FOR GENERATIONS

Report Title: *Peace River Fisheries & Aquatic Resources Literature Summary*
Project: Peace River Site C Hydro Project
Prepared By: Amec Earth & Environmental
Prepared For: BC Hydro

NOTE TO READER:

This is a report on a study commissioned toward the development of engineering, environmental and technical work conducted to further define the potential Site C project.

For environmental studies, the focus is on the development of an environmental and socio-economic baseline around the area of the potential Site C Project. Baseline studies are generally a survey of existing conditions within a project study area.

This report and other information may be used for future planning work or an environmental assessment or regulatory applications related to the potential Site C Project.

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PEACE RIVER
FISHERIES AND AQUATIC RESOURCES
LITERATURE SUMMARY

Prepared for

BC Hydro

by

AMEC Earth & Environmental

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1.0 INTRODUCTION

BC Hydro retained AMEC Earth and Environmental to review and summarize fisheries and aquatics literature for the Peace River, with a focus on studies completed for the proposed Site C hydroelectric project. This document provides a review of available literature and summarizes fisheries and aquatic studies done in the Site C project area of the Peace River over the past 30 years. An assessment of the data quality was also conducted to aid in planning additional studies that may be needed for any future environmental assessment of the proposed Site C project. Data gaps are prioritized in a companion document (AMEC 2007) that examines the proposed Site C project using the Department of Fisheries Oceans (DFO) Risk Management Framework (DFO 2004).

1.1 Site C Project Area

The proposed Site C project would be located approximately 62 km upstream from the British Columbia/Alberta border near the town of Fort St. John in north eastern British Columbia (Figure 1). The Site C dam would be located downstream of the two previously constructed hydroelectric facilities on the Peace River: W.A.C. Bennett Dam completed in 1968 and the Peace Canyon Dam completed in 1980.

The Site C reservoir would extend approximately 83 km upstream to the base of the Peace Canyon dam (BC Hydro 1990). Major tributaries between the Peace Canyon Dam and Site C that would be affected by reservoir inundation include Maurice Creek, Lynx Creek, Farrell Creek, the Halfway River, Cache Creek, and the Moberly River. Major tributaries downstream of the proposed Site C dam include the Pine River, the Beatton River, the Kiskatinaw River, and the Alces River.

The study area for the current literature review included the Peace River mainstem from the Peace Canyon Dam to the BC/Alberta border and all tributaries listed above. The geographic scope of the review was expanded as necessary. Selected information from Williston Lake was included as this reservoir influences several key environmental variables downstream (e.g., dissolved oxygen concentration, discharge). Information from the Peace Canyon Dam reservoir (i.e., Dinosaur Lake) was also included in this review because it is the closest existing reservoir to Site C and is the most recently constructed reservoir on the Peace River. Information collected for the proposed Dunvegan hydroelectric facility in Alberta (located 189 km downstream of the proposed Site C project) is included in this literature review along with selected information from the Peace River in Alberta. Assessing the effects on the downstream environment will be important in any future environmental impact assessment in addition to determining any potential cumulative effects.

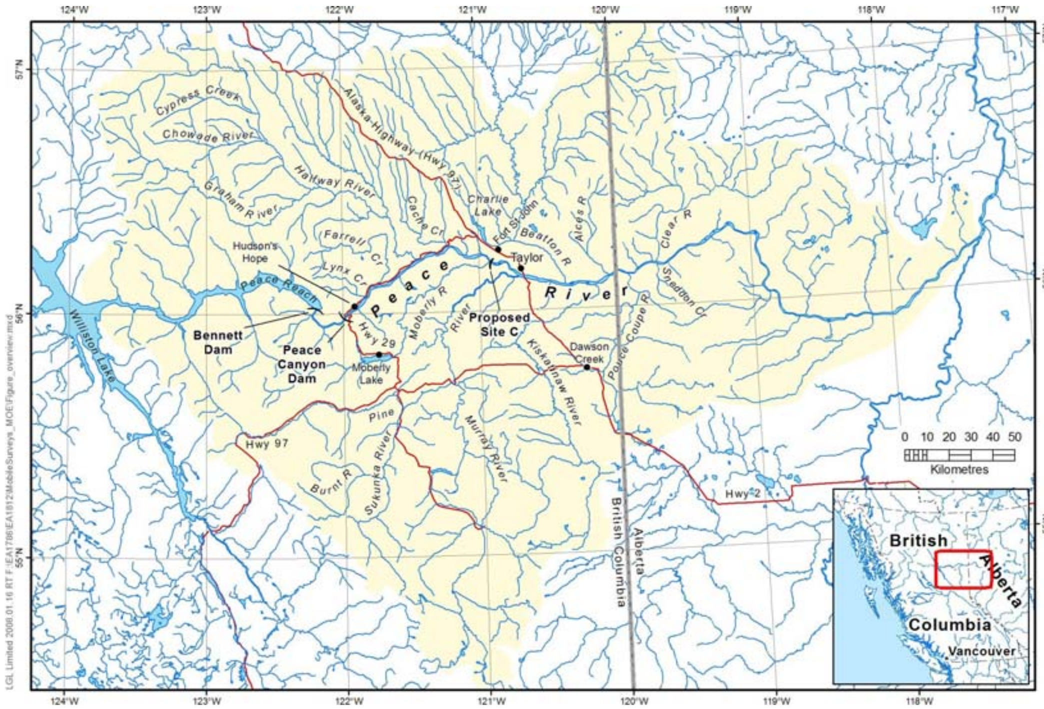

Figure 1: ***Existing and potential hydroelectric development on the Peace River in northeast British Columbia***

1.2 Summary of Previous Literature Reviews

Several literature reviews or data gap analysis have been completed previously in regards to the proposed Site C project. Valenius (2001) compiled a summary of environmental and socio-economic studies completed for the Site C project. This document provides overview summaries of the studies completed up to 2001, outlines the BC Utilities Commission's findings in regards to the environmental impact assessment submission in the early 1980's, and summarizes studies carried out in the early 1990's that addressed deficiencies in the environmental review. Valenius (2001) also references the beginnings of the contemporary studies including the Peace River community indexing program (P & E 2002).

Pottinger Gaherty (2001) completed an environmental and social data gap summary and gap analysis for the Peace River Water Use Plan (WUP). Using a table format they outlined the available information under several topics including fish distribution and abundance, aquatic habitat, enhancement, angler use, and impacts/benefits of hydroelectric activities. General descriptions of the information were provided along with a rating on the data quality and data limitations with respect to the Peace River WUP.

Pottinger Gaherty (2005) also completed a data gap analysis for impacts associated with the proposed Site C project. Reports were categorized according the valued ecosystem component (e.g. water quality, fisheries, wildlife) and general descriptions of the information were provided. Limitations of the reports in regards to their use for an environmental impact assessment were assessed.

2.0 METHODS

This literature review is organized into topics from the Pathway of Effects linkage diagrams generated for the DFO Risk Management Framework report (AMEC 2007). Each Pathway of Effect for each project activity provided a number of direct or indirect pathways through which the project activity could affect the health, mortality, habitat and/or species composition, relative abundance, and distribution of fish in the Peace River. As expected, each of these potential fish and fish habitat endpoints were linked through a number of reoccurring physical, chemical, or biological changes to the river (e.g. change in lower trophic levels). These intermediate linkages and, the final endpoints themselves, provided the basis for information topics used in this literature summary (Table 1).

Table 1: Potential pathway of effects endpoints and information topics

Pathway of Effect Endpoint	Information Topics
Change in fish health	Fish community abundance, distribution and composition
Change in abundance, distribution and species composition	Fish life history characteristics
Change in fish habitat	Mercury concentration
Direct mortality to fish	Fish habitat quality/quantity
	Fish habitat utilization
	Fish migration
	Gene flow and unique populations
	Sediment loads and transport
	Water quality
	Lower trophic communities
	Peace River flows and habitat availability
	Turbine mortality and entrainment
	Peace River recreational fishing
	Compensation options
	Rare and listed fish species

A preliminary document list was compiled from the previous literature summaries and data gap analysis completed for the Peace River (Valenius 2001; Pottinger Gaherty 2001, 2005). Selected references from these documents were also reviewed.

The majority of the documents were obtained from BC Hydro, with additional documents obtained from AMEC's in-house library, the Peace Williston Compensation Program website (http://www.bchydro.com/pwcp) and the British Columbia Ecological Reports Catalogue (http://www.env.gov.bc.ca/ecocat/). Documents were read for content and the methods used, study location and important results were summarized.

Data quality in each report was assessed under the lens of utilizing the information for an environmental impact assessment for the proposed Site C project. Criteria used for assessing data quality are provided in Table 2. For inclusion into any future impact assessment, data must be collected using reliable standardized methods, ideally be robust enough to conduct statistical analysis, and should reflect, as closely as possible, the current state of the environmental variable measured.

Table 2: Data quality criteria

Rating	Data Quality
0	Data is out of date and has little use for any future EIA or monitoring program. Historical reference only.
1	Data or methods used are of low quality. Document is a review of other information sources and did not involve collection of field data.
2	Data and methods are of high quality, however data is out-of-date. Data can be used as a historical reference only.
3	Data and methods are of high quality. Data was collected recently and can be used in a near-future EIA.

3.0 LITERATURE SUMMARY

3.1 Fish Community Abundance, Distribution and Composition

Data collection on the Peace River fish community has been conducted since the 1970's and carries on to this day in the fish community indexing program (Table 3). Standardized, large-scale sampling in the Peace River and tributaries first occurred in the early 1990's with multi-year studies conducted by R.L. & L. Environmental Consultants (RL & L) and Aquatic Resources Ltd (ARL). The small-bodied fish community of the Peace River was studied in 1999 and 2000 (RL & L 2001). In 2002, the multi-year fish community indexing program was initiated to determine which species and population statistics could be used as indicators of the effects of flow manipulations in the Peace River. Though this study concentrates on bull trout, mountain whitefish and Arctic grayling, it does provide multi-year data on abundance and distribution on all species in the Peace River mainstem.

Most of the work to date regarding the abundance, distribution, and composition of the fish community has focused on the Peace River mainstem. Prior to 2005, there were only two years of data from the Peace River tributaries upstream of the Site C project area (ARL 1991a, 1991b). Similarly, limited information on the fish community of Dinosaur Lake exists and no comprehensive inventory work has been completed to date. In addition, various studies are available describing the Peace River fish community downstream of the British Columbia/Alberta border. There is also limited information on the species composition in the headwaters of select Peace River tributaries.

Table 3: Documents containing information regarding the Peace River system fish community, abundance and distribution

Year	Title	Author	Data Quality
1978	Peace River Site C Hydroelectric Development Fish and Aquatic Environment	Renewable Resources Consulting Ltd.	0
1990	Investigations of Fish and Habitat Resources in the Peace River in Alberta	RL & L Environmental Services Ltd.	2
1990	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Fish Movements and Population Status 1989 Studies	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Fish Movements and Population Status 1990 Studies	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Development: Fisheries Habitat and Tributary Surveys Year 1	Aquatic Resources Ltd.	2
1991	Peace River Site C Development: Fisheries Habitat and Tributary Surveys Year 2	Aquatic Resources Ltd.	2
1993	Dinosaur Lake Summer Creel Surveys, Results of the 1988 Program and a Five Year Review (1984-1988)	Pattenden and Ash	2
1997	Bull Trout/Grayling Distribution/Temperature Synoptic Survey Peace River	Aquatic Resources Ltd.	2
1997	Fisheries Inventory and Stream Classification of Peace River Tributaries	Aquatic Resources Ltd.	2
2000	Dunvegan Hydroelectric Project Fish and Fish Habitat Inventory Comprehensive Report Dunvegan Study Area, Peace River	RL & L Environmental Services Ltd.	3
2001	Fish Habitat Utilization Study	RL & L Environmental Services Ltd.	3
2002	Peace River Fish Community Indexing Program – Phase 1 Studies (2001)	P & E Environmental Consultants Ltd.	3
2003	Peace River Fish Community Indexing Program – Phase 2 Studies (2002)	P & E Environmental Consultants Ltd.	3
2004	Peace River Fish Community Indexing Program – Phase 3 Studies (2003)	Mainstream Aquatics Ltd.	3
2004	Dinosaur Reservoir Fish Collection Summary 2001	Murphy and Blackman	3

Year	Title	Author	Data Quality
2004	Dinosaur Reservoir 2002 Fish Collection Summary	Murphy et al.	3
2004	2003 Dinosaur Reservoir Littoral Fish Population and Habitat Enhancements	Blackman et al.	3
2005	Peace River Fish Community Indexing Program – Phase 4 Studies (2004)	Mainstream Aquatics Ltd.	3
2005	2004 Assessments of Habitat Improvements in Dinosaur Reservoir	Blackman and Cowie	3
2006	Peace River Fish Community Indexing Program – Phase 5 Studies (2005)	Mainstream Aquatics Ltd.	3
2006	Peace River Fish and Aquatics Investigations 2005	AMEC Earth and Environmental and LGL Ltd.	3

3.1.1 Peace River

The Peace River fish community in British Columbia consists of 29 reported fish species (Table 4). This species list has been compiled from both large-bodied and small-bodied fish surveys using numerous capture methods including boat electrofishing, backpack electrofishing, beach seining, gill netting, and minnow trapping. Sampling has been conducted mostly in the summer, with some fall and spring sampling surveys. With the exception of overnight gillnetting and minnow trapping, all sampling was conducted during the day, mostly with single pass effort.

Table 4: Common and scientific names of fish species in the Peace River in British Columbia

Common Name	Scientific Name
Sport fish	
Arctic grayling	*Thymallus arcticus*
Brook trout	*Salvelinus fontinalis*
Bull trout	*Salvelinus confluentus*
Burbot	*Lota lota*
Goldeye	*Hiodon alosoides*
Kokanee	*Oncorhynchus nerka*
Lake trout	*Salvelinus namaycush*
Lake whitefish	*Coregonus clupeaformis*
Mountain whitefish	*Prosopium williamsoni*
Northern pike	*Esox lucius*
Rainbow trout	*Oncorhynchus mykiss*
Walleye	*Sander vitreus*
Yellow perch	*Perca flavescens*
Pygmy whitefish	*Prosopium coulteri*
Suckers	
Largescale sucker	*Catostomus macrocheilus*
Longnose sucker	*Catostomus catostomus*

Common Name	Scientific Name
White sucker	*Catostomus commersoni*
Cyprinids	
Finescale dace	*Phoxinus neogaeus*
Flathead chub	*Platygobio gracilis*
Lake chub	*Couesius plumbeus*
Longnose dace	*Rhinichthys cataractae*
Northern pikeminnow	*Ptychochelius oregonensis*
Peamouth	*Mylochelius caurinus*
Redside shiner	*Richardsonius balteatus*
Spottail shiner	*Notropis hudsonius*
Trout perches	
Trout perch	*Percopsis omiscomaycus*
Sculpins	
Prickly sculpin	*Cottus asper*
Slimy sculpin	*Cottus cognatus*
Spoonhead sculpin	*Cottus ricei*

Note: Summarized from P & E 2002, Mainstream Aquatics 2006.

The Pine River confluence acts as a rough transition point delineating the cold-water species dominated fish community upstream from the cool-water species dominated community downstream. Cold-water species such as rainbow trout and Arctic grayling are typically restricted to areas upstream of the Pine River, while cool-water species such as goldeye, northern pike and walleye are generally restricted to areas downstream of the Pine River. Mountain whitefish and longnose sucker are ubiquitous throughout the Peace River in British Columbia.

Mountain whitefish are the most abundant species in the Peace River in British Columbia in both the large and small fish communities (RRCS 1978; RL & L 1990b, 1991, 2001; P & E 2002, 2003; Mainstream 2004, 2005, 2006). They are found in all habitat types and all life-stages inhabit the river. Juvenile and young-of-the-year (YOY) mountain whitefish have been captured in the mainstem indicating that they utilize the Peace River for spawning (RL & L 2001). Mountain whitefish are most abundant between the confluences of the Halfway River and Maurice Creek and exhibit a seasonal movement upstream between spring and fall (RL & L 1990b). Population estimates from the large fish community indexing program estimate the population of mountain whitefish over 250 mm in length at approximately 36,000 (P & E 2003) in the sample areas.

Adult rainbow trout are present in the Peace River though at a much lower abundance than mountain whitefish (RRCS 1978; RL & L 1990b, 1991; P & E 2002). Juvenile rainbow trout are rarely observed (RL & L 2001) in the mainstem. Rainbow trout are restricted to the upper reaches of the Peace River and are found in greatest densities upstream of Maurice Creek. Catches sharply decrease moving downstream (RL & L 1990b, 1991) likely due to warming water temperatures. In 1989, 28% of the rainbow trout captured were hatchery fish entrained from Dinosaur Lake (RL & L 1990b). In 1990, 55% of the rainbow trout captured were hatchery fish (RL & L 1991).

Arctic grayling are most abundant between the confluences of the Pine and Halfway Rivers (RL & L 1991). Adult Arctic grayling are more common than juveniles which are rarely encountered in the mainstem (RL & L 2001). Though uncommon in the mainstem, overall abundance of juvenile Arctic grayling increased in the summer and fall suggesting an influx of individuals from the tributaries (RL & L 1991). Young-of-the-year Arctic grayling have been captured at the mouth of Farrell Creek (RL & L 2001) suggesting that Farrell Creek is used by Arctic grayling for spawning.

Several other sport fish species are present in the Peace River but in relatively low abundance. Bull trout have been captured in all areas of the Peace River but in small numbers (RL & L 1990b). They are more commonly found in the Halfway River system, where they spawn and rear in the upper tributaries (ARL 1991a).

Burbot have been captured incidentally in several studies (RL & L 1990b, 1991; P & E 2002) and burbot densities in the Peace River mainstem appear to be low. Northern pike have mostly been captured downstream of the Pine River. However, pike have been observed as far upstream as Hudson Hope (RL & L 1990b). Walleye are normally found downstream of the Pine River confluence but concentrations of walleye have been observed at the mouth of the Moberly River (RL & L 1991). Goldeye are mostly restricted to the Peace River below the Pine River confluence (RL & L 1990b; P & E 2002).

Longnose sucker are the most abundant non-sportfish species in the Peace River and are second behind mountain whitefish in overall abundance (RL & L 1990b, 1991, 2001; P & E 2003). Longnose sucker are widely distributed throughout the river and are commonly captured in both large and small fish surveys. Other sucker species such as largescale sucker and white sucker are also found in the Peace River but are generally less abundant than longnose sucker (RL & L 1990b, 1991, 2001). Various cyprinid and sculpin species are also present in the Peace River (Table 4).

Fish entrained from Williston Lake or Dinosaur Lake have been frequently captured in the Peace River downstream of Peace Canyon Dam. Kokanee, lake trout, lake whitefish and hatchery reared rainbow trout have all been captured downstream of the Peace Canyon Dam (RL & L 1990b, 1991, 2001).

Several uncommon species to the Peace River have also been captured. Yellow perch were captured in an off-channel area downstream from the Moberly River in 1990 and 2001 (RL & L 1991; P & E 2002). A single brook trout was captured downstream of the Halfway River in 2002 and was the first reported record of this species in the Peace River (P & E 2002).

The fish community of the Peace River downstream of the BC/Alberta border is dominated by cool-water species (RL & L 1990a, 2000a). Longnose sucker are the most abundant species. Mountain whitefish are also present but their abundance decreases moving downstream and other sportfish such as goldeye, burbot, and walleye become increasingly more abundant. Cold-water species such as Arctic grayling, rainbow trout and bull trout are rarely encountered in the reaches near the BC/Alberta border.

Data Quality

The large-bodied fish community of the Peace River has been intensively examined, both recently during the Fish Community Indexing Program, and in past studies conducted in 1989 and 1990. All of these studies have been conducted using appropriate methodologies and analyses and have sampled the variety of habitats present in the river. Earlier studies included sampling in spring, summer, fall, and winter seasons in reaches upstream and downstream of the Site C project area. The more recent Fish Community Indexing Program provides reliable population estimates for mountain whitefish but for no other species.

Data from the Fish Community Indexing Program provides information that can be used to assess potential effects of the Site C project on fish populations in the Peace River. The RL & L studies from 1989 and 1990 provide a useful data set from which to compare to newer data to determine if any changes in the fish community has occurred in the last 15 years.

The small-bodied fish community is less well understood than the large-bodied fish community due to the limited spatial and temporal extent of sampling (i.e., only one year of sampling in all reaches in all seasons). No multi-year data is available. However, the data collection and analysis are valid and the report provides an initial assessment of the species composition, distribution, and the habitat use by the small fish community of the Peace River.

3.1.2 Peace River Tributaries

Information regarding fish species composition, distribution and abundance of fish in the Peace River tributaries is limited in scope, as it has only been collected three times over the last 30 years. The majority of sampling has occurred in the Peace River tributaries between the Peace Canyon Dam and the proposed Site C project area: Maurice, Lynx, Farrell, Cache, and Wilder creeks and in the

Moberly and Halfway rivers. A total of 22 species of fish have been captured or observed in these Peace River tributaries (Table 5). Sampling has primarily occurred in the summer and fall. Sampling has included backpack electrofishing, beach seining, angling and snorkel surveys.

Table 5: Fish species present in the Peace River tributaries

Species	Moberly River	Wilder Creek	Cache Creek	Halfway River	Farrell Creek	Lynx Creek	Maurice Creek
Arctic grayling	X		X	X	X	X	X
Bull trout	X			X		X	X
Kokanee				X			
Mountain whitefish	X		X	X	X	X	X
Rainbow trout	X			X	X	X	X
Burbot	X			X	X	X	
Northern pike	X			X			X
Walleye	X						
Lake whitefish	X						X
Largescale sucker	X			X	X	X	X
Longnose sucker	X	X	X	X	X	X	X
White sucker	X		X	X	X	X	X
Flathead chub	X	X	X	X	X		
Lake chub	X	X	X	X	X	X	
Longnose dace	X	X	X	X	X	X	X
Northern pikeminnow	X		X	X	X	X	X
Peamouth	X	X					
Redside shiner	X	X	X		X	X	X
Trout perch					X		
Prickly sculpin					X		
Slimy sculpin	X	X		X	X	X	X
Spoonhead sculpin	X						

Note: Halfway River includes species that were captured in its tributaries. Summarized from RRCS 1978; ARL 1991a, 1991b; AMEC and LGL 2006a.

Moberly River

The Moberly River is the second largest Peace River tributary upstream of the proposed Site C project area. It drains an area of approximately 1833 km^2 and enters the Peace River approximately 2 km upstream from the proposed Site C project area. It is predicted that the lower 10 km of the Moberly River would be inundated by the Site C reservoir.

The Moberly River is used by the widest assemblage of fish species of any Peace River tributary upstream of the Site C project; a total of 20 species have been documented (Table 5). Mountain whitefish are the most abundant sportfish species in the Moberly River (ARL 1991a, 1991b). Adult and juvenile mountain whitefish have been observed and spawning adults have been captured in the fall, primarily in the lower 25 km of the river (RRCS 1978; ARL 1991a, 1991b). These data suggest that mountain whitefish use the Moberly River for spawning and rearing.

Juvenile Arctic grayling have also been captured in the Moberly River. Densities of juveniles decline moving upstream from the confluence (RRCS 1978; ARL 1991a). Juvenile and adult northern pike are found through out the Moberly system but are generally more numerous immediately downstream of Moberly Lake (RRCS 1978; ARL 1991a). Lake whitefish have also been captured immediately downstream of Moberly Lake (ARL 1991a). Sculpins and redside shiners are the most numerous non-sportfish species in the Moberly River.

Wilder Creek

Wilder Creek is a small creek entering the Peace River approximately 14 km upstream from proposed Site C project area on the north side of the river. No sportfish have ever been captured or observed in Wilder Creek (RRCS 1978; ARL 1991a; AMEC 2006). Of the fish species captured, peamouth and flathead chub are the most common species but the number of fish captured or observed is low.

Cache Creek

Cache Creek is located approximately 25 km upstream from the proposed Site C project area. Northern pikeminnow and lake chub were commonly found in all reaches of Cache Creek (ARL 1991a). Longnose dace and longnose sucker were also found in Cache Creek. Young-of-the-year Arctic grayling were observed in a beaver pond in surveys conducted in 1989 but no sportfish were observed in more recent surveys (ARL 1991a; AMEC 2006a).

Halfway River

The Halfway River is the largest tributary upstream of the proposed Site C project area. The total watershed area of the Halfway River is 9402 km^2. Major tributaries of the Halfway River include the Chowade, Graham, and Cameron rivers and Cypress, Colt, Kobes, and Ground Birch creeks.

The Halfway River is known to be used by 16 fish species: 7 sportfish and 9 non-sportfish species (Table 5). Mountain whitefish are the most abundant species in the Halfway system and adults, juveniles and YOY have been captured or observed (RL & L 1991; ARL 1991a). The presence of YOY fish suggests that mountain whitefish use the Halfway River for spawning and rearing. Juvenile and adult rainbow trout and Arctic grayling have also been observed in the Halfway River and its tributaries (RL & L 1990a; ARL 1991a, 1991b). Adult and juvenile bull trout are commonly found in the Halfway River and its tributaries (RL & L 1990b; ARL 1991a, 1991b; AMEC 2006a). The Halfway River system also provides habitat for numerous sucker, cyprinid and sculpin species (Table 5).

Farrell Creek

Farrell Creek is a small stream located approximately 63 km upstream from the proposed Site C project area. Juvenile mountain whitefish were the most abundant species in Farrell Creek in the first set of surveys completed in the late 1970's (RRCS 1978). In subsequent studies, very few mountain whitefish were captured or observed in Farrell Creek (ARL 1990a; AMEC 2006a). Non-sportfish including redside shiners, longnose sucker, slimy sculpin, longnose dace and lake chub are present in Farrell Creek (RRCS 1978; ARL 1991a; AMEC 2006a). A pair of spawned out walleye were observed in the creek in 1989 and these fish mark the furthest upstream observation of this species (ARL 1990a). A resident population of rainbow trout has been reported in the upper reaches of Farrell Creek and juvenile rainbow trout were observed in small numbers in the lower sections of the stream (RRCS 1978).

Lynx Creek

Lynx Creek is a small stream located approximately 73 km upstream from the proposed Site C project area. Mountain whitefish, rainbow trout and Arctic grayling have been captured in Lynx Creek. Adults, juveniles and YOY of these three species have been observed in Lynx Creek (RRCS 1978, ARL 1991a) suggesting that Lynx Creek provides spawning and rearing habitat for these species. Upstream distribution of fish is limited in Lynx Creek by a steep canyon approximately 3.2 km upstream from the confluence. Rainbow trout have been found above the canyon but likely represent an isolated population (RRCS 1978; ARL 1991a). Rainbow trout were captured throughout Lynx Creek with densities highest adjacent to the confluence of Brenot Creek, a Lynx Creek tributary (ARL 1991a, 1991b). Most rainbow trout captured were YOY or juveniles. Longnose sucker and northern pikeminnow were the most abundant non-sportfish captured. Adult longnose sucker and rainbow trout were captured in Lynx Creek in the spring (ARL 1991b). Two juvenile bull trout were captured in Lynx Creek in recent studies (AMEC 2006a).

Maurice Creek

Maurice Creek is located approximately 79 km upstream from the proposed Site C project area. Rainbow trout are commonly found in Maurice Creek (RRCS 1978; ARL 1991a, 1991b; AMEC 2006a) and Maurice Creek has the highest density of rainbow trout in all the tributaries sampled (ARL 1991a). A set of waterfalls 4.1 km upstream from the confluence acts as a barrier to upstream movement. Sampling upstream of the waterfalls has found no fish to be present (RRCS 1978; ARL 1991a, 1997b). Adult Arctic grayling in spawning condition and YOY Arctic grayling have also been observed in Maurice Creek indicating that Maurice Creek is used by Arctic grayling for spawning and rearing (RRCS 1978). Adult longnose sucker have also been captured in Maurice Creek (RRCS 1978). Juvenile mountain whitefish were observed in Maurice Creek but their distribution was restricted to the lowermost reaches (ARL 1991a). Sculpins are commonly found in Maurice Creek (ARL 1991a, 1991b; AMEC 2006a). Bull trout and northern pike have also been found in Maurice Creek (ARL 1991a, 1991b) but infrequently and in very low numbers.

Data Quality

Enumeration of spring spawning migrations in the tributaries upstream of the proposed Site C project area has been attempted in only two years (1989 and 1990). These data are over 15 years old and, because of technical difficulties associated with fish fences, high water conditions, and delayed installation, do not provide an accurate assessment of the species composition, timing, and relative abundance of large-bodied fish species using these tributaries for spawning and rearing in spring. Consecutive years of data collection are not available and the natural variability in spawning runs size and timing cannot be characterized.

Juvenile rearing data are out-of-date and were collected by reach and not by discreet habitat type. This precludes using habitat assessments to determine the amount of spawning and rearing habitat available above and below the potential Site C zone of inundation in each of the tributaries. The positive identification of critical spawning and rearing sites for different species upstream and downstream of the potential zone of inundation cannot be determined.

The available data are useful only for qualitative comparisons. These data do not provide sufficient information regarding the relative importance of Peace River tributaries to recruitment of the Peace River fish community.

3.1.3 Dinosaur Lake

Dinosaur Lake is the reservoir created in the Peace River mainstem by the Peace Canyon Dam. It is a run-of-river reservoir with steep sides and a short (< 3-days) water-retention period (Pattenden and Ash 1993a). The reservoir is approximately 20 km long and approximately 800 ha in area. Water level fluctuations due to operation of W.A.C. Bennett dam are generally < 2 m (Pattenden and Ash 1993a).

Rainbow trout were stocked in the lake until 2003 to provide recreational opportunities for local fisherman. Until recently, the only information on fish stocks in the reservoir was from creel surveys conducted in the mid 1980's. Rainbow trout were the most common species reported in the creel with kokanee, bull trout, lake whitefish, mountain whitefish, and Arctic grayling also reported (Hammond 1984, 1986a, 1987b, 1988; Pattenden and Ash 1993a). Hatchery-reared rainbow trout accounted for over 50% of the rainbow trout catch in the creel.

A comprehensive stock assessment of Dinosaur Lake has not been conducted but recent sampling in Dinosaur Lake using boat electrofishing and trap nets has been conducted (Murphy and Blackman 2004; Murphy et al. 2004; Blackman et al. 2004; Blackman and Cowie 2005). The purpose of these surveys has been primarily to determine the effectiveness of habitat enhancement structures (i.e., log structures) to increase trout production. The most abundant species during these surveys were rainbow trout and mountain whitefish. Bull trout, lake trout, kokanee, and lake whitefish were also captured. Non-sportfish captured included peamouth, longnose sucker, redside shiner and northern pikeminnow. Over 50% of the fish caught were under 20 cm in length (Murphy and Blackman 2004). The presence of juvenile fish may suggest that natural spawning and rearing is occurring in the reservoir.

Five small tributaries flow into Dinosaur Lake. Of these, only Johnson and Gething Creeks provide spawning and rearing habitat for Dinosaur Lake fish (Pattenden and Ash 1993). Johnson Creek provides spawning and rearing habitat for rainbow trout but only in the lower 500 m because of the presence of an impassable falls. Gething Creek provides spawning habitat for bull trout and rainbow trout (Hammond 1987b) but fish use is limited by an impassable falls 600 m upstream.

Data Quality

Available information provides preliminary information on the species composition of the large-bodied fish community of Dinosaur Lake. However, this information is not adequate to characterize the fish community of Dinosaur Lake because: 1) results from creel surveys are biased towards sportfish, specifically salmonids; 2) previous boat electrofishing surveys are biased by focusing effort on shallow, nearshore habitats with and without woody debris (i.e., no gillnetting in deep, offshore habitats); 3) previous trap netting efforts were generally ineffective; 4) a random, stratified sampling design has not been previously used to sample all available habitat types in the reservoir; 5) the small fish community has not been effectively sampled; and 6) consecutive years of field data are unavailable.

3.2 Fish Community Biological Characteristics

Length-weight relationships, growth, condition factors, recruitment, age structure and other biological characteristic information are important to determine the health and viability of the Peace River fish community. Long-term monitoring programs often use life history characteristics to monitor changes over time.

Life history information has been collected at three distinct periods in the Peace River mainstem; the initial 1970s studies, the RL & L studies in 1989-90 and most recently, through the fish community indexing program (Table 6). Limited life history information is available for fish in the tributaries.

Table 6: Documents containing information regarding the Peace River system fish life history.

Year	Title	Author	Data Quality
1978	Peace River Site C Hydroelectric Development Fish and Aquatic Environment	Renewable Resources Consulting Ltd.	0
1990	Investigations of Fish and Habitat Resources in the Peace River in Alberta	RL & L Environmental Services Ltd.	2
1990	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Fish Movements and Population Status 1989 Studies	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Fish Movements and Population Status 1990 Studies	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Development: Fisheries Habitat and Tributary Surveys Year 1	Aquatic Resources Ltd.	2
1991	Peace River Site C Development: Fisheries Habitat and Tributary Surveys Year 2	Aquatic Resources Ltd.	2

Year	Title	Author	Data Quality
2000	Dunvegan Hydroelectric Project Fish and Fish Habitat Inventory Comprehensive Report Dunvegan Study Area, Peace River	RL & L Environmental Services Ltd.	3
2001	Fish Habitat Utilization Study	RL & L Environmental Services Ltd.	3
2002	Peace River Fish Community Indexing Program – Phase 1 Studies (2001)	P & E Environmental Consultants Ltd.	3
2003	Peace River Fish Community Indexing Program – Phase 2 Studies (2002)	P & E Environmental Consultants Ltd.	3
2004	Peace River Fish Community Indexing Program – Phase 3 Studies (2003)	Mainstream Aquatics Ltd.	3
2005	Peace River Fish Community Indexing Program – Phase 4 Studies (2004)	Mainstream Aquatics Ltd.	3
2006	Peace River Fish Community Indexing Program – Phase 5 Studies (2005)	Mainstream Aquatics Ltd.	3
2006	Peace River Fish and Aquatics Investigations 2005	AMEC Earth and Environmental and LGL Ltd.	3

3.2.1 Peace River

The first comprehensive study of life history information from fish in the Peace River was collected by RL & L in 1989 and 1990. Life history parameters reported on included length distributions, conditions factors, length-weight relationships and age-length relationships from several sport fish species (Table 7). Life history information was also collected by RL & L in 1999 for the Peace River.

Table 7: Summary of life history parameters for species in the Peace River from sampling by RL & L in 1989 and 1990.

Year	Species	Sample Size	Median Length (mm)	Dom. Size Class		Largest Individual		Mean Condition Factor
				Range (mm)	% of sample	Length (mm)	Weight (g)	
1989	MW	3544	302	280 – 299	17.9	630	1410	1.23
	GR	243	316	180 – 199	11.9	449	1200	1.43
	RB - H	40	201	180 – 199	19.0	397	NA	1.01
	RB - W	152	275	260 – 279	19.1	405	NA	1.19
	WP	31	423	400 – 419 460 – 479	16.1 16.1	586	4100	1.18

Year	Species	Sample Size	Median Length (mm)	Dom. Size Class Range (mm)	Dom. Size Class % of sample	Largest Individual Length (mm)	Largest Individual Weight (g)	Mean Condition Factor
	BT	38	441	320 – 339 440 – 459 460 – 479	13.2 13.2 13.2	850	6500	1.19
	LW	83	339	320 – 339	43.4	NA	NA	1.20
1990	LW	1174	335	320 – 339	34.9	NA	NA	1.09
	GR	425	345	340 – 359	16.4	434	987	1.19
	RB - H	347	267	260 – 279	29.1	391	NA	1.03
	RB - W	232	287	260 – 279	18.1	356	NA	1.09
	WP	137	396	380 – 396	24.1	601	2510	1.08
	BT	44	323	300 – 349	25.0	500	1918	1.18
	MW	77	216	60 – 90	14.8	453	1112	1.08
	NP	91	496	250 – 299	12.5	860	4908	0.72
	KO	99	270	260 – 279	54.0	300	342	1.27

Note: MW – mountain whitefish. GR – Arctic grayling. RB – H – hatchery reared rainbow trout. RB – W – wild rainbow trout. WP – walleye. BT – bull trout. LW – lake whitefish. NP – northern pike.

Strong size classes were observed in walleye, hatchery-reared rainbow trout, bull trout, lake whitefish and kokanee. The largest sized fish observed were walleye, northern pike and bull trout.

Diet of Arctic grayling, rainbow trout, kokanee, mountain whitefish and lake whitefish were also assessed by RL & L (1990b). The most common food group consumed by all species was insects. Rainbow trout, Arctic grayling, and mountain whitefish preferred benthic invertebrates. None of the fish species preferred zooplankton.

Very few parasites were observed in captured fish (RL & L 1990b). No abundant parasitic infections were observed in any species. Nematodes in the swim bladder were observed in a few rainbow trout and Arctic grayling. Cysts were observed in several lake whitefish and mountain whitefish. Though limited in scope, the data suggests that the sportfish in the Peace River do not suffer from large-scale parasite infections.

The 1999 sampling by RL & L exhibited similar results to the early 1990s studies (Table 8). Calculated growth rates were similar to those reported in the early 1990s studies.

Table 8: Summary of Fish Life History Characteristics from RL & L 2001.

Species	Sample Size	Length Range (mm)	Weight Range (g)	Mean Condition Factor
Mountain whitefish	1234	15 – 482	5 – 1235	1.22
Bull trout	60	203 – 867	95 – 6700	1.07
Rainbow trout	32	70 – 458	55 – 1045	1.21
Arctic grayling	23	29 – 390	35 – 615	1.27
Walleye	9	230 – 475	300 – 1215	NA
Northern pike	3	426 – 543	NA	NA
Kokanee	4	77 – 263	NA	NA
Burbot	1	508	1010	NA
Longnose sucker	349	NA	NA	1.34

Recently, the fish community indexing program has provided detailed biological characteristic information for bull trout, Arctic grayling and mountain whitefish (P& E 2002, 2003; Mainstream 2004, 2005, 2006). These fish are being systematically sampled in continuous years to develop a series of indicators that will assist in monitoring changes due to different flow regimes in the Peace River.

Life history information collected for bull trout, Arctic grayling and mountain whitefish in the community indexing program provides a detailed assessment of the following:

- Length frequency distribution
- Age frequency distribution
- length-at-age relationship
- growth
- mortality rate
- body condition

Due to the high level of detail in these reports general trends and significant observations are summarized below.

Various trends in the Arctic grayling community have been observed from the data. In 2003, 2004 and 2005, there was a scarcity of fish over 3 years old and 300 mm in length (Mainstream 2005, 2006). The authors suggested that this may be due to an increase in angling pressure on the species since current regulations have minimum harvest size set at 300 mm. No differences in Arctic grayling age-class growth have been observed in the study. Mortality rates in 2003 and 2004 exceeded 75%, compared to 40% in 1990 (Mainstream 2005).

Bull trout exhibited yearly differences in growth and body condition. In 2004, spatial differences in the median size of bull trout was observed (Mainstream 2005); smaller fish were captured just downstream of the Peace Canyon Dam in comparison to fish captured downstream of the Halfway River or downstream of the Moberly River. A 20% mortality rate was suggested for bull trout in the Peace River (Mainstream 2005). Bull trout tended to be smaller at a given age in 2003 and 2004 compared to 2002. However sample sizes were too small to determine if this was statistically significant or not. Age-classes of 6 and 7 year old bull trout, which were weak in 2002 and absent in 2003, were more strongly present in the 2004 sample (Mainstream 2005). Strong Age 1 and 2 year-classes were observed in 2005 (Mainstream 2006). These younger age classes were relatively absent from previous sample years. The presence of these younger fish may indicate increased reproductive success or displacement of younger fish from rearing tributaries into the Peace River mainstem.

Various trends were reported for mountain whitefish. Growth of mountain whitefish increased between 2002 and 2003 with the majority of age classes demonstrating an increase in mean length between 2002 and 2003 (Mainstream 2004). Body condition of mountain whitefish was significantly greater in 2003 than 2002 (Mainstream 2004). Body condition decreased between 2004 and 2005 (Mainstream 2006). Younger (Ages 0 and 1) and older (> Age 6) fish were absent from the sample section from Lynx Creek to Maurice Creek (Mainstream 2005). Mortality for mountain whitefish ranged from 34% to above 40% (Mainstream 2006).

Data Quality

Information from the 1978 Renewable Resources study has limited application in any future effects assessment due to small sample sizes for most of the species captured (in some cases n=1). Life history information collected by studies conducted in the early 1990's and during the Fish Community Indexing Program provide a reliable baseline for bull trout, Arctic grayling and mountain whitefish that can be used to compare to any future monitoring program for the Site C project.

Diet and parasite load data collected in the early 1990's is useful in providing historical background information but should be re-confirmed with newer data.

3.2.2 Tributaries

Due to the limited sampling in comparison to the mainstream Peace River, there is very little life history information for fish species using Peace River tributaries. Information collected by ARL in 1989 and 1990 and AMEC in 2005 is summarized below. Lengths and weights were recorded by ARL and where possible, length-weight and length-age relationships and condition factors were calculated. AMEC only reported lengths and weights in their study and no statistical analysis was completed.

The average length of mountain whitefish in the Moberly River in the spring was 104 mm and most fish were age 0 and 1. In October, the average size of mountain whitefish was 262 mm with fish ranging in age from 2 to 6 years. Arctic grayling caught in the spring had an average size of 79 mm. Northern pike caught in the Moberly River ranged from 115 mm to 660 mm in length and from 0+ to 9 years in age. Lake whitefish ranged from 290 mm to 360 mm and were 5 and 6 years old.

Peamouth captured in Wilder Creek ranged from 32 to 53 mm long and averaged 42 mm. No other fish were captured or observed.

Only four Arctic grayling were captured in Cache Creek. They averaged 49 mm and were young of the year.

Rainbow trout sampled in Lynx Creek and Maurice Creek averaged 124 mm in length and were typically age 0+ or 1+ fish.

Data Quality

Life history characteristics for species captured in the Peace River tributaries are not as well reported as those in the mainstem due to small sample sizes, limited seasonal sampling, and the few years of study much of which is over 15 years old. Information on the biological characteristics of Peace River fish using Peace River tributaries for spawning is limited in its utility because: 1) data from is out-of-date; 2) does not include all tributaries upstream of the Site C project; 3) it is biased by difficulties encountered with the spring fences, and 4) it relies on relatively small sample sizes.

3.3 Mercury Concentration

Flooding terrestrial landscapes can mobilize mercury into the aquatic environment, thus increasing the amount available for bioaccumulation in the aquatic food-web. Piscivorous fish typically bioaccumulate mercury in higher concentrations then other aquatic organisms lower on the food chain. Because these fish are usually targeted for human consumption, increased mercury concentrations can potentially affect the health of fish as well as the wildlife and humans that eat the fish.

Limited information is available for mercury concentration in the Peace River downstream of Williston Lake (Table 9). Tissue samples were taken from several fish species during the initial studies conducted by RL & L in 1989 and 1990. These were taken from Peace River fish species and, where sample sizes are sufficient, provide an initial baseline of mercury concentrations in the river.

Mercury concentrations were compared to two previous studies regarding mercury concentrations in the Peace River. A summary of information regarding mercury concentrations in the Williston Lake and Peace River drainage was prepared by Triton in 1992. This document summarizes the geological and environmental causes of elevated mercury levels and presents mercury concentrations for water, soil, and vertebrates calculated from various compiled sources. Samples from the Peace River and Dinosaur Lake are reported. However, sample sizes are small for several species and do not provide a statistically reliable source of information. Mercury concentrations were recalculated by EVS in 1998 using only reliable data sets. No recent information on mercury in the Peace River fish has been collected.

Table 9: Documents containing information regarding Peace River system mercury concentrations.

Year	Title	Author	Data Quality
1990	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Fish Movements and Population Status 1989 Studies	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Fish Movements and Population Status 1990 Studies	RL & L Environmental Services Ltd.	2
1992	Evaluation of Mercury Concentration in Selected Environmental Receptors in the Williston Lake and Peace River Areas of British Columbia	Triton Environmental Consultants	1
1998	1998 Status of Fish Mercury Concentrations in BC Hydro Reservoirs	EVS Environmental Consultants	2

Mercury concentrations in fish tissues collected from fish species captured in the Peace River mainstem are presented in Table 10. The highest mercury concentration (0.835 ppm) was observed in one bull trout collected by RL & L in 1990 (RL & L 1991). The highest mean mercury concentrations were observed in piscivorous fish species such as bull trout, walleye, and burbot.

Table 10: Summary of mean mercury concentrations (ppm) in various fish species in the Peace River downstream of Peace Canyon Dam.

Species	RL & L 1989, 1990	Reuben 1989	Zenon 1987	Triton 1992	EVS 1998
Arctic grayling	0.034 (2)				
Bull trout	0.153 (13)	0.24 (2)	0.07 (1)	0.21 (8)	
Kokanee	0.020 (23)	0.06 (1)		0.04 (2)	
Burbot	0.126 (9)			0.11 (2)	
Lake whitefish	0.073 (11)	0.09 (20)		0.091 (20)	0.09 (20)
Mountain whitefish	0.043 (34)				
Northern pike	0.073 (31)	0.10 (1)			
Rainbow trout	0.034 (33)	0.05 (3)		0.03 (23)	
Walleye	0.147 (8)		0.17 (4)		

Note: Number in brackets indicates the sample size.

Data Quality

Mercury concentrations in fish from Dinosaur Lake and the Peace River are based on samples which are over 15 years old and may not accurately represent the current baseline mercury concentrations in fish muscle tissues in the river. Sample sizes for bull trout collected in the Peace River and Dinosaur Lake in 1988 were small (2 and 4 individuals, respectively) and mean concentrations are not statistically robust enough to draw conclusions. Similarly, data reported by Triton should be viewed with caution due to errors in data analysis that was subsequently rectified by the EVS report.

The available data should be used as only as a historical reference until additional sampling can be completed. The existing data from Dinosaur Lake provides a snap-shot of mercury concentrations in fish approximately 10 years after impoundment. Mercury concentrations in reservoirs are known to peak between 15 and 30 years after impoundment depending on environmental conditions (Bodaly et al., 1997). Therefore, existing data from Dinosaur Lake fish is insufficient to predict the timing and magnitude of peak mercury concentrations that can be expected to occur after impoundment.

3.4 Fish Habitat Quality and Quantity

One of the most important impacts from any large scale development is a potential change in fish habitat quality and quantity. Pre-development assessments of the location, abundance and characteristics of habitat are needed to describe or predict any changes or alterations.

Habitat in the Peace River and its tributaries has been quantified on several occasions (Table 11). General habitat descriptions were presented in 1978 as part of the initial environmental impact studies. Habitat maps of the Peace River were completed in discrete sections in 2001. Habitat information has also been collected for the Peace River in Alberta. Tributary habitat has been described on three separate occasions with standardized mapping completed in 2006. No habitat information has been collected previously for Dinosaur Lake.

Table 11: Documents containing information regarding Peace River system fish habitat.

Year	Title	Author	Data Quality
1978	Peace River Site C Hydroelectric Development Fish and Aquatic Environment	Renewable Resources Consulting Ltd.	0
1990	Investigations of Fish and Habitat Resources in the Peace River in Alberta	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Fish Movements and Population Status 1990 Studies	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Development: Fisheries Habitat and Tributary Surveys Year 1	Aquatic Resources Ltd.	2
1997	Fisheries Inventory and Stream Classification of Peace River Tributaries	Aquatic Resources Ltd.	2
2000	Dunvegan Hydroelectric Project Fish and Fish Habitat Inventory Comprehensive Report Dunvegan Study Area, Peace River	RL & L Environmental Services Ltd.	3
2001	Fish Habitat Utilization Study	RL & L Environmental Services Ltd.	3
2006	Peace River Fish and Aquatics Investigations 2005	AMEC Earth and Environmental and LGL Ltd.	3

3.4.1 Peace River

Habitat in the Peace River is typical of large, northern rivers. The channel is dominated by deep glide/run habitat, with shorter areas of riffle habitat (RRCS 1978; ARL 1991a; AMEC 2006). Pool habitat in the Peace River is limited (AMEC 2006a). Numerous side channels and sloughs with fine substrates are present (ARL 1991a; RL & L 2001). Moving upstream from the BC/Alberta border, the channel becomes less braided and riffle habitat becomes more prevalent. The majority of the banks are armoured and provide little cover for fish.

The mainstem of the Peace River was mapped in 1999 and 2000 at a discharge of 330 m^3/s (RL & L 2001). Channels, bank types and instream habitat was mapped for each of reach (Kiskatinaw River to Beatton River, Cache Creek to Halfway River, Farrell Creek to Peace Canyon Dam) using aerial photos. Habitat in the Peace River was dominated by run type habitat in all reaches (> 96% of all available habitat). The percentage of backwater habitat types was very low in all sample sections. Bank habitat was dominated by armoured bank types. The total channel area and the ratio of side channel to main channel decreased moving upstream. Availability of back water habitats was low in all sample areas. Riffles and areas with physical cover were present but infrequent. Small fish habitat was limited due to flow regulation which restricted the amount of habitat available in side channels and near-shore areas of the Peace River.

The habitat of the Peace River has been described downstream of the BC/Alberta border (RL & L 1990; 2000a). Various habitat types were present including riffle dominated sections in the upstream areas near the provincial border and large, glide dominated areas further downstream. Habitat quality downstream from the BC/Alberta border was limited by frequent flow changes that reduced availability of riffle habitat and dewatered shoals (RL & L 2000a).

Data Quality

Information collected to date has limited use because habitat has been mapped in detail at only one specific flow and has not been completed for the entire river from Peace Canyon Dam downstream to the BC/Alberta border. Habitat units were delineated using digital maps and additional information was added during field surveys. Bank habitat classifications in the field were completed at a variety of flows and represent general bank conditions well. Habitat data collected to date would allow a course quantification of the amount of habitat that would be affected upstream and downstream of Site C project area.

3.4.2 Tributaries

Habitat in Peace River tributaries upstream of the Site C project was mapped in 2005 and classified using the BC Fish Habitat Assessment Procedure (AMEC and LGL 2006a). Maps depicting the location of the habitat types were produced. The sections of stream surveyed were separated into a lower and upper reach of approximately equal in length separated by the projected upstream limit of the Site C reservoir at full supply level. Table 12 summarizes key habitat characteristics from the potential inundated lower reaches of each Peace River tributary upstream of the Site C project. Descriptions of the habitat characteristics for each tributary, including historical information, are summarized below.

Table 12: Summary of key habitat characteristics in the Peace River tributaries from the 2005 habitat surveys in the potentially inundated (lower) reach.

Stream	Channel Width (m)	Dominant Habitat	Sub-Dominant Habitat	Dominant Substrate	Sub-dominate Substrate

Stream	Channel Width (m)	Dominant Habitat	Sub-Dominant Habitat	Dominant Substrate	Sub-dominate Substrate
Moberly River	37.3	run	riffle	cobble	fines
Wilder Creek	8.9	riffle	run	fines	cobble
Cache Creek	21	pool	riffle	gravel	cobble
Red Creek	9.2	riffle	run	gravel	fines
Halfway River	118.5	run	pool	gravel	cobble
Farrell Creek	26.1	riffle	pool	gravel	cobble
Lynx Creek	11	riffle	pool	fines	boulder
Maurice Creek	24	riffle	pool	boulder	fines

Note: AMEC and LGL 2006a.

Habitat surveys of the Moberly River have extended from the confluence with the Peace River to Moberly Lake (RRCS 1978; ARL 1991a). The channel width of the Moberly River ranges from 28 to 58 m (ARL 1991a). Upstream from the confluence, the Moberly River is braided and dominated by riffles and shallow fast-flowing glide habitat. Channel depths ranged from 1 to 2 m. The instream habitat transitions to slower and deeper glide habitat moving upstream. In the areas downstream from Moberly Lake, there is a large amount of submergent vegetation along the margins. Pool habitat and cover in the Moberly River was rated as poor quality (AMEC 2006a). Gravel substrates were present; however they were often compacted with fines. Good quality off-channel habitat was present.

Wilder Creek is deeply entrenched in a valley with 150 m high banks comprised of fines (ARL 1991a). The stream consists of shallow glide/riffle habitat with average depths of 0.03 m and pool depths of 0.2 m. Approximately 9 km upstream from the confluence, there is extensive beaver activity. The beaver ponds are over 100 m long and 8 m wide. A shallow channel 5 m in width is present between the beaver ponds. Gravel substrates are present in Wilder Creek and may be utilized by spring spawning species (AMEC 2006a). During the 2005 survey, the channel was heavily aggraded and no fish habitat was present.

The lower sections of Cache Creek consist of a series of large shallow pools connected by short riffle sections (ARL 1991a). Habitat in the pools was rated as low quality (AMEC 2006a) though there was some woody debris present and at higher flows the pools may provide better quality rearing habitat. Riffles lacked boulder cover and runs had silt-embedded substrates with no cover for fish. Spawning gravels were observed in Cache Creek. Red Creek, a tributary to Cache Creek, contained significant iron deposits and poor quality habitat. Good off-channel habitat existed in the potentially inundated reach of Cache Creek. Approximately 20 km upstream from the confluence, Cache Creek consists largely of beaver ponds (ARL 1991a).

The Halfway River is the largest Peace River tributary upstream of the proposed Site C project area and has a channel width varying from 80 m to >100 m. The channel becomes increasingly more braided moving upstream (ARL 1991a). Habitat consists of mostly glides and riffles. Numerous side channels are present but are typically covered in silt (AMEC 2006a). Pool habitat was rated as poor quality accordingly (AMEC 2006a). Cover from overhead riparian vegetation and large-woody debris were also rated as poor. Good quality gravels that could be utilized for spawning were present throughout the Halfway River mainstem.

Farrell Creek is confined by steep banks up to 30 m high (ARL 1991a). Channel width is 25 m and wetted width at the time of survey was 7 m. Pool depth was 0.8 m. The channel becomes increasingly braided moving upstream. Pool habitat was rated between fair and good quality but may be too shallow for larger sized fish (AMEC 2006a). The stream had a high percentage of riffle habitat with boulder cover. There was a large amount of good quality spawning gravel present. Off-channel habitat with woody debris cover was present but the channel was aggraded and had insufficient flows at the time of survey.

Habitat in Lynx Creek consists of glide/riffles with boulder substrates (ARL 1991a). Approximately 2 km upstream from the confluence, the channel becomes entrenched in a shale valley. Channel width was approximately 8 m while the average water depth was 0.25 m. A series of waterfalls are located approximately 10 km upstream from the confluence. Above the waterfalls, beaver activity is extensive. There is gravel present in the stream but the quality was rated as poor due to the presence of fines (AMEC 2006a).

Habitat in Maurice Creek consists mostly of boulder-dominated riffles with little pool or glide habitat (ARL 1991a). Approximately 3 km upstream from the confluence, there is a series of waterfalls ranging from 2.5 m to 30 m in height. The waterfalls are a barrier to upstream fish movements. The channel becomes more braided moving upstream from the confluence. Holding pools with adequate cover were present in the lower sections of Maurice Creek below the waterfalls (AMEC 2006a). Even though this stream is utilized by several species for spawning, the presence of suitable gravel substrates in lower Maurice Creek is limited.

Tributary access was assessed at the mouths of Maurice, Lynx, and Farrell creeks during low flow conditions (~5000 cfs in the Peace River) in 1993 (R.L.&L., 1993). Water depths at the tributary mouths ranged from 13 cm to 38 cm and none of the tributaries surveyed was determined to block upstream or downstream migrations of fish.

Data Quality

Recent studies have quantified and mapped habitat in upstream tributaries that would be affected by the Site C project using standardized methods. Estimates of available habitat before and after the creation of the Site C reservoir can be made can from the FHAP mapping completed in 2006. Habitat quality has been rated but these ratings may be biased since surveys were conducted in a low flow year and may not be representative of conditions during spring or summer. Information collected in studies in the 1990s provide historical information on habitat types, however this information is limited in use because they were conducted only in fall.

3.5 Fish Habitat Utilization

Fish will occupy different habitat types during their life history and at different times of the year for spawning, rearing, foraging, and overwintering. Identifying critical habitat types and their use by fish is important to determine the severity of impacts for any future hydroelectric development on the Peace River.

Fish habitat utilization information is available from several reports (Table 13). A specific fish utilization study was conducted in 2001 to assess habitat utilization by small-bodied fish in the Peace River. Table 14 presents a summary of the habitat utilization information for sportfish compiled from the studies completed on the Peace River and its tributaries.

Table 13: Documents containing information regarding Peace River system fish habitat utilization.

Year	Title	Author	Data Quality
1978	Peace River Site C Hydroelectric Development fish and Aquatic Environment	Renewable Resources Consulting Ltd.	0
1990	Investigations of Fish and Habitat Resources in the Peace River in Alberta	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Fish Movements and Population Status 1990 Studies	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Development: Fisheries Habitat and Tributary Surveys Year 1	Aquatic Resources Ltd.	2
2000	Dunvegan Hydroelectric Project Fish and Fish Habitat Inventory Comprehensive Report Dunvegan Study Area, Peace River	RL & L Environmental Services Ltd.	3
2001	Fish Habitat Utilization Study	RL & L Environmental Services Ltd.	3

Table 14: Known sportfish habitat utilization in the Peace River and tributaries

Species	Peace River	Moberly River	Wilder Creek	Cache Creek	Halfway River	Farrell Creek	Lynx Creek	Maurice Creek
Arctic grayling	Rearing Foraging	Spawning Rearing		Spawning Rearing	Spawning Rearing	Spawning	Spawning Rearing Foraging	Spawning Rearing
Bull trout	Rearing Foraging				Spawning Rearing		Rearing	Spawning
Mountain whitefish	Spawning Rearing Foraging	Spawning Rearing		Rearing	Spawning Rearing	Rearing	Spawning Rearing	Spawning Rearing
Rainbow trout	Rearing Foraging				Spawning Rearing	Spawning	Spawning Rearing	Spawning Rearing
Northern pike	Spawning Rearing Foraging	Spawning Rearing			Foraging			Foraging
Walleye	Foraging							

Note: Spawning – use of habitat for laying eggs and reproduction. Rearing – use of habitat by YOY and juveniles. Foraging – use of habitat by adults during non-spawning period.

3.5.1 Peace River

The Peace River provides habitat for mostly large-bodied species but also has limited habitat for small-bodied fish, including juveniles of large-bodied species, cyprinids, and sculpins. Fluctuating water levels limit the amount of shallow near-shore habitat used by many small fish species (RL & L 2001).

Mountain whitefish complete all of their life history in the mainstream Peace River. Mountain whitefish spawning sites were observed in the mainstem Peace River and concentrations of mountain whitefish eggs were found near Hudson Hope (RRCS 1978). Spawning mountain whitefish were most often associated with pools and backwater areas adjacent to deep riffles with gravel/cobble substrates (RL & L, 1991, 1992). Juvenile mountain whitefish were found rearing in shallow nearshore glide and pool habitat (RL & L 1991). Adult mountain whitefish were found in areas with deep glide and riffle habitats in both thalweg and shoreline areas (RL & L 1991). Mountain whitefish prefer areas without physical cover (P & E 2002) and were associated with off-channel habitat areas (RL & L 2001). Mountain whitefish catch rates were also higher in areas with small substrates and low water velocities.

Due to fluctuating water levels in near shore areas and lack of suitable habitat, use of the Peace River by rainbow trout for rearing is limited (RL & L 2001). Adult rainbow trout utilize the Peace River primarily for foraging activities. Both juvenile and adult rainbow trout were found most often in nearshore habitats associated with cover (RL & L 1991). Adult rainbow trout were found in deep water habitats while juveniles preferred shallow riffle areas.

Similar to rainbow trout, adult Arctic grayling use the Peace River mostly for foraging (RL & L 1991). Adult Arctic grayling were found in deep and shallow glides with varying gradients. Juvenile Arctic grayling are also found in the Peace River mainstem most often associated with shallow glide and riffle areas with cover. Catch rates for Arctic grayling were higher in areas with cover (P & E 2002).

Bull trout use the Peace River for rearing, foraging and overwintering. Adult bull trout were found in deep glides, pools, and riffles associated with cover (RL & L 1991). Juvenile bull trout were found in shallow riffle areas with cover. Catch rates for bull trout were higher in areas with physical cover (P & E 2002). During the fall, bull trout migrate into the Peace River from the Halfway River system to overwinter (Burrows et al. 1997).

Northern pike use the vegetated off-channel areas of the Peace River for spawning, rearing and foraging. In 1991, northern pike were found exclusively in side channel and backwater habitats with large amounts of cover (RL & L 1991).

Northern pike are typically found in the warmer, more turbid water downstream of the Pine River confluence. Walleye use the Peace River for foraging. Walleye are usually found in deep water habitats, particularly near the Beatton River confluence (RL & L 1991).

Suckers are usually found in low velocity areas with fine substrates (RL & L 1991, 2001). Adult suckers are mostly found in deep pool or glide habitats while juvenile suckers were found mostly in shallow pools and glides with fines. Catch rates for suckers were higher at tributary confluences and at areas of armoured bank types (RL & L 2001).

Sculpins are most commonly caught in side channels and in areas with coarse substrates and higher water velocities (RL & L 2001). Cyprinids are found in a variety of habitat types throughout the mainstem (RL & L 1991, 2001).

Data Quality

The RL & L studies from the early 1990's provide qualitative information on habitat use by large-bodied fish species as these studies generally did not sample discreet habitat types. These data are out-of-date and quantitative catch-rates (CPUE) for different species and life stages in discreet habitat types are unavailable. Sampling was effective in shoreline areas but not in deeper pools and in the river thalweg. Fish utilization in these areas remains unknown.

One year of quantitative data (CPUE) regarding habitat use of juvenile mountain whitefish, suckers, and cyprinids in discreet nearshore habitats is available. However, the paucity of multi-year data does not describe the natural variability in mountain whitefish and longnose sucker recruitment in the Peace River mainstem.

The current Fish Community Indexing Program samples only in late summer/fall and cannot be used to identify critical spawning and rearing areas for spring spawning species (e.g., suckers). In addition, these surveys sample four broad habitat types that do not correspond to recent habitat classifications (i.e., FHAP) in the river.

3.5.2 Tributaries

Tributaries of the Peace River upstream of the Site C project are used for spawning and rearing by most sportfish species in the river. Due to general paucity of juvenile fish encountered in the Peace River mainstem, these tributaries appear to provide most of the annual recruitment for most Peace River fish populations. Mountain whitefish appear to be one of the few large-bodied fish species able to utilize mainstem habitat for spawning and rearing.

The Moberly River is used by several species for spawning and rearing. Adult mountain whitefish in spawning condition have been captured in the Moberly River (RRCS 1978; ARL 1991a). Larval mountain whitefish were most dense between 25 km and 75 km upstream from the mouth (and above the proposed full reservoir supply level) suggesting that this is the primary spawning and rearing habitat for mountain whitefish in the river (ARL, 1991a). Juvenile Arctic grayling were also captured in Moberly River. Juvenile and adult northern pike were captured in the Moberly River along the stream margins with cover (RRCS 1978; ARL 1991a). Most northern pike were found closer to Moberly Lake than to the Peace River. The use of the lower 5 km of the Moberly River as spawning habitat by Peace River fish is limited by the instability of sediments (ARL, 1991a).

Minimal fish use has been documented in Wilder Creek. Several species of cyprinids have been documented in the beaver ponds, however, no spawning or rearing sportfish have been captured or observed (RRCS 1978; ARL 1991a). Habitat suitability in Wilder creek is limited by beaver dams, low summer flows, and high summer temperatures.

The Halfway River and its tributaries are known to provide spawning, rearing foraging and overwintering habitat for mountain whitefish, bull trout, Arctic grayling and rainbow trout. Large numbers of mountain whitefish were captured in the lower 45 km of the river in fall and large numbers of larval mountain whitefish were found downstream the following summer (RL& L., 1991a, b). These fish indicate that the Halfway River is an important spawning area for mountain whitefish and may contribute significantly to the annual recruitment of the Peace River population. Juvenile bull trout are commonly found rearing in upper Halfway River tributaries (ARL 1991a). Radio-tagged Arctic grayling moved into small Halfway River tributaries to spawn in spring (Burrows et al., 2001).

Young-of-the-year Arctic grayling were captured in the beaver ponds in Cache Creek indicating that spawning occurs in this stream in some years (ARL 1991a). Cyprinids were found in high densities in the beaver ponds. Juvenile mountain whitefish were also observed rearing in Cache Creek (RRCS 1978).

Farrell Creek is mostly used by non-sportfish species. Only one juvenile mountain whitefish has been captured (ARL 1991a). Arctic grayling were reported to use Farrell Creek for spawning (RRCS 1978). However, sucker species were more common. A fish fence in 1990 captured longnose suckers moving into and out of Farrell Creek in spring indicating that Farrell Creek is used by longnose suckers for spawning (ARL 1991b). Rainbow trout were also captured in the fish fence in spring.

Longnose sucker and rainbow trout from the Peace River move into Lynx Creek in spring to spawn (ARL, 1991a). Juvenile rainbow trout were captured in all habitat types (ARL 1991a) and these may be Peace River migrants or part of a resident population. Various cyprinid species are commonly found in glide and riffle habitats in Lynx Creek as well (ARL 1991a).

The highest concentrations of juvenile rainbow trout were reported in Maurice Creek indicating that it is an important spawning and rearing tributary for the species (ARL 1991a). Adult rainbow trout densities were highest in riffle and pool habitats while juvenile densities were higher in glide habitats (ARL 1991b). Migrations of longnose suckers and rainbow trout from the Peace River have also been observed moving into Maurice Creek in spring (ARL 1991b). Juvenile mountain whitefish were observed rearing in glide and pool habitats.

Data Quality

Information collected to date provides only cursory information on fish habitat utilization in the Peace River tributaries. Movements of adult spawners into the tributaries are limited to two years of data and, in both years, sampling efficiency was limited by late trap installations and high flow conditions. These studies are also over 15 years old.

Juvenile rearing surveys were conducted by reach and not by habitat type, therefore it is not possible to determine with any certainty where, and in what habitat type, most spawning and rearing is occurring. In addition, most sampling to date has been conducted in spring and fall outside of the normal summer rearing period. The available information is insufficient to base conclusions regarding potential effects of the Site C reservoir on Peace River fish utilization in the upstream tributaries.

3.6 Fish Migration

Understanding the migration patterns of fish species of the Peace River is important to identify any potential effects that may impede or influence fish movements.

Several migration studies have been completed on the Peace River (Table 15). These include tagging programs and radio telemetry programs. The majority of the research has focused on bull trout, a blue-listed species known to make extensive pre- and post-spawning migrations in the Peace River and in other river systems in British Columbia.

Table 15: Documents containing information regarding Peace River system fish migration.

Year	Title	Author	Data Quality
1978	Peace River Site C Hydroelectric Development fish and Aquatic Environment	Renewable Resources Consulting Ltd.	0
1990	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Fish Movements and Population Status 1989 Studies	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Fish Movements and Population Status 1990 Studies	RL & L Environmental Services Ltd.	2
1992	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Data Summary Report 1991	RL & L Environmental Services Ltd.	2
2001	Bull Trout Movement Patterns: Halfway River and Peace River Progress	Burrows et al.	2
2006	Peace River Fish and Aquatics Investigations. Movements of Radio-tagged Bull Trout and Arctic Grayling in the Upper peace River System, 1996-99	AMEC Earth and Environmental and LGL Limited	3
2006	Peace River Fish and Aquatics Investigations. Interim Report on Movements of Radio-tagged Walleye, Arctic Grayling, and Rainbow Trout in the Upper Peace River System	AMEC Earth and Environmental and LGL Limited	3

Mountain whitefish are ubiquitous in the Peace River and some proportion of this population is known to move from the Peace River into the Halfway River in the fall to spawn (RL & L 1990b). Arctic grayling are found primarily in the reach between the confluences of the Halfway and Moberly rivers and appear to exhibit only localized movements (RL & L 1990b, 1992; AMEC and LGL 2006b). Rainbow trout are located primarily upstream of Farrell Creek and, similar to Arctic grayling, appear to make only localized movements. Rainbow trout are known to move into upper Peace tributaries to spawn in the spring, particularly Maurice and Lynx creeks (RL & L 1990b, 1992; AMEC and LGL 2006b).

Walleye are generally concentrated near the mouth of the Beatton River and use the Beatton River for spawning. A proportion of the walleye population concentrated near the Beatton River appear to move upstream in the summer past the proposed Site C project area to the Moberly River and as far upstream as Farrell Creek (RL & L 1991, 1992). This migration is most likely for foraging after spawning.

Radio-tagging by the BC Ministry of Environment in the late 1990's showed that a proportion of the 77 bull trout tagged in the upper Halfway River tributaries move downstream to the Peace River after spawning in fall. Some tagged individuals moved downstream to Alberta while others moved upstream to Peace Canyon Dam (Burrows et al., 2001). Similar downstream movement of tagged bull trout to Alberta was also recorded in 2006 (AMEC and LGL 2006b). Radio-tagged bull trout were generally concentrated near the Halfway River year-round and a movement of fish back to the Halfway River in late summer/fall was evident (Burrows et al., 2001). Similar movements of bull trout to the Halfway River have also been observed by others (RL & L 1990b, 1992; AMEC and LGL 2006b). Bull trout overwinter in either the mainstem Halfway River or Peace River (Burrows et al. 2001).

Data Quality

The BC Ministry data provides reliable and recent information regarding the extent and timing of bull trout movements within and between the Halfway and Peace Rivers. The unidirectional movement of walleye between the Beatton River and the Moberly River observed in 1991 is based only on five fish. Because this movement appears to involve fish passing past the proposed Site C project area, it will be important to determine if this movement is occurring each year and, if so, to determine the proportion of the walleye population participating.

Movements of mountain whitefish, Arctic grayling, and rainbow trout are based on information collected in the early 1990's. While movements of mountain whitefish were based on mark and recapture of large numbers of Floy-tagged fish, more recent work conducted during the Fish Community Indexing Program has indicated that Floy-tagging can significantly impair growth and behaviour of tagged fish, particularly whitefish which are more sensitive to handling than other species. In contrast to mountain whitefish, movements of Arctic grayling and rainbow trout are based on relatively small numbers of marked and recaptured fish. Mountain whitefish, Arctic grayling, and rainbow trout have not been previously radio-tagged in the Peace River.

3.7 Gene Flow and Unique Populations

Very little genetic information has been collected and reported for the Peace River system (Table 16). Recently, there have been a few studies examining the genetic characteristics of Arctic grayling in the Peace River system (Stamford, 2001). Stamford (2001) suggested that there was local adaptation by Peace River Arctic grayling populations living in distinct environments. Arctic grayling in the Halfway and Beatton Rivers were determined to be genetically discrete populations with restricted gene flow (Stamford and Taylor 2004). A study on bull trout in the Pine River indicated that there were genetically distinct populations present within this system (Costello et al. 2003).

Table 16: Documents containing information regarding Peace River system gene flow and unique populations.

Year	Title	Author	Data Quality
2001	Mitochondrial and Microsatellite DNA Diversity Throughout the Range of a Cold Adapted Freshwater Salmonid: Arctic Grayling (*Thymallus arcticus*)	Stamford	3
2003	The influence of history and contemporary stream hydrology on the evolution of genetic diversity within species: an examination of microsatellite DNA variation in bull trout	Costello et al.	3
2004	Population subdivision and genetic signatures of demographic changes in Arctic grayling from an impounded watershed	Stamford and Taylor	3

Data Quality

The information available to date provides an indication that unique populations of Arctic grayling exist in large Peace River tributaries and that gene flow between populations upstream and downstream of the Site C project area is limited. Genetic differentiation between Pine River and Peace River bull trout populations has not been determined nor has the amount of gene flow between and within the two river systems. The data collected provides information useful in the design of future studies.

3.8 Sediment Loads and Transport

Hydroelectric development in the Peace River can dramatically alter sediment transport in the Peace River. Changes in the sediment load and transport can affect fish habitat in the river and, ultimately, the abundance, distribution and composition of the Peace River fish community. Assessment of sediment load data and transport capacities from hydrological or river engineering reports was outside the scope of this review. However, information regarding sediment loads and transport in the Peace River from habitat studies conducted in the past were reviewed (Table 17).

Table 17: Documents containing information regarding Peace River system sediments

Year	Title	Author	Data Quality
1978	Peace River Site C Hydroelectric Development Fish and Aquatic Environment	Renewable Resources Consulting Services Ltd.	0

Year	Title	Author	Data Quality
1990	Investigations of Fish and Habitat Resources in the Peace River in Alberta	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Development: Fisheries Habitat and Tributary Surveys Year 1	Aquatic Resources Ltd.	2

3.8.1 Sediment Loading and Transport

No information specific to sediment loads and transport in the Peace River or its tributaries was found in any of the documents reviewed. The documents in this review were limited to fisheries related issues, thus information regarding sediment loading and transport may be available from other disciplines (e.g. hydrology) and/or internal BC Hydro engineering reports not reviewed.

An examination of the changes to the channel morphology and riparian vegetation was completed as part of the Northern River Basins Study Project (Church et. al. 1997). Maps of the channel morphology from 1968 (pre-regulation) and 1993 (post-regulation) revealed that the river has substantially narrowed downstream of the BC/Alberta border to Dunvegan and between Tompkins Landing to Fort Vermillion. It was noted that the river had abandoned side channels and vegetation had become established on sand and gravel bars. The river still has the same sediment load, but due to reduced flows, more deposition is occurring downstream of Tompkins Landing, Alberta.

3.8.2 Contaminated Sediments

Based on review of available documents, sediments in the Site C project area have not been tested for contaminants nor have they been tested for their toxicity to aquatic biota. Again, documents in this review were specific to fisheries related issues and information regarding toxicity of Peace River sediments may be available from other disciplines (e.g. water quality) and/or internal BC Hydro engineering reports not reviewed.

3.8.3 Substrate Composition

Substrates in the Peace River mainstem in British Columbia consist of cobble/boulder in riffle areas and gravel/cobble in larger glides (RRCS 1978; ARL 1991a). Finer materials, such as sand and silt, typically fill the interstitial spaces of the larger substrate materials in lower velocity areas. However, the amount of fines decreases moving upstream from the Site C project area (i.e., substrates become less embedded closer to the Peace Canyon Dam). Upstream of Maurice Creek, there is more sandstone present in the channel substrates.

Substrates in the Peace River downstream of the BC/Alberta border change from gravel, cobble and boulder in the upper reaches to sand with localized patches of larger substrates in downstream reaches (RL & L 1990a).

Data Quality

Substrates in the Peace River have been described in general terms during various habitat assessments of the river. Detailed habitat maps using a habitat classification system which incorporates substrate composition has not been completed but information is available to do so. Areas where the channel is aggrading or degrading have not been clearly identified.

3.9 Water Quality

Water quality in this review pertains to temperature, dissolved oxygen concentrations, nutrients, total gas pressure, contaminants and total suspended solids in the Peace River. These abiotic parameters help describe the aquatic environment and can be useful indicators of change and of stressful conditions to fish and other aquatic organisms. Because of the broad nature of this topic, large amounts of historical information have been collected, especially related to water temperature (Table 18).

Table 18: Documents containing information regarding Peace River water quality

Year	Title	Author	Data Quality
1978	Peace River Site C Hydroelectric Development Fish and Aquatic Environment	Renewable Resources Consulting Services Ltd.	0
1990	Investigations of Fish and Habitat Resources in the Peace River in Alberta	RL & L Environmental Services Ltd.	2
1990	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Fish Movements and Population Status 1989 Studies	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Fish Movements and Population Status 1990 Studies	RL & L Environmental Services Ltd.	2
1991	Peace River Site C Development: Fisheries Habitat and Tributary Surveys Year 1	Aquatic Resources Ltd.	2
1991	Peace River Site C Development: Fisheries Habitat and Tributary Surveys Year 2	Aquatic Resources Ltd.	2
1992	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Data Summary Report 1991	RL & L Environmental Services Ltd.	2
1993	Peace River Site C Hydroelectric Development Pre-construction Fisheries Studies: Data Summary Report 1992	RL & L Environmental Services Ltd.	2

Year	Title	Author	Data Quality
1993	Peace River – Low Flow Surveys	RL & L Environmental Services Ltd.	2
1997	Spillway Discharge Environmental Overview Report peace River Generating Facilities	BC Hydro	2
1999	Total Gas Pressure at Peace River Generating Facilities	BC Hydro	3
2000	Dunvegan Hydroelectric Project Fish and Habitat Inventory Comprehensive Report Dunvegan Study Area, Peace River	RL & L Environmental Services Ltd.	3
2000	Dunvegan Hydroelectric Project Water and Sediment Quality, Benthic Algae and Benthic Invertebrate Comprehensive Report Dunvegan Study Area	RL & L Environmental Services Ltd.	1
2001	The Limnology of Williston Reservoir	Stockner et al.	2
2001	Peace River Fish Habitat Utilization Study	RL & L Environmental Services Ltd.	3
2002	Peace River Generation Spill 2002	BC Hydro	2
2002	Peace River Community Indexing Program: Phase 2 Studies. Summer 2002 Water Level Monitoring Program Final Report	M. Miles and Associates	3

3.9.1 Total Suspended Sediments and Turbidity

Increases in total suspended sediments and turbidity can affect egg survival, and the feeding efficiency, respiration, behaviour, and health of juvenile and adult fish. It can also affect fish indirectly by affecting lower trophic productivity by reducing light penetration required for photosynthesis. Increases in total suspended sediments in watersheds can be attributed to natural processes such as slope failures and to man-made sources such as land-use practices.

Suspended solid concentrations and turbidity is higher at the proposed Site C project area than those further upstream near the Peace Canyon Dam (RL & L 1990b, 1991). This is likely due to the input of suspended sediments from the tributaries and the relative paucity of suspended sediments released through the dam. Highest suspended solid concentrations were observed in June and were probably due to the higher flows during the spring freshet. Suspended solid concentrations and turbidity were much higher in the tributaries than in the mainstem Peace River. Highest suspended solid concentrations were observed in Lynx Creek in August. Turbidity in the tributaries showed no differences between seasons.

Turbidity and suspended sediment concentrations were monitored on the Peace River during a spill from WAC Bennett Dam in 1996 (BC Hydro 1997). Field measurements from monitoring stations on the Peace River and in tributaries were reported along with laboratory settling results. Field measurements differed considerably from the laboratory measurements resulting in a large amount of uncertainty. No comparisons of the field or laboratory measurements with water quality reference values were made.

Turbidity and suspended sediments were measured downstream in the Peace River in Alberta in 1990 (RL & L 1990a) and more recently in 1999 (RL & L 2000a). Turbidity of the Peace River in Alberta was generally highest in June and lowest in August to October (RL & L 1990a). Turbidity at the Dunvegan site was significantly higher in the spring than the summer or fall (RL & L 2000a). Suspended sediment levels were also higher in the spring than the summer or fall.

Data Quality

Turbidity and suspended sediment data from the Peace River from the early 1990's provides historical information useful for comparison but is likely too old to be considered representative of current conditions. Field and laboratory measurements for turbidity and suspended sediment concentrations for the 1996 spill did not agree and the data should be viewed with caution. Data from the Alberta portion of the Peace River provides a downstream-most baseline only.

3.9.2 Thermal Regime

Temperature monitoring has been conducted irregularly in the Peace River and tributaries since the initial surveys in the 1970's (RRCS 1978; RL & L 1990b, 1991, 1992, 1993a, 2001; ARL 1991; MMA 2002; AMEC and LGL 2006a). From these data, we can determine a number of characteristics of the thermal regime in the regulated Peace River mainstem. Temperatures in the Peace River normally range from 0°C to 20°C over the course of a year. Water temperatures in the Peace River increase moving downstream from the Peace Canyon Dam. Water temperatures in side channels are higher than the mainstem and are more variable. Water temperatures are related to discharge and, during periods of high flow, temperature differences between the mainstem and side channels are reduced or eliminated. In the summer, an increase in discharge produces a reduction in water temperature due to water releases from W.A.C. Bennett and Peace Canyon dams.

Water temperature measurements were recorded during low flow surveys conducted in June 1993 (RL & L 1993b). Temperatures in side channels that had been cut off from the mainstem were recorded. Water temperatures in surveyed pools ranged from 22°C to 28°C. Temperatures were also recorded at the mouth of Maurice Creek, Lynx Creek and Farrell Creek. Temperatures at these locations ranged from 13°C to 15°C.

Temperatures were monitored during the 1996 and 2002 spills from W.A.C. Bennett Dam (BC Hydro 1997, 2002). Temperature was monitored continuously at the tailrace immediately downstream from W.A.C. Bennett Dam, in the Peace River downstream of the Peace Canyon Dam at the Hudson's Hope pumphouse and in the Bear Flats area. Water temperatures increased moving downstream. The range of water temperatures during the monitoring period were within the preference ranges for all fish species present in the river.

Water temperatures in the Peace River at the proposed Dunvegan Dam site were monitored in 1999 (RL & L 2000a). Temperatures were monitored continuously during the open water period. Summer temperatures in this area occasionally exceeded preference ranges for cold-water species such as Arctic grayling, rainbow trout, and mountain whitefish.

Data Quality

Daily temperature data from the early 1990's provides a reliable historical temperature record for comparison with more current temperature measurements. Temperature monitoring in the Peace River is currently ongoing and should provide adequate characterization of temperature variability throughout the river if the program is continued. If so, a long-term database would be available to assess potential changes in downstream and upstream water temperatures on fish and lower trophic levels in the Peace River.

3.9.3 Dissolved Oxygen

Dissolved oxygen spot measurements were taken during field surveys in 1989 and 1990 (RL & L 1990b, 1991). Dissolved oxygen concentrations in the Peace River were highest in February and lowest in August. Concentrations were slightly higher near the Peace Canyon Dam than downstream near Site C. Both sampling sites were supersaturated in October. Concentrations at the Peace Canyon Dam and Site C in August 1990 were low (6.0 mg/L and 5.4 mg/L respectively). These low levels may have resulted from an instrument malfunction and should be treated with caution.

Dissolved oxygen measurements were monitored during the 1996 spill event (BC Hydro 1997). Dissolved oxygen profiles collected from Dinosaur and Williston Lake during the spill showed no significant changes and were typical for that time of the year.

Dissolved oxygen was measured at the proposed Dunvegan hydroelectric site on the Peace River in Alberta (RL & L 2000a). Spot measurements of dissolved oxygen were collected. Dissolved oxygen measurements were moderately high in all seasons measured (9.0 to 11.2 mg/L) with the highest measurements in the spring.

Data Quality

Dissolved oxygen data for the Peace River and Dinosaur Lake reservoir are out-of-date and are based primarily on spot measurements. The data provides historical information but is not indicative of current oxygen levels and does not indicate how dissolved oxygen concentrations change with flow levels. Data currently available is insufficient to characterize or predict changes in the dissolved oxygen concentrations upstream and downstream of Site C or to assess its effect on fish and lower trophic levels.

3.9.4 Nutrient Regime

Nutrient data for the Peace River and tributaries was collected in 1989 and 1990 (RL & L 1990b, 1991). Samples were collected during spring, summer and fall sampling periods. Nutrient parameters analyzed included nitrates, nitrite, total nitrogen, total phosphorus, and total organic carbon. Total phosphorus concentrations ranged from <3 µg/L to 2740 µg/L and showed a positive relationship with discharge. The highest total phosphorus value was recorded at Site C on the Peace River in June 1990. Concentrations of total phosphorous were generally higher in the tributaries with the highest value reported in the Halfway River in June 1990 (2240 µg/L). Nitrogen levels in the Peace River and tributaries ranged from <7 µg/L to 5687 µg/L. The highest value was at Site C in June 1990. Nutrient information was collected for several tributaries in the Halfway River system (ARL 1991b). All measured parameters were below recommended upper limits for aquatic life (as based on the 1987 CCME water quality guidelines).

The limnology of Williston Lake was assessed in a two year sampling program from 1999 to 2001 (Stockner et al. 2001). The program was developed to provide baseline information for the reservoir and to determine its current trophic status and productivity. Based on information collected, Williston Lake was characterized as an ultra-oligotrophic lake.

RL & L (2000b) reviewed previously collected nutrient information for the Peace River in Alberta to summarize the nutrient levels in Dunvegan area. Nitrate and nitrite levels were occasionally high but were within the range reported for other northern Alberta rivers. Ammonia levels were within Alberta and Canadian water quality guidelines. Total nitrogen levels were found to occasionally exceed Alberta water quality guidelines and these levels increased at higher flows. Total phosphorous levels were found to exceed Alberta water quality guidelines on numerous occasions. The high total dissolved phosphorous levels were attributed to natural processes found in rivers of northern Alberta.

Data Quality

Information from the RL & L studies is useful for historical comparison but may not represent current conditions. The information for Dunvegan is a summary of past data (none of it recent) and is outside of the likely influence of the Site C project area. It is understood that the water quality discipline has conducted a separate review of available information. Data currently available (as reviewed) is insufficient to assess effects of the proposed Site C dam on nutrient availability in the Peace River.

3.9.5 Total Gas Pressure

In 1995, BC Hydro (1999) commenced monitoring total gas pressure (TGP) in the Peace River to describe TGP levels in relation to specific dam operations. Monitoring during generation only (from 1995 to 1998) at three locations downstream of Peace Canyon Dam indicated that TGP levels did not exceed the BC Water Quality Guideline of 110% saturation. Monitoring during a high discharge spillway release in 1996 indicated TGP levels of 125% downstream of the Peace Canyon Dam (BC Hydro 1997). Natural dissipation and tributary inflow diluted TGP levels moving downstream. Elevated TGP levels were associated with spillway discharge, low discharge levels during low power demand and synchronous condense operations.[1] During the 1996 spill from W.A.C. Bennett Dam (BC Hydro 1997), fish in Dinosaur Lake were monitored for gas bubble trauma. Of the fish observed, 19% had signs of gas bubble trauma.

Monitoring for TGP downstream of W.A.C. Bennett Dam was conducted in July 1998 during synchronous condense operations in two of the ten turbines. TGP increased to a maximum of 148% and averaged between 114% and 129%. TGP decreased to an average of 107% with a maximum of 112% in the tailrace. Under normal operations, tailrace concentrations ranged between 105% and 107%.

During the 2002 spill from WAC Bennett Dam, total gas pressure was monitored downstream using continuous monitoring stations at the Peace Canyon Dam

[1] During synchronous condense operations, the turbine spins without any water, acting as a voltage regulator. Some water leakage does occur and the water becomes supersaturated as compressed air is dissolved into the water. When the unit is returned to normal operation the supersaturated water contained within is released downstream (BC Hydro 1999).

tailrace and the Hudson's Hope pumphouse. Spot measurements in Dinosaur Lake and the Peace River were also taken. The peak total gas pressure during the monitoring period was 125.9% at Hudson's Hope and 125.2% at Johnson Creek in Dinosaur Lake (BC Hydro 2002).

Data Quality

The spatial extent of continuous monitoring during the 1996 and 2002 spills was limited in both years to two sites downstream of Peace Canyon Dam. In 1996, continuous monitoring stations were located at the Hudson Hope pumphouse and one at Bear Flats near Cache Creek. In 2002, continuous monitoring stations were located in the Peace Canyon Dam tailrace and at the Hudson Hope pumphouse All other data downstream were based on spot measurements. Total gas pressures downstream of Peace Canyon Dam during synchronous condense operations have not been continuously monitored beyond the tailrace area.

The acute and chronic toxicity of supersaturation to various fish species in the Peace River is unknown.

3.9.6 Contaminants

Sources of contaminants to the aquatic ecosystem of the Peace River include point and non-point sources. Point sources may include industrial effluents (e.g., pulp and paper), waste-water treatment plants, and residential septic fields. Non-point sources may include run-off of agricultural pesticides and atmospheric deposition from surrounding industry (e.g., Tumbler Ridge oil and gas). All of these sources may result in direct or cumulative toxicological effects on fish and other aquatic biota. Site C has the potential to accumulate point and non-point source contaminants in the water and sediments of its reservoir.

RL & L (2000b) reviewed information regarding contaminants in the Peace River in Alberta. Contaminants including phenolic compounds, pesticides, polychlorinated byphenyls (PCBs), polyaromatic hydrocarbons (PAHs), dioxins and furans were generally below detection limits and did not represent an environmental concern in the Dunvegan area.

Data Quality

No information on contaminants in the Peace River in the Site C project area was found during this literature review. The information in the Dunvegan report is a summary of information collected in historical Alberta studies.

3.10 Lower Trophic Communities

Zooplankton, phytoplankton, periphyton, benthic invertebrates and aquatic macrophytes comprise the lower trophic communities of the aquatic environment and provide the basis for fish production in a river. Monitoring these organisms can provide information on the overall health of the system, as well as act as an important indicator of environmental change. Determining the characteristics of the lower trophic communities will be required for any potential environmental assessment of further hydroelectric development on the Peace River.

Very limited lower trophic community data is available for the Peace River as most of the work that has been done in this field has been concentrated on Williston Lake (Table 19). Information collected from the Peace River is downstream of the Site C study area in Alberta. No recent information was been collected anywhere in the BC portion of the Peace River.

Table 19: Documents containing information regarding Peace River lower trophic community

Year	Title	Author	Data Quality
1978	Peace River Site C Hydroelectric Development Fish and Aquatic Environment	Renewable Resources Consulting Services Ltd.	0
2000	Williston Reservoir Zooplankton Analysis Program 1999	Wilson and Langston	2
2000	Dunvegan Hydroelectric Project Water and Sediment Quality, Benthic Algae and Benthic Invertebrate Comprehensive Report Dunvegan Study Area	RL & L Environmental Services Ltd.	1
2000	Dinosaur Lake Aquatic Plant Enhancement Potential	AIM Ecological Consultants	2
2001	The Limnology of Williston Reservoir	Stockner et al.	2

3.10.1 Phytoplankton and Zooplankton

The pelagic zooplankton population of Williston Lake was sampled in 1999 to determine population composition, density and biomass (Wilson and Langston 2000). Density and biomass were determined from June to October. Total community density was comprised primarily of copepods (88%) and cladocerans (11%) while biomass was 56% copepods and 44% cladocerans. Zooplankton density at the W.A.C. Bennett dam forebay was 14.6 individuals per litre.

The limnology of Williston Lake was examined in a two-year study in 1999 and 2000 (Stockner et al. 2001). Chlorophyll (a photosynthetic pigment) concentrations in the reservoir were uniform and the average concentration in 2000 was 1.4 mg/m^3. The highest chlorophyll concentrations were observed in the Finlay Reach of Williston Lake while the lowest concentrations were observed in the Forebay Station.

Average phytoplankton cell density in Williston Lake in 2000 was 4,571 cells/mL. Pico-cyanobacteria were the most numerically dominant class followed by nano-flagellates and diatoms. There were no major peaks or blooms observed. Lowest population densities of phytoplankton occurred in May and peaked in July/August. Zooplankton showed a diverse species assemblage with copepods being the most numerically dominant group. Zooplankton density peaked with phytoplankton density in July/August. The density at the dam forebay station was highest among the stations sampled.

Data Quality

The information from Williston Lake is useful for reference species but is insufficient to describe the natural variability of these high variable communities in time and space. Morphology and hydrologic conditions in Williston Lake are very different from Dinosaur Lake and the Peace River mainstem. Therefore, data from Williston Lake are unlikely to provide an accurate picture of conditions in either the future Site C reservoir or downstream in the regulated river.

3.10.2 Benthic Invertebrates

Benthic invertebrates in the Peace River have been sampled on two occasions (RRCS 1978; Cross and Nix 1986). Benthic invertebrate samples were collected in the vicinity of the Site C dam site and several tributaries in 1976 (RRCS 1978). Chironomids were the most dominant benthic invertebrate taxa in this survey. Benthos production declined moving downstream. Sampling downstream of the proposed Site C dam site collected Oligochaeta, Ephemeroptera, Nemotoda, Coelenterata and Chironomidae. Densities of invertebrates were higher in October than in July.

The benthic invertebrate community at the Dunvegan hydroelectric site located on the Peace River in Alberta was described as being dominated by oligochaetes, chironomids and nematodes (RL & L 2000b). Benthic invertebrate densities were described as low.

Data Quality

Data from Cross and Nix (1986) is out of date, too limited in geographic scope, does not include multiple year sampling, and relies on only one kind of sampling technique (artificial substrate traps). Therefore, these data do not adequately describe the natural variability of the benthic invertebrate community in the Peace River. The RL & L (2000b) report was based only on a literature review and did not include actual samples the benthic invertebrate community in the vicinity of the Dunvegan Dam. For these reasons, available data is insufficient for assessing the effects of the proposed Site C project on the benthic invertebrate community of the Peace River.

3.10.3 Aquatic Macrophytes

To date, only one study has been conducted regarding aquatic macrophytes in the Peace River. AIM (2000) examined the feasibility of re-establishing aquatic plants along the shoreline of Dinosaur Lake reservoir. Several sites were identified as potentially providing the right conditions for vegetation to establish. Establishment of plant species was indicated as the most important factor in colonization of the drawdown zone.

Data Quality

The information gathered for Dinosaur Lake does not reflect conditions downstream of the Peace Canyon Dam and has very limited use for any assessment of impacts from the Site C project since the objective of the study was to determine the feasibility of re-establishing aquatic macrophytes in Dinosaur Lake.

3.11 Peace River Flows and Habitat Availability

Regulated flows below dams can have profound effects on the downstream fish community. Fluctuating flows can affect habitat quantity (wetted area) and quality (i.e., depth, water velocity, wetted perimeter, and cover), increase fish stranding, and effect habitat connectivity and tributary access. The effects of regulated flows in the Peace River will need to be considered during an environmental review of Site C.

Some work has been done on the effects of regulated flows on the Peace River aquatic community (Table 20). One low flow survey was completed in 1993. The fish habitat utilization study completed in 2001 examined the effects of low flows on habitat for small-bodied fish.

Table 20: Documents containing information regarding Peace River lower trophic community

Year	Title	Author	Data Quality
1991	Peace River Instream Flow Needs	Alberta/British Columbia Instream Flow Needs Subcommittee	1
1993	Peace River – Low Flow Surveys	RL & L Environmental Services Ltd.	2

Year	Title	Author	Data Quality
1994	Peace River Flows Impact Study - Fisheries	Sigma Engineering Ltd.	1
1997	Spillway Discharge Environmental Overview Report Peace River Generating Facilities	BC Hydro	2
2001	Peace River Fish Habitat Utilization Study	RL & L Environmental Services Ltd.	3
2002	Peace River Generation Spill 2002. Environmental Information Summary Report	BC Hydro	2

3.11.1 Flow Regime and Habitat Availability

Minimum flow levels for the Peace River at Taylor were recommended in 1991 to meet downstream flow needs (Alberta/British Columbia Instream Flow Needs Subcommittee 1991). Flow needs were determined by reviewing previously collected data for the Peace River. Recommended minimum flows were derived by using the largest of the monthly minimum flows needed for fish or water quality requirements which were determined to be priority management issues. Recommended flows ranged from 500 m^3/s in January to 1910 m^3/s in June. A flushing flow of 2840 m^3/s for 14 days in the spring was also recommended.

Impacts of Peace River flows on fish were examined in 1994 (Sigma Engineering 1994). Data collected in other studies was compiled and analyzed to determine the magnitude of potential impacts from low flows on the Peace River. Areas of possible habitat degradation were identified. Reduction of flow had the greatest impact from the Peace Canyon Dam downstream to the Halfway River with effects becoming attenuated further downstream. Using hydraulic geometry information from 1975 surveys, average widths, depths and velocities were predicted for the Peace River at flow levels of 142 and 283 m^3/s and at historic average discharge levels (1011 to 1721 m^3/s). At flow levels of 283 m^3/s, between 15% and 21% of the channel area was subjected to dewatering. The length of secondary channels was reduced by at least 57%. Loss of secondary channel habitat had the potential to impact the northern pike population most severely.

Discharge was monitored by RL & L (2001) during the fish habitat utilization study. Large fluctuations in mean daily discharge were observed. Flow variability was highest in the summer and fall sampling periods when tributary inputs are lowest. Water releases from the Peace Canyon Dam provided the majority of flow in the Peace River with the Halfway and Pine Rivers each contributing significantly. The amount of channel area subject to dewatering was calculated. Values ranged from 10% to 20% in the mainstem and 27% to 50% in side channels. Habitat was mapped for a discharge level of 300 m^3/s in the three study zones (Kiskatinaw River to Beatton River, Cache Creek to Halfway River, Farrell Creek to Peace Canyon Dam). Risk levels associated with flow regulation for fish species in the Peace River were provided. Risk ratings of severe were given for mountain whitefish, northern pike, rainbow trout, cyprinids and sculpins. Risk ratings of moderate were given for Arctic grayling and sucker species. Risk ratings of low were given for bull trout, lake whitefish and walleye.

Flow levels have been recorded during the fish community indexing program (P & E 2002, 2003; Mainstream 2004, 2005, 2006) and have been correlated to catch rates. Discharge levels were only recorded for the sampling periods. In August, discharge was characterized by rapid changes followed by periods of static water levels. Flows in October were higher and less variable. Water level changes were attenuated downstream. Statistical analysis did not indicate that fish catch rates were affected by water levels and water level stability.

Data Quality

The information used by the Instream Flow Needs Committee to recommend flows is out-of-date and should be updated to reflect current conditions in the river. Flow information analyzed by Sigma is also out of date and should not be used in any future environmental impact assessments to determine flow effects. The information collected by RL & L is of limited use, since it only examined habitat at a few flow levels and habitat availability was determined only for the sample sites selected.

3.11.2 Fish Stranding

Limited information on fish stranding in the Peace River is available. Low flow surveys were conducted in 1993 during a low flow discharge event of approximately 141 m^3/s (5,000 cfs) (RL & L 1993b). Mainstem habitat was examined from the Peace Canyon Dam to the confluence of the Halfway River. Isolated pools were identified and sampled to determine the presence of stranded fish. Only three isolated pools were observed in a side channel upstream of the Halfway River and all three pools contained fish. Pools were too large and deep to sample completely. Longnose sucker, sculpins and cyprinids were captured and several mountain whitefish approximately 18 cm long were observed.

In this same year, an aerial flight survey from Taylor, BC to the peace Canyon Dam was conducted at two flow levels, 141 m^3/s and 283 m^3/s. Side channels were visually inspected and notes regarding location and connection to the mainstem were recorded. No information on habitat types or channel length was collected. At the lower discharge, several side channels were cut off from mainstem flows and isolated. Other side channels were completely dry. At the higher flow value of 283 m^3/s, some but not all of the side-channels were re-watered or access to the mainstem was restored.

During the 1996 spill from W.A.C. Bennett Dam (BC Hydro 1997), stranding surveys were conducted on the Peace River downstream of the Peace Canyon Dam during flow ramp-down. Fish found in isolated pools were relocated back to the mainstem. Fish identified during the salvage included sculpins, mountain whitefish, dace, northern pike, suckers, rainbow trout, sticklebacks, northern pikeminnow and Arctic grayling.

At the end of the spill from W.A.C. Bennett Dam in 2002, the discharge was ramped down from 2,237 m^3/s to 1,925 m^3/s over three hours (BC Hydro 2002). A fish stranding survey in the Peace River mainstem was conducted at the end of the flow ramp-down. Only one stranded sculpin near the Halfway River confluence was observed.

Data Quality

The available data provides background historical information but does not provide a method of quantifying the number of fish that would be stranded during a sustained low flow event because the relationship between discharge and side channel habitat availability has not been developed. Surveys conducted after the 1996 and 2002 spills provide an initial starting-point for developing conservative ramping rate criteria but are limited because they do not provide a means for comparing the effectiveness of varying ramping rates on fish stranding.

3.11.3 Riparian and Aquatic Habitat Connectivity

No information has been collected on the frequency, magnitude, and duration of riparian floodplain connectivity or its importance to aquatic biota in the Peace River. The Peace River has been regulated since construction of W.A.C. Bennett Dam and information for natural, pre-regulation conditions is unavailable. As far as we are aware, no study of the annual flood frequency of the regulated river and its effect on riparian vegetation and aquatic productivity has been completed.

3.11.4 Ice Regime

The ice front in the Peace River has moved upstream of Taylor, BC five times since 1973 (Dan Nixon, BC Hydro, pers. comm.). BC Hydro's operating license for the Peace Canyon Dam requires augmentation of winter flow rates to reduce potential flooding in Taylor due to ice dams.

A RICE model for the Peace River has been developed by BC Hydro to predict the location of the ice front under various climatic conditions and Site C discharge regimes. Preliminary model results indicate that Site C would reduce the amount of open water in the Peace River in an average winter by approximately 20 km (Dan Nixon, BC Hydro, pers. comm.).

Areas of shore-fast ice were identified as far upstream as the Halfway River along the shore margins in winter 2000 (RL & L, 2001).

Data quality

The RICE model is a state-of-the-art ice model and, once calibrated will provide an unbiased prediction of future ice conditions on the Peace River under different flow regimes.

3.11.5 Tributary Access

Tributary access was assessed during low flows (approximately 141 m^3/s) in 1993 (RL & L 1993). Maurice Creek, Lynx Creek, Farrell Creek, and the Halfway River were surveyed at the mouth for water depth, stream width, and water temperature. Water depths at the mouth of the tributaries ranged from 13 to 38 cm. Access was not restricted at any of the surveyed tributaries at this flow level in the Peace River.

Data Quality

This single report provides information regarding tributary access in only four of the seven major tributaries upstream of the proposed Site C project area and at only one discharge level. Access criteria were based on professional judgement and should be confirmed for the species that utilize these streams for spawning activities.

3.12 Turbine Mortality and Spillway Entrainment

Entrainment through a dam's turbine can result in mortality of fish due to physical damage and/or changes in gas pressure. Similar mortality can occur due to entrainment over a dam spillway during a spill event. Two spill events have occurred on the Peace River since W.A.C. Bennett and Peace Canyon Dams were built. Spillway entrainment and associated mortality was monitored during both of these events (Table 21).

Manitoba Hydro has recently conducted a review of available literature regarding turbine mortality (R. Bukowsky, Manitoba Hydro, pers. comm.) and is likely available to BC Hydro through its association with the Canadian Electric Association. The current report does not include information from the Manitoba Hydro review.

Table 21: Documents containing information regarding turbine entrainment and spillway mortality

Year	Title	Author	Data Quality
1993	Fisheries Enhancement Options for Dinosaur Lake, A Review	Pattenden and Ash	2
1997	Spillway Discharge Environmental Overview Report Peace River Generating Facilities	BC Hydro	2
2002	Peace River Generation Spill 2002. Environmental Information Summary Report	BC Hydro	2

Creel surveys conducted in the 1980's found that a portion of the rainbow trout captured in the Peace River below Peace Canyon dam were hatchery-raised (Hammond, 1986c). These fish were released in Dinosaur Lake and were most likely entrained through the turbines of Peace Canyon Dam. RL& L (1991a) estimated that approximately 28% of rainbow trout captured in the Peace River below Peace Canyon Dam in 1989 were hatchery-reared fish planted in Dinosaur Lake. Lake trout and kokanee have also been captured in the Peace River and are likely downstream migrants from Williston Lake (RL & L, 1991, 2001).

Options to mitigate entrainment in the turbines were suggested by Pattenden and Ash (1993b). The installation of deflectors was considered unfeasible due to the high cost of construction and operation. Pen rearing stocked fingerlings was recommended so that stocked trout could attain a larger size in the reservoir before release to minimize entrainment. Different locations, timing and strains of fish released into the reservoir were also suggested to help reduce entrainment.

Entrainment and mortality of fish was monitored during a spill event at W.A.C. Bennett Dam in 1996 (BC Hydro 1997). Fish mortalities due to entrainment were monitored in Dinosaur Lake by visual observation and mark-recapture techniques. Most of the dead fish observed were lake whitefish aged 4 to 8 years. All dead fish showed signs of damage and scale loss. Hydroacoustic monitoring in the dam spillways estimated 15,000 fish per day were entrained over the spillway during the 6 day period it was monitored.

In 2002, there was a continuous spill from W.A.C. Bennett Dam from July 8 to July 29. Maximum discharge during the spill was approximately 1,700 m^3/s (BC Hydro 2002). A monitoring program was initiated to monitor for fish mortalities due to entrainment over the spillway. Dinosaur Lake was monitored for fish mortalities through visual observation and by using a mark-recapture technique similar to that used in 1996. The majority of expired fish observed were lake whitefish similar to that observed during the 1996 spill. Average scale loss for fish entrained through the dam was 45%.

Data Quality

Fish mortality during spill operations has been observed and an attempt has been made to quantify numbers of fish killed using a number of techniques during both previous spill events at W.A.C. Bennett Dam: visual observations and mark-recapture studies concentrated on fish observed at the surface immediately after the spill. These techniques do not provide an accurate picture of fish mortality caused by the spills because they likely missed a significant number of fish that died at deeper depths and did not account for fish dying days or weeks after the program was completed.

Data from the hydroacoustic study were corrected for debris and false fish signals and, probably, provide the most accurate information on the number of fish entrained per day over the spillway at W.A.C. Bennett Dam.

All data collected to date has been based on entrainment of fish through W.A.C. Bennett Dam. However, the fish community of Site C reservoir is likely to be more similar to the fish community in Dinosaur Lake than the one in Williston Lake. For this reason and the study deficiencies noted above, the available data does not allow for the potential effects of future spills at Site C to be assessed with the highest accuracy possible.

3.13 Peace River Recreational Fishing

Anglers use the Peace River and Dinosaur Lake for recreational fishing. Several creel surveys have been completed in the region to determine angler use, harvest rates, and fishing success rate (Table 22).

Table 22: Documents containing information regarding Peace River recreational fishing

Year	Title	Author	Data Quality
1978	Peace River Site C Hydroelectric Development Fish and Aquatic Environment	Renewable Resources Consulting Services Ltd.	0
1984	Evaluation of Dinosaur Lake Stocking Program (1983 Year 1)	Hammond	2
1986	Evaluation of Dinosaur Lake Stocking Program (1984 Year 2)	Hammond	2
1986	Dinosaur Lake Summer Creel Census 1985	Hammond	2
1986	Peace River Summer Creel Census 1985	Hammond	
1987	Evaluation of Dinosaur Lake Stocking Program (1986 Year 4)		

Year	Title	Author	Data Quality
1987	Evaluation of Dinosaur Lake Stocking Program Summary Report	Hammond	2
1987	Dinosaur Lake Summer Creel Survey 1987	Hammond	2
1991	Peace River Site C Sport Fishing Survey 1989-1990	The DPA Group	2
1993	Dinosaur Lake Summer Creel Surveys, Results of the 1988 Program and a Five Year Review (1984-1988)	Pattenden and Ash	2
2001	1999 Dinosaur Reservoir Creel Survey Report	Joslin	2
2001	2000 Dinosaur Reservoir Creel Survey Report	Joslin	2
2004	Dinosaur Reservoir and Peace River Volunteer Creel Summary 2003	Cowie	1
2006	2005 Dinosaur Reservoir Creel Survey Report	Stiemer	3

Initial creel surveys conducted during the 1970's noted that fishing in the Peace River was concentrated between the Peace Canyon Dam construction site and the Halfway River (RRCS 1978). Rainbow trout was the most desired species and the quality of the fishing experience in the Site C project area was rated as good.

Creel surveys conducted in 1989 and 1990 reported that over half of the angler effort was concentrated in the Hudson Hope area of the river with less than 6% of total fishing effort occurring below the proposed Site C project area (DPA 1991). Over the two year study period, anglers caught just under 10,000 sportfish, the majority of which were mountain whitefish. Most of these fish were caught during the winter fishery. The total number of fish caught per angler hour was 0.53 (all species). The total number of fish caught per angler day was 1.22 (all species). Rainbow trout, Arctic grayling and kokanee were fully recruited to the fishery at age 4. Whitefish were recruited to the fishery at age 5 and bull trout were recruited at age 6. Over 90% of the anglers surveyed were local residents.

The most recent survey conducted on the Peace River was a volunteer survey that consisted of 10 anglers in 2003 (Cowie 2004). Due to the small sample size, no reliable interpretations can be made of the data. Mountain whitefish were the most frequently caught fish and none were kept.

Creel surveys were conducted in the mid-1980's in Dinosaur Lake and again in 1999, 2000, and 2005 (Hammond 1984, 1986b, 1987b, 1987c; Pattenden and Ash 1993a; Joslin 2001a, 2001b; Stiemer 2006). Local residents comprised the majority of anglers utilizing Dinosaur Lake. Rainbow trout dominated the catch and, in the 1980's, approximately 50% of all rainbow trout caught were hatchery-reared. Catch rate in the 1980's was < 0.4 fish/hr (Pattenden and Ash 1993a). This rate declined in the 1999 and 2000 surveys with a catch rate of only 0.25 fish/hr (Joslin 2001b). An increased catch rate of 0.67 fish/hr was reported in 2005 however the author indicated that this may be elevated due to low angling effort (Stiemer 2006). The number of anglers utilizing Dinosaur Lake and the angler day length has declined since the survey conducted in 2000.

Data Quality

Creel surveys in the 1980's in Dinosaur Lake are out-of-date and were not based on statistically valid sampling protocols and, therefore, provide only historical information for qualitative comparisons. To the extent possible, recent creel surveys conducted in Dinosaur Lake since 1999 provide sufficient information to predict the future utilization of Site C reservoir by anglers. The 1990 creel survey (DPA, 1991) of the Peace River downstream of Peace Canyon Dam is out-of-date and does not reflect the current utilization of the Peace River sport fishery especially given the changes in population growth in the Fort St. John area in the last decade. The recent creel of the Peace River by Cowie (2004) has a sample size too low to draw meaningful conclusions.

3.14 Compensation Options

Numerous options have been suggested as possible compensation measures for past and future impoundment of the Peace River by BC Hydro hydroelectric facilities (Table 23). These have varied from stocking reservoirs to enhancement of the reservoir and downstream areas with artificial structures.

Table 23: Documents containing information regarding Site C Compensation and Mitigation

Year	Title	Author	Data Quality
1978	Peace River Site C Hydroelectric Development Fish and Aquatic Environment	Renewable Resources Consulting Services Ltd.	0
1987	Habitat Suitability of the Proposed Site C Reservoir for Walleye (*Stizostedion vitreum* and Rainbow Trout (*Salmo gairdneri*)	Hammond	1
1990	A Review of Fisheries Enhancement Techniques for BC Reservoirs	Aquatic Resources Ltd.	2
1991	A Review of Fisheries Enhancement Techniques for BC Reservoirs	Aquatic Resources Ltd.	2
1993	Fisheries Enhancement Options for Dinosaur Lake, A Review	Pattenden and Ash	2

Year	Title	Author	Data Quality
1995	Literature Review of Life History, Habitat Requirements and Mitigation Compensation Strategies for Selected Fish Species in the Peace, Liard, and Columbia River Drainages of British Columbia	Fort et al.	2
2000	Dinosaur Lake Aquatic Plant Enhancement Potential	AIM Ecological Consulting	2
2005	2004 Assessment of Habitat Improvements in Dinosaur Reservoir	Blackman and Cowie	3

Stocking and rearing sportfish in the reservoirs has been suggested on several occasions (RRCS 1978; Hammond 1987a; ARL 1990; Pattenden and Ash 1993b). Hammond (1987a) used several habitat suitability indexes to assess the likelihood of survival and establishment of rainbow trout and walleye in the Site C reservoir from hatchery stocking. The results suggested that rainbow trout were more likely to develop self-sustaining populations in the reservoir than walleye. This was due to environmental factors such as water quality and temperature that were likely to be unsuitable for walleye.

Several enhancement options for the tributaries have also been suggested. These include enhancing spawning through the construction of side channels.

Several large woody debris structures were place in Dinosaur Lake in 2002 and 2003 (Blackman and Cowie 2005). Sampling at these structures found more fish associated with these structures than at control (no structure) sites. However, small sample sizes did not allow for statistical analysis of differences. Mountain whitefish and bull trout were found associated with the habitat structures while rainbow trout were found in both the control and enhanced sites.

The feasibility of re-establishing aquatic plants along the shoreline of Dinosaur Lake has been examined (AIM 2000). Several sites were identified as suitable for re-vegetation.

Data Quality

Recent information on the use of habitat enhancement structures in the Dinosaur Lake reservoir by rainbow trout and bull trout suggests similar structures may be useful as partial compensation for Site C. Statistical evidence of their effectiveness is currently unavailable and long-term data sets are required to determine inter-annual and seasonal variability of use and any correlation to the evolving Dinosaur Lake fish community.

Other than woody debris structures, the effectiveness of compensation measures has not been evaluated. The federal *Fisheries Act* requires that compensation be provided so that there is “no net loss of productive capacity of fish habitat”. Data collected to date provides only a cursory indication of the productive capacity of woody debris structure and no indication of the utility of stream enhancement options as compensation.

3.15 Rare and Listed Fish Species

The Ministry of Environment BC Species and Ecosystems Explorer (http://www.env.gov.bc.ca/atrisk/toolintro.html) was searched for fish species that are red or blue-listed in British Columbia. Red listed species include any indigenous species that have extirpated, endangered or threatened status in British Columbia. Blue listed species are those that are sensitive or vulnerable to human activities or natural events. Spottail shiner is the only red listed fish species present in the Peace River. Goldeye, pearl dace and bull trout are blue listed species although pearl dace have never been positively identified in the Peace River upstream of the BC/Alberta border.

Spottail shiner were not captured or observed in the Peace River or any of its tributaries in 1989 or 1990 (RL & L 1991a, 1991b; ARL 1991a, 1991b). However, spottail shiner were caught in the Peace River mainstem in 1999 (RL & L 2001). Spottail shiner were captured in all three sample zones (Kiskatinaw River to Beatton River, Cache Creek to Halfway River, Farrell Creek to Peace Canyon Dam) but only 30 fish were caught over the course of the study. Almost 300 spottail shiner (comprising 20% of the small-bodied fish sample size) were caught in the first year of the fish community indexing program (P & E 2002). The fish were caught in the Peace River from the Kiskatinaw River to the Beatton River, the Pine River to the Moberly River and from Cache Creek to Halfway River. Twenty-three spottail shiner were captured in the fish community indexing program in 2005 (Mainstream 2006). Two spottail shiner were caught between Lynx Creek and the Halfway River during mainstem sampling in the fall of 2005 (AMEC and LGL 2006a). The paucity of spottail shiner in the late 1980’s and their appearance in recent years suggests that spottail shiner have expanded their distribution in the Peace River since 1990.

Goldeye were caught in 1989 and 1990 from the BC/Alberta border to the confluence of the Pine River in the spring, summer and fall sampling sessions (RL & L 1990b, 1991). More recently, goldeye were caught between the Kiskatinaw River and the Beatton River in the first year of the fish community indexing program (P & E 2002) but only nine individuals were captured. Goldeye comprise a larger portion of the sportfish community in the Peace River downstream of the BC/Alberta border (RL & L 1990a, 2000a). These studies suggest that goldeye are restricted to the lower Peace River mainstem below the

Pine River and that individuals upstream of the BC/Alberta border are likely opportunistic upstream migrants from the Alberta population.

Bull trout are present throughout the Peace River mainstem and are known to move between the Halfway and Peace Rivers for spawning and overwintering. While a portion of the radio-tagged bull trout remained in the Halfway River year-round, 56% of the radio-tagged bull trout in the Halfway River migrated into the Peace River and moved downstream past the Moberly River and the proposed Site C project area (AMEC and LGL 2006a). Some of these fish moved up to 500 km downstream into Alberta. A smaller proportion (24%) of radio-tagged fish moved into the Peace River and moved upstream of the Halfway River, some as far upstream as the Peace Canyon Dam.

Data Quality

Movements of bull trout between the Halfway and Peace Rivers is well understood and is based on extensive radio-tagging and tracking conducted by the BC Ministry of Environment and more recent telemetry work conducted by AMEC and LGL.

Information regarding the distribution of spottail shiner in the Peace River is evolving. The fish community indexing program uses techniques suited primarily for the capture of large-bodied fish species and the presence of spottail shiner in their catch is more coincidental than intended. This program does not explicitly sample habitats where spottail shiner are likely to be most abundant (side channels, tributary mouths) and is restricted to a fall sampling program. Small-bodied fish sampling which best determines the abundance and distribution of spottail shiner has been conducted in only one year to date (RL & L 2001).

Past studies have indicated that goldeye are restricted to the Peace River below the Pine River and the on-going fish community indexing program has confirmed this information.

4.0 SUMMARY

Studies regarding the fish community and habitat of the Peace River have been conducted intermittently over the last 30 years. Studies include investigations conducted in the mid-1970's and the late 1980's and early 1990's as part of previous baseline studies for the Site C project. Since 2000, additional studies have been conducted to fill data gaps (e.g., small-bodied fish habitat utilization) and to develop a monitoring protocol for on-going Water Use Planning that can be used to detect changes in the fish community caused by potential flow modifications (i.e., Peace River Fish Community Indexing Program).

Information in this report has been summarized based on topics and information requirements identified in the "Pathways of Effects" analysis for the Risk Management Framework for Baseline Fish and Fish Habitat Studies of the Peace River (AMEC, 2007), to which this report is the companion. In general, information for most topics is limited in its utility for an effects assessment of Site C dam because it is out-of-date; the most recent data was largely collected in the early 1990's. Other limitations of the data include inadequate description of natural variability in fish population dynamics (e.g., only one or two years of data), difficulty correlating physical and biological data to flow conditions (e.g., how habitat quality and quantity changes with discharge), and inadequacy of data to meet updated and more stringent regulatory requirements enacted since the 1970's (e.g., CEAA, BC CEA, *Fisheries Act*).

A summary of the available information and data quality for each topic identified in the Pathways of Effects analysis is presented in Table 24. A total of 31 topics were identified. Studies initiated by BC Hydro in 2005/2006, including enumeration of spring spawning surveys in Peace River tributaries, summer juvenile rearing surveys in the Peace River mainstem and tributaries, and a radio-telemetry program are currently updating some of the older data in this review.

Table 24: Information Summary by Topics Identified in Pathways of Effects Analysis

Topic	Information Summary	Data Quality
Peace River Fish Community	Twenty-nine reported fish species in the British Columbia portion of the Peace River. Mountain whitefish are the most abundant large-bodied fish species and are found throughout the river. Other sportfish (e.g., rainbow trout, bull trout, Arctic grayling) found in lower densities with more restricted distributions. Longnose sucker second most abundant fish species, most abundant non-sport-fish species, and found throughout the river. Pine River confluence acts as rough transition point delineating more cold-water fish community upstream from more cool-water dominated fish community downstream. Small-bodied fish community dominated by juvenile mountain whitefish.	Long-term data set for large-bodied fish community available for comparison. Studies from 1989/1990 included four season sampling through river. Fish Community Indexing Program includes fall sampling in select reaches only. Data set for small-bodied fish community limited to one-year of data collection.
Peace River Tributary Fish Communities	Moberly River utilized by the most diverse assemblage of fish species of any tributary upstream of Site C project (20 species); mountain whitefish are the most abundant species in the Moberly River. Sixteen fish species are known to use the Halfway River, including mountain whitefish, Arctic grayling and bull trout. Rainbow trout are the most common sport-fish found in Maurice Creek. Northern pikeminnow, lake chub, longnose dace, and longnose sucker are the most common species found in Cache Creek although Arctic grayling have also been found. Mountain whitefish and Arctic grayling are known to use Farrell and Lynx creeks. Various cyprinid and sucker species are present in all Peace River tributaries at some time of the year.	Only two years of spring data available and only from Lynx and Maurice creeks and data hindered by low sampling efficiency due to high water and delayed trap installation. The magnitude and timing of spawning runs and relative importance of various tributaries to Peace River fish populations can not be determined. Juvenile sampling is limited.
Dinosaur Reservoir Fish Community	Rainbow trout most abundant fish species in Dinosaur Lake. Fish community also includes lake whitefish, bull trout, lake trout, kokanee, and mountain whitefish as well as peamouth, longnose sucker, redside shiner, and northern pikeminnow. Two tributaries, Johnson and Gething creeks, provide limited spawning habitat for rainbow trout and bull trout.	Sampling has been conducted to determine success of habitat enhancement structures to increase trout production. Sampling does not accurately characterize the abundance and distribution of the reservoir's fish community.
Fish Community Biological Characteristics	Extensive biological data (length, weight, condition, growth, age structure, mortality rate) available for mountain whitefish, Arctic grayling and bull trout in the Peace River mainstem from the fish community indexing program. Biological data for other sportfish species more limited. Information on diet and parasite loads also available. Basic length, weight, and age structure data available for some Peace River tributaries.	Information from fish community indexing program provides quantitative information but is based on fall sampling in select reaches. Data from tributaries is limited by few sample years, ineffective sampling techniques, and low sample sizes.

Topic	Information Summary	Data Quality
Mercury Concentrations	Mercury concentrations for fish in Williston and Dinosaur Lake reservoirs as well as the Peace River mainstem are available from data collected in the late 1980's. Average mercury concentrations in fish in the Peace River mainstem were highest in bull trout, burbot, and walleye.	Data from Dinosaur Lake and the Peace River are over 15 years old. Only one year of data from Dinosaur Lake available and this is insufficient to detect changes over time in a recently established reservoir. Sample sizes in Dinosaur Lake and the Peace River mainstem are small.
Peace River Fish Habitat	Run/glide habitat is the most common habitat type in the Peace River. Pool habitat is limiting. There are numerous side channels with fine substrates whose frequency increases moving downstream. Geomorphology becomes more braided with more islands moving downstream, particularly in Alberta. Banks are typically well armoured and provide little cover for fish.	Habitat has been classified at specific sampling sites using a variety of methods and parameters. Habitat mapping of the entire river has been conducted only at low flow. Recent information classifying habitat at specific sites and flows is available.
Tributary Fish Habitat	Habitat in the Moberly River is braided and dominated by riffles and glides. Lower 5 km dominated by shifting sand substrates. Habitat in Wilder Creek is limited by aggradation, beaver activity, and low summer flows. Shallow pools and riffles with embedded gravels dominate lower Cache Creek. Very little cover for rearing fish is available. Habitat in the Halfway River becomes more braided moving upstream and consists of glides and riffles with numerous side channels and silt-dominated pools. Farrell Creek is confined within a high, steep valley. Boulder/gravel riffles are present. Habitat in Lynx and Maurice creeks consists primarily of glides and boulder-dominated riffles. Embedded gravels are present but of low quality to spawning salmonids.	Habitat in tributaries upstream of the proposed Site C project was assessed using BC Fish Habitat Assessment Procedures and maps have been produced including habitat upstream and downstream of the full reservoir supply level.

Topic	Information Summary	Data Quality
Peace River Habitat Utilization	Mountain whitefish are one of the few fish species to complete all of their life history requirements in the Peace River mainstem. Spawning mountain whitefish are most commonly associated with pools adjacent to riffles with gravel/cobble substrates. Juvenile and YOY mountain whitefish are typically found in side-channels and in nearshore areas with no cover. Rainbow trout, Arctic grayling, and bull trout use the Peace River primarily for foraging and overwintering. Rainbow trout prefer deep, nearshore areas with cover. Arctic grayling are most commonly found in fast-flowing glides. Bull trout prefer deep glides and pools with cover. Juvenile bull trout are found in shallow riffles with cover. Northern pike use off-channel habitats with cover for spawning, rearing, and foraging. Adult suckers are typically found in deep pool or glides while juveniles are typically found in shallow glides with silt substrates.	Quantitative sampling has been conducted in discreet habitat types in fall during the fish community indexing program. Earlier studies are more qualitative. Data on habitat use by small-bodied fish species limited to one-year. Sampling in the nearshore areas has been much more effective than in deeper, offshore areas such as the thalweg.
Tributary Habitat Utilization	Tributaries upstream of the Site C project are used by most sportfish species for spawning and rearing. Peace River tributaries appear to provide most of the annual recruitment to Peace River fish populations. The Moberly River is used by mountain whitefish and Arctic grayling for spawning and rearing. The Halfway River is utilized by mountain whitefish and bull trout for spawning and rearing. Maurice and Lynx creeks are utilized by rainbow trout, Arctic grayling, and longnose sucker for spawning and rearing. Farrell and Cache creeks are utilized more by non-sport-fish species for spawning and rearing than by salmonids. Life-stages of various cyprinid and sucker species are present in most tributaries upstream of Site C.	Only two years of spring data is available and only from Lynx and Maurice creeks and data collection was hindered by low sampling efficiency due to high water and delayed trap installation. The magnitude and timing of spawning runs and relative importance of various tributaries to Peace River fish populations can not be determined. Juvenile sampling is limited to spring and fall periods and was conducted by reach and not by discreet habitat type.

Topic	Information Summary	Data Quality
Fish Migration	A proportion of the bull trout in the Halfway River migrate downstream to the Peace River to overwinter; some individuals move past the Site C dam site to Alberta while others move upstream as far as Peace Canyon Dam. A spawning migration of mountain whitefish into the Halfway River in fall has been observed. Rainbow trout and Arctic grayling are found primarily upstream of the Halfway River and exhibit only localized movements within the mainstem. Both species move into tributaries in spring to spawn. A post-spawning migration of walleye from the Beatton River upstream past Site C to the Moberly River has been observed in summer.	Radio-tracking of bull trout in the Halfway River by BC Ministry of Environment based on 77 fish, base stations, and tracking flights. Similar movements of bull trout have been observed by others. Apparent upstream movement of walleye is based only on 5 tagged fish. Movements of mountain whitefish, Arctic grayling, and rainbow trout are based on mark/recapture of floy-tagged fish and recent evidence from the fish community indexing program has shown behavioural changes due to tagging.
Gene Flow and Populations	There is very limited genetic information available for Peace River fish populations. However, some information on Arctic grayling does exist. There are local adaptations by Arctic grayling populations living in distinct environments within the Peace River watershed. Additionally, Arctic grayling populations in the Halfway and Beatton rivers are genetically discrete with restricted gene flow between them.	Information on genetic make-up of Arctic grayling populations in the Peace River watershed is reported in peer-reviewed journals.
Sediment Loading and Transport	No specific information regarding sediment loading and transport was found in any of the fisheries-specific documents reviewed.	Not available
Contaminated sediments	No specific information regarding contaminated sediments was found in any of the fisheries-specific documents reviewed.	Not available
Substrate Composition	Substrates in the Site C area consist primarily of cobble/boulders in riffle areas and gravel/cobble in larger glides. Sand and silt substrates typically fill the interstitial spaces between larger substrates throughout the mainstem. The amount of fines increases moving downstream from the Peace Canyon dam.	Detailed mapping using a habitat classification system that incorporates substrate composition has not yet been completed but the information is available to do so.
Total Suspended Sediments and Turbidity	Turbidity and total suspended sediments in the Peace River increase moving downstream from the Peace Canyon Dam. This increase is due to inputs from tributaries. Turbidity and total suspended sediments were measured during the 1996 emergency spill at the W.A.C. Bennett dam.	Information is available only the early 1990's. Field and laboratory results from the 1996 spill are contradictory.

Topic	Information Summary	Data Quality
Thermal Regime	Water temperature information is available from 1989, 1990, 1991, 1992 for the Peace River and its major tributaries. Temperature loggers are currently collecting continuous water temperature information (installed during the 2005 field studies). Water temperature in the Peace River increase moving downstream from the Peace Canyon Dam. Temperatures in side channels are higher than mainstem and more variable.	Data from the late 1980's and early 1990's provides a reliable historic record to compare to more recent data. Temperature data from the tributaries is limited.
Dissolved Oxygen	Dissolved oxygen concentrations in Peace River are typically higher near Peace Canyon Dam then downstream near the Site C project. Dissolved oxygen concentrations are typically highest in February and lowest in August. Spot measurements taken during the 1996 spill event showed no significant spike in dissolved oxygen concentrations in Dinosaur Lake.	Available information is over 10 years old and is based on spot measurements only.
Nutrient Regime	Nutrient sampling in Peace River and tributaries was conducted in 1989-1990. Total phosphorus highest in June and showed a positive relationship with discharge. Phosphorus concentrations were generally higher in the tributaries. Nitrogen concentrations in the Peace River were highly variable (7 µg/L to >5500 µl). All measured parameters were below recommended upper limits for the protection of aquatic life.	The information review is out-of-date and insufficient to develop a time-series or to determine if relationships between flow and nutrient parameters exist. Review of all of the water quality literature available for the Peace River was outside the scope of this project.
Total Gas Pressure	Total gas pressure (TGP) in the Peace River has been monitored intermittently by BC Hydro since 1995. TGP levels downstream of the Peace Canyon Dam did not exceed the BC Water Quality Guideline of 110% saturation during generation only conditions in 1995. TGP concentrations exceeded 125% saturation immediately downstream of Peace Canyon Dam during the 1996 and 2002 spill events at W.A.C. Bennett dam. TGP levels averaged 114% to 129% in the W.A.C. Bennett tailrace during synchronous condense operations in 2 of the 10 turbine units. TGP levels averaged 105% saturation downstream of W.A.C. Bennett dam during normal operations.	Continuous monitoring during normal operations and during the two spill events was limited to two sites downstream of the Peace Canyon Dam; both sites were located less than 10 km downstream from the dam. All other data in the river is based on spot measurements.
Contaminants	No specific information regarding contaminants was found in any of the fisheries-specific documents reviewed.	Not available

Topic	Information Summary	Data Quality
Phytoplankton and Zooplankton	Very little information regarding the phytoplankton and zooplankton in the Peace River is available and what is available is from Williston Lake and the Alberta portion of the river. The zooplankton community of Williston Lake is dominated numerically by copepods and cladocerans. The zooplankton community density peaked in July/August at the same time as the phytoplankton community.	Morphological and hydrologic conditions in Williston Lake are very different from the Peace River mainstem and although the phytoplankton and zooplankton communities of the Peace River are likely to be profoundly influenced by the Williston Lake communities, river specific information is unavailable.
Benthic Invertebrates	Benthic invertebrate information from the Peace River near the Site C project have been studied twice: in 1978 and in 1986. Chironomids were the most numerous taxa found in the 1978 study. Density of benthos decreased moving upstream.	Data from the 1978 study is out-of-date. The 1986 study is also out of date, is limited to two sample sites, and relies entirely on the use of artificial substrate traps. The spatial and temporal variability of the benthic invertebrate community cannot be determined from either of these studies.
Aquatic Macrophytes	A single study examining the potential for aquatic macrophyte enhancement in Dinosaur Lake reservoir is available.	Available data is only for Dinosaur Lake reservoir and was intended only to determine the feasibility of re-establishing aquatic macrophytes in the reservoir.
Flow Regime and habitat availability	Minimum flows requirements (500 m^3/s in January to 1910 m^3/s in June) were estimated in 1991 based on the largest month minimum flow needs for fish or water quality criteria. Flow needs for fish were based on previously collected information. Using hydraulic geometry data collected in 1975, average width, depth, and water velocities were determined at two low flow discharges of 142 m^3/s and 283 m^3/s. Between 15% and 21% of channel area was dewatered at a discharge of 283 m^3/s while the length of side-channels was reduced 57%. Daily flow variability is highest in summer and fall. The amount of channel dewatered daily varied from 10% and 20% in the mainstem and between 27% and 50% in the side channels. The effect of water releases from the Peace Canyon Dam was more pronounced when inputs to system from tributaries was low (i.e., summer).	Minimum flow requirements established in 1991 are not based on a hydrology-habitat model. Habitat availability at different flows has been determined for only limited discharges and at only select reaches of the river.

Topic	Information Summary	Data Quality
Fish Stranding	Fish stranding surveys were conducted during low flows in 1993 and also during ramp-down of flows after spill events at the W.A.C. Bennett dam in 1996 and 2002. Isolated pools were observed in 1993 at a discharge of 141 m^3/s and all contained fish. Fish were found in isolated pools downstream of the Peace Canyon dam after the 1996 spill event.	Surveys indicate that fish can become stranded in side channels and isolated pools at low flows and after spill events. However, a method of quantifying the number of fish stranded can not be determined because the relationship between discharge and side-channel availability has not be established.
Riparian and Aquatic Habitat Connectivity	As far as we are aware, no information exists on the frequency, magnitude, and duration of riparian floodplain connectivity or its importance to aquatic biota in the Peace River.	Not available
Ice Regime	A RICE model for the Peace River has been developed to predict the location of the ice front under different climate conditions and flow levels.	The RICE model is a state-of-the-art model and once calibrated will provide a prediction of future ice conditions on the Peace River under different flow and climatic conditions.
Tributary Access	A survey was conducted during low flows in June 1993 to assess to Maurice, Lynx, and Farrell creeks and to the Halfway River. No impediments to fish passage were found at any of these tributaries at a Peace River discharge of 141 m^3/s.	Only four of the seven tributaries upstream of the Site C project area were assessed and at only one discharge level. Access criteria were based on professional judgement.
Turbine Mortality and Entrainment	An estimated 28% of rainbow trout captured in the Peace River were hatchery-reared juveniles planted in Dinosaur Lake. The presence of these fish indicates that a relatively high percentage of fish successfully pass through Peace Canyon Dam. Also, the presence of kokanee, lake whitefish, and lake trout in the Peace River also indicates successful passage of fish from Williston Lake downstream through the dams. Entrainment and mortalities of fish were monitored during 1996 and 2002 spill events at the W.A.C. Bennett dam. Mortalities were determined using visual observations and a mark-recapture program. Most mortalities were lake whitefish. An estimated 15,000 fish per day were entrained over the W.A.C. Bennett Dam during the 1996 spill event.	Mortality measurements during the two spill events were based only on fish visible on surface and because they did not include fish dying at depths or fish dying after the program had ended, are likely to under-represent the total mortality during the spills. The hydroacoustic study was corrected for debris and false fish signals and provides the most accurate estimate of spillway entrainment available.

Topic	Information Summary	Data Quality
Fishing Pressure	Creel surveys on the Peace River and in Dinosaur Lake were completed in late 1980's. More recent creel surveys were conducted again on Dinosaur Lake in the late 1990's/early 2000's. No recent information exists for the Peace River downstream of the Peace Canyon Dam. Rainbow trout are the target species for most anglers in Dinosaur Lake and on the Peace River. Most fish captured by the sport fishery were mountain whitefish. Most angling effort on the Peace River is concentrated around Hudson Hope with less than 6% of effort near the Site C area. Angling use of Dinosaur Lake reservoir has declined over time. Over 90% of anglers surveyed in 1989 and 1990 were local residents	The most recent creel data from the Peace River mainstem is from 2004 but has a very low sample size and does not accurately represent the current sport fishery on the river. Data from 1989/90 are unlikely to reflect the current sport fishery especially given the population growth on Fort St. John in the past two decades.
Site C Compensation and Mitigation	Various compensation options for the Site C reservoir have been suggested including stocking of sport fish in the reservoirs, enhancing spawning in tributaries through construction of side channels, placement of large woody debris structures, and re-establishing aquatic plants. Habitat structures were recently placed in Dinosaur Lake and monitored for fish use.	Other than woody debris structures in Dinosaur Lake, the feasibility and effectiveness of most compensation options to achieve "no-net-loss" has not been thoroughly assessed.
Rare and Listed Fish Species	Spottail shiner are the only red-listed (i.e., endangered or threatened) fish species in the BC portion of the Peace River. Spottail shiner were not captured during extensive sampling conducted in the Peace River mainstem in 1989 or 1990. However, 30 spottail shiner were captured in 1999 and almost 300 spottail shiner (~20% of the small-bodied fish sample) were captured in the first year of the fish community indexing program. The paucity of spottail shiner in the late 1980's and their appearance in more recent surveys suggests that the number and/or the distribution of spottail shiner in the river is increasing. Goldeye, pearl dace, and bull trout and are blue-listed (i.e., special concern) species in the Peace River drainage. Goldeye are generally restricted to the lower Peace River downstream of the Pine River confluence. Bull trout are present throughout the Peace River mainstem and are known to make large spawning migrations between the Peace and Halfway rivers. Pearl dace have never been positively identified in the BC portion of the Peace River.	Movements of bull trout between the Halfway and Peace river are well understood and based on radio-telemetry studies. Information on the abundance and distribution of spottail shiner is evolving as more work on the river is conducted, however, the fish community indexing program uses techniques primarily suited to the capture of large-bodied fish. The detection of spottail shiner is more coincidental than intended as a result. Small-bodied fish sampling has been conducted in only one year to date.

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