Canada Alberta Northwest Territories

Northern River Basins Study















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R.L.&L. Environmental Services Ltd.

NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 2

BENTHOS AND BOTTOM SEDIMENT FIELD COLLECTIONS UPPER ATHABASCA RIVER APRIL TO MAY, 1992

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PREFACE:

The Northern River Basins Study was initiated through the "Canada-Alberta-Northwest Territories Agreement Respecting the Peace-Athabasca-Slave River Basin Study, Phase II - Technical Studies" which was signed September 27, 1991. The purpose of the Study is to understand and characterize the cumulative effects of development on the water and aquatic environment of the Study Area by coordinating with existing programs and undertaking appropriate new technical studies.

This publication reports the method and findings of one project of many that were conducted as part of the Northern River Basins Study. As such, the project was governed by a specific terms of reference and is expected to contribute information about the Study Area within the context of the overall study as described by the Study Final Report. This project report has been reviewed by the Study Science Advisory Committee in regards to scientific content and has been approved by the Study Board of Directors for public release.

It is explicit in the objectives of the Study to report the results of technical work regularly to the public. This objective is served by distributing project reports to an extensive network of libraries, agencies, organizations and interested individuals and by granting universal permission to reproduce the material.

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SECTION 1.0
INTRODUCTION

The growing demand for supply and use of new chemicals in the industrialized society during the twentieth century has placed increasing stress on the natural environment (Jaffé 1991). Diverse contaminants (organic compounds and metals) enter the environment through industrial discharges and other anthropogenic activities. The toxicological characteristics and the ability of contaminants to accumulate in the environment are of particular concern. Indeed, many models explaining bioaccumulation (the ability of a living organism to concentrate, accumulate, and magnify a contaminant within it, either directly from surrounding medium or indirectly through the food chain; Bruggeman 1982) in aquatic systems have been developed (e.g., Norstrom *et al.* 1976, Thomann and Connolly 1984; Swackhammer and Hites 1988; Connolly and Pedersen 1988).

The objective of this pilot project was to obtain samples of benthic aquatic macroinvertebrates, epilithon (algae, bacteria and fungi that cover stones in aquatic systems) and sediments from six sites in the Athabasca River. These samples will be analyzed for organic contaminant (e.g., dioxins, furans, chlorophenols, and PCBs), resin acids, metals (e.g., arsenic, vanadium, copper, chromium, lead, zinc, and methyl mercury) and stable isotopes (e.g., carbon, nitrogen, sulphur). Quantitative samples of aquatic invertebrates were also collected to document differences among sites in species composition, numeric density and other relevant population or community characteristics. Biomass data from quantitative samples will also be used to assess contaminant loads in aquatic invertebrates from the Athabasca River.

This data report identifies and describes all field sampling, methodologies, observations, schedules and lists all sample sites and samples delivered to Northern Rivers Basins Study. Also included are recommendations that outline problems and solutions for further field studies of this kind.

SECTION 2.0
METHODS

2.1 FIELD COLLECTION SITES

Six benthic sampling sites were established on the Athabasca River; they were situated both upstream and at varying distances downstream of the Weldwood Pulp Mill and the Town of Hinton's combined effluent (HCE) discharge structure. Sites were located on the right (looking downstream) bank of the Athabasca River. They corresponded approximately to the location of sample sites 1,2, 3, 4, and 6 described in the Northern River Basins Study schedule of Terms of Reference. Due to access problems, Site 5 was located about 22 km downstream of the location described in the Terms of Reference. The sampling sites were as follows:

Site 1 (Control, near Entrance)

Located on the south side of the river, approximately 2.2 km downstream of Hwy. 40 crossing on the Athabasca River and approximately 0.2 km upstream of the confluence with Maskuta Creek. The purpose of this site was to provide reference data from areas not impacted by discharges from HCE.

Site 2 (Weldwood Haul Road Bridge)

Located approximately 1.0 km downstream of HCE discharge point, near bank and immediately downstream of the bridge.

Site 3 (Obed Mountain Coal Bridge)

Located approximately 20 km downstream of HCE discharge point. All sampling was near bank and upstream of the bridge.

Site 4 (Emerson Lakes Road Bridge)

Located approximately 50 km downstream of HCE discharge point. All sampling was near bank and varied from 0.5 to 1.5 km upstream of the bridge.

Site 5 (Knight Bridge)

Located approximately 120 km downstream of HCE discharge point. Sampling was near bank and on the south bank of an island approximately 200 m upstream of the bridge.

Site 6 (Windfall Bridge)

Located approximately 160 km downstream of HCE discharge point. Sampling for epilithon and erosional macroinvertebrates was approximately 200 m downstream of the bridge. All depositional habitat samples were collected approximately 4 km upstream of the bridge.

Two sampling surveys were carried out, both were prior to the spring freshet. Benthic invertebrates, epilithon and sediments were collected during the first survey, only depositional sediments were collected during the second survey. The initial survey was conducted from 7 to 14 April 1992 and the second sampling event occurred on 13 and 14 May 1992. Discharge at Hinton (River Forecast Centre, Alberta Environment) was approximately 43 - 50 m^3/s and 178 - 203 m^3/s during the first and second sampling trips, respectively. At Windfall, discharge was approximately 91 - 114 m^3/s and 290 - 307 m^3/s during the first and second surveys, respectively. Ice break-up occurred on or about 4 March 1992 at Hinton and on or about 3 April 1992 at Windfall (River Forecast Centre, Alberta Environment).

2.2 TRACE CONTAMINANT SAMPLING

2.2.1 HANDLING AND QUALITY CONTROL

The following collection and handling procedures were taken to avoid contamination of samples.

1. To avoid contamination of stable isotope samples, liquids high in nitrogen, carbon or sulphur were not used.

2. All equipment that came in contact with the samples for trace organic contaminants was first rinsed in ultra-pure acetone, then in ultra-pure (pesticide grade) hexane.

3. All equipment that came in contact with the samples for trace metal analysis was soaked in a 10% acid bath made of reagent grade HCL.

4. Aluminum foil was baked at 350°C for 6 to 12 h before being used to line lids and protect equipment.

5. Metal, Teflon® or glass equipment was used for trace organic contaminant samples; plastic, Teflon® or glass equipment was used for trace metal samples.

6. All equipment was thoroughly cleaned between sites. This included scrubbing all organic debris off of the barrier mesh equipment prior to washing in acid (for metals) or rinsing with acetone and hexane (for organics).

7. All samples were stored in clean containers (glass jars with lids lined with treated aluminum foil for organic and stable isotope analyses; Teflon® coated or plastic containers for metals). **N.B.** Amber glass jars were not available in time for the scheduled field trip. Therefore, clear glass jars were used; precautions were taken to keep these samples out of direct light (e.g., placed in a box/cooler).

8. Precautions were taken so that samples were not contaminated during sampling or sample preparation. Combustion exhaust from running motors, smoke, dust, paper products, etc. were avoided.

9. Blank (fish) tissue samples were provided by the Northern River Basins Study and subjected to routine handling procedures.

10. Additional sets (duplicates) of all types of samples were collected from various sites.

11. All residual chemical solutions (i.e., acetone, hexane, acid) were collected, stored and disposed of in a manner consistent with the Alberta Occupational Health and Safety Act.

Analytical laboratories required the following minimum amounts for tissue analyses:

Trace organic contaminants:	
- dioxins and furans:	10 g wet weight
- chlorophenols:	5 g wet weight
- PAHs, PCBs, resin acids:	10 g wet weight
Trace metals:	5 g wet weight
Stable isotopes:	2 g wet weight

2.2.2 COLLECTION OF MACROINVERTEBRATE TISSUE

Macroinvertebrate tissue samples for trace contaminant analyses were collected from erosional habitats (Table 2.1). Originally, four taxa were to be sampled (chironomids, ephemeropterans, plecopterans and trichopterans). However, midges (Chironomidae) were not present in sufficient numbers and biomass to warrant sampling. Caddisfly (Trichoptera) and mayfly (Ephemeroptera) densities varied among sites. Thus, a full complement of wet weights required for contaminant analyses was not collected for these taxa at all sites. Stonefly (Plecoptera) larvae were abundant at all sites, thus, a complete complement of contaminant samples was collected for this taxon. Although some brachycentrid caddisflies were present, only hydropsychids were collected.

Trace Organic Contaminants and Stable Isotope Sampling Methods

To collect invertebrate tissue samples, a coarse mesh (1.5 mm) barrier net (metal mesh fastened between two wooden dowels) was used. The barrier was positioned downstream of a person overturning stones with their feet. Dislodged animals were swept by the river current into the barrier mesh (same principle as a kick net). This method was most effective when two people were collecting invertebrates. One person disturbed the substrate and gathered animals off the mesh while a second person held the mesh barrier in place. Animals were transferred from the mesh to a small glass jar containing some river water, and subsequently into a glass tray where they were sorted into taxonomic groups and separated from organic debris and fine sediments. Samples were then placed in appropriately prepared containers (scintillation vials that had lids lined with treated aluminum foil), fully labelled and frozen on dry ice immediately after collection. Teflon® coated forceps were used to transfer specimens among sampling equipment/containers. Samples were kept frozen at all times. Labels on containers displayed the following information: river, site, taxon, date, number of replicate, wet weight in grams, and type of analysis (i.e., dioxins and furans, chlorophenols, etc.).

In addition, a representative sub-sample of approximately 10-20 organisms from each taxonomic group was collected for identification at each site except Site 1. At Site 1, a composite of 3 kick net samples was placed in a 1-L jar. These samples were preserved in 4% formaldehyde and labelled appropriately.

Table 2.1 Summary of benthic invertebrate trace contaminant tissue samples collected from the Athabasca River in 1992.

SITE	DATE COLLECTED	TAXON	APPROX. WET WEIGHT COLLECTED (g)	CONTAMINANT ANALYSIS*
Site 1 Near Entrance (Control)	08&09 April	Plecoptera	10	Dioxins & Furans
		Plecoptera	2	Isotopes
		Plecoptera	5	Chlorophenols
		Plecoptera	5	PAHs/PCBs/etc.
		Plecoptera	5	Metals
		Trichoptera	2	Dioxins & Furans
		Trichoptera	<1	Isotopes**
		Ephemeroptera	9	Dioxins & Furans
		Ephemeroptera	2	Isotopes
		Ephemeroptera	4	Chlorophenols
		Ephemeroptera	3	Chlorophenols
		Ephemeroptera	4	Metals
Site 2 Weldwood Bridge	09 April	Plecoptera	10	Dioxins & Furans
		Plecoptera	3	Isotopes
		Plecoptera	5	Chlorophenols
		Plecoptera	10	PAHs/PCBs/etc. (Rep. 1)
		Plecoptera	5	PAHs/PCBs/etc. (Rep. 2)
		Plecoptera	12	Metals
		Trichoptera	10	Dioxins & Furans
		Trichoptera	3	Isotopes
		Trichoptera	2	Metals
		Ephemeroptera	10	Dioxins & Furans
		Ephemeroptera	6	Isotopes
		Ephemeroptera	11	Chlorophenols
		Ephemeroptera	10	PAHs/PCBs/etc.
		Ephemeroptera	17	Metals
		Blank	<10	Organics***
		Blank	14	Metals
Site 3 Obed Mountain Coal Road Bridge	10 April	Plecoptera	11	Dioxins & Furans
		Plecoptera	4	Isotopes (Rep. 1)
		Plecoptera	2	Isotopes (Rep. 2)
		Plecoptera	6	Chlorophenols (Rep. 1)
		Plecoptera	3	Chlorophenols (Rep. 2)
		Plecoptera	10	PAHs/PCBs/etc.
		Plecoptera	6	Metals
		Trichoptera	2	Dioxins & Furans
		Ephemeroptera	8	Dioxins & Furans
		Ephemeroptera	<1	Isotopes
Site 4 Emerson Lakes Bridge	12 April	Plecoptera	11	Dioxins & Furans (Rep. 1)
		Plecoptera	11	Dioxins & Furans (Rep. 2)
		Plecoptera	3	Isotopes (Rep. 1)
		Plecoptera	3	Isotopes (Rep. 2)
		Plecoptera	7	Chlorophenols (Rep. 1)
		Plecoptera	7	Chlorophenols (Rep. 2)
		Plecoptera	11	PAHs/PCBs/etc.(Rep. 1)
		Plecoptera	8	PAHs/PCBs/etc.(Rep. 2)
		Plecoptera	6	Metals (Rep. 1)
		Plecoptera	6	Metals (Rep. 2)

Table 2.1 Continued on next page ...

Table 2.1 Continued.

SITE	DATE COLLECTED	TAXON	APPROX. WET WEIGHT COLLECTED (g)	CONTAMINANT ANALYSIS*
Site 4 Con't		Trichoptera	10	Dioxins & Furans
		Trichoptera	2	Isotopes
		Trichoptera	7	Chlorophenols
		Trichoptera	5	Metals
		Ephemeroptera	10	Dioxins & Furans
	12 April	Ephemeroptera	2	Isotopes
		Ephemeroptera	7	Metals
		Blank	10	Dioxins & Furans
		Blank	3	Isotopes
		Blank	6	Chlorophenols
		Blank	10	PAHs/PCBs/etc.
		Blank	8	Metals
Site 5 Knight Bridge		Plecoptera	11	Dioxins & Furans
		Plecoptera	4	Isotopes
		Plecoptera	6	Chlorophenols
		Plecoptera	10	PAHs/PCBs/etc.
		Plecoptera	6	Metals
		Trichoptera	10	Dioxins & Furans
	13 April	Trichoptera	4	Isotopes
		Trichoptera	6	Chlorophenols
		Trichoptera	3	PAHs/PCBs/etc.
		Trichoptera	5	Metals
		Ephemeroptera	10	Dioxins & Furans
		Ephemeroptera	3	Isotopes
		Ephemeroptera	<1	Chlorophenols
		Ephemeroptera	4	Metals
Site 6 Windfall Bridge		Plecoptera	10	Dioxins & Furans
		Plecoptera	3	Isotopes
		Plecoptera	5	Chlorophenols
		Plecoptera	10	PAHs/PCBs/etc.
		Plecoptera	6	Metals
		Trichoptera	10	Dioxins & Furans
		Trichoptera	4	Isotopes
		Trichoptera	6	Chlorophenols
		Trichoptera	4	Metals
		Ephemeroptera	10	Dioxins & Furans (Rep. 1)
	14 April	Ephemeroptera	10	Dioxins & Furans (Rep. 2)
		Ephemeroptera	3	Isotopes (Rep. 1)
		Ephemeroptera	<1	Isotopes (Rep. 2)
		Ephemeroptera	5	Chlorophenols
		Ephemeroptera	10	PAHs/PCBs/etc.
		Ephemeroptera	2	Metals
		Blank	12	Dioxins & Furans
		Blank	5	Isotopes
		Blank	8	Chlorophenols
		Blank	14	PAHs/PCBs/etc.
		Blank	9	Metals

* Samples for metal analyses were placed in 30 ml plastic "pill-vial" containers. All other sample types were placed in 20 ml glass scintillation vials.

** Sample may be contaminated because the vial shattered when accidentally dropped. Sample was placed in a new vial.

*** Only one blank sample container for trace organic analyses was prepared

Trace Metal Contaminant Sampling Methods

Macroinvertebrates sampled for trace metal contaminants were collected using the methods outlined previously for organic contaminants. However, a plastic mesh (mesh size=1.5 mm) barrier was used instead of a metal mesh. Samples were stored in plastic "pill-vial" containers.

Blank Tissue Handling Methods

Northern River Basins Study provided blank (fish) tissue. This tissue was handled using the same equipment and procedures as were the macroinvertebrate tissue samples. A full complement of blank samples was processed at Sites 4 and 6. An incomplete complement of blank tissue samples was processed at Site 2 (Table 2.1).

2.2.3 COLLECTION OF EPILITHON TISSUE

Epilithon refers to the assemblage of algae and associated organisms (algae, fungi, bacteria, protozoans, etc. and their secretions) that surround solid surfaces in aquatic systems. Epilithon was sampled at the six sites, within the same general area as benthic invertebrates (Table 2.2). Samples were collected from a least 10 stones chosen at random from erosional areas at each site. Scrapings from the stones were combined and mixed to form a composite sample for each site and type of analysis (organic or metal contaminants). Care was taken to avoid inclusion of macroinvertebrates and large organic debris in the composite samples. Aliquots were withdrawn and apportioned to the appropriate sample containers as described in Section 2.2.1.

Additional epilithon samples were reserved for taxonomic identification. At each site, two aliquots from the composite organic contaminant sample were preserved; one with a modified Lugol's solution and the other with 4% formaldehyde.

2.2.4 COLLECTION OF SEDIMENTS

Sediment samples were collected from both erosional and depositional habitat zones concurrently with the sampling program for invertebrate tissues (7 through 14 April 1992) (Table 2.3). These samples were collected from substrates that had not been previously disturbed by other types of sampling (e.g., benthic invertebrate community samples). The erosional habitats were cobble-gravel areas with fine sediment occurring as a film on stones and in the interstitial spaces. All depositional habitat sampling zones were marked with flagging tape along the shorelines so that they could be relocated during a second sampling trip prior to typical annual peak water flows in late May through June.

On 13 and 14 May 1992, depositional sediments were collected from the same sample sites as in the first sampling trip. Water levels were approximately 30 to 40 cm greater than during the first sampling

Table 2.2 Summary of epilithon trace contaminant tissue samples collected from the Athabasca River in 1992.

SITE	DATE COLLECTED	APPROX. WET WEIGHT COLLECTED (g)	CONTAMINANT ANALYSIS*
Site 1 Near Entrance (Control)	08 April	2	Dioxins & Furans
		15	Isotopes
		27	Chlorophenols
		20	PAHs/PCBs/etc.
		25	Metals (Rep. 1)
		20	Metals (Rep. 2)
Site 2 Weldwood Bridge	09 April	14	Dioxins & Furans
		5	Isotopes
		6	Biophenols
		10	PAHs/PCBs/etc.
		19	Organic duplicate
		10	Metals
Site 3 Obed Mountain Coal Road Bridge	10 April	12	Dioxins & Furans (Rep. 1)
		12	Dioxins & Furans (Rep. 2)
		2	Isotopes (Rep. 1)
		2	Isotopes (Rep. 2)
		5	Chlorophenols (Rep. 1)
		5	Chlorophenols (Rep. 2)
		12	PAHs/PCBs/etc. (Rep. 1)
		12	PAHs/PCBs/etc. (Rep. 2)
		32	Metals
Site 4 Emerson Lakes Bridge	11 April	11	Dioxins & Furans (Rep. 1)
		11	Dioxins & Furans (Rep. 2)
		3	Isotopes (Rep. 1)
		3	Isotopes (Rep. 2)
		6	Chlorophenols (Rep. 1)
		6	Chlorophenols (Rep. 2)
		11	PAHs/PCBs/etc. (Rep. 1)
		5	PAHs/PCBs/etc. (Rep. 2)
		7	Metals (Rep. 1)
		7	Metals (Rep. 2)
Site 5 Knight Bridge	12 April	13	Dioxins & Furans
		4	Isotopes
		8	Chlorophenols
		13	PAHs/PCBs/etc.
		22	Metals
Site 6 Windfall Bridge	13 April	12	Dioxins & Furans (Rep. 1)
		13	Dioxins & Furans (Rep. 2)
		5	Isotopes (Rep. 1)
		4	Isotopes (Rep. 2)
		9	Chlorophenols (Rep. 1)
		9	Chlorophenols (Rep. 2)
		12	PAHs/PCBs/etc. (Rep. 1)
		?	PAHs/PCBs/etc. (Rep. 2)
		13	Metals (Rep. 1)
		13	Metals (Rep. 2)

* Samples for metal analysis were placed in 20 ml plastic "pill-vial" containers. All other sample types were placed in 20 ml glass scintillation vials.

Table 2.3 Summary of sediment trace contaminant samples collected from the Athabasca River in 1992.

CONTAMINANT ANALYSIS*	FIRST SAMPLING SURVEY				SECOND SAMPLING SURVEY	
	DEPOSITIONAL		EROSIONAL		DEPOSITIONAL	
	Replicate 1	Replicate 2	Replicate 1	Replicate 2	Replicate 1	Replicate 2
SITE 1, near Entrance	08 April		08 April		13 May	13 May
Dioxins & Furans	X		X		X	X
Isotopes	X		X		X	X
Chlorophenols	X		X		X	X
PAHs/PCBs/etc.	X		X		X	X
Metals	X		X		X	X
TOC/Particle Size/etc.	X		X		X	X
SITE 2, Weldwood Bridge	09 April		09 April		13 May	
Dioxins & Furans	X		X		X	
Isotopes	X		X		X	
Chlorophenols	X		X		X	
PAHs/PCBs/etc.	X		X		X	
Metals	X		X		X	
TOC/Particle Size/etc.	X		X		X	
SITE 3, Obed Mountain Coal Bridge	10 April		10 April		13 May	
Dioxins & Furans	X		X		X	
Isotopes	X		X		X	
Chlorophenols	X		X		X	
PAHs/PCBs/etc.	X		X		X	
Metals	X		X		X	
TOC/Particle Size/etc.	X		X		X	
SITE 4, Emerson Lakes Bridge	11 April	11 April	11 April		14 May	
Dioxins & Furans	X	X	X		X	
Isotopes	X	X	X		X	
Chlorophenols	X	X	X		X	
PAHs/PCBs/etc.	X	X	X		X	
Metals	X	X	X		X	
TOC/Particle Size/etc.	X		X		X	
SITE 5, Knight Bridge	12 April	13 April	13 April		14 May	
Dioxins & Furans	X**	X	X		X	
Isotopes	X**	X	X		X	
Chlorophenols	X**	X	X		X	
PAHs/PCBs/etc.	X**	X	X		X	
Metals	X**	X	X		X	
TOC/Particle Size/etc.	X		X		X	
SITE 6, Windfall Bridge	14 April	14 April	14 April	14 April	14 May	14 May
Dioxins & Furans	X	X	X	X	X	X
Isotopes	X	X	X	X	X	X
Chlorophenols	X	X	X	X	X	X
PAHs/PCBs/etc.	X	X	X	X	X	X
Metals	X	X	X	X	X	X
TOC/Particle Size/etc.	X	X	X	X	X	

* TOC/Particle Size/etc. samples were placed in 1L plastic containers. Metal samples were stored in ½L plastic containers. All other sample types were placed in ½L glass containers.

** Organics were placed in a container without a foil liner, therefore, a second replicate was collected.

program. There was evidence (e.g., scoured shoreline and location of driftwood) that the river peaked approximately 1 m between the two sampling trips.

Preference was given to fine-textured sediments (i.e., mud versus sand). Each sample was a composite of a minimum of 10 individual grabs distributed in a radius of 50 to 100 m at each site. Only the top five cm of each individual sample was retained. Individual samples were combined and well mixed. Water entry was minimized while sampling, but was not decanted from the tray when the sample was mixed. From the mixed sample the following containers were filled:

- 1/2 L glass container for Dioxins & Furans
- 1/2 L glass container for Stable Isotopes
- 1/2 L glass container for Chlorophenols
- 1/2 L glass container for PAHs, PCBs,and Resin Acids
- 1/2 L plastic container for Metals
- 1 L plastic container for TOC, Particle Size, etc.

Trace Organic Contaminants and Stable Isotope Sampling Methods

Erosional sediments were collected with a large stainless steel spoon, and individual scoops were pooled in a large stainless steel tray. Depositional sediments were collected with the use of a stainless steel Ekman-dredge sampler, spoon and tray. All samples were stored on ice until delivered to Northern River Basins Study.

Trace Metal Contaminant Sampling Methods

Erosional sediments were collected with a large, slotted plastic spoon. Individual scoops were pooled in a large plastic or glass tray. Depositional sediments were collected with the use of a stainless steel Ekman-dredge sampler, a slotted, plastic spoon, and a plastic or glass tray. Care was taken to avoid including the portion of the sediment that came into contact with the walls of the Ekman dredge. All samples were stored on ice until delivered to Northern River Basins Study.

2.3 AQUATIC INVERTEBRATE COMMUNITY SAMPLING

Aquatic macroinvertebrate community samples were collected from the Athabasca River concurrent with the collection of invertebrate tissue samples for trace contaminant analyses. A minimum of five replicate samples was collected from erosional and depositional habitats at each of the six sites specified in Section 2.1. Sampling locations were not disturbed by previous sampling programs. All methods used in sampling aquatic invertebrates followed procedures outlined in Alberta Environment (1990). A modified Neill (1938) cylinder sampler (0.1 m^2) was used to collect animals from erosional habitats (210 μm mesh). An Ekman Dredge sampler (225 cm^2) was used to collect invertebrates from depositional zones. Individual samples were stored in labelled, 1-L plastic Nalgene® bottles and preserved, in the field, with 4% formaldehyde. Prior to placement in these bottles, the depositional samples were sieved (213 μm mesh) to remove fine sediment particles. Variables that may influence invertebrate distribution (e.g., current velocity, substrate characteristics, depth, etc.) were recorded and are described below in Section 3.0. Mean current velocity over sampling locations was measured with a Marsh-McBirney, Inc. Model 2000 current meter. Substrate composition was visually assessed according to a modified Wentworth (1922) scale.

SECTION 3.0
FIELD OBSERVATIONS

General

The first field survey commenced on 7 April 1992 and terminated on 14 April 1992. The second sampling event was conducted on 13 and 14 May 1992. During these trips the weather varied from well below freezing to moderately mild temperatures, typical of early spring (Table 3.1). Water temperatures varied from 0 to 8°C. The first sampling trip commenced shortly after ice-off. At many of the sites, snow and ice was present on the banks. Photographs of the sample sites are in Appendix 1. The onset of cold weather on 10 and 11 April necessitated that epilithon and macroinvertebrate tissue be processed inside a propane heated camper (i.e., at Sites 3 and 4). Exhaust from the furnace was vented outside, thus, any contact with sample tissue was avoided.

Densities of benthic macroinvertebrates varied among the six sites. Plecoptera were present in sufficient density at all six sites to allow collection a full complement of tissue samples. In general, Trichoptera and Ephemeroptera larvae increased in density from upstream to downstream sites (i.e., lowest at Site 1 and greatest at Site 6). Chironomidae larvae were low in density at all sites and only relatively small specimens were observed, therefore, tissue samples for this taxon were not collected.

Table 3.1 Summary of weather conditions measured in the field (April - May 1992).

DATE	TIME	TEMPERATURE (°C)		DESCRIPTION
		WATER	AIR	
SITE 1 near Entrance				
7 April	1700	2	-4	overcast & cold, breeze 20-40 km/h
8 April	0630	2	-7	10 cm snow overnight, overcast & light snow
	1230	2	-2	calm, partly cloudy
	1400	-	-	overcast, gusting winds (25-50 km/h)
13 May	1400	8	16	partly cloudy and breezy
SITE 2 Weldwood Bridge				
9 April	0700	-	-7	snow overnight, calm & overcast
	1000	1.5	-2	overcast and calm
	1400	1.5	-1	overcast with windy periods (25-50 km/h)
13 May	1530	8	16	partly cloudy and breezy
SITE 3 Obed Mountain Coal Bridge				
10 April	0800	0	-12	Cold and overcast
	0945	0	-10	overcast
	1400	0	-4	overcast
13 May	1700	8	15	partly cloudy and breezy
SITE 4 Emerson Lakes Bridge				
11 April	0830	-	-12	clear
	1200	1	-1	clear and breezy
	1600	0	0	breezy, partly cloudy
12 April	0930	1	-2	clear, calm
14 May	0900	8	10	overcast, light breeze
SITE 5 Knight Bridge				
12 April	1600	2.5	22	breezy, clear, warm and pleasant
13 April	0800	-	-2	bright, clear and breezy
	0900	1.5	6	
	1200	2	14	sunny and breezy
	1400	4	17	sunny and breezy
14 May	1300	8	12	90% overcast, isolated showers, gusting winds (20-40 km/h)
SITE 6 Windfall Bridge				
14 April	0900	4	3	clear and breezy
	1100	4	14	partly cloudy and breezy
	1400	4	14	cloudy, showerheads
14 May	1600	8	12	100% overcast, isolated showers, gusting winds (20-40 km/h)

Although plecopteran larvae were plentiful at all sites and they were relatively easy to collect, a size class sampling bias may have occurred. Since larger specimens were easier to collect, smaller stoneflies tended to be under-represented in the sample relative to their true abundance. This would also have biased sampling for larger species. It was also noted that stoneflies were consuming mayflies while being handled prior to placement in sample containers. Baetid-type (possibly *Ameletus* Eaton; Siphlonuridae) mayflies were observed to be the taxon most often preyed upon by plecopterans. The dominant trichopterans collected were hydrospychid larvae. This taxon tended to have the greatest amounts of attached detritus and foreign organic matter. This was due to behavioral characteristics (i.e., tendency to cling onto any foreign material when distressed) and physical structure (i.e., abdominal gills and anal prolegs with claws that foreign substances could easily adhere to). Stoneflies were emerging (most likely *Taenionema* Banks; Taeniopterygidae) at the time of the survey and adults were abundant at Sites 3 through 6.

Epilithon tissue was relatively sparse at Sites 1 and 6 as compared to Sites 2, 3, 4 and 5. At Sites 1 and 6 epilithon consisted of a sparse growth (primarily algae) overlying a thin film of sediment/detritus material (possibly senescent or old decaying epilithic material). At Sites 2 through 5, epilithon consisted of short strands (0.2 to 4.0 cm) of algae overlying a gelatinous mass. The gelatinous mass may have been bacteria and/or a winter form of *Nostoc* Vaucher sp. and varied from approximately 0.1 to 2.0 cm in thickness. Epilithon tissue collection was easier at Sites 2 through 5 than at Sites 1 and 6. Site 3 was the most prolific site for epilithon tissue.

Since epilithon was similar in structure at Sites 1 and 6, this may reflect non-impact sites. Site 1 is a control site located above the HCE discharge structure. Site 6, is located furthest downstream of the HCE discharge structure and may be located in a recovery zone. However, this site was the last to be free of ice cover (on or about 3 April) and may have had low epilithon biomass levels (similar to Site 1) because of light limitation.

Four of the six sites (1, 2, 3 and 5), had relatively easy access to all habitat zones. However, depositional habitats were difficult to locate at Sites 4 and 6. Depositional sediment trace contaminant samples and benthic community samples at Site 4 were collected approximately 1.5 km downstream of Emerson Lakes Haul Road Bridge. These samples were collected approximately 4 km upstream of Windfall Bridge at Site 6.

Site 1 - Control, Near Entrance

All samples were collected in a 1.0 km reach of the Athabasca River commencing approximately 2.2 km downstream of where Highway 40 crosses the river (Figure 3.1). Depositional invertebrate community samples (Ekman grabs) were collected on 7 April 1992. Sediments, epilition, erosional invertebrate community and macroinvertebrate tissue samples were collected on 8 April 1992. Additional Trichoptera trace contaminant tissue and a benthic invertebrate identification samples (composite of 3 kick nets) were collected on 9 April

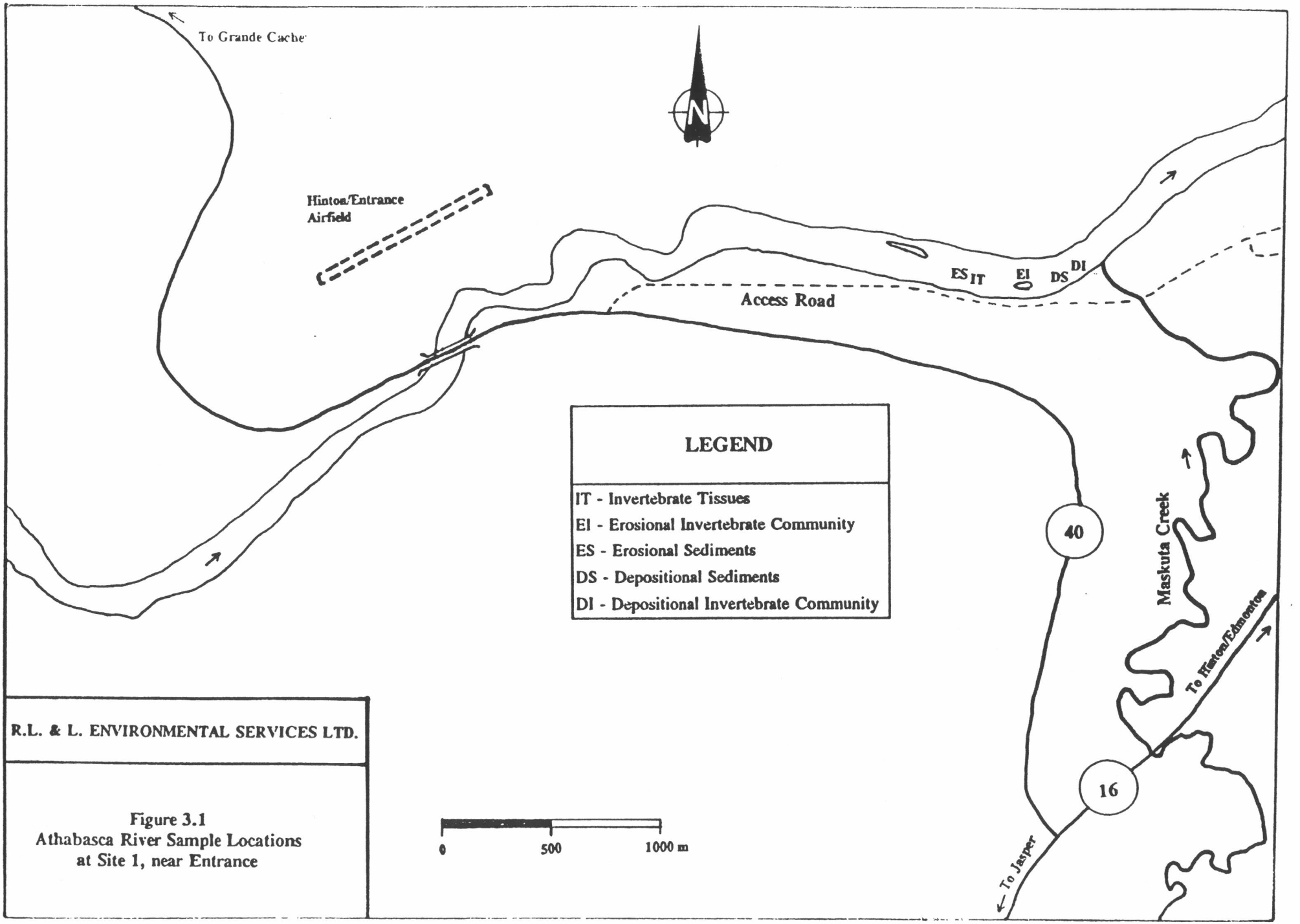

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Figure 3.1
Athabasca River Sample Locations
at Site 1, near Entrance

1992. Depositional sediments consisted of brown silt overlying clay that contained some fine sand. Erosional sediments were similar to depositional sediments but contained relatively more sand. Table 3.2 summarizes the physical variables measured/recorded at the benthic invertebrate community sample locations.

Table 3.2 Physical variables measured at benthic invertebrate community sample locations, Site 1.

SAMPLE	MEAN CURRENT VELOCITY (cm/s)	DEPTH (cm)	DISTANCE FROM SHORE (m)	SUBSTRATE DESCRIPTION
Neill #1	22	41	3.1	25% CB, 35% PB, 30% GR, 10% S/O
Neill #2	21	47	4.4	15% BO, 15% CB, 10% PB, 50% GR, 10% S/O
Neill #3	24	41	4.6	20% CB, 30% PB, 30% GR, 20% S/O
Neill #4	20	41	4.5	25% BO, 45% CB, 10% PB, 10% GR, 10% S/O
Neill #5	30	45	4.7	20% BO, 30% CB, 10% PB, 30% GR, 10% S/O
Ekman #1	0	76	4.3	Approximately 30 cm of fine silt/clay/sand over cobble/pebble.
Ekman #2	0	77	5.5	
Ekman #3	0	74	7.6	
Ekman #4	0	69	5.8	
Ekman #5	0	54	3.3	

BO = Boulder, CB = Cobble, PB = Pebble, GR = Gravel, S/O = Silt/Organics

Site 2 - Near Weldwood Haul Road Bridge

Samples were collected approximately 100 to 500 m downstream of Weldwood Haul Road Bridge on 9 April 1992 (Figure 3.2). It was noted that the water here was less murky than at Site 1 and that the surface of the water had small (10 - 100 cm^2) patches of foam (1 - 2 cm thick). General industrial and municipal debris was intermittently scattered throughout the sample reach (e.g., 24 and 30 cm diameter canvass fire/water hoses, metal cans and large gauge wire). Depositional sediment samples consisted of brown fine silt-clay material with virtually no sand. Small patches (2 - 10 cm^2) of an oily sheen was observed on the surface of the depositional sediment composite sample prior to placement in appropriate containers. Erosional sediments were relatively the same as the depositional sediments but had more black organic, woody fines. Benthic invertebrate community samples collected and physical variables measured at each sample location are summarized in Table 3.3.

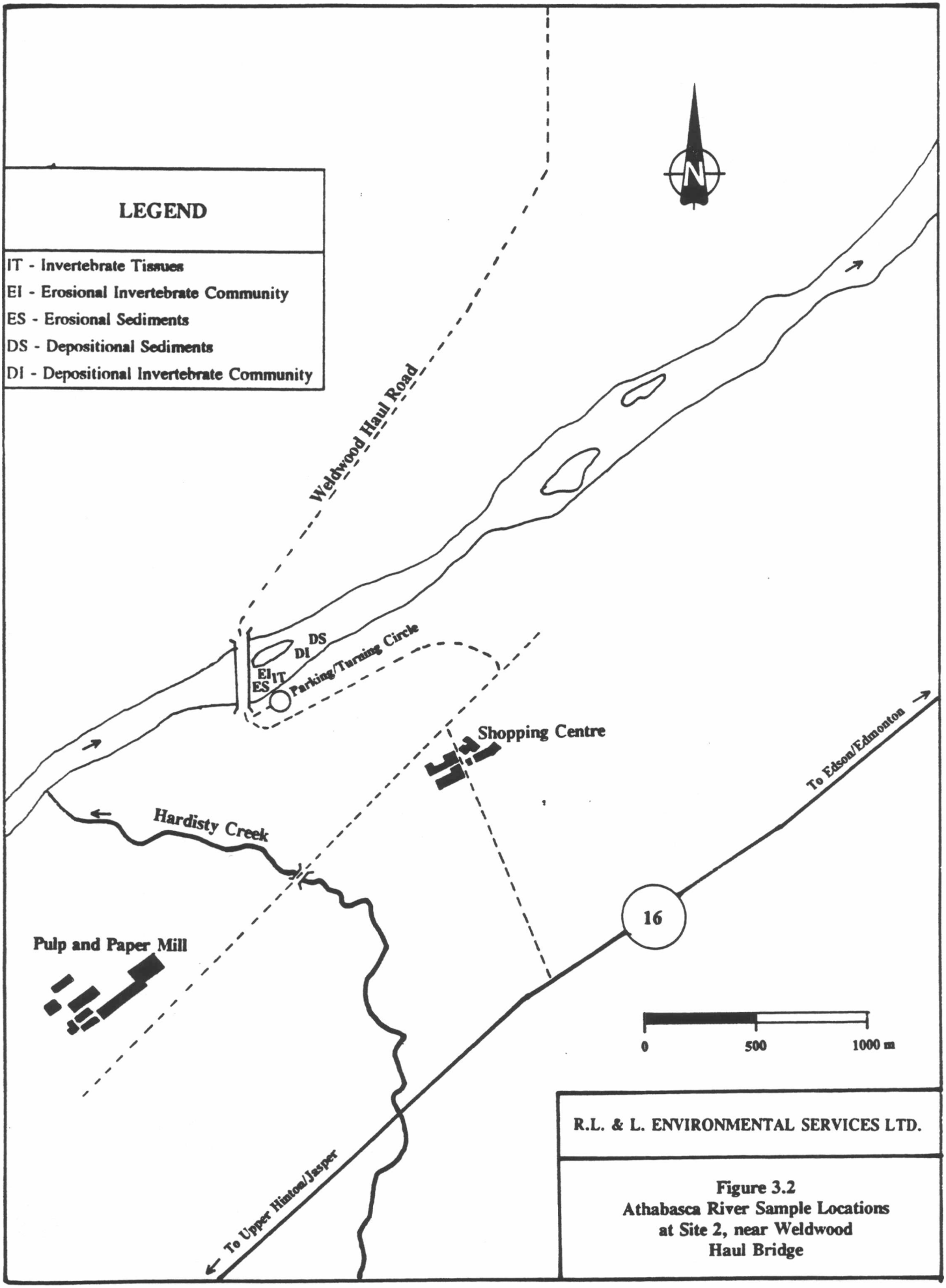

Figure 3.2
Athabasca River Sample Locations at Site 2, near Weldwood Haul Bridge

Table 3.3 Physical variables measured at benthic invertebrate community sample locations, Site 2.

SAMPLE	MEAN CURRENT VELOCITY (cm/s)	DEPTH (cm)	DISTANCE FROM SHORE (m)	SUBSTRATE DESCRIPTION
Neill #1	49	38	12.5	45% CB, 25% PB, 25% GR, 5% S/O
Neill #2	48	30	10.0	40% CB, 20% PB, 35% GR, 5% S/O
Neill #3	45	26	10.4	50% CB, 20% PB, 25% GR, 5% S/O
Neill #4	39	29	11.1	35% CB, 10% PB, 50% GR, 5% S/O
Neill #5	39	25	11.0	25% CB, 15% PB, 55% GR, 5% S/O
Ekman #1	0	34	4.4	Approximately 20 cm of silt overlying clay.
Ekman #2	0	32	4.5	
Ekman #3	0	52	5.0	
Ekman #4	0	59	5.0	
Ekman #5	0	41	3.6	

CB = Cobble, PB = Pebble, GR = Gravel, S/O = Silt/Organics

Site 3 - Near Obed Mountain Coal Bridge

All samples were collected approximately 100 to 500 m upstream of the Obed Mountain Coal Bridge on 10 April 1992 (Figure 3.3). Air temperatures were in the -15 to -3°C range. Therefore, trace contaminant tissue samples were processed inside of a heated camper. Depositional habitats had 3 to 4 cm of ice on the water surface. Depositional sediments consisted of a brown silt overlying a thick darker clay. Erosional sediments consisted mainly of a brown silty material and very little clay. Physical variables measured at benthic invertebrate community sample points are summarized in Table. 3.4.

Table 3.4 Physical variables measured at benthic invertebrate community sample locations, Site 3.

SAMPLE	MEAN CURRENT VELOCITY (cm/s)	DEPTH (cm)	DISTANCE FROM SHORE (m)	SUBSTRATE DESCRIPTION
Neill #1	27	28	5.3	50% CB, 10% PB, 30% GR, 10% S/O
Neill #2	28	25	5.4	60% CB, 20% PB, 10% GR, 10% S/O
Neill #3	33	29	6.3	30% CB, 20% PB, 40% GR, 10% S/O
Neill #4	40	35	7.5	20% CB, 20% PB, 40% GR, 10% S/O
Neill #5	37	23	5.3	25% CB, 25% PB, 40% GR, 10% S/O
Ekman #1	2	34	9.8	10 to 20 cm of fine silt and some clay over 40% CB
Ekman #2	3	35	16.5	15% PB, 10% GR. 1 to 6 small CB and PB in all grabs
Ekman #3	1	32	15.5	
Ekman #4	0	10	17.3	
Ekman #5	0	35	12.6	

BO = Boulder, CB = Cobble, PB = Pebble, GR = Gravel, S/O = Silt/Organics

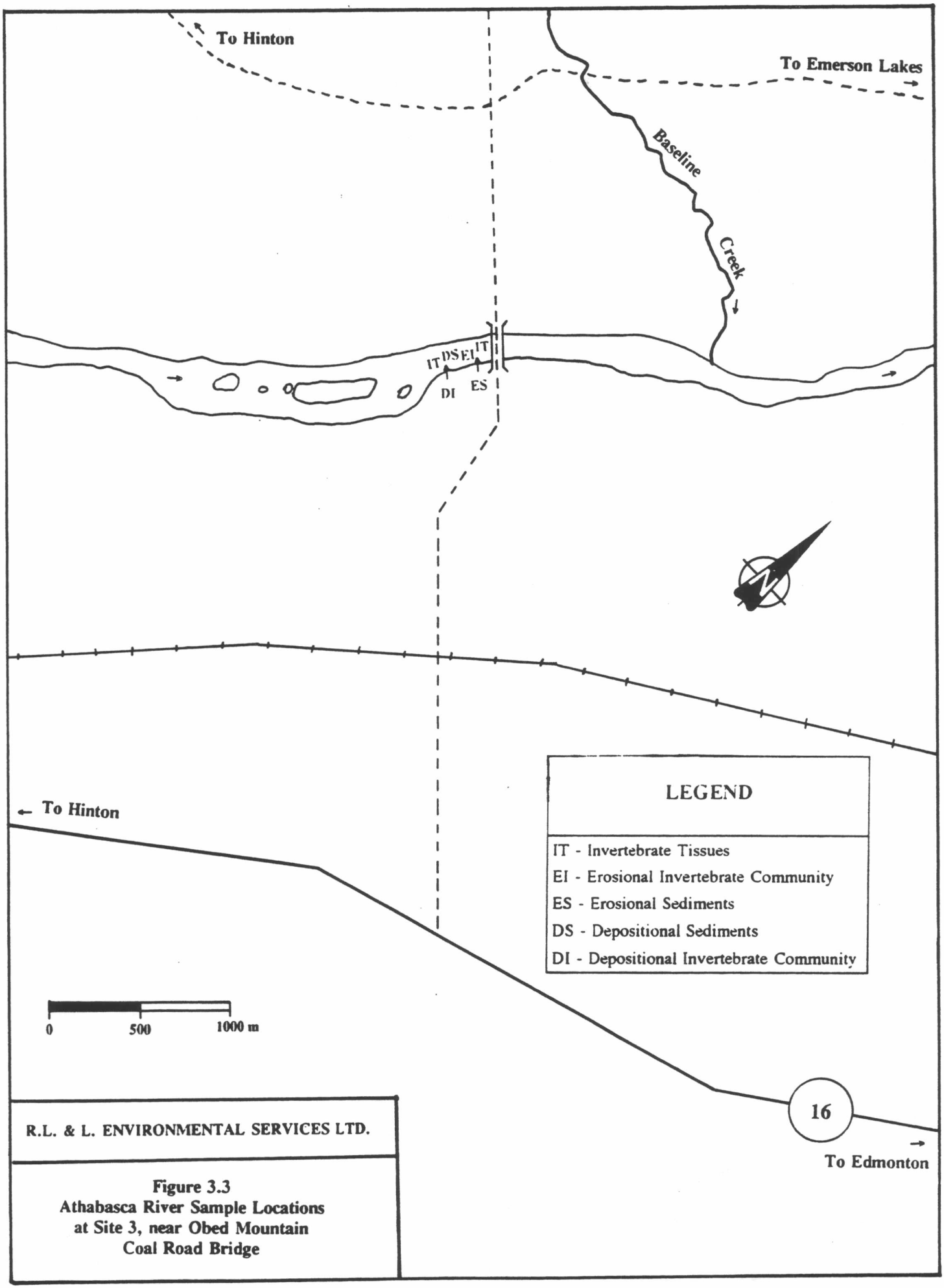

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Figure 3.3
Athabasca River Sample Locations at Site 3, near Obed Mountain Coal Road Bridge

Site 4 - Near Emerson Lakes Road Bridge

Sediment, epilithon and benthic invertebrate community samples were collected on 11 April 1992. Invertebrate trace contaminant tissue samples were collected on 12 April 1992. All samples were collected in a reach of the river approximately 0.2 to 2.0 km downstream of Emerson Lakes Bridge (Figure 3.4). Depositional sediments consisted of brown silty material containing some fine to coarse sand. These sediments contained much more organic (woody) material than at Sites 1, 2 and 3. Corixids were observed under 6 cm of surface ice overtop of depositional zones. Erosional sediments were much the same as depositional sediments, only with much less organic material. Air temperatures were well below 0°C on both sampling days at this site. Thus, trace contaminant tissue samples were processed in a heated camper. A summary of variables measured when collecting benthic invertebrate community samples is in Table 3.5.

Table 3.5 Physical variables measured at benthic invertebrate community sample locations, Site 4.

SAMPLE	MEAN CURRENT VELOCITY (cm/s)	DEPTH (cm)	DISTANCE FROM SHORE (m)	SUBSTRATE DESCRIPTION
Neill #1	13	73	5.8	50% CB, 20% PB, 20% GR, 10% S/O
Neill #2	11	67	5.3	30% CB, 40% PB, 20% GR, 10% S/O
Neill #3	12	46	2.8	20% CB, 30% PB, 30% GR, 20% S/O
Neill #4	18	65	6.8	40% CB, 20% PB, 20% GR, 20% S/O
Neill #5	10	41	3.7	30% CB, 40% PB, 10% GR, 20% S/O
Ekman #1	9*	25	1.1	Approximately 20-30 cm silt/sand overlying clay intermixed with black organic material.
Ekman #2	14*	35	1.3	
Ekman #3	7*	10	0.7	
Ekman #4	10*	25	1.7	
Ekman #5	11*	19	1.2	

BO = Boulder, CB = Cobble, PB = Pebble, GR = Gravel, S/O = Silt/Organics
* Collections were behind a large fallen tree that had sediments trapped behind/beneath it.

Site 5 - Near Knight Bridge

All samples were collected within 500 m upstream of Knight Bridge (Figure 3.5). Epilithon tissue samples, depositional sediments and erosional benthic community samples were collected on 12 April 1992. Remaining samples were collected on 13 April 1992. A second series of depositional sediment samples for organic contaminant analyses was also collected on 13 April. The first set of these samples was originally placed in sample containers that did not have an aluminum foil lining in the lid. Three additional erosional invertebrate community samples (Neill's #6, 7 & 8) were collected on 13 April 1992 because current velocities were relatively low in some of the original five replicates collected on 12 April (Table 3.6).

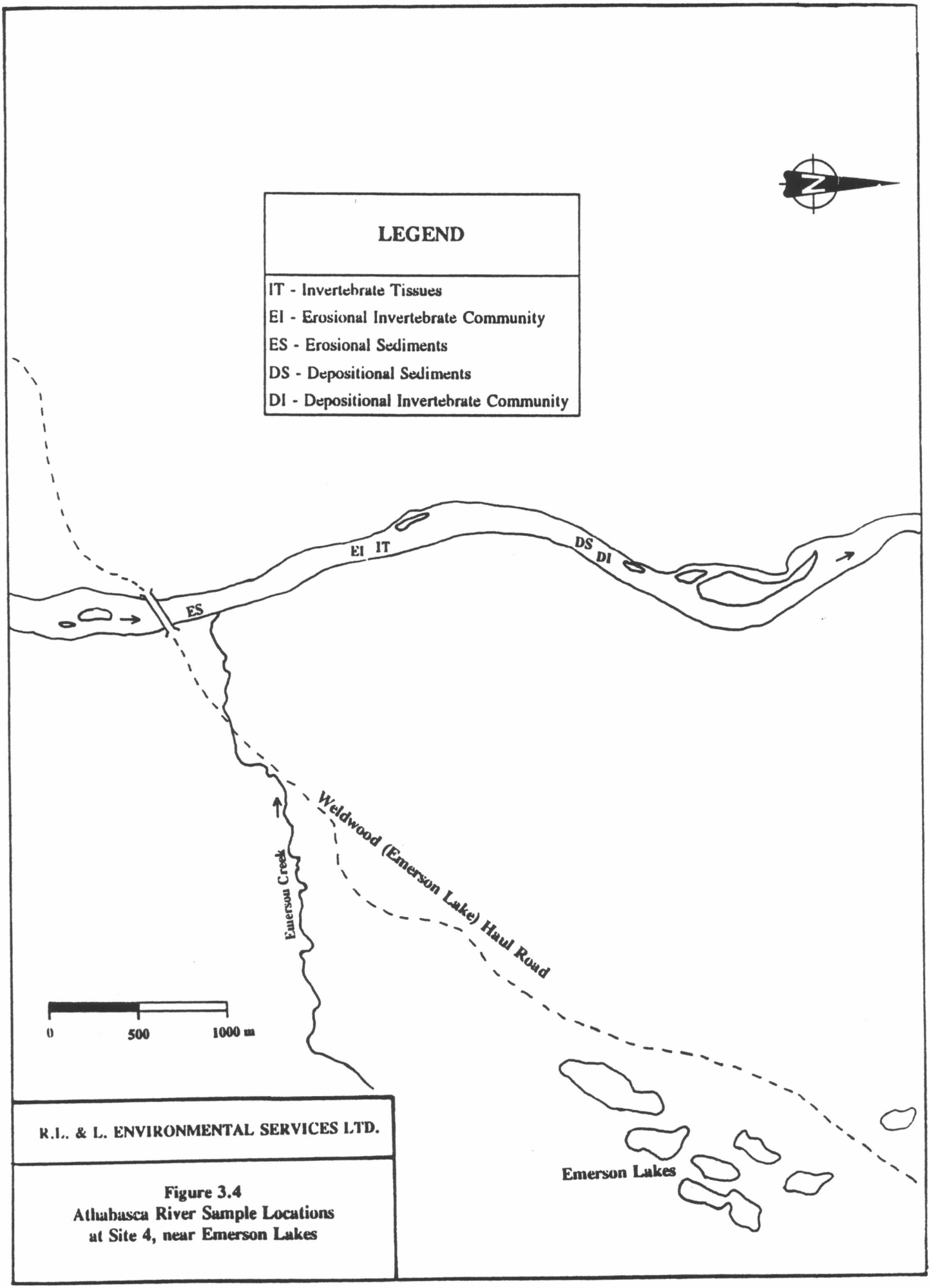

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Figure 3.4
Athabasca River Sample Locations at Site 4, near Emerson Lakes

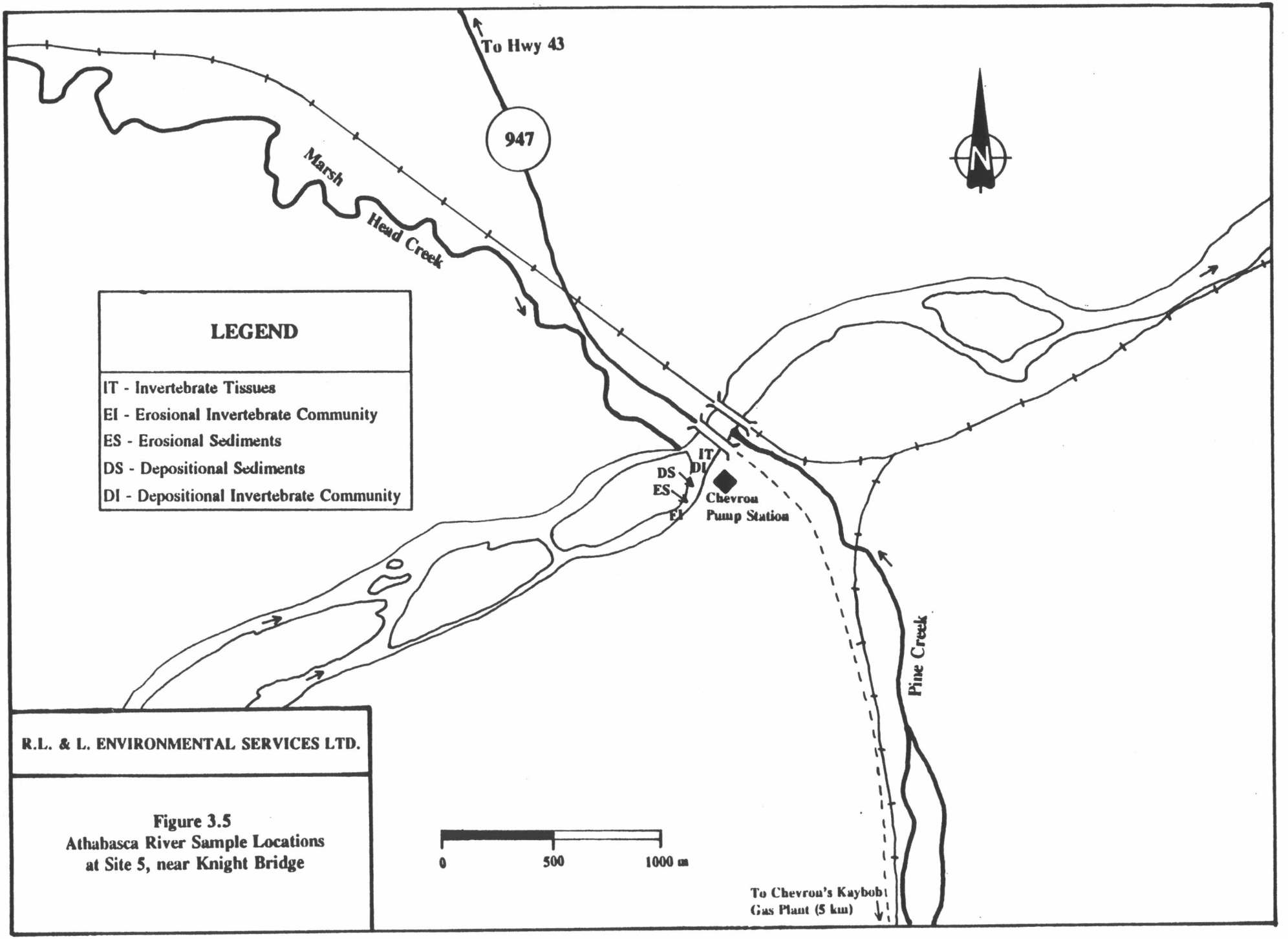

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Figure 3.5
Athabasca River Sample Locations at Site 5, near Knight Bridge

Table 3.6 Physical variables measured at benthic invertebrate community sample locations, Site 5.

SAMPLE	MEAN CURRENT VELOCITY (cm/s)	DEPTH (cm)	DISTANCE FROM SHORE (m)	SUBSTRATE DESCRIPTION
Neill #1	20	46	6.6	80% CB, 5% PB, 10% GR, 5% S/O
Neill #2	15	45	8.1	20% BO, 40% CB, 20% PB, 15% GR, 5% S/O
Neill #3	11	41	7.1	10% BO, 40% CB, 30% PB, 15% GR, 5% S/O
Neill #4	12	42	6.6	60% CB, 20% PB, 15% GR, 5% S/O
Neill #5	8	46	6.8	50% CB, 20% PB, 25% GR, 5% S/O
Neill #6	24	40	5.3	60% CB, 20% PB, 15% GR, 5% S/O
Neill #7	26	40	6.1	15% CB, 30% PB, 50% GR, 5% S/O
Neill #8	34	40	5.9	10% CB, 40% PB, 45% GR, 5% S/O
Ekman #1	0	6	1.1	Thin layer (<10cm) of silt on a sand detritus mixture
Ekman #2	0	9	1.3	
Ekman #3	0	9	0.9	
Ekman #4	0	12	2.1	
Ekman #5	0	7	2.4	

BO = Boulder, CB = Cobble, PB = Pebble, GR = Gravel, S/O = Silt/Organics

Depositional sediments consisted of a brown-grey silt layer overlying sandy clay. A black organic matrix was interspersed within these layers. The thickness of these sediments varied from 0.1 to 1.0 m. Erosional sediments contained less amounts of sand and organics, but relatively more clay material than did the depositional sediments.

Sampling was performed near Chevron's Kaybob gas plant water pumping station. The gas plant is located approximately 5 km south of Knight Bridge. A Chevron employee inspected the pump house, inquired into our activities and then provided the following information.

1. Water used in the plant's boilers must meet certain water quality criteria and that the normal process of using lime and alum has been altered in the last year or two because of changing conditions in Athabasca River's water quality. Polymers are now used to remove hardness and oxygen.

2. Depending on water quality, the Kaybob gas plant adds chlorine to kill bacteria. Presently, 2 to 3 chlorine "shock" treatments are performed every shift. Approximately two years ago, chlorine additions were performed once every six months.

3. The Chevron employee was born and raised in the upper Athabasca River area and owns a farm north of Fox Creek. He stated that local people no longer fish in the Athabasca River because fish are no longer present or are believed to be contaminated with toxins. His period of reference extends from the forties through today.

4. There are settling basins and flare pits at the Kaybob gas plant. These pits have clay liners. The Chevron employee believes these liners have cracks and leak. He believes that groundwater is contaminated and that contaminants are reaching the Athabasca River.

5. Pine Creek confluences with the Athabasca River under Knight Bridge (Figure 3.5). This creek flows by a sulphur processing plant and storage area. The Chevron employee stated that Pine Creek is often polluted from this sulphur plant, especially during high water and rain storms. Pine Creek's stones have been observed to have numerous colours (brown, green, yellow, etc.) during pollution events.

Site 6 - Near Windfall Bridge

Epilithon tissue and erosional invertebrate community samples were collected on 13 April 1992. All other samples were collected on 14 April 1992. Sediment and depositional macroinvertebrate community samples were collected approximately 4.0 km upstream (access via Zodiac® inflatable boat) of Windfall Bridge (Figure 3.6). Whereas, all other samples were collected approximately 200 to 400 m downstream of the bridge. Depositional sediments consisted of grey-brown silt overlying black clay and organics. Erosional sediments were similar, but consisted of relatively less amounts of silt overlying fine sand. Physical variables measured at benthic invertebrate community sample sites are outlined in Table 3.6.

Table 3.7 Physical variables measured at benthic invertebrate community sample locations, Site 6.

SAMPLE	MEAN CURRENT VELOCITY (cm/s)	DEPTH (cm)	DISTANCE FROM SHORE* (m)	SUBSTRATE DESCRIPTION
Neill #1	33	20	3.6	65% CB, 20% PB, 10% GR, 5% S/O
Neill #2	36	33	3.6	70% CB, 10% PB, 15% GR, 5% S/O
Neill #3	41	18	3.4	60% CB, 20% PB, 15% GR, 5% S/O
Neill #4	44	19	2.5	30% CB, 40% PB, 25% GR, 5% S/O
Neill #5	41	25	2.9	30% CB, 40% PB, 25% GR, 5% S/O
Ekman #1	0	16	0*	Approximately 10-20 cm of silt over a clay/sand layer. Lots of organic material in sample
Ekman #2	0	18	-	
Ekman #3	0	15	-	
Ekman #4	0	18	-	
Ekman #5	0	20	-	

BO = Boulder, CB = Cobble, PB = Pebble, GR = Gravel, S/O = Silt/Organics

* Distance from shore was not measured because collections were made near an island in middle of the river (approximately 150 m offshore)

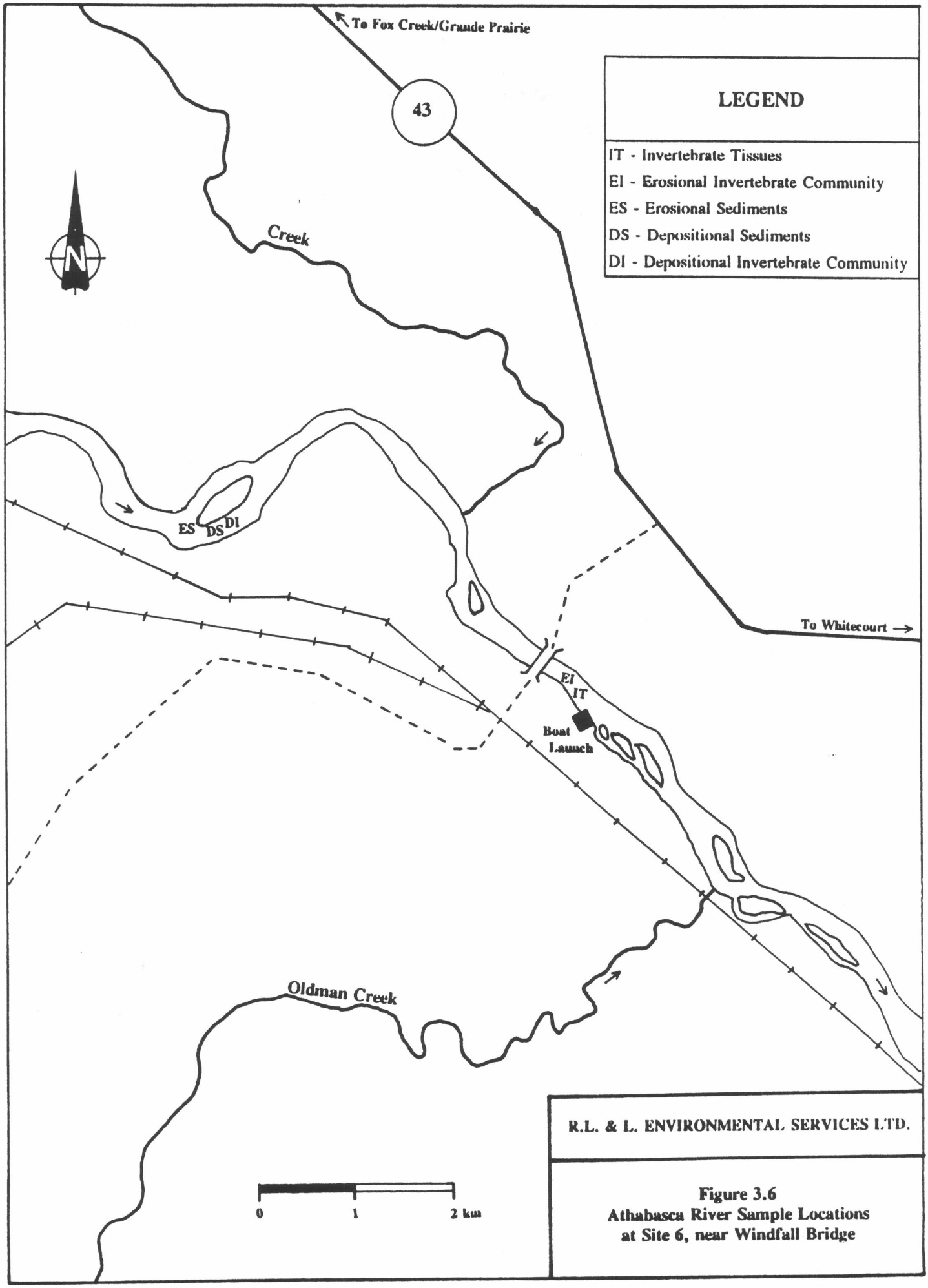

Figure 3.6
Athabasca River Sample Locations at Site 6, near Windfall Bridge

SECTION 4.0
RECOMMENDATIONS

Most sampling effort was expended collecting benthic macroinvertebrate tissue for trace contaminant analyses (Table 4.1). Over 25 man hours were spent collecting animal tissue at Site 1, and 22 or fewer man hours were spent at all other sites. Relative to the amount of tissue collected (see Table 2.1), Site 1 was the most labour intensive. Benthic invertebrate densities may have been relatively low at Site 1 as compared to the remaining five sites. Hydropsychid (caddisflies) and mayfly larvae were particularly difficult to collect at Site 1. This may have reflected relative amounts of food available for these taxa. Hydropsychids filter organic material from the water column via fine-mesh netting (Wiggins 1977) and, in general, mayflies are collector-gatherers that feed upon epilithon and detritus (Edmunds *et al.* 1976; Edmunds 1984). Site 1 is the control site, above the HCE discharge point where suspended particulates are low (no effluent particulates) and may limit the numbers and/or growth rates of hydropsychids relative to the other sites. The same reasoning applies to epilithon biomass. The HCE discharge may provide nutrients for epilithic growth. Thus, Site 1 may have low densities of mayflies relative to the other sites because of food limitations.

Table 4.1 Estimated man hours expended while collecting specified samples.

SITE #	INVERTEBRATE TISSUE		EPILITHON	DEPOSITIONAL AND EROSIONAL SEDIMENT	BENTHIC INVERTEBRATE COMMUNITY	
	ORGANICS	METALS	ORGANICS & METALS	ORGANICS & METALS	DEPOSITIONAL	EROSIONAL
1	24	1.5	6.5 to 8.5	9	8	8
2	16	2	4	7	4	4
3	19	2	3	4.5	2	3
4	20	2	4.5	8	7	6
5	17	2	2	7.5	5	5
6	16	2	5	11	5	5

Site 1 was the first site sampled, therefore, extra time was spent "fine tuning" collecting techniques. For example, macroinvertebrates destined for trace contaminant analyses were originally collected by transferring animals from mesh barriers into large shallow trays where the organisms could be separated from detritus and other organic material before placing into sample containers. During cold weather, this method was not effective because animals froze to the mesh and ice formed on the sorting trays. Based on this, a system was developed whereby macroinvertebrates were immediately placed into small containers as soon as the mesh barrier was lifted from the water and then transferred into sorting trays (see section 2.2.2 for detailed methods). We emphasize that a pilot ("dry-run") sampling program should be performed at least a few days prior to commencement of actual field work. This will help to avoid mistakes, missing samples and use of improper methods.

Furthermore, more expeditious sampling methods and "fine-tuning" of techniques can be developed beforehand. Due to time constraints, a pilot sampling program was not conducted before sampling commenced for this project.

Full complements of macroinvertebrate trace contaminant samples were not collected at all sites. To ensure all invertebrate tissue samples are collected we recommend that sampling effort should be increased (increase manpower and/or time at each site). However, field collection trips are often conducted under time and/or financial constraints. Therefore, preparatory work performed prior to field trips can free up time for invertebrate collecting.

The following suggestions should be considered prior to commencement of field collection.

1. Prepare all sampling equipment and containers to specified QA/QC requirements. If possible, purchase precleaned containers and equipment from manufacturers/suppliers. Where possible, one set of sampling equipment should be used per site. This would leave only a few large items and expensive equipment (e.g., stainless steel Ekman Dredge, large stainless steel and glass trays) to clean and prepare between sites.

2. Time was expended cleaning and preparing the mesh barriers (see Section 2.2.2) among sampling sites. These barriers are relatively inexpensive to make. To save time, we recommend that one set of barriers be prepared for each sample site.

3. A significant amount of time was spent labelling containers prior to placing them in storage. We suggest pre-labelling all containers as fully as possible. Spaces can be left for dates, estimated wet weight and other undetermined information.

One recurring problem was the ripping and tearing of aluminum foil when fastening lids on the organic sample containers. To avoid this problem and possible contamination of samples, we suggest that a lid manufactured with an inert material be used (i.e., Teflon®). If this is not possible, have plenty of extra aluminum foil (precleaned to QA/QC requirements) on hand.

4.1 FUTURE RESEARCH SUGGESTIONS

Aquatic insects play an important role in energy transfer through trophic levels in fresh water habitats (Resh and Rosenberg 1984). Larvae feed on a variety of materials, including detritus, bacteria, algae, plant material and other invertebrates. Aquatic insect larvae in polluted water bodies may be exposed to high concentrations of contaminants through uptake from water and feeding (Lundrum and Poore 1988; Novak *et al.*. 1988). By converting food materials and potentially associated contaminants into readily available living tissue, benthic invertebrates allow organisms at higher trophic levels (fish, invertebrate predators) to bioaccumulate pollutants.

Success of field collections of larval aquatic insects for contaminant monitoring is often limited, especially in large rivers (Kovats and Ciborowski 1989; Kovats 1990). Benthic invertebrates are difficult to sample because they are patchy in distribution (Downing 1979) and require specialized collecting equipment. Furthermore, aquatic invertebrates are often collected with large amounts of sediment that requires extensive processing prior to analysis (Kovats & Ciborowski 1989) and may make the collection of adequate biomass (i.e., 32 g in this study) impractical.

This survey was performed in early spring when very few adult aquatic insects are present. At this time, the winter invertebrate fauna that was sampled would have been subjected to low flow volumes and potentially greater concentrations of contaminants. However, adult aquatic insects may contribute significantly to the diet of terrestrial predators (e.g., birds, bats, spiders), thereby acting as a link between aquatic and terrestrial food chains (Menzie 1980, Jackson and Resh 1989).

To simplify sampling of aquatic insects and to quantify the amount of contaminants that are potentially transferred to terrestrial systems, we suggest that the potential of light-trapped adult aquatic insects should be examined.

Adult aquatic insects are nocturnally active and exhibit strong attraction to ultraviolet light (Nimmo 1966), thus, light traps are ideally suited for efficient collection of large numbers of these organisms during summer and autumn. Indeed, light traps have been used in many studies of the benthic insect fauna of rivers and wetlands (e.g., Corbet et al. 1966; Resh and Sorg 1978; Garono and MacLean 1988; Kovats 1990).

The use of light-trapped adults of aquatic insects could circumvent many sampling difficulties (Kovats 1990). Inexpensive, non-specialized, equipment is necessary for their collection (Kovats and Ciborowski 1989). Furthermore, large numbers of animals, free of bottom sediment, can be quickly acquired and sorted. Thus, adult insects that have emerged from aquatic habitats have great potential as a biomonitoring tool and may provide a cost-effective and practical alternative to sampling organisms directly within the aquatic environment (Kovats and Ciborowski 1989; Kovats 1990).

SECTION 5.0
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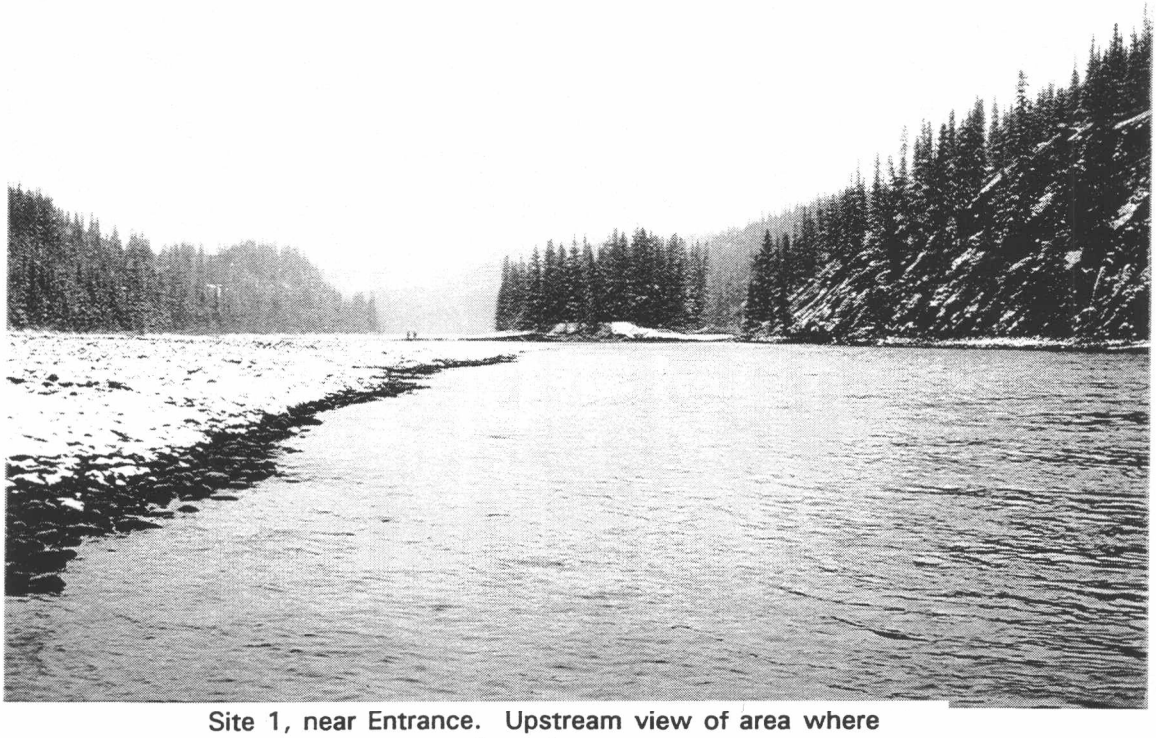
APPENDIX 1

Photographs

Site 1, near Entrance. Looking upstream at area where depositional sediments were collected.



Site 1, near Entrance. Upstream view of area where invertebrates were collected.

Site 1, near Entrance. Collecting invertebrate tissue samples.

Site 2, near Weldwood Haul Bridge. Downstream view overlooking area where invertebrate community samples were collected.

Site 2, near Weldwood Haul Bridge. Upstream view of area.

Site 2, near Weldwood Haul Bridge. Sorting invertebrates.

Site 2, near Weldwood Haul Bridge. Upstream view.

Site 2, near Weldwood Haul Bridge. The "field laboratory".

Site 3, near Obed Mountain Road Bridge. Collecting invertebrates for trace contaminant analyses.

Site 3, near Obed Mountain Road Bridge. Downstream view.

Site 3, near Obed Mountain Road Bridge. Looking upstream at area where sediments were collected.

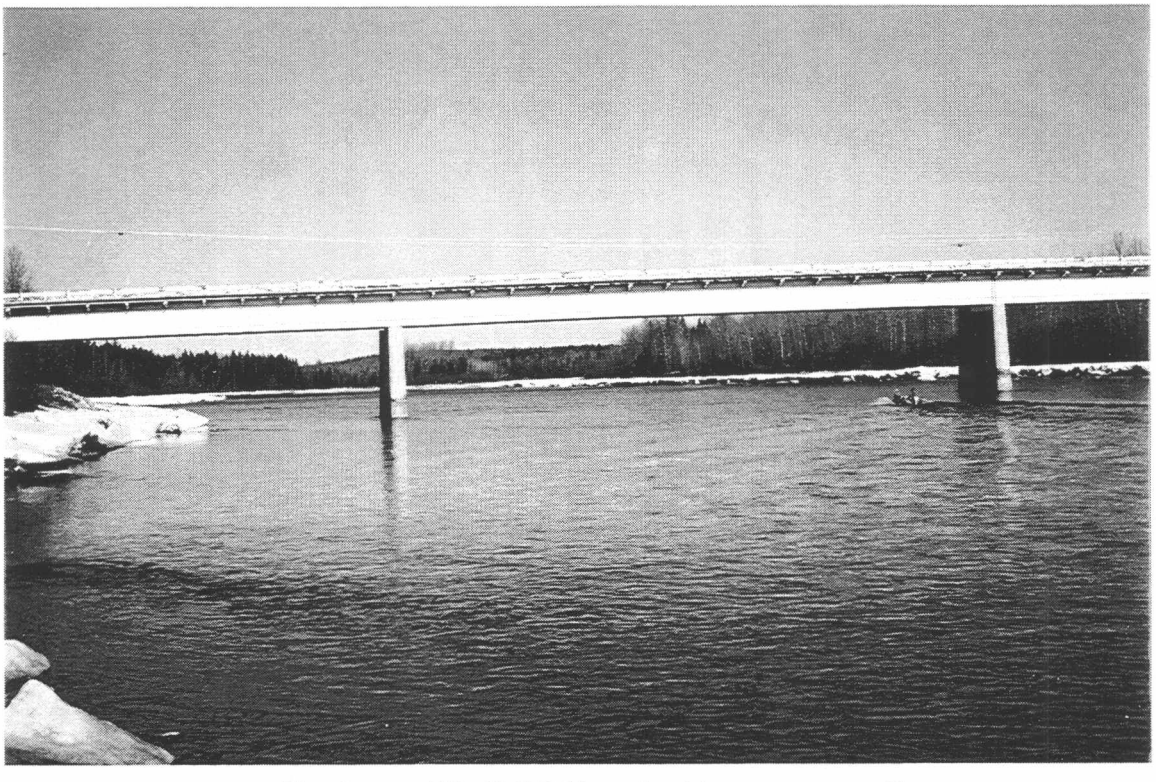
Site 4, near Emerson Lakes. Downstream view from bridge.

Site 4, near Emerson Lakes. Upstream view from bridge

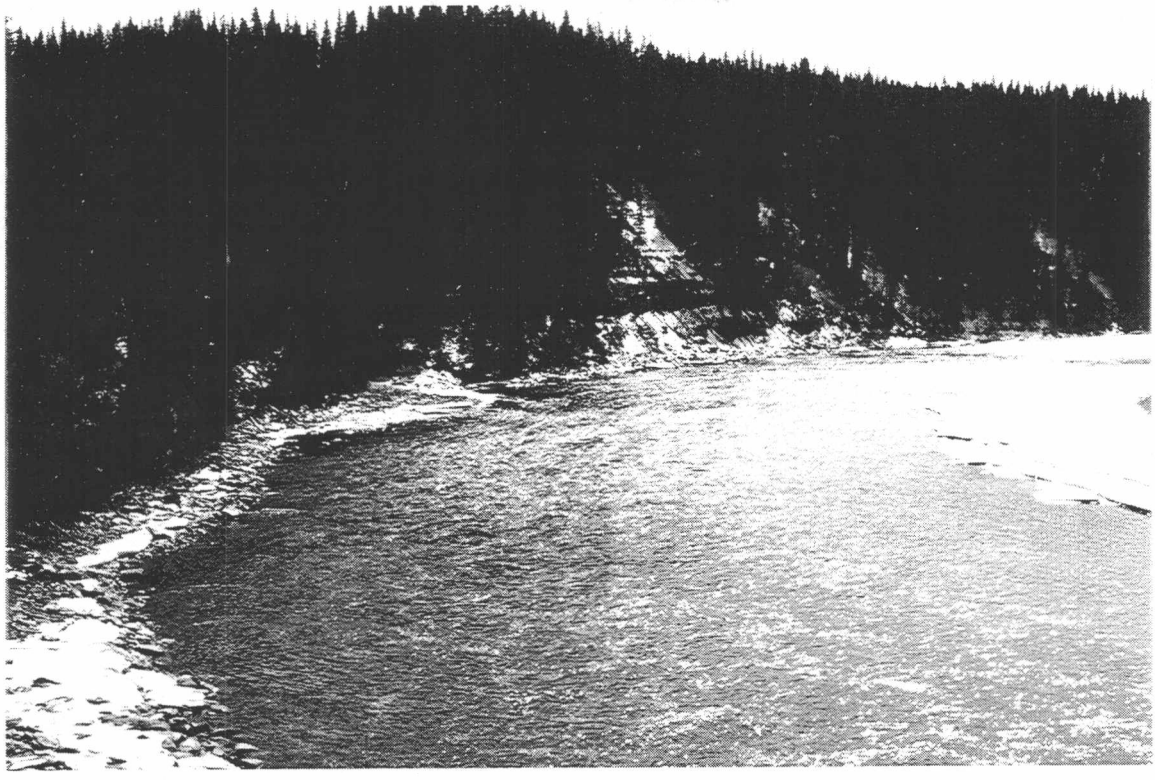
Site 5, near Knight Bridge. Downstream view. Note: Pine Creek confluencing with Athabasca River underneath the bridge.

Site 5, near Knight Bridge. Panoramic view looking upstream. Invertebrate community and sediment samples were collected in the area shown on the left photograph.

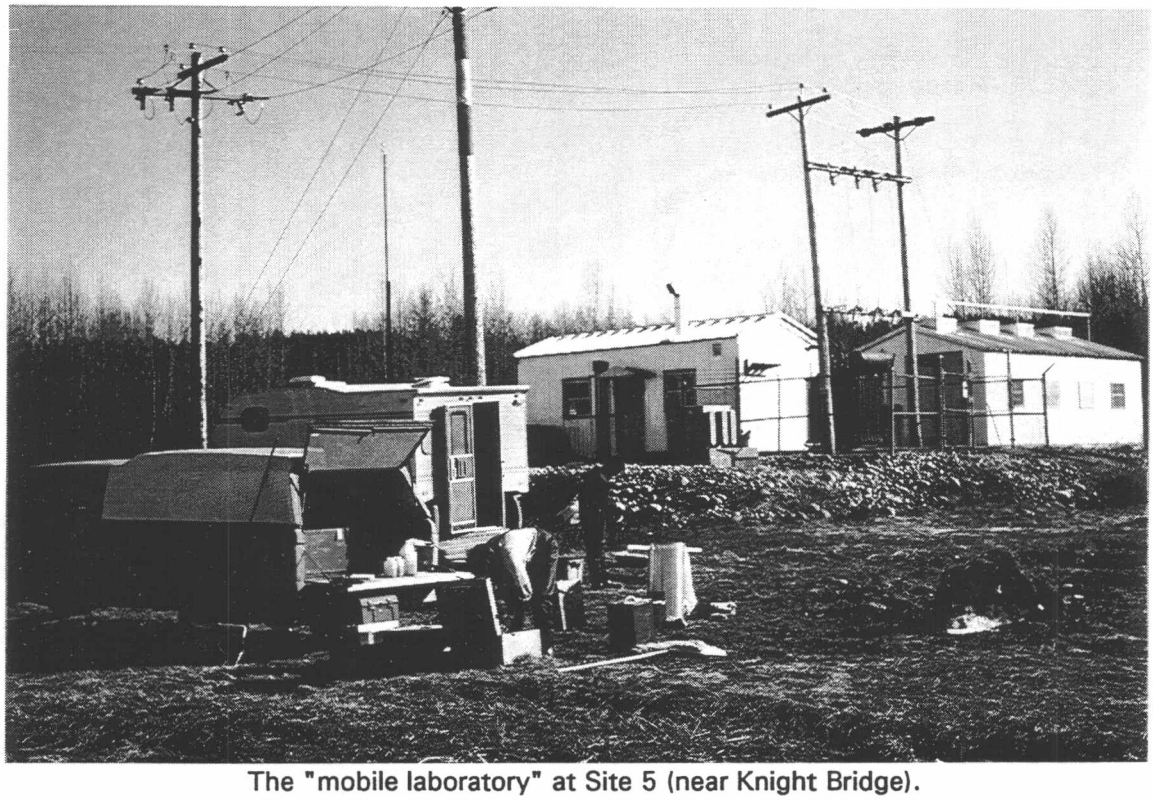
Site 6, near Windfall Bridge. Downstream view of area where erosional invertebrate community, invertebrate tissue, and epilithon tissue samples were collected.



Site 6, near Windfall Bridge. Looking upstream. Note: Zodiac® on river; searching for depositional habitat.

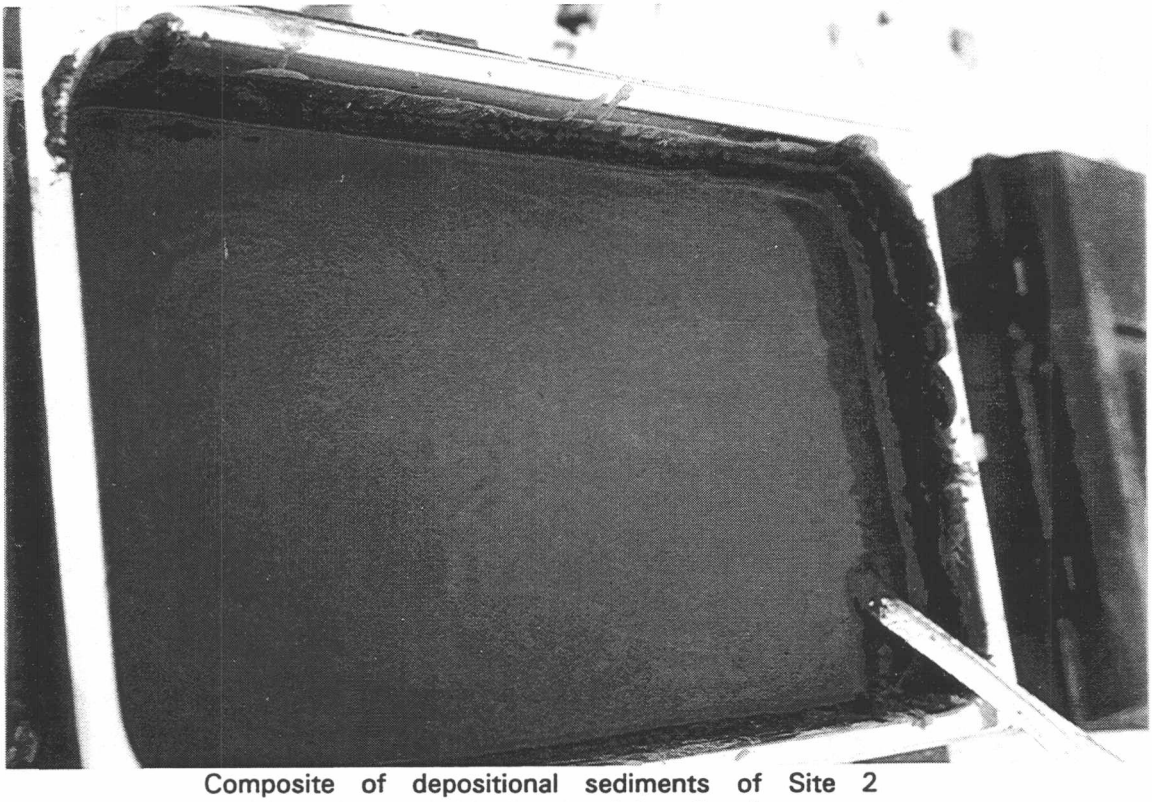


Upstream view of Athabasca River from Berland Bridge.
This site was not sampled.

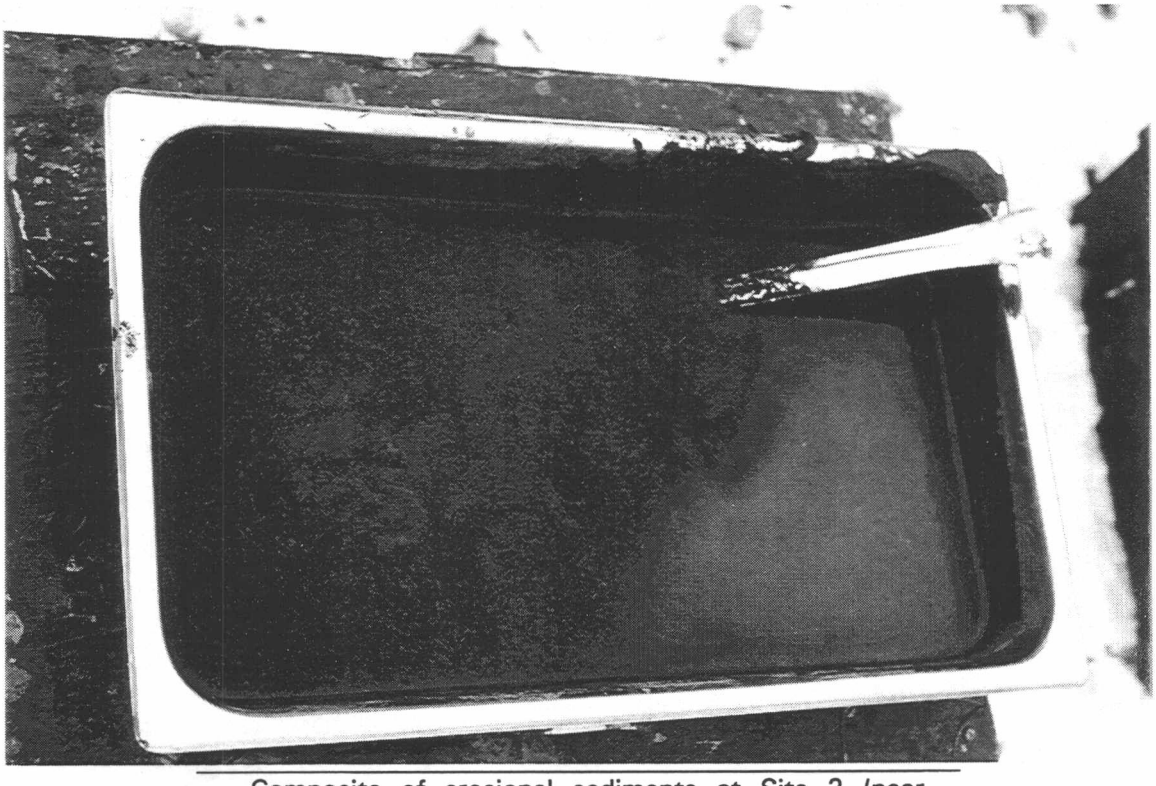


The "mobile laboratory" at Site 5 (near Knight Bridge).
Chevron's pump houses are in the background.

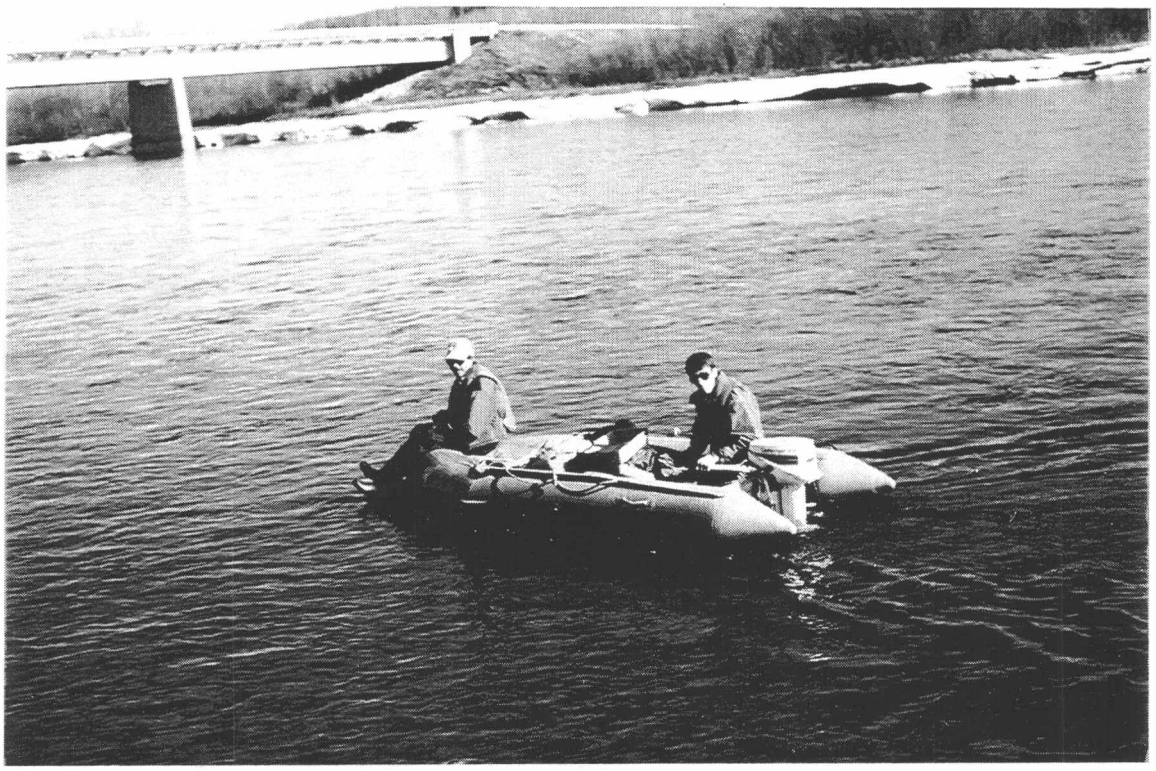
Panoramic downstream view of the Athabasca River from Berland Bridge. Although not obvious in the photograph, the plume from the Berland River is against the left bank. Note the bluff on the right bank.



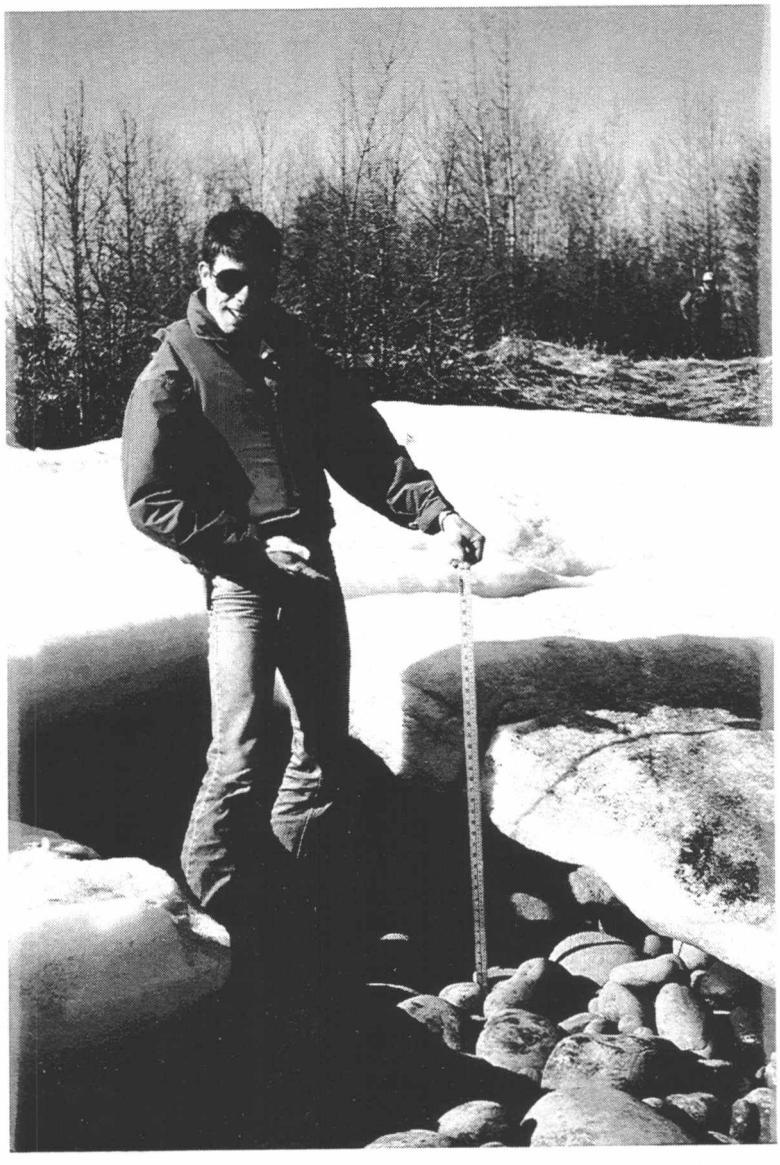
Composite of depositional sediments of Site 2 (Weldwood Haul Bridge). A slight oily sheen was observed on the surface.



Composite of erosional sediments at Site 2 (near Weldwood Haul Bridge). Note the black organic fines.



The Zodiac®, loaded up and ready to go.



Ice was covering the riverbanks at many of the sample sites.