
AF111	Leggett Creek (mouth)	4.35	-
AF114	Wood Creek (mouth)	4.35	1 (0.230)
Grand Total		120.65	1

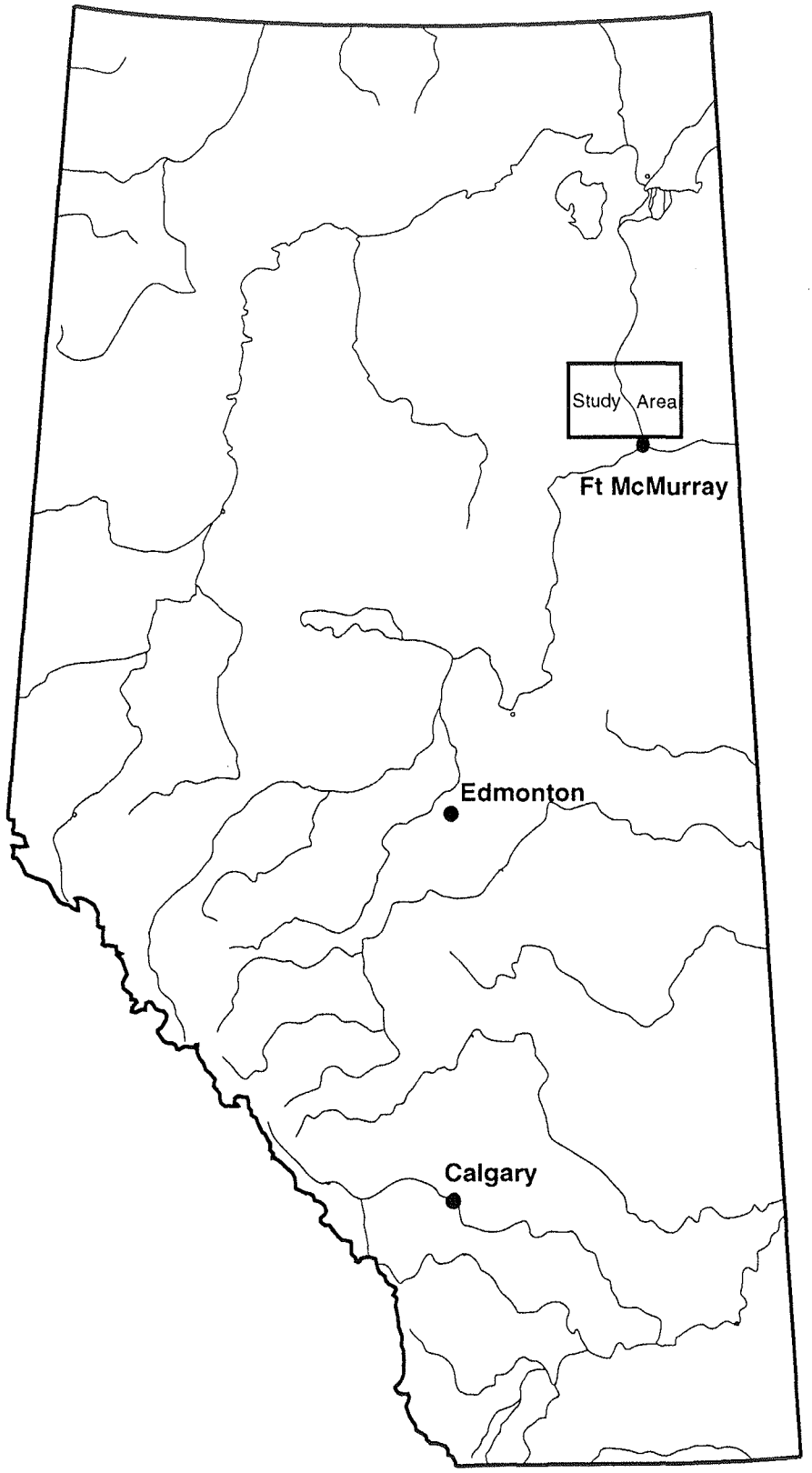
Table 3.2-4

Total Catch and Catch-Per-Unit-Effort for Fish taken by Gill Nets, 1996

Station	Watercourse	Time Sampled (hours)	Mesh Size	Northern Pike
AF071	Horseshoe Lake	20.57	8.89	-
AF073	Horseshoe Lake	19.92	5.08	-
AF082	Leggett Creek (upper)	3.08	5.08	-
AF091	Shipyard Lake	27.33	5.08	-
AF092	Shipyard Lake	26.3	8.89	3 (0.114)
AF093	Shipyard Lake	26.13	5.08	-
AF094	Shipyard Lake	23.28	8.89	2 (0.086)
Grand Total		146.61		5

Location of the Study Area Within Alberta

Figure 1.1-1



PROJECT 962.2320 DRAWN RP REVIEWED DATE 19 June 1996

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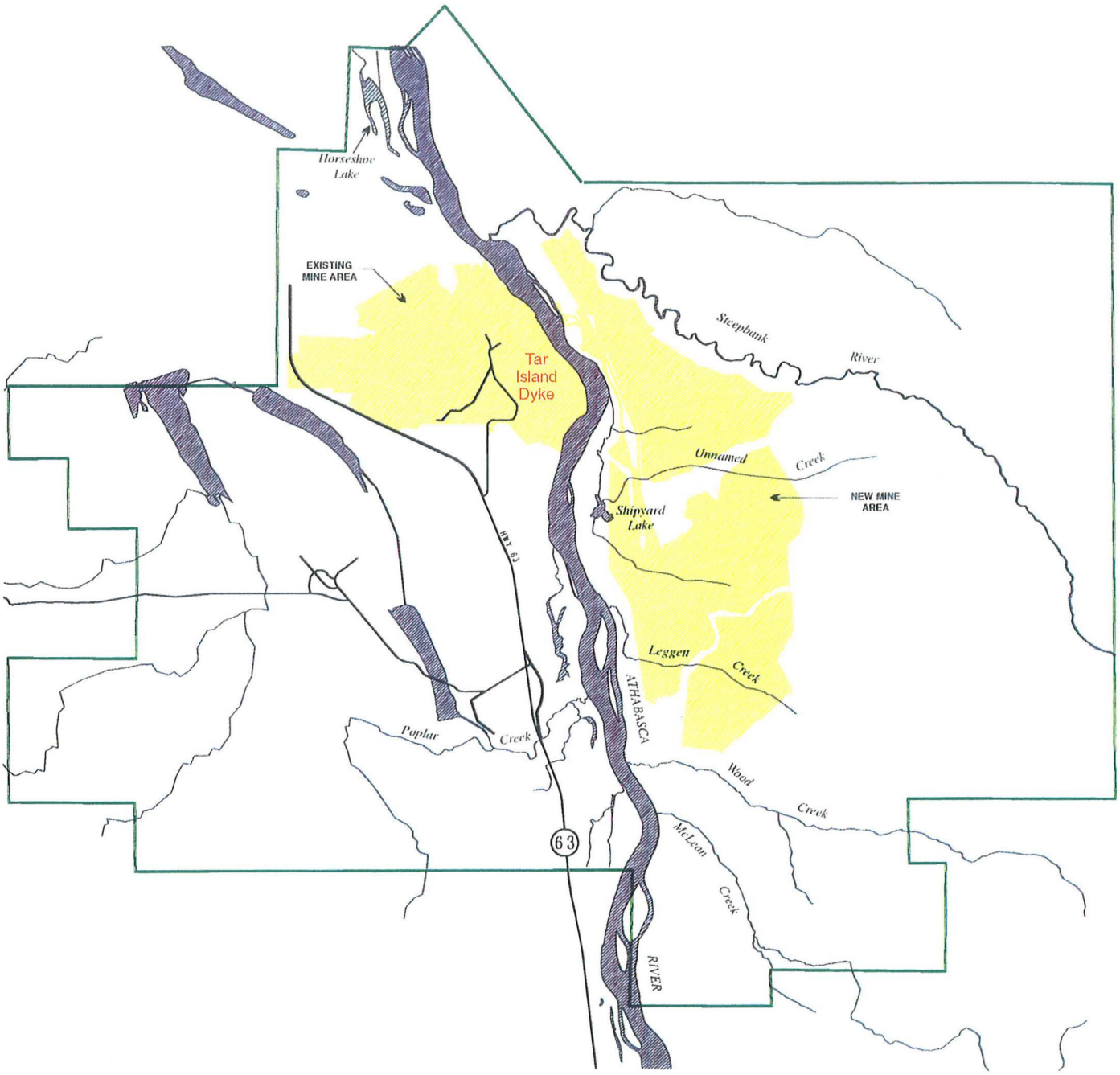
Local Study Area for the Steepbank Mine Environmental Baseline Program

Figure 1.1-2



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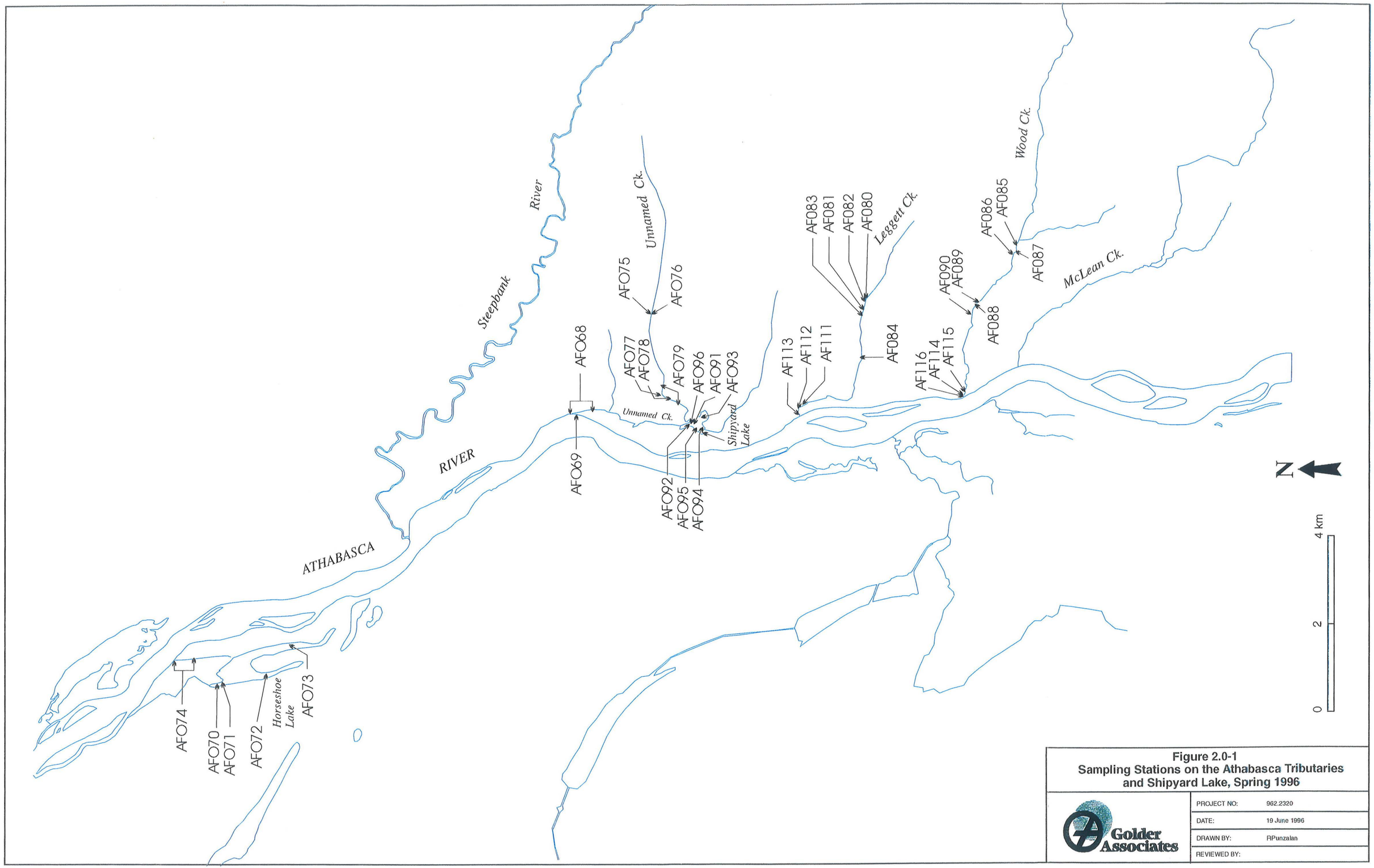

Figure 2.0-1
Sampling Stations on the Athabasca Tributaries and Shipyard Lake, Spring 1996

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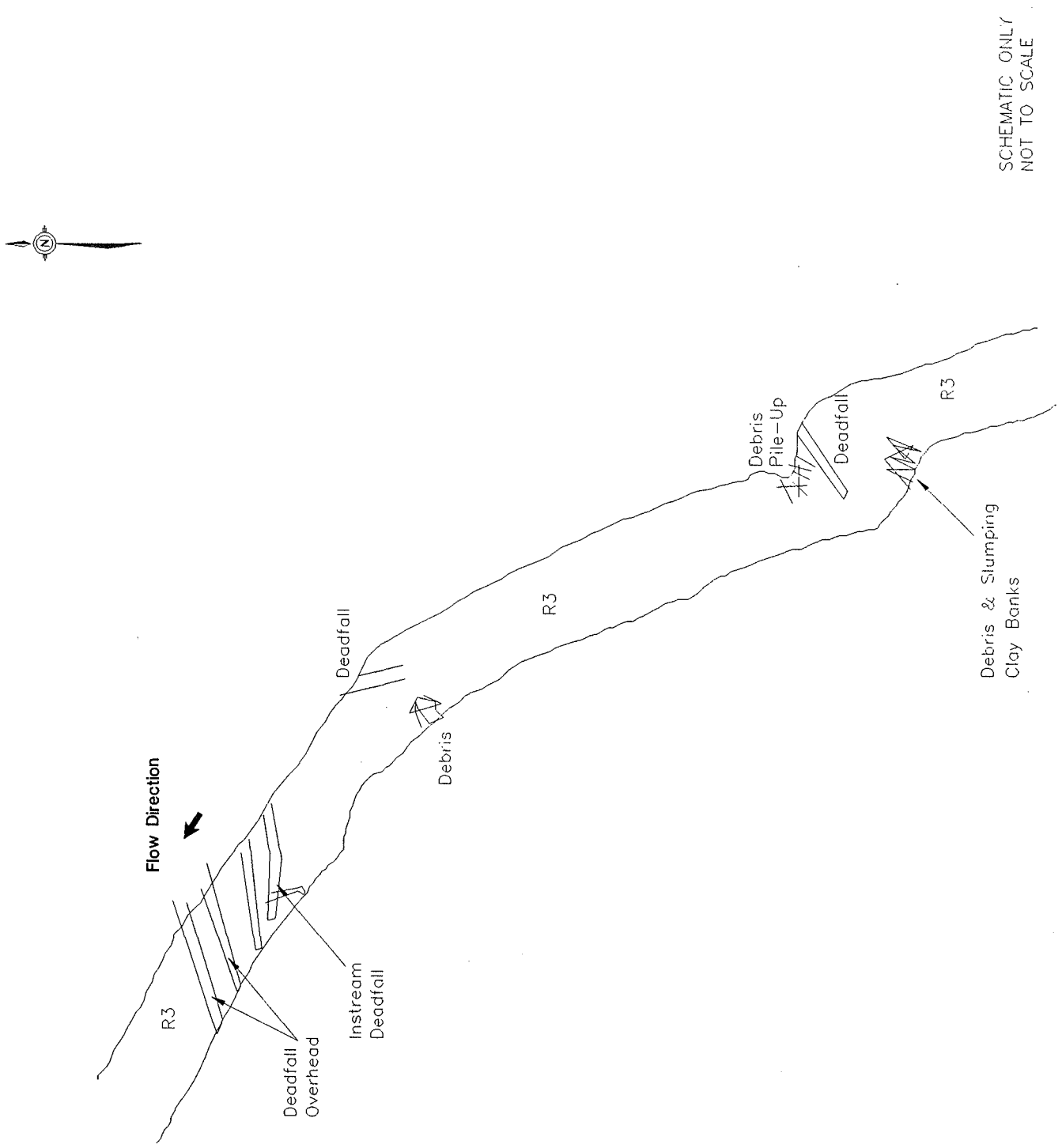
PROJECT NO:	962.2320
DATE:	19 June 1996
DRAWN BY:	RPunzalan
REVIEWED BY:	

HABITAT MAP
LOWER SECTION OF UNNAMED CREEK
(SEE APPENDIX I FOR HABITAT CODES)

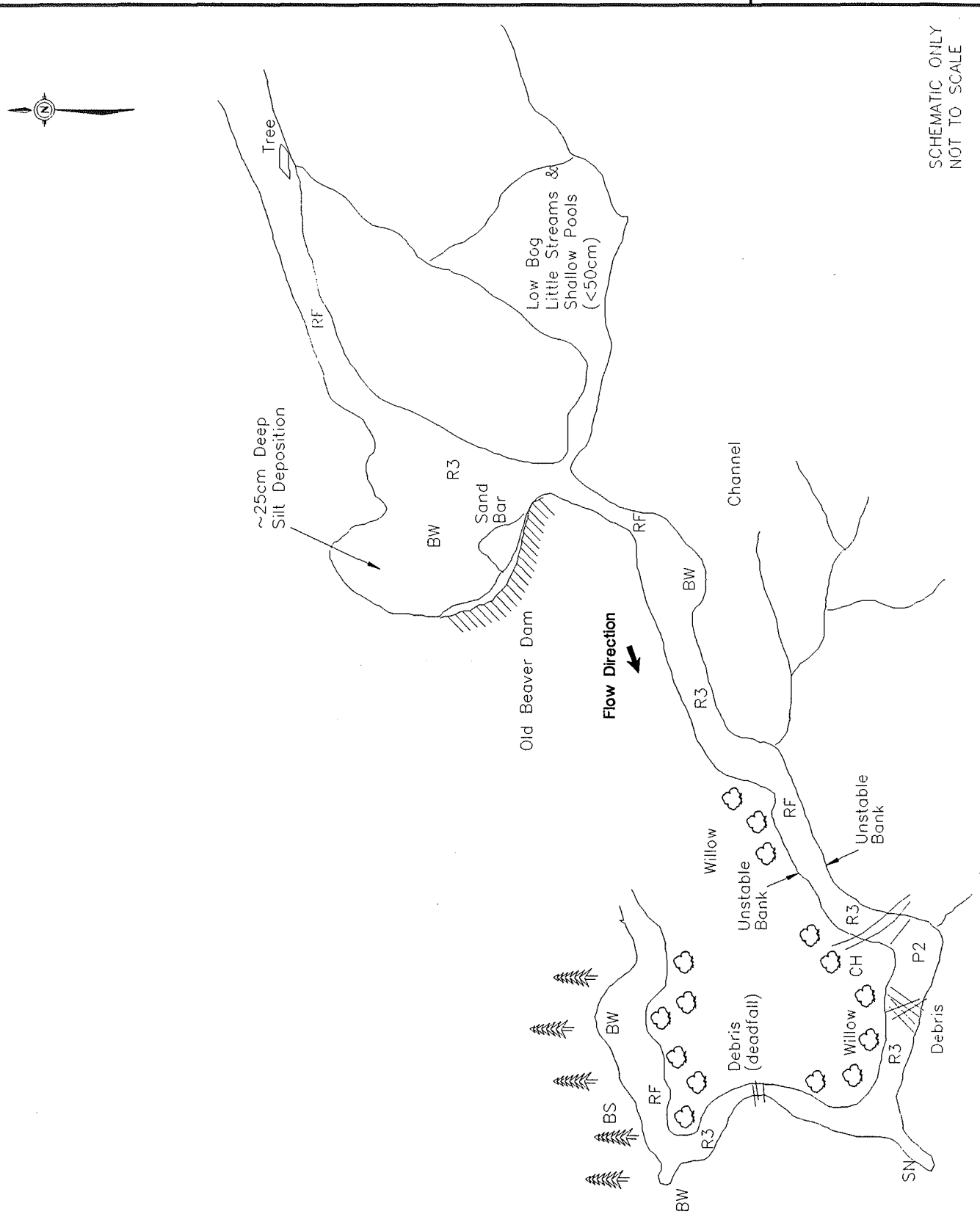
Figure 3.1-1



PROJECT 962-2320 DRAWN TM REVIEWED _____ DATE 19 JUNE 1996 J:\1996\2320\UNNAMED1\LOWERLEG.DWG

HABITAT MAP
MIDDLE SECTION OF UNNAMED CREEK
(SEE APPENDIX I FOR HABITAT CODES)

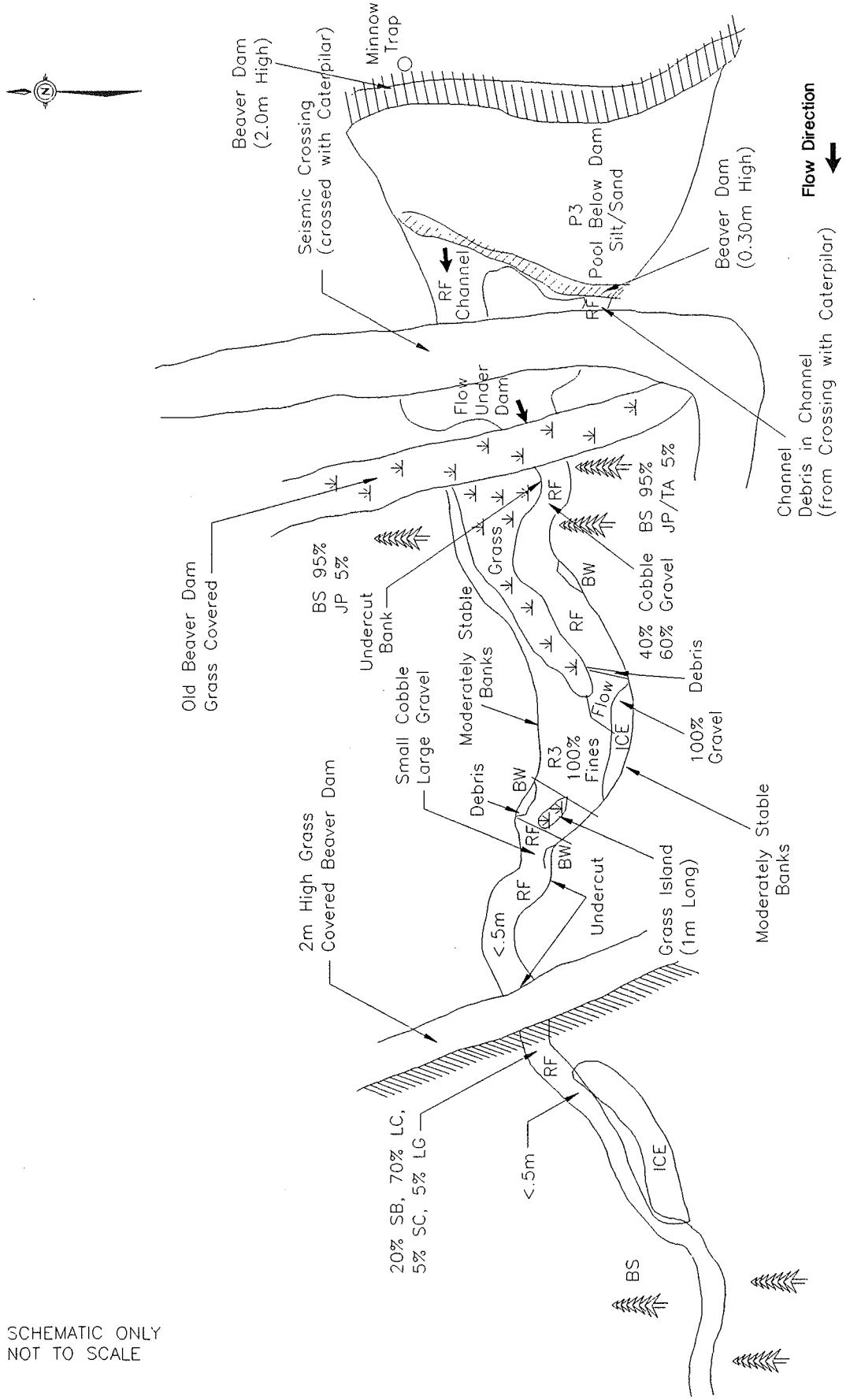
Figure 3.1-2



PROJECT 962-2320 DRAWN TM REVIEWED _____ DATE 19 JUNE 1996 J:\1996\2320\UNNAMED1\MIDDLE.DWG

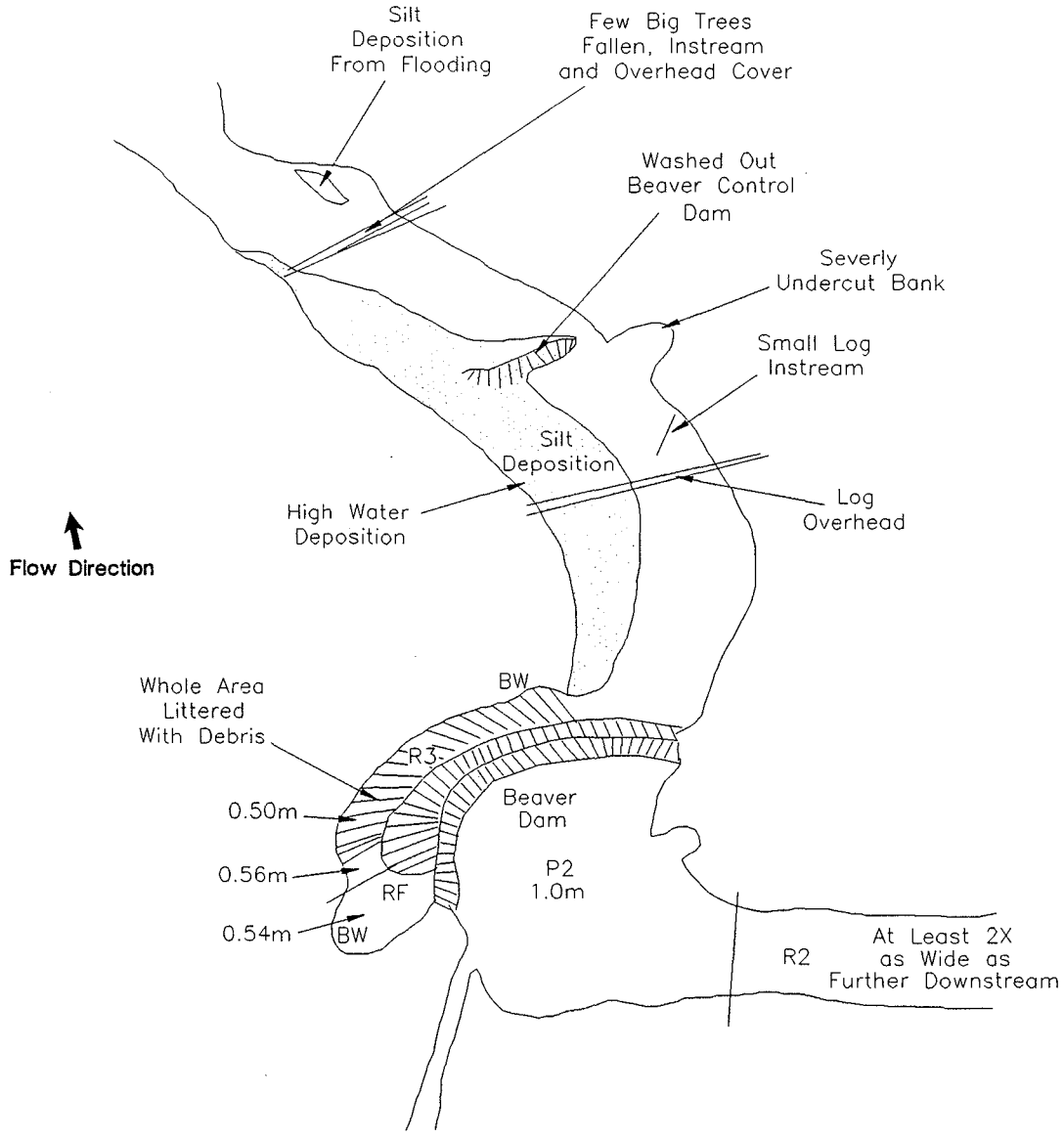
HABITAT MAP
UPPER SECTION OF UNNAMED CREEK
(SEE APPENDIX I FOR HABITAT CODES)

Figure 3.1-3



HABITAT MAP
LOWER SECTION OF LEGGETT CREEK
(SEE APPENDIX I FOR HABITAT CODES)

Figure 3.1-4



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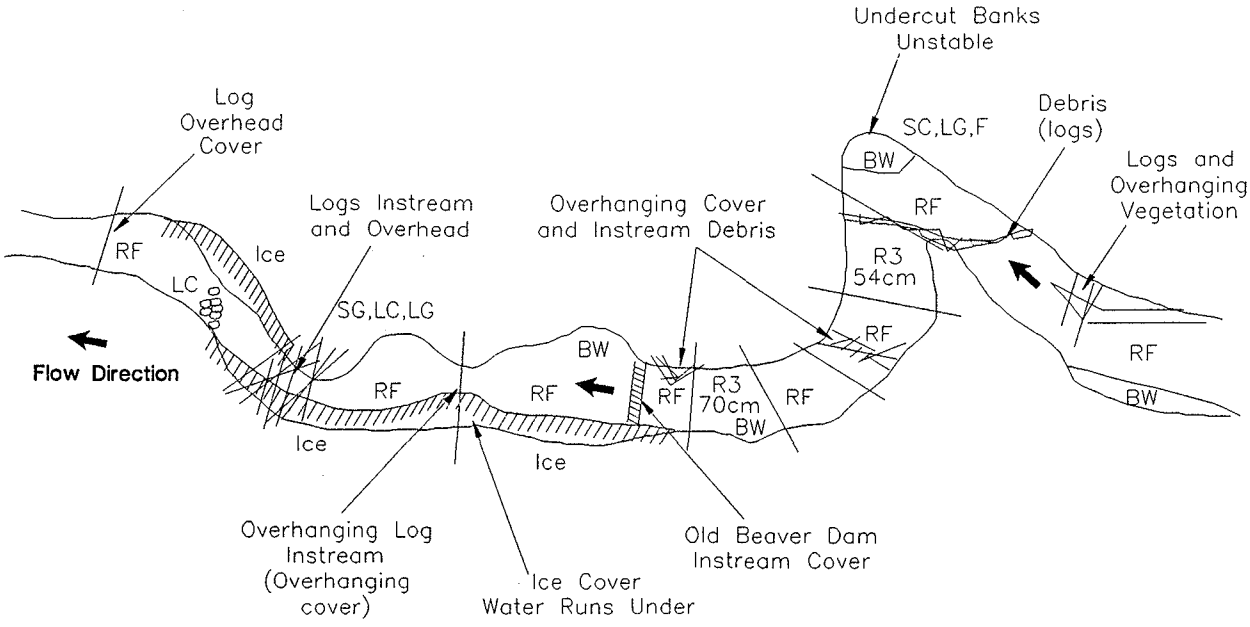
NOT TO SCALE

PROJECT 962-2320 DRAWN TM REVIEWED DATE 19 JUNE 1996 J:\1996\2320\WOODCREEK\LOLEGGET.DWG

HABITAT MAP
MIDDLE SECTION OF LEGGETT CREEK
(SEE APPENDIX I FOR HABITAT CODES)

Figure 3.1-5



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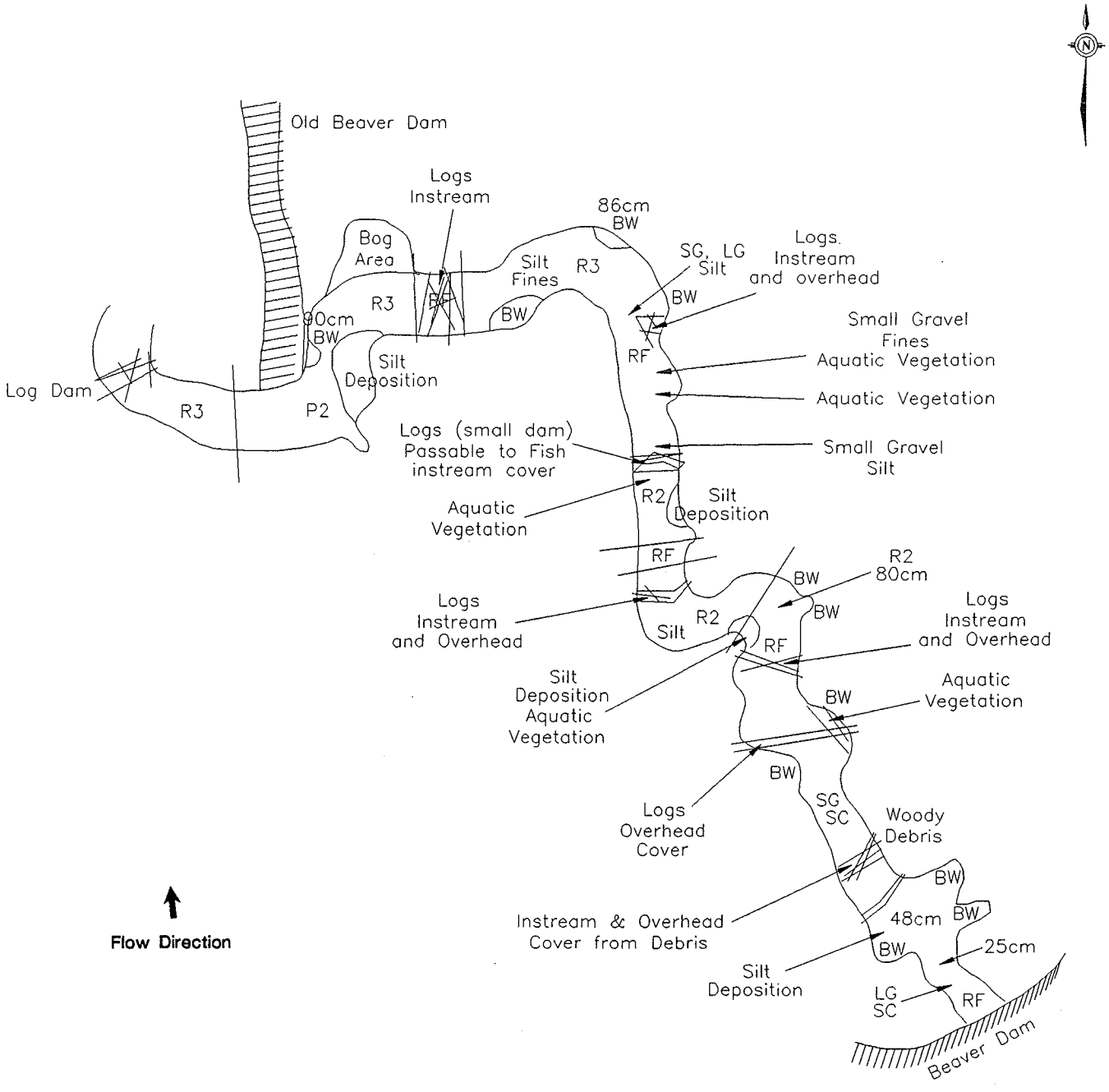
HABITAT MAP
UPPER SECTION OF LEGGETT CREEK
(SEE APPENDIX I FOR HABITAT CODES)

Figure 3.1-6



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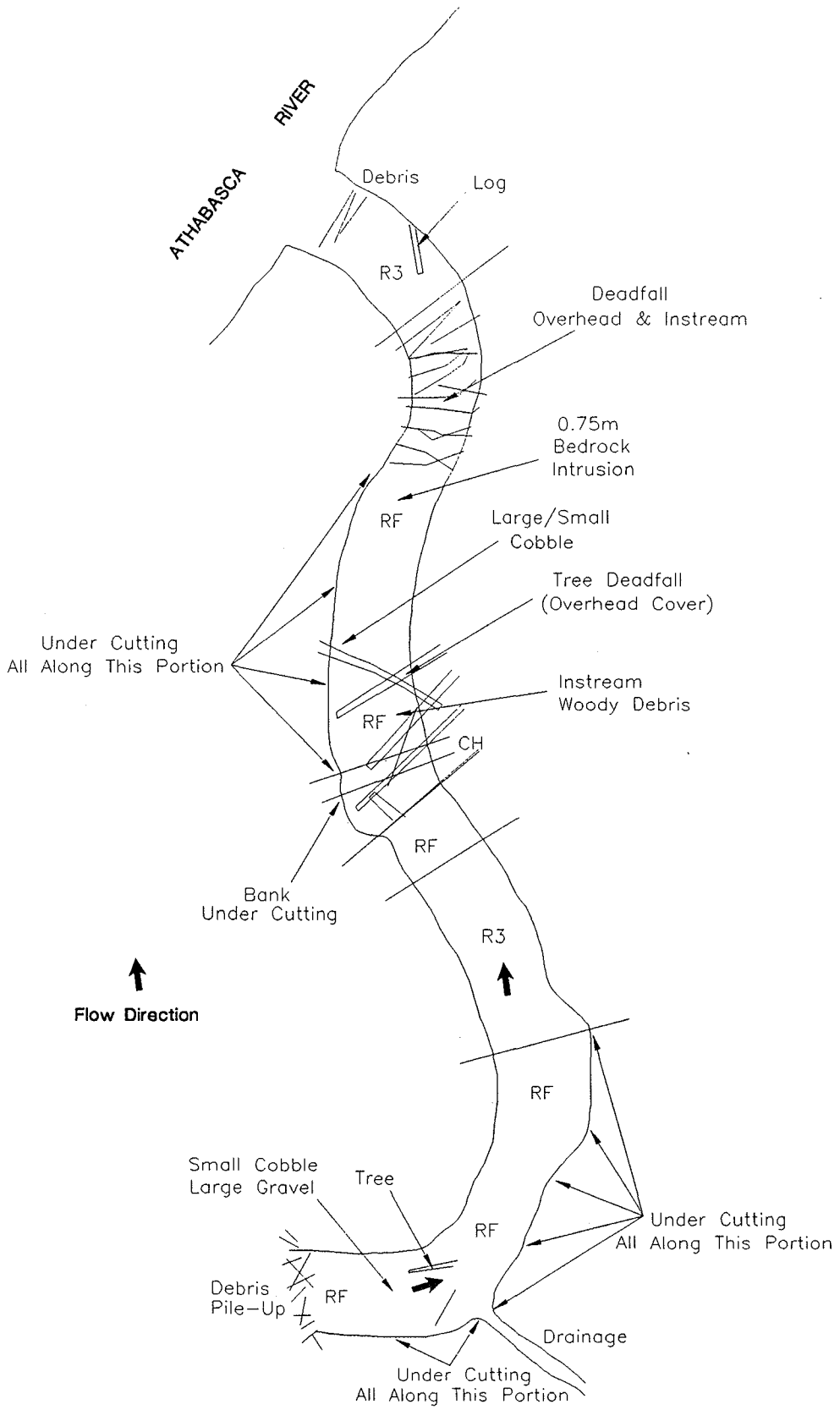
PROJECT 962-2320 DRAWN TM REVIEWED DATE 21 JUNE 1996 J:\1996\2320\LEGGETT\UPLEGGET.DWG

HABITAT MAP
LOWER SECTION OF WOOD CREEK
(SEE APPENDIX I FOR HABITAT CODES)

Figure 3.1-7



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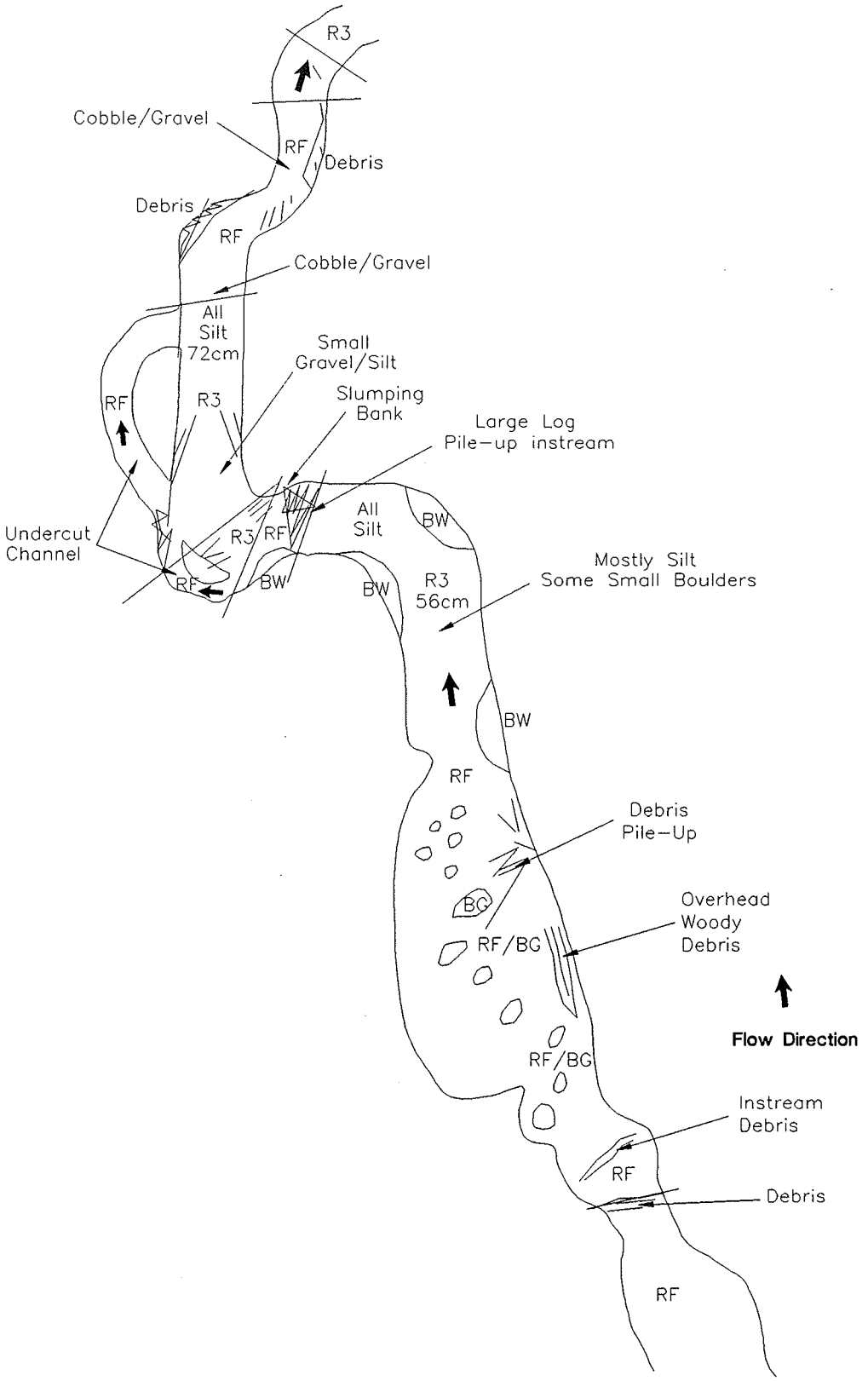
PROJECT 962-2320 DRAWN TM REVIEWED DATE 19 JUNE 1996 J:\1996\2320\WOODCREEK\LOWWOOD.DWG

HABITAT MAP
MIDDLE SECTION OF WOOD CREEK
(SEE APPENDIX I FOR HABITAT CODES)

Figure 3.1-8



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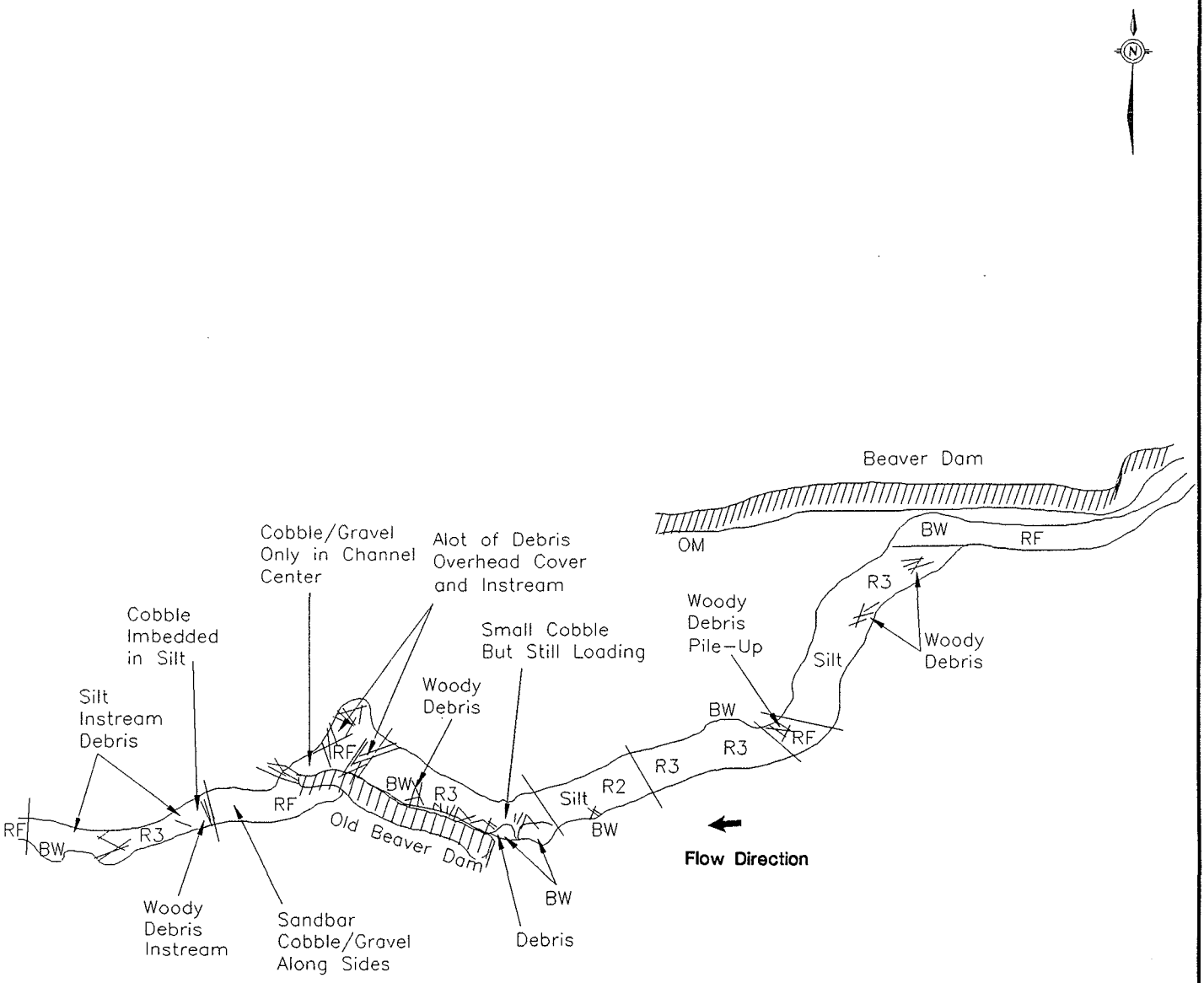
HABITAT MAP
UPPER SECTION OF WOOD CREEK
(SEE APPENDIX I FOR HABITAT CODES

Figure 3.1-9



SCHEMATIC ONLY
NOT TO SCALE

PROJECT 962-2320 DRAWN TM REVIEWED DATE 19 JUNE 1996 J:\1996\2320\WOODCREEK\UPPWOOD.DWG

Photo 1 Lower Section of Unnamed Creek on 10 May 1996

Photo 2 Beaver Dam in Unnamed Creek Approximately 2 km from the Confluence with the Athabasca River, 21 May 1996

Photo 3

Middle Section of Unnamed Creek, 12 May 1996

Photo 4

A Riffle Area in the Upper Section of Unnamed Creek, 12 May 1996

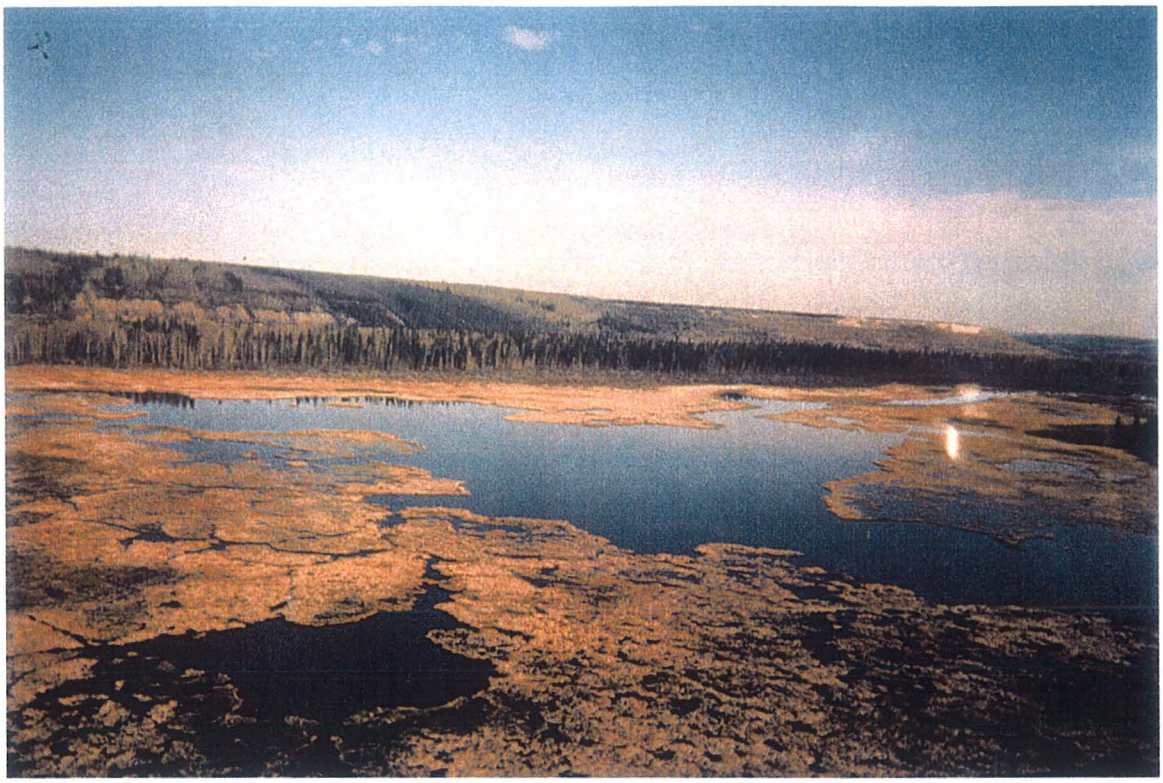


Photo 5 Aerial Photograph of Shipyard Lake, 11 May 1996

Photo 6 Lower Section of Leggett Creek, 20 May 1996

Photo 7 Middle Section of Leggett Creek, 13 May 1996

Photo 8 Upper Section of Leggett Creek, 13 May 1996

Photo 9 Lower Section of Wood Creek, 20 May 1996

Photo 10 Boulder Garden in the Middle Section of Wood Creek, 14 May 1996

Photo 11 Upper Section of Wood Creek, 14 May 1996

Photo 12 Horseshoe Lake, 11 May 1996

APPENDIX I

GOLDER HABITAT MAPPING TECHNICAL PROCEDURE

1. PURPOSE

This technical procedure details the classification system and map coding system to be used for habitat mapping a watercourse. The habitat mapping system consists of two components; a general system for mapping large mainstem rivers and a more detailed system for mapping discrete channels units which is primarily used for smaller streams.

2. APPLICABILITY

This technical procedure is applicable to all personnel involved in habitat mapping of all sizes of watercourses in Alberta. The technique was developed primarily in Alberta in consultation with Alberta Fish and Wildlife. With respect to describing aquatic habitats it is applicable outside of Alberta but may be superseded by local criteria (eg. B.C. MOE guidelines).

3. DEFINITIONS

The habitat mapping system is divided into a set of habitat types or categories, the definitions of which are included in the classification system. Some more general definitions are presented here.

3.1 Channel

A natural or artificial waterway which periodically or continuously contains moving water. It has a definite bed and banks which normally confine the water, and which display evidence of fluvial processes.

3.2 Channel Form

The shape of river confinement.

3.3 Channel Unit

Hydraulic and morphological features of a stream channel. A channel unit is a section of channel which exhibits homogeneity with respect to water depth and velocity and is separated from other channel units by gradients in these parameters. The most common channel units are pool, riffle and run.

3.4 Channel Width

The horizontal distance along a transect line from stream bank to stream bank (rooted vegetation to rooted vegetation) at the normal high water marks measured at right angles to the direction of flow.

3.5 Cover

Aspects of the physical environment which provide cover for fish which is defined as resting places or protection from predators. Cover consists of two categories: 1) instream cover - any feature which

provides a velocity shelter (eg. large substrate particles, submerged debris, etc.); 2) overhead cover - any feature which provides visual isolation for the fish (eg. overhanging vegetation, undercut bank, turbulence, etc).

3.6 Discharge

A measurement of the volume of surface water flowing in the stream channel, measured as the volume flowing past a specific point over a given time (i.e. m^3/s).

3.7 Stream Habitat

The physical stream environment which provides a place for aquatic biota (fish, invertebrates, plants, etc.) to live, grow and reproduce. Several types of fish habitat should be considered when habitat mapping and include spawning habitat, nursery/rearing habitat, feeding habitat and overwintering habitat.

3.8 Stream Gradient

The slope of the streambed over which the stream runs. Some channel characteristics are directly related to the gradient, such as average velocity, substrate coarseness, and presence and extent of various channel units. Gradient classification: low <2%; medium 2-5%; high >5%.

3.9 Wetted Width

The width of the water surface measured at right angles to the direction of flow. Multiple channel widths are summed to obtain total wetted width.

4. REFERENCES AND SUGGESTED READING

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Hawkins C.P., J.L. Kershner, P.A. Bison, M.D. Bryant, L.M. Decker, S.V. Gregory, D.A. McCullough, C.K. Overton, G.H. Reeves, R.J. Steedman, and M.K. Young. 1993. A hierarchial approach to classifying stream habitat features. Fisheries 18(6):3-12.

Northern River Basins Study. 1994. A general fish and riverine habitat inventory; Athabasca River, October 1993. Prepared by R.L.& L. Environmental Services Ltd. for the NRBS, Edmonton. Northern River Basins Study Project Report No. 40. 129 pp. + App.

Roper, B.B., and D.L. Scarnecchia. 1995. Observer variability in classifying habitat types in stream surveys. N.A. Journal of Fish. Manag. 15(1):49-53.

R.L.& L Environmental Services Ltd. 1986. Fisheries resources upstream of the Oldman Dam: Prepared for Alberta Environment Planning Division, Edmonton. 131 pp. + App.

5. DISCUSSION

The habitat mapping and classification system is used to provide an ecologically relevant inventory of stream habitats within a designated study area. The mapping procedure is meant to describe the habitats available within the stream and to detail the location and extent of each habitat type/class. The habitat classification system is intended to be ecologically meaningful with respect to describing and cataloguing physical habitats in relation to the requirements of fish species and their various life stages (spawning, incubation, nursery, rearing, summer feeding, holding, overwintering, migration); and also to a lesser extent the relationship between physical habitat and benthic invertebrate productivity, at least with respect to fish food production. Researchers have determined that fish distinguish between the habitat types and sub-classes of habitat types that have been used to map streams and it is intended that this classification system provide an ecological association of habitat characteristics and fish use/abundance.

Streams are habitat mapped to provide an inventory of the available habitats and to show the locations of critical habitats, that is habitats that are of importance to a fish population such as migration routes, spawning habitat, rearing habitat etc. Habitat maps are used in several applications. A habitat map can be used to show the habitat types present at a specific site that may be impacted by a proposed point disturbance such as a pipeline crossing or bridge construction. A habitat map of a length of stream can be used to evaluate optional locations for such a disturbance to minimize the impacts to the fisheries resource. Habitat maps may be used to document changes to a stream environment over time, such as impacts from a disturbance or improvements due to habitat rehabilitation or improvement programs. Habitat maps can provide an inventory of habitat types present downstream of a discharge/effluent which has a continual impact on those habitats. A primary use of the habitat mapping procedure is to provide an inventory of the habitats present in a stream that is subject to a proposed impact in order to ensure compliance with the Federal Regulations stating that "No Net Loss" of productive fish habitat is to occur as a result of a proposed disturbance or alteration of the stream.

The habitat mapping and classification system is composed of two components. The first is a general system called the "Large River Habitat Classification System" which is used to map large mainstem rivers such as the Peace or Athabasca rivers where habitat heterogeneity is less than for smaller streams, and use of a more detailed system may not be appropriate or required by the project. The second component is a the more detailed "Stream Habitat Classification and Rating System", which itself consists of more than one component depending on the level of detailed required by the project.

The habitat map is produced by delineating on a base map the location and extent of each of the habitat features. The features to be included, the definitions of these features, and the abbreviations (map symbols) used to label each feature on the habitat map are detailed in Tables 1 and 2. Also to be recorded during the habitat mapping process is the location of the stream or section of stream being mapped, the project number, the date and, if possible, the discharge or water level at the time of mapping. If possible, conduct the habitat mapping procedures under late summer base flow conditions.

Whether the large river classification system (Table 1) is used or the stream classification and rating system (Table 2) is used will depend on the size of the watercourse and the level of mapping detail required

to meet the objectives of the project. For medium to large sized watercourses it may be possible to apply both systems to the same mapping program.

In addition to the two habitat classification systems, additional detail can be recorded on the habitat maps which describe, in qualitative terms, the general substrate conditions. Typically, this process would be applied during use of the stream habitat classification and rating system to describe the substrate conditions for specific areas, such as potential spawning habitats, or to describe the substrate type within each individual channel unit. Substrate composition is presented as the percent occurrence (visual estimation) of each substrate size category. Substrate particle sizes are presented on Table 3.

5.1 Large River Habitat Classification System

This is a general system based on gross morphology, surficial and hydraulic characteristics and consists of two primary components. These are: 1) "major habitat type", which defines the type of channel present, and; 2) "bank habitat type", which details the structure of the bank and near shore habitats. Also included on the map are "special habitat features" which are significant to fish distribution/use in these large rivers. Table 1 presents the details of the large river habitat classification system.

5.2 Stream Habitat Classification and Rating System

This is a detailed mapping system based on individual channel units, which are sections of stream of homogenous character with respect to depth, velocity and cover. The extent of each habitat unit is delineated on the map, as is the class rating for each unit (where appropriate). Some of the channel units also have modifiers (types) which should also be recorded. Table 2 presents the details of the stream habitat classification and rating system.

The use of the channel unit and class categories are meant to relate instream habitats with potential utilization by fish species and life stages. Much of the criteria used to establish the classifications are based on the habitat requirements of salmonid species, which in Alberta include non-anadromous trout and whitefish. The following table provides the fish utilization expected for each of the habitat types. The overall goal of the Stream Habitat Classification and Rating System is to provide habitat classifications that relate to fish utilization.

Spawning		Nursery/Rearing	Adult Feeding	Overwintering
Trout (gravel sub.)	Whitefish (cobble sub.)			
RF	R2	RF	R1	P1
RF/BG	R2/BG	RF/BG	R2	R1
R3		R1	R2/BG	R2
R3/BG		R2	P1	R2/BG
		R2/BG		
		R3/BG		

TABLE 1: LARGE RIVER HABITAT CLASSIFICATION SYSTEM
(From R.L.&L. 1992 - General Habitat Inventory for the NRBS)

MAJOR HABITAT TYPES

Type	Abbreviation	Description
Unobstructed channel	U	single main channel, no permanent islands, side bars occasionally present, limited development of exposed mid-channel bars at low flow
Singular island	S	two channels around single, permanent island, side and mid-channel bars often present at low flow
Multiple island	M	more than two channels and permanent islands, generally extensive side and mid-channel bars at low flow

SPECIAL HABITAT FEATURES

Tributary confluences	TC	confluence area of tributary entering mainstem
[sub-classified according	TC1	intermittent flow, ephemeral stream
to tributary flow and	TC2	flowing, width <5m
wetted width at mouth at	TC3	flowing, width 5-15m
the time of the survey]	TC4	flowing, width 16-30m
	TC5	flowing, width 31-60m
	TC6	flowing, width >60m
Shoal	SH	shallow (<1m deep), submerged areas in mid-channel or associated with depositional areas around islands/side bars
	SHC	submerged area of coarse substrates
	SHF	submerged area of fine substrates
Backwater	BW	discrete, localized area exhibiting reverse flow direction and, generally, lower velocity than main current; substrate similar to adjacent channel with more fines
Rapid	RA	area with turbulent flow, broken surface (standing waves, chutes etc.), high velocity (>1 m/s), armoured substrate (large boulder/bedrock) with low fines
Snye	SN	discrete section of non-flowing water connected to a flowing channel only at its downstream end, generally formed in a side channel or behind a peninsula (bar)
Slough	SL	non-flowing water body isolated from flowing waters except during flood events; oxbows
Log jam	LJ	accumulation of woody debris; generally located on island tips, heads of sidechannels, stream meanders; provide excellent instream cover

BANK HABITAT TYPES

Armoured/Stable	A1	largely stable and at repose; cobble/s.boulder/gravel predominant; uniform shoreline configuration; bank velocities low-moderate; instream/overhead cover limited to substrate and turbidity
	A2	cobble/s.-l.boulder predominant; irregular shoreline due to cob/boulder outcrops producing BW habitats; bank velocity low (BW)-mod; instream/overhead cover from depth, substrate and turbidity
	A3	similar to A2 with more l.boulder/bedrock; very irregular shoreline; bank velocities mod-high with low velocity BW/eddy pools providing instream cover; overhead cover from depth/turbidity
	A4	rip-rap substrates consisting of angular boulder sized fill; often associated with high velocity areas; shoreline usually regular; instream cover from substrate; overhead cover from depth/turbulence
Canyon	C1	banks formed by valley walls; l.cobble/boulder bedrock; stable at bank-water interface; typically deep/high velocity water offshore; abundant velocity cover from substrate/bank irregularities
	C2	steep, stable bedrock banks; regular shoreline; mod-deep/mod-fast water offshore; occasional velocity cover from bedrock fractures
	C3	banks formed by valley walls, primarily fines with some gravel/cobble at base; moderately eroded at bank-water interface; mod-high velocities; no instream cover
Depositional	D1	low relief, gently sloping bank; shallow/slow offshore; primarily fines; instream cover absent or consisting of shallow depressions or embedded cobble/boulder; generally associated with bars
	D2	similar to D1 with gravel/cobble substrate; some areas of higher velocities producing riffles; instream/overhead cover provided by substrate/turbulence; often associated with bars/shoals
	D3	similar to D2 with coarser substrates (cobble/boulder); boulders often imbedded; mod-high velocities offshore; instream cover abundant from substrate; overhead cover from turbulence
Erosional	E1	high, steep eroded banks with terraced profile; unstable; fines; mod-high offshore velocity; deep immediately offshore; instream/overhead cover from submerged bank materials/vegetation/depth
	E2	similar to E1 without the large amount of instream vegetative debris; offshore depths shallower
	E3	high, steep eroding banks; loose till deposits (gravel/cobble/sand); mod-high velocities and depths; instream cover limited to substrate roughness; overhead cover provided by turbidity
	E4	steep, eroding/slumping highwall bank; primarily fines; mod-high depths/velocities; instream cover limited to occasional BW formed by bank irregularities; overhead cover from depth/turbidity
	E5	low, steep banks, often terraced; fines; low velocity; shallow-moderate; no instream cover; overhead cover from turbidity
	E6	low slumping/eroding bank; substrate either cobble/gravel or silt with cobble/gravel patches; moderate depths; mod-high velocities; instream cover from abundant debris/boulder; overhead cover from depth/turbidity/overhanging vegetation

TABLE 2:

STREAM HABITAT CLASSIFICATION AND RATING SYSTEM

(Adapted from R.L.&L. 1992 & Hawkins et. al 1993)

Channel Unit	Type	Class	Symbol	Description
Falls			FA	highest water velocity; involves water falling over a vertical drop; impassable to fish
Cascade			CA	extremely high gradient and velocity; extremely turbulent with entire water surface broken; may have short vertical sections, but overall is passable to fish; armoured substrate; may be assoc. with chute (RA/CH)
Chute			CH	area of channel constriction, usually due to bedrock intrusions; associated with channel deepening and increased velocity
Rapids			RA	extremely high velocity; deeper than riffle; substrate extremely coarse (1.cobble/boulder); instream cover in pocket eddies and associated with substrate
Riffle			RF	high velocity/gradient relative to run habitat; surface broken due to submerged or exposed bed material; relatively shallow; coarse substrate; limited instream or overhead cover for juvenile or adult fish (<0.5m deep)
Run (glide)			R	moderate to high velocity; surface largely unbroken; deeper than RF; substrate size dependent on hydraulics
	Depth/Velocity Type			run habitat is differentiated into 4 types; deep/slow, deep/fast, shallow/slow, shallow/fast
		Class 1	R1	highest quality/deepest run habitat; generally deep/slow type; coarse substrate; high instream cover from substrate/depth (>1.0 m deep)
		Class 2	R2	moderate quality/depth; high-mod instream cover except at low flow; generally deep/fast or moderately deep/slow type (.75-1.0m deep)
		Class 3	R3	lowest quality/depth; generally shallow/slow or shallow/fast type; low instream cover in all but high flows (0.5-0.75m deep)
Flat			FL	area characterized by low velocity and near-laminar flow; differentiated from pool habitat by high channel uniformity; more depositional than R3 habitat
Pool			P	discrete portion of channel featuring increased depth and reduced velocity relative to riffle/run habitats; formed by channel scour
		Class 1	P1	highest quality pool habitat based on size and depth; high instream cover due to instream features and depth; suitable holding water for adults and for overwintering (>1.5m deep)
		Class 2	P2	moderate quality; shallower than P1 with high-mod instream cover except during low flow conditions, not suitable for overwintering
		Class 3	P3	low quality pool habitat; shallow and/or small; low instream cover at all but high flow events
	Pool Type		Label	several types of pool are specified, depending on the hydraulic factors which formed them, they include; eddy, trench, lateral, mid-channel, plunge and convergence
Impoundment		Class 1-3	IP (1-3)	includes pools which are formed behind dams; tend to accumulate sediment/organic debris more than scour pools; may have cover associated with damming structure; identify as Class 1, 2 or 3 as for scour pools
	Dam Type			four types of impoundments have been identified based on dam type; debris, beaver, landslide and abandoned channel
Backwater			BW	discrete, localized area of variable size exhibiting reverse flow direction; generally produced by bank irregularities; velocities variable but generally lower than main flow; substrate similar to adjacent channel with higher percentage of fines
Snye			SN	discrete section of non-flowing water connected to a flowing channel only at its downstream end; generally formed in a side-channel or behind a peninsula
Boulder Garden			BG	significant occurrence of large boulders providing significant instream cover; always in association with an overall channel unit such as a riffle (RF/BG) or run (eg. R1/BG)

ADDITIONAL HABITAT MAPPING SYMBOLS

Feature	Symbol	Description
Ledge	LE	area of bedrock intrusion into the channel; often associated with chute or plunge pool habitat
Overhead Cover	OC	area of extensive or high quality overhead cover
Instream Cover	IC	area of high quality instream cover (velocity shelter) for all life stages
Undercut Bank	UB	area of extensive/high quality undercut bank providing overhead cover
Unstable Bank	US	area of unstable bank with potential to collapse instream, affecting instream habitat or producing sedimentation
Overhanging Veg.	OV	area of high quality overhanging vegetation providing overhead cover and stream shading
Inundated Veg.	IV	area of inundated vegetation; either submergent macrophytes or flooded terrestrial
Debris Pile	DP	debris pile (eg. log jam) which influences instream habitat; include effect on cover and fish passage
Root Wad	RW	fallen terrestrial vegetation large enough to provide cover for fish
Beaver Dam	BD	include effect on fish passage
Stream Blockage	XX	include effect on fish passage

Considerations

Overhead cover includes overhanging vegetation, undercut bank or debris which has an effective width >9 cm over water with a depth > 0.15 m.

Instream cover is provided by aquatic vegetation or by substrate particles as large or larger than small cobbles when associated with water depths >0.15 m.

Deep water may provide cover if depth is >0.45 m.

Vertical drops >0.8 m are potentially impassable for resident trout species.

Generally, suitable spawning sites for salmonids occur in pool tail-outs, riffles and the transition areas from runs to riffles where the dominant substrate sizes range from small gravel to small cobble, fines (particles <2 mm) comprise <30% of the substrate, minimum water depths exceed 0.15 m, and velocities range from 0.3 to 1.0 m/s. Individual patches of gravel must be 1-2 m^2 to be considered as spawning habitat.

TABLE 3: SUBSTRATE CRITERIA

SUBSTRATE DEFINITIONS, CODES AND SIZE-RANGE CATEGORIES

CLASS NAME	SIZE RANGE	
	MM	INCHES
Clay/Silt	<0.06	<0.0024
Sand	0.06-2.0	0.0024-0.08
Small Gravel	2-8	0.08-0.3
Medium Gravel	8-32	0.3-1.3
Large Gravel	32-64	1.3-2.5
Small Cobble	64-128	2.5-5
Large Cobble	128-256	5-10
Small Boulder	256-762	10-30
Large Boulder	>762	>30
Bedrock	-	-

APPENDIX II

GOLDER FISH INVENTORY AND BIOMARKING METHOD

1. PURPOSE

This technical procedure establishes the methodology to be used for the standard sampling of fish. Because of the nature of fisheries work, decisions regarding the type of sampling gear to use and the timing of sampling will depend upon conditions in the field. The following methods are covered in this technical procedure:

- General Fisheries Work
- Biomarkers
- Organochlorine Contaminants Sampling
- Mixed Function Oxidase Sampling
- Sex Steroid Sampling
- Biomarker Number
- Field Records and Logbook
- Chain-of-Custody Form

2. APPLICABILITY

This technical procedure is applicable to all personnel involved in fish surveys.

3. DEFINITIONS

3.1 Ageing Structures

Parts of the fish which are taken for ageing analyses. These structures contain bands (annuli) which delineate seasonal variation in growth which can be counted. Primary examples of these structures are scales, fin rays, otoliths, eleithra and opercula. The appropriate ageing structures to collect vary according to fish species and lifestage and include lethal and non-lethal sampling measures.

3.2 Tagging

3.2.1 Anchor (Floy) Tagging

A practical and inexpensive method of permanently marking individual fish. The tag, shaped like an inverted "T", is most commonly inserted in the epipleural bones of the dorsal spine. The posterior of the tag is usually brightly coloured and carries a numeric identification code. This method is preferred when seeking angler return data to aid in establishing fish movements.

3.2.2 Visual Implant (VI) Tagging

A "micro-tag" method suitable for use when a tagging method is required which has minimal effects on the swimming and feeding efficiency of the fish. Good for tagging smaller fish than is possible with the anchor

tag method, such as small fish species or juvenile fish. Each tag consists of a small metal strip with an individual alpha-numeric code which is inserted using an injector into a clear tissue somewhere on the fishes body (i.e. post-ocular tissue for salmonids).

3.2.3 Batch Marking

A marking method which does not distinguish between individual fish. Common methods are fin clipping or dye marking.

3.3 Archive Samples

Extra samples which are taken and kept in storage for possible later analysis.

3.4 Bile

An alkaline secretion of the vertebrate liver, which is temporarily stored in the gall bladder. It is composed of organic salts, excretion products and bile pigment. It is responsible primarily for emulsifying fats in the small intestine.

3.5 Biomarker

Biomarker refers to a chemical, physiological or pathological measurement of exposure or effect in an individual organism from the laboratory or the field. Examples include: contaminants in liver enzymes; bile; sex steroids.

3.6 Chain-of-Custody Forms

Standardized forms which are used as a means of keeping close track of samples which are taken from the field and transported to laboratories for analysis. Whenever the samples are transported from the field, the custody is relinquished from the delivery person to the receiver by signatures on the forms. These forms substantially decrease the risk of losing samples because they provide a clear record of the chain of transport and handling of the samples.

3.7 Contaminants

A general term referring to any chemical compound added to a receiving environment in excess of natural concentrations. The term includes chemicals not generally regarded as "toxic", such as nutrients, colour and salts.

3.8 CPUE

Catch-Per-Unit-Effort. A measure which relates the catch of fish, with a particular type of gear, to the sampling effort expended; it is expressed as: number of fish captured/unit of effort. Results can be given for a particular species or the entire catch. CPUE is used to define species relative abundance and compare abundance between sites and/or seasons. Effort can be expressed a number of ways depending on

the sampling equipment. Some examples are time (sec/hr), area (m^3) and net length (m). If CPUE data is required, sampling effort must be recorded.

3.9 Effluent

A waste material discharged into the environment.

3.10 Effluent Plume

The portion of a water body exposed to discharge; the plume is delineated by tracking concentrations of compounds known to occur in the discharge. A plume ends when concentrations are equal to natural background levels or when they reach an arbitrary limit, for example 0.1%.

3.11 Electroshocking

The use of electricity to stun and capture fish. An electrical current is passed between electrodes placed in the water and attracts passing fish (galvanotaxis) toward the positive electrode (anode). Once fish pass close to the anode the current acts as a narcotic and stuns the fish (galvanonarcosis), allowing them to be easily netted. Once captured, the fish may be identified, weighed, measured, tagged and then returned to the water. Fish taken by electrofishing revive quickly when returned to the water. Effort is automatically recorded by the electrofishing unit as the number of seconds of active electrofishing (i.e. time current is applied to the water).

3.12 EROD

Ethoxyresorufin-O-deethylase. EROD is a laboratory technique that indirectly measures the presence of catalytic proteins that remove a CH_3CH_2-group from the substrate ethoxyresorufin. The substrate was chosen because of the fluorescent product formed is very easy to monitor in the laboratory. In the animal, various hydrophobic compounds can be transformed by this more polar products, which prepares them for eventual elimination from the body. Thus, this is a "detoxification" system that reduces the amounts of potentially harmful substances in the body. Cytochrome P4501A is the scientific designation of the dominant protein that carries out this catalytic function in fish and animals. EROD activity refers to the rate of deethylation and indirectly reflects the amount of protein present.

3.13 Fecundity

The most common measure of reproductive potential in fish. It is the total number of eggs in the ovary of a gravid female fish. Fecundity normally increases with the size of the female within a given species.

3.14 Forage Fish

A general term applied to smaller species of fish that "forage" on small invertebrate animals or plant materials.

3.15 Game Fish

Fish used by anglers for recreational fishing, e.g., northern pike, walleye.

3.16 Gillnetting

A method of capturing fish that involves the setting of nets of various mesh sizes (usually from about 2 to 10 cm) anchored in place in a river or lake. The nets function by catching on the gills of fish as they attempt to swim through. Effort should be recorded as the number of hours the net is set and expressed as either duration (hrs), panel-hours, or meter-hours, depending on the type and variety of nets set.

3.17 Gonads

Organs which are responsible for producing haploid reproductive cells in multicellular animals. In the male, these are the testes and in the female, the ovaries.

3.18 GSI

Gonad-Somatic Index. The proportion of reproductive tissue in the body of a fish. It is calculated by dividing the total weight of the gonad by the total body weight and multiplying the result by 100. It is used as an index of the proportion of growth allocated to reproductive tissues in relation to somatic growth.

3.19 LSI

Liver-Somatic Index. Ratio of liver versus total body weight. Expressed as a percentage of total body weight.

3.20 Lesions

Pathological change in body tissue.

3.21 m^3/s

Cubic metres per second. The standard measure of water flows in rivers, i.e., the volume of water in cubic metres that passes a given point in one second.

3.22 Necrosis

The death of a tissue due to injury or disease.

3.23 Reach

A reach is a relatively homogenous section of stream having repetitious sequence of assigned characteristics and habitat types. A reach is relatively uniform with respect to channel morphology, flow volume, gradient and habitat types and is separated from other reaches by changes in these characteristics.

Conventionally, reach numbers are assigned upstream ascending order starting from the mouth of the stream. Reach boundaries are identified using maps or air photos, then verified in the field.

3.24 Reference Site

A site used for comparison with a site exposed to the discharge being studied. Ideally, reference sites should be as similar as possible to the exposed site, but without the discharge.

3.25 Relative Abundance

The proportional representation of a species in a sample or a community.

3.26 Sampling Error

Sample inaccuracy caused by bias or imprecision in sampling; e.g., bias towards large fish because of the type of sampling gear. In statistics, sample error is expressed by the standard deviation, which expresses the variability of results around the mean.

3.27 Secondary Sex Characteristics

External physical characteristics displayed by fish, particularly during spawning season. Examples are tubercles on fins or body coloration.

3.28 Seine Netting

The use of a large, fine mesh net to catch fish from shallow (wadable) areas. The net is dragged along the bottom or through the water column to collect fish by straining them from the water. This technique is typically used to catch forage species, using fine mesh nets.

3.29 Set Lines

A series of leaders and baited hooks strung from one central line which is anchored to shore. Set lines are usually set out overnight to catch predatory fish..

3.30 Sex Determination (Lethal)

To determine the sex of a fish, an incision should be made on the ventral surface of the body from a point immediately anterior to the anus toward the head to a point immediately posterior to the pelvic fins exposing the gonads. If necessary, a second incision may be made on the left side of the fish from the initial point of the first incision toward the dorsal fin (USEPA, 1993). To observe the gonads, fold back the tissue. Ovaries appear whitish to greenish to orange and have a granular texture. Testes appear creamy white and have a smooth texture (Texas Water Commission, 1990).

3.31 Sex Determination (Non-Lethal)

For some species, sex may be determined from external secondary sexual characteristics, observable either during the spawning season (e.g. suckers - tubercles) or at any time of year (e.g. goldeye - anal fin morphology). For most fish species, sex can be determined during the spawning season by forcing extrusion of the sexual product (milt/roe)

3.32 Species Composition

A term that refers to the species found in the sampling area.

3.33 Species Distribution

Where the various species in an ecosystem are found at any given time. Species distribution varies with season and life history stage.

3.34 Standard Deviation

A measure of the variability or spread of the measurements about the mean. It is calculated as the positive square root of the variance.

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5. DISCUSSION

5.1 General Fisheries Survey

A combination of sampling techniques should be used according to river flow conditions lake morphometry, season, fish species and previous sampling success. These sampling techniques include: boat electroshocking, back-pack electroshocking, gillnetting, seine netting, set lines, minnow traps, fry traps, drift traps, underwater videos, counting fence and angling. However, only the sampling techniques specified for in the project fish collection permit are allowed. If a change in sampling techniques is deemed necessary, the Project Manager should be informed before altering planned fishing methods. Therefore, all techniques that may be required, including those in contingency plans, must be included in the request for a collection permit. Note: for targeting a specific species, the sampling gear used can be selective to minimize variance in fish size, thus reducing sample size and processing requirements.

For seine netting, gill netting, back-pack electroshocking, set lines and angling, the sample site should be described fully and a sketch map of the location provided in the field book. Sufficient detail on the site must be known to enable accurate assignment of grid coordinates. It is preferable to note the location on a topographical map directly when in the field. Some studies may require that sites be located by a Geographic Positioning System. Specific Work Instructions will note this requirement. Assign a code number for each sample site according to the main sites in the study area. For example, if gill net set #2 is within site 2, then code number would be #GS2-2. This code is to marked on the topographical map. For boat electroshocking, the reach (start point to end point of boat run) should be recorded on the map. For all sampling types, the effort set should be recorded. That is, the start and end times, using a 24 hour clock, for each individual effort and the number of fish caught during that effort. In addition, time of active electrofishing for each run should be recorded from the counter on the electrofishing unit. Moreover, all seine netting effort should be recorded by pacing or measuring the distance seined and recording the haul type (upstream or downstream). The dimensions (length/panel, depth, mesh size(s)) of all seine nets and gill nets used should be recorded.

At each site, supporting receiving environment measurements are to be taken and recorded. These measurements include: water temperature, pH, dissolved oxygen, conductivity, secchi reading and current weather conditions (e.g., cloud cover, air temperature, approximate wind speed, precipitation, etc.).

All fish that are captured should be identified to species, assigned a fish number, weighed (g), measured for length (mm), determined for life history stage (fry, juvenile, adult), sex (refer to Section 3.27) and sexual maturity (if possible), noted for abnormal external pathology (e.g., fin erosion, ulcers, skeletal anomalies, neoplasms) and aging structures taken. Ageing materials to be collected for each fish species are specified in MacKay et al. 1990. For field collections, refer to Table 2 for recommended ageing structures. Non-target species or specimens of target species that do not meet size requirements should be tagged if necessary (refer to Specific Work Instructions) and returned to the water. If required, tag fish with either Floy Tags, Visual Implant Tags or Dye Marks depending on age and size of fish. Fish should be identified to species by experienced crew members. Taxonomic keys appropriate for the sampling waters, should be reviewed. Any fish that cannot be identified in the field should be sacrificed and preserved in 10% neutral buffered formalin with the appropriate label showing date and location of capture. Collected fish should be marked on the data sheets as unidentified and collected and following identification, the data sheets should

be updated. For fish selected for biomarker processing, record time (24-hour clock) of capture. Large fish that are moribund or dead should be fully processed for biological data (sex maturity, internal pathology).

Standard abbreviation of fish species names is based on the following rules (MacKay et al. 1990):

a) use a four letter base abbreviation
b) for a one word name - use the first four letters
   e.g., GOLD for goldeye
c) two word names - use the first letter in each word plus the next consonant in each word
   e.g., ARGR for Arctic grayling,
   LKWH for lake whitefish, and,
   WHSC for white sucker
d) three word names - use the first letter in the first two words and the first letter and next consonant in the last word
   e.g., NRDC for northern redbelly dace

5.1.1 General Safety

Refer to Golder Associates Ltd. Safety Manual.

5.1.2 Electrofishing Safety

All crew leaders must be thoroughly familiar with electrofishing safety standards. All crew leaders must ensure that each crew member is instructed in safety requirements and complies with safety measures. Please refer to the Golder Safety Manual and Electrofishing Manual by the United States Department of the Interior, Fish and Wildlife Service, section on Electrical Safety and Electrofishing.

5.2 Fish Biomarkers Collection

Note: The full biomarker procedure may not be required for a particular project. Refer to the Specific Work Instructions for your project.

Preparation

1. All new personnel must read the protocol, have it demonstrated and then practice the procedures on at least 2 practice fish.

2. All dissecting instruments and aluminum foil (assuming no metal analysis samples to be taken) should be cleaned in a acetone wash followed by a hexane wash. Dirt and tissues should be removed from the instruments with organic-free water before the acetone/hexane wash. All dissecting equipment is to be wrapped in the washed foil.

3. Battery operated balances are to be checked daily. Level balance at work area and check calibration using standard weights. A vial, weigh paper; anything that has been weighed on a calibrated lab balance may be used. Shield from wind if necessary.

4. All biomarker data are to be recorded in waterproof field notebooks, Biomarker forms (Exhibit A), Internal and External Examination forms (Exhibit B and C).

5. All dissecting equipment, sample containers, sample wrapping and wash equipment must be shipped and stored in clean waterproof containers with leak-proof lids.

6. All solvents and preservatives required for field work must be packaged and labelled according to WHMIS and TDG regulations.

Sampling

1. Put on a clean pair of non-chlorinated, non-powdered latex examination gloves.

2. Select fish from holding facility. Only live fish are to be sampled. Excessive handling of fish and stress is to be avoided. *Any fish that has been held after capture for more than an hour must be rejected*, refer to time of capture. If necessary, fish can be marked with temporary tags for identification at time of capture. Ensure that the skin on the specimen has not been lacerated during sampling. If there has been laceration and loss of fluids, reject the specimen.

3. Assign a biomarker number to fish based on instructions in 5.7.

4. Take blood from fish via the caudal artery using a 10 cc syringe and an 18-21 gauge needle. Label and store blood on wet ice (4°). Within 24 hours, blood tubes are to be centrifuged for at least 10 minutes. Decant the resulting separated serum using a micro-pipette and placed in a 3-5 ml cryovial. Preserve samples on dry ice until shipment to a laboratory.

5. Sacrifice the fish with a blow to the head. Note sacrifice time (24 hour clock) on log sheet.

6. Weigh and measure the fish (to nearest gram and mm) and record results. Use fork length measurement except for species with no anal fin indentation which should be measured for total length.

7. Rinse the fish in ambient water to remove any foreign material from the external surface.

8. Place the fish on a piece of acetone/hexane washed foil on a clean cutting board.

9. Make an full incision just below the area between the left pectoral fin and midline. Carefully remove liver and gall bladder. Clamp bile duct with a hemostat. Separate gall bladder from liver. Weigh liver to nearest 0.1 gr., note colour and firmness and record. If analysing for Mixed Function Oxidase (MFO), quickly place liver on a small rectangle of washed foil, wrap, place label between folds of foil (no contact with liver) and freeze immediately in liquid nitrogen. If mincing of liver is required by Specific Work Instructions, rinse the liver first in 0.15 M KCl, mince, wrap in washed foil and then

freeze in liquid nitrogen (Hodson et al., 1991). **MFO analysis requires approximately 1.00 g liver, MFO samples must be taken within 2 - 5 minutes of sacrifice of fish. Samples not meeting this requirement must be rejected.** For species with diffuse livers (e.g., longnose sucker), quickly sample a representative portion of the liver from several locations along the intestine.. If analysing for organic contaminants (i.e., non-metal), quickly place liver on a small rectangle of washed foil, wrap, place label between folds of foil (no contact with liver), wrap with medical tape and label externally. Place sample in cooler of dry ice. NOTE: ANY PORTIONS OF LIVER FOR CONTAMINANTS ANALYSIS WHICH COME IN CONTACT WITH BILE FROM A RUPTURED GALL BLADDER SHOULD BE RINSED WITH 0.15 KCl. Remove bile from gall bladder with a 5 ml syringe and a 27-28 gauge needle. Note and record bile volume and colour on biomarker form. Place bile sample in a labelled 5 ml cryovial and store on dry ice.

10. Complete external examination and record on external examination form.

11. **REFER TO SPECIFIC WORK INSTRUCTIONS FOR PROJECT APPLICABLE PROCEDURES.**

For individual fillet contaminant samples: remove approximately two 100 g fillets with a filleting knife that has been washed in acetone/hexane. Remove skin from fillets and ensure that no part of the fillet touches a surface that has not been washed in acetone/hexane. Place each fillet on a piece of washed foil and record weight. Wrap each fillet in the washed foil, insert label between folds of foil taking care not to touch the fillet. Securely tape a label onto the foil, make sure that one fillet per fish is labelled as an archive sample for possible later analysis. Place one fillet sample from each fish in a cooler with dry ice and store there until shipment to a lab. Place the archive fillet sample per fish in a cooler with dry ice clearly marked "archive samples or QC samples". Note: an alternative packaging for contaminant samples is organic-free plastic bags.

For samples taken for metals analysis: take care that the tissues designated as metal samples are dissected on a glass (preferably) or washable plastic surface, rather than on the foil. Dissecting instruments and knives used to take samples for metals analysis should be made of quartz, PTFE, ceramic, polypropylene or polyethylene. Stainless steel dissecting instruments are made predominantly of chromium and nickel. If these metals are not of concern, the use of high-quality, corrosion-resistant stainless steel sample processing is acceptable (USEPA 1993). Knives with titanium blades and PTFE handles are recommended for performing tissue resections (Lowenstien and Young 1986, USEPA 1993). For fillets, it is recommended that the fillet destined for organics analysis be taken first on the washed foil. Then the fish should be transferred to a plastic dissection surface and the fillet for metals taken. The fillet for metals must be placed in a plastic bag. If other organs are also being taken for contaminants analysis (e.g. liver, kidney) special care will have to be taken to isolate the section of the organ to be used for organics and take it while still on foil and then carefully remove the other section of the organ without contacting foil. ALL SAMPLES TO BE ANALYSED FOR METALS MUST BE PLACED IN PLASTIC BAGS, NOT FOIL. Utensils and containers should be cleaned thoroughly with a detergent solution, rinsed with tap water, soaked in acid, and then rinsed with metal-free water. Quartz, PTFE, glass, or plastic containers should be soaked in 50% HNO_3 for 12 to 24 hours at room temperature (USEPA 1993). **Chromic acid should not be used for cleaning any materials.** A

minimum of regeant grade acids should be used. Stainless steel parts may be cleaned as stated for glass or plastic, omitting the acid soaking step (Stober 1991, USEPA 1993).

NOTE: THE SAMPLE MUST NOT THAW ONCE FROZEN. ONCE FROZEN, PROTECT SAMPLE INTEGRITY BY ENSURING ADEQUATE ICE LEVELS IN COOLER AND THEN TAKE MEASURES TO EXPEDITE SHIPPING TO THE ANALYTICAL LABORATORY.

For composite fillet contaminant samples: remove approximately two 100 g fillets with a filleting knife that has been washed in acetone/hexane. Remove skin from fillets and ensure that no part of the fillet touches a surface that has not been washed in acetone/hexane. Place each fillet on a piece of washed foil and record weight. Wrap each fillet in the washed foil, insert label between folds of foil taking care not to touch the fillet). Place one wrapped fillet per fish into a plastic "zip-loc" bag and then place the Zip-loc bag into a large plastic bag that will hold all the specimens to be made into the composite. Put a "composite identification label" on the large plastic bag with tape or string. Place the other wrapped fillet per fish into a zip-loc bag and place into another large plastic bag that will hold all of the specimens to be archived for possible individual identification or QC analysis. Place an "archive sample label" on the large plastic bag with tape or string and store on dry ice until shipment. Note: only fillets from same species may make up a composite sample.

NOTE: IF SAMPLES ARE FOR ANALYSIS OF METALS, THEY MUST BE PLACED IN PLASTIC BAGS, NEVER WRAP METALS SAMPLES IN FOIL

NOTE: THE SAMPLE MUST NOT THAW ONCE FROZEN. ONCE FROZEN, PROTECT SAMPLE INTEGRITY BY ENSURING ADEQUATE ICE LEVELS IN COOLER AND THEN TAKE MEASURES TO EXPEDITE SHIPPING TO THE ANALYTICAL LABORATORY.

For composite internal organ contaminant samples: composite homogenates should be prepared from equal weights of individual homogenates (internal organ). The same type of homogenate should always be used in a given composite sample (USEPA 1993). Remove homogenate sample and any associated liquid using a washed scalpel or dissecting scissors. Divide into two 100 g samples (if sample is large enough). Ensure that no part of the sample touches a surface that has not been washed in acetone/hexane. Place each sample on a piece of washed foil and record weight. Wrap each sample in the washed foil, insert label between folds of foil taking care not to touch the fillet). Place one wrapped sample per fish into a plastic "zip-loc" bag and then place the Zip-loc bag into a large plastic bag that will hold all the specimens to be made into the composite. Put a "composite identification label" on the large plastic bag with tape or string. Place the other wrapped fillet per fish into a zip-loc bag and place into another large plastic bag that will hold all of the specimens to be archived for possible individual identification or QC analysis. Place an "archive sample label" on the large plastic bag with tape or string and store on dry ice until shipment.

NOTE: SAMPLES TO BE ANALYSED FOR METALS MUST BE PLACED IN PLASTIC BAGS; NEVER WRAP METALS SAMPLES IN FOIL.

NOTE: THE SAMPLE MUST NOT THAW ONCE FROZEN. ONCE FROZEN, PROTECT SAMPLE INTEGRITY BY ENSURING ADEQUATE ICE LEVELS IN COOLER AND THEN TAKE MEASURES TO EXPEDITE SHIPPING TO THE ANALYTICAL LABORATORY.

For whole fish contaminant samples to be later resected in the laboratory: each fish should be individually wrapped in extra heavy duty wash aluminum foil. Spines on fish should be sheared to minimize punctures in the aluminum foil packaging (Stober, 1991). The sample identification label should be taped to the outside of the package, each individual fish should be placed into a waterproof plastic bag and sealed. The Chain-of-Custody form should be attached to the outside of the plastic bag with string or tape. Note: for specimens making up a composite sample, keep all composite sample specimens together (if possible) in the same shipping container for transport. Once packaged, samples should be cooled on wet ice or blue ice immediately. Samples are to be shipped to the processing laboratory within 24 hours (Smith 1985; USEPA, 1990d). If the shipping time to the laboratory is to exceed 24 hours, dry ice should be used. Note: if analyses will include edible tissue, freezing may cause internal organs to rupture and contaminate fillets or other edible tissues (Stober, 1991, USEPA 1986b).

12. Examine and record the internal condition of the fish on the Internal Examination Form. Preserve any abnormal tissues in 10% neutral, buffered formalin for later histopath analysis. Ensure that histopath samples contain both internal labels (waterproof paper and pencil) and external labels. Record tissues taken on the internal examination sheet as well as in field notebook.

13. Examine gonad, remove and weigh to nearest 0.1 g. Note sex (refer to Section 3.27) and assign maturity rating (refer to Table 1 for maturity codes). If there is uncertainty regarding the maturity code to assign, take a section of the gonad (mid-section) and preserve it in 10% buffered formalin for later examination in the laboratory. If collecting for fecundity and egg diameters, then remove 1 gram of eggs from the midregion of the ovary and place them in round histology cassettes that are lined with foil. Tare the balance to the weight of any empty cassette and then weigh the samples. Label the cassette. A minimum of 50% of the total sample size per species per site must have fresh measurements of egg diameter. Measure 30 individual fresh eggs/female using a micrometer for egg diameter. Record, label and store each egg individually in a histology cassette with 10% neutral, buffered formalin. After the minimum sample size for fresh measurements has been reached, store 30 eggs/female together in a histology cassette with 10% neutral, buffered formalin for analysis at the lab. At the lab, the individual eggs measured fresh in the field will be remeasured and calculated for % shrinkage. The % shrinkage will be used to correct measurement of the samples that were not measured fresh in the field. Volumetric determinations of egg size are made by counting 100 eggs and placing in a graduated cylinder with a pre-measured volume of water. Measure the new volume after the eggs have been added and record. Eg. Pre-volume = 5 ml. Volume with eggs = 5.5 ml. Volume of eggs = 0.5 ml. Precision of volumetric measurements will be dependent upon the graduated cylinder used. NOTE: The precision required for volumetric measurements of egg size in Environmental Effects Monitoring studies is $\pm$ 1%. (E.g. if a 10-ml cylinder is used, measurements are expected to be precise to 0.1 ml. This may not be achievable with 100 very small eggs. If not achievable, make note in the field notes and record the actual precision - e.g. 0.5 ml).

14. Observe and record qualitative stomach contents on internal examination form. Qualitative measurement of stomach contents is to be done by estimating the % of total volume of contents taken up by each food item. Be as specific as possible. For example, mayflies, stoneflies, caddisflies, water boatmen, water striders, beetles, not just "insects". Include % sediment or detritus and % plant material. Identify fish to species if possible, e.g., longnose sucker. Identify amphibian, bird or mammal prey as accurately as possible.

15. Collect two different ageing structure materials (i.e., scales, pectoral fin ray, otoliths) as per species requirements in Table 2, unless otherwise specified in the Specific Work Instructions. Place ageing materials in an "ageing materials" envelope and label.

16. Discard the remains of the specimen into a sealed bag for later disposal at a landfill. Discard latex gloves.

17. Rinse off cutting board with ambient water. Put on a clean pair of latex gloves and place a fresh piece of washed foil on the board. Proceed to the next fish.

    NOTE: IF YOU ARE COLLECTING CONTAMINANT SAMPLES, USE A FRESH FILLETING KNIFE AND DISSECTING EQUIPMENT FOR EACH FISH. FRESH SYRINGES MUST ALSO BE USED FOR EACH BILE AND BLOOD SAMPLE.

18. Once all samples have been taken from one site, ensure adequate ice levels in the cooler, attach a Chain-of-Custody (Exhibit D) to the inside lid of the cooler and then seal the cooler using duct tape. Do not mix samples from different sites in one cooler.

19. All used "sharp" dissecting/sampling equipment (needles, scalpel blades, etc.) must be placed in a designated "sharps" disposal container.

5.3 Field Recordkeeping

For proper interpretation of field survey results, thorough documentation of all field sample collection and processing activities is required. All logbooks should be perfect-bound and waterproof, forms should be preprinted on waterproof paper, and only indelible ink and pencil (if form or paper is wet) should be used.

To document field activities, sample identification labels, Chain-of-Custody forms, field logbooks, biomarker form, internal/external examination forms, catch records (Exhibit E) and fish sample records (Exhibit F) should be used. This will serve as an overall "Chain-of-Custody" documenting all field samples and field events beginning with sample collection through biomarker processing and preservation and shipment to the laboratory.

5.3.1 Sample Identification Label

Individual Contaminant Samples

All individual samples must be labelled. Each label must be completed in indelible ink for each sample. For contaminant samples, the following information must be included on the label:

Project number
Collecting Agency or Firm-Golder
Sampler (name)
Biomarker number
Length/weight of specimen
Sampling date/time (24 hour clock)
Sample type: F = fillet, W = whole, ungutted, L = liver, B = bile, G = gonad, S = stomach, K = kidney.
Time-frame for analysis - immediate or archive

A completed sample identification label must be taped securely onto each foil-wrapped or bagged sample.

Composite Contaminant Samples

All composite samples must be labelled. Each label must be completed in indelible ink for each sample. For contaminant samples, the following information must be included on the label:

Project number
Collecting agency or firm
Sampling date/time (24 hour clock)
Sample Site
Sampler (name and signature)
Composite number
Species abbreviation
Sample type: F = fillet, W = whole, ungutted, L = liver, B = bile, G = gonad, S = stomach, K = kidney.
Chemical analysis requested - or refer to an accompanying Chain-of-Custody Form or Analysis Request Form
Time-frame for analysis - immediate or archive

A completed sample identification label must be taped securely onto each foil-wrapped or bagged sample. An additional label identifying the composite sample must be placed on each plastic bag containing the foil-wrapped or bagged samples. The same type of label may also be used for archive samples; simply indicate on the label that the samples are to be archived.

MFO's, Blood and Bile Samples

All MFO, blood and bile samples must be labelled. Each label must be completed in indelible ink for each sample. For MFO, blood and bile samples, the following information must be included on the label:

Biomarker number
Sampling date/time (24 hour clock)

Then place a label on outside of the dewar, bag or cooler containing several bile, blood or MFO samples and including the following information on the label:

Project number
Collecting agency or firm
Sampler (name)
Time frame for analysis - immediate or archive
General sample type (eg., bile, liver, etc.)

Histopathology and Egg Samples

All histopathology and egg samples must be labelled. Each label must be completed in indelible ink for each sample. For histopathological and egg samples, the following information must be included on the label:

Project number
Sampling date/time (24 hour clock)
Biomarker number
Tissue type:

O = ovary	T = testes
L = liver	S = spleen
H = heart	K = kidney
G = gill	I = intestine
ST = stomach	SK = skin
F = fin	AB = air bladder

An additional label must be placed on the jar or plastic bag identifying the several cassettes or jars of preserved specimens contained within. The label must include the following:

Project number
Collecting agency or firm
Sampler (name)
Time frame for analysis - immediate or archive
General sample type (eg., eggs for fecundity, histopathology samples)

NOTE: THE USE OF PRE-PRINTED LABELS IS STRONGLY ENCOURAGED.

5.4 Chain-of-Custody Form

Sample possession and proper handling of samples must be traceable from the time of sample collection, through laboratory and data analysis. A Golder Chain-of-Custody form must be completed and signed in indelible ink for each shipping container (e.g. ice cooler) used. Prior to sealing the cooler, two copies of the

Chain-of-Custody form must be sealed in a plastic bag and taped to the inside cover of the cooler. Ensure that the carrier responsible for delivering the samples also signs and dates all Chain-of-Custody forms.

5.5 Field Records and Logbook

All pertinent information on field activities and sampling efforts must be recorded in an appropriate (i.e., waterproof) bound logbook. The field crew leader is responsible for ensuring that sufficient detail is recorded in the logbook. The logbook must be complete enough to enable someone unfamiliar with the project to completely reconstruct field activity without relying on the memory of the field crew. All entries must be made in indelible ink, with each page numbered, signed and dated by the author, and a line drawn through the remainder of any partly used page. All corrections are made by a single-line cross-out of the error, entering the correct information, dating and initialing the change. Upon return to the office, all field notes must be photocopied and placed in the appropriate project files.

Entries in the field logbook must include:

- Purpose of proposed sampling effort.
- Date and time (24 hour clock) of sampling.
- Names of field crew leader and team members.
- Description of each sampling site, including information on any photographs that may be taken.
- Location of each sampling site, name and number, applicable navigational coordinates, waterbody name/segment number.
- Details of sampling method and effort, particularly deviations from Specific Work Instructions.
- Clear identification of site names and sample numbers.
- Field observations.
- Field measurements taken (e.g., pH, temperature, flow, dissolved oxygen, secchi, weather conditions).
- Sample shipping information.

The field logbook should also be used to document any additional information on sample collection activities, hydrologic conditions, boat or equipment operations, or any unusual activities observed or problems encountered that would be useful to the project manager when evaluating the quality of the monitoring data.

A biomarker logbook should also be kept. All pertinent information on fish biomarkers must be recorded in an appropriate (i.e., waterproof) bound logbook. The field crew leader is responsible for ensuring that sufficient detail is recorded in the logbook. The logbook must be complete enough to enable someone unfamiliar with the project to completely reconstruct fish biomarker field activity without relying on the memory of the field crew. All entries must be made in indelible ink, with each page numbered, signed and dated by the author, and a line drawn through the remainder of any partly used page. All corrections are made by a single-line cross-out of the error, entering the correct information, dating and initialing the

change. Upon return to the office, all field logbooks and notes must be photocopied and placed in the appropriate project files.

Entries in the fish biomarker field logbook must include:

- Date and time (24 hour clock) of sampling.
- Names of field crew leader and team members.
- Site name and number.
- Secchi, water temperature, conductivity,
- Fish number and Biomarker number.
- Capture time/sacrifice time (24 hour clock)
- Length/ Total Weight.
- Sex and stage
- Liver: total weight, sample weights, sample time (24 hour clock), canister storage number, colour
- Fillet: sample weights
- Bile: color, volume, canister storage number
- Gonads: total weight (testes or ovaries), egg weights, total fecundity count
- Abnormal tissues collected and preserved
- Ageing structures collected

Biomarker Forms, Catch Records, Fish Sample Records, External/Internal Examination Forms and Photo-Log Sheets are to be filled out, dated and signed. All forms should be cross-referenced to the appropriate field record via the fish number and/or composite number.

5.6 Fish Biomarker Number

All fish that are selected for biomarker analysis are to be given an individual biomarker number. This number is to be recorded on all individual sample labels. The biomarker number is an unique number which identifies the fish by project, species type, site, season and year.

The following format is to be used for biomarker numbering:

e.g.,

WLD	95	P	2A	LNSC	013
Project	Year	Season	Site	Species	Fish No.

Project - a unique 3 character code relating to the project.
Year - use the last two numbers of the year e.g., 1986 = 86.
Season - a one character code relating to season.

P - Spring
U - Summer
F - Fall
W - Winter

Site - a one or two alphanumeric code relating to the site the sample was caught.
Species - a four character abbreviation for species, see Section 5.1.
Fish No. - a three digit consecutive number. Individual numbering scheme for each species are to be used.

NOTE: THIS LABELLING SCHEME MAY BE SUPERCEDED BY LABELLING REQUIREMENTS SPECIFIC TO A PROJECT. HOWEVER, A SPECIAL LABELLING SCHEME MAY ONLY BE USED AT THE AUTHORIZATION OF THE PROJECT MANAGER AND QA OFFICER.

5.7 Shipping of Samples

Samples are to be shipped by the fastest possible means to the analytical laboratory. The primary QA consideration in shipping samples is protecting sample integrity. Preserve sample integrity by ensuring adequate ice levels in coolers before shipment to laboratory. Coolers are to remain sealed throughout shipment. Weigh-bill numbers are to be noted on the copies of the Chain-of-Custody form retained after sealing the coolers. Each transfer of custody is to be noted and signed for. The coolers should be labelled as Perishable/Keep Cold/Time-Sensitive. Clearly indicate the analytical laboratory address as well as a Golder contact person and phone number. The crew leader is to telephone the processing laboratory and inform them of the upcoming delivery. The crew leader is also required to phone the processing laboratory to confirm arrival of the shipment and that analysis instructions are clear.

5.8 Procedure Alteration Checklist

Variations from the established procedure requirements may be necessary due to unique circumstances in the field. All variations from established procedures shall be documented on Procedure Alteration Checklists (Exhibit G) and reviewed by the Project Manager and the QA Manager.

The Project Manager may authorize the individual Field Crew Members to initiate variations as necessary. If practical, the request for variations shall be reviewed by the Project Manager and the QA Manager prior to implementation. If prior review is not possible, the variation may be implemented at the direction of the Field Biologist, provided that the Project Manager is notified of the variation within 24 hours of implementation and the Procedure Alteration Checklist is forwarded to the Project Manager and the QA Manager for review within 2 working days of implementation. If the variation is unacceptable to either reviewer, the activity shall be repeated or action shall be taken as indicated in the Comments section of the checklist.

All completed Procedure Alterations Checklists shall be maintained in project records.

6. RESPONSIBILITY

All aquatic field crew members engaged in conducting fish inventories or fish biomarking studies are responsible for compliance with this procedure.

7. EQUIPMENT AND MATERIALS

Boat supplies
Fuel supply (primary and auxiliary supply)
Spare parts repair kit
Life preservers
First aid kit (including emergency phone numbers of local hospitals, family contacts for each crew member)
Spare paddles
Spare key
Floater Coats
Topographical maps of sampling sites
Flagging material
Tool box
Electrical tape
Water pump

Collection Equipment
Seine nets
Electroshocking device (boat and/or backpack unit)
Gill nets (if required)
Rubber gloves
Dip nets
Fish tubs (if required)

Recordkeeping
Field logbook (perfect-bound, waterproof)
Labels
Chain-of-Custody forms
Fish Sample Records
Unique Catch Records (boat, backpack, gillnet, seine net, etc.)
Indelible pens
Pencils
Applicable MSDS sheets and TGD placards

Biomarking Equipment (to be stored in waterproof, sealable equipment containers)
Specific Work Instructions
20 Litre pails for transfer and holding of fish
Fish measuring board (metric)
Balance (metric), calibration weights, balance levels and 9 volt batteries
Stainless steel forceps
Stainless steel filleting knives
Stainless steel dissecting scissors
Stainless steel scalpels
Stainless steel scalpel blades
Centrifuge (if taking blood samples)

Small whirlpacks
Nalgene bottles or small jars for pathology samples
Histology cassettes
Hemostats for clamping off gall bladder
5 ml Cryovials
Blood tubes
Tube rack
Paper towels
0.15 M KCl
Non-chlorinated, non-powdered latex surgical gloves
Aluminum foil (extra heavy duty)
10 ml syringe
18 g needle
5 ml syringe
27 g needle
Pipettes (if taking blood smears or serum samples)
Pipette Bulbs
Goggles for Liquid Nitrogen handling
Gloves for handling dewar racks (to prevent burns from Liquid Nitrogen)
"Sharps" disposal containers
Wash-tubs for field-washing of dissecting equipment in acetone/hexane
Used acetone/hexane containers
Cutting boards (washable)
Fish bonker
Folding tables (for biomarking stations)
Biomarker tent
Teflon wash bottle with distilled water
Medical tape
String
Several sizes of plastic bags including garbage bags
Cage material for holding fish in situ, if live-wells or fish tubs not available or too small

Sample preservation and shipping supplies
Ice (wet ice and/or dry ice)
Dewar (charged with liquid nitrogen if taking MFO samples)
Dry shipper (if taking MFO samples)
10% neutral buffered formalin
0.15% KCl
Scale envelopes
Ice chests
Duct tape
Clear shipping tape for Chain-of-Custody forms
Pesticide grade Hexane
Acetone
Pre-printed labels

Addendum to Golder Technical Protocol TP8-1

Instructions for making a composite fish fillet sample

1) All fish fillet samples for each composite will be placed in a labelled bag. The bag containing the samples to be composited will be labelled in indelible ink with the following information:

- name of the composite
- type of sample (i.e. bile, fillet etc.)
- project number
- name of the collecting company (i.e. Golder)
- analysis requested

2) Upon arrival at the laboratory all samples should be kept in the labelled bag and returned to it upon completion of preparation of the composite

For fish fillets the following procedure should be used to prepare the composite:

- unwrap the individual samples that are to form one composite
- take a portion of fillet from each individual sample to use in the composite
- make sure to retain a portion of each individual sample and rewrap it
- the remaining portion of each individual sample should be returned to the labelled composite bag and archived (frozen to -25° C)

For bile samples the following procedure should be used to prepare the composite:

- take a small amount of bile from each cryovial that is to form part of the composite
- if possible, leave some of the bile in each cryovial to be archived for future analysis. In some circumstances when the volume of bile is small (< 0.1 ml), the whole sample may have to be used
- the remaining portion of each individual sample should be returned to the labelled composite bag and archived (frozen to -25° C)

For serum samples the following procedure should be used to prepare the composite:

- take a small amount of serum from each cryovial that is to form part of the composite
- leave some of the serum in each cryovial to be archived for future analysis
- each remaining portion of the individual samples should be returned to the labelled composite bag and archived (frozen to -25° C)

SPECIAL INSTRUCTION TO ETL FOR COMPOSITES OF LIVERS

For liver samples from Golder project 952-2308 (Syncrude/Aquatic Baseline/Ft. McMurray) presently archived by Environ-test in liquid nitrogen:

- remove individual samples that are to form part of the composite sample from liquid nitrogen
- unwrap individual samples that are specified on the Analytical Request forms to be used in the composites
- cut the individual livers in half and retain half of the liver for the required analysis
- re-wrap each individual sample and place in liquid nitrogen
- further instructions will be sent to you shortly regarding shipment of these archived samples to another laboratory