ENBRIDGE
NORTHERN
GATEWAY PIPELINES

July 12, 2012 E-FILE

Attention: **Ms. Sheri Young, Secretary to the Joint Review Panel**
Enbridge Northern Gateway Project

National Energy Board
444 Seventh Avenue SW
Calgary, AB T2P 0X8

Dear Ms. Young,

Re: Northern Gateway Pipelines Application to the National Energy Board
Enbridge Northern Gateway Project
OH-4-2011
NEB File No: OF-Fac-Oil-N304-2010-01 01
Follow-up to Information Requests

Northern Gateway is now providing reports that have been prepared which respond to various information requests as follows:

- Ecological and Human Health Risk Assessment for Pipeline Spills (refer to Northern Gateway's response to Federal Government IR 118;
- Conceptual Fish Habitat Mitigation and Compensation Plan (refer to Northern Gateway's response to Federal Government IR 2.8a);
- Conceptual Marine Fish Habitat Compensation Plan (refer to Northern Gateway's response to Federal Government IR 2.8a) and JRP IR 8.18a) and b); and
- Wetland Function Assessment Framework (refer to Northern Gateway's response to Federal Government IR 1.69 and 2.54).

3000, 425 1st Street SW, Calgary, AB, T2P 3L8 (T) 403.231.3900 (F) 403.718.3525

These documents are being filed electronically with the Board and will be served upon all OH-4-2011 Parties.

If the Board should require additional information, please contact the undersigned at (403) 718-3444.

Yours truly,

Ken MacDonald
Vice President, Law and Regulatory
Northern Gateway Pipelines Limited Partnership

cc: CEAA
Attention: Sarah Devin

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(A42789)

Technical Data Report

Conceptual Freshwater Fish Habitat Compensation Plan

ENBRIDGE NORTHERN GATEWAY PROJECT

VERSION 2.0

July 2012

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Acronyms

AB	Alberta
AENV	Alberta Environment
asl	above sea level
ASRD	Alberta Sustainable Resource Development
BACI	before, after, control impact
BC	British Columbia
BC CDC	British Columbia Conservation Data Centre
BC MoFR	British Columbia Ministry of Forests and Range
BC MoE	British Columbia Ministry of Environment
BC MoF	British Columbia Ministry of Forests
BC MWLAP	British Columbia Ministry of Water, Land and Air Protection
BEC	Biogeoclimatic Ecosystem Classification
BFW	bank full width
BMP	Best Management Practices
CAPP	Canadian Association of Petroleum Producers
CEPA	Canadian Energy Pipeline Association
CGA	Canadian Gas Association
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Fisheries and Oceans Canada
EAWR	estimated additional workspace required
EMP	Environmental Management Plan
EPMP	Environmental Protection and Management Plan
HADD	harmful alteration, disruption or destruction
HSI	habitat suitability index
ID	identification
KP	kilometre post
LNG	liquefied natural gas
LWD	large woody debris
LRP	least risk period
MWLAP	Ministry of Water, Land and Air Protection
NCD	non-classified drainage
NEB	National Energy Board
NNL	no net loss
NVC	no visible channel
OHWM	ordinary high water mark
OS	Operational Statement
PoE	pathways of effects
REAA	regional effects assessment area
RMF	risk management framework
RoW	right-of-way

RSC .... Revised Statutes of Canada
SARA........ *Species at Risk Act*
SWAT........ sensitive watercourse assessment team
the Project........ Enbridge Northern Gateway Project
TDR........ technical data report
TW........ trench width
ZOI .... zone of influence

1 Introduction

1.1 Background

Northern Gateway Pipelines Limited Partnership (Northern Gateway) proposes to design, construct and operate two pipelines extending from Bruderheim, Alberta (near Edmonton) to Kitimat, British Columbia. One pipeline will transport crude oil from Alberta to British Columbia while the second pipeline will transport condensate from Kitimat to Bruderheim. The marine terminal at Kitimat will be used to load tankers with oil for export to international markets and will also be used to unload tankers carrying condensate.

Construction, operation and decommissioning of the pipelines has the potential to cause a harmful alteration, disruption or destruction (HADD) of fish habitat. Such HADD of fish habitat could result from instream works required to bury the pipelines under streams and rivers along the proposed pipeline route, or from the alteration of stream banks and clearing or pruning of riparian vegetation required to provide access to the stream crossings. While mitigation measures will be implemented specifically to reduce effects on instream habitats, riparian areas and fish, some HADD of fish habitat will be unavoidable. These HADDs would occur primarily during construction, but may also occur during routine operations and maintenance and during pipeline decommissioning.

HADD of fish habitat are prohibited in Canada by Section 35(1) of the *Fisheries Act*. However, Fisheries and Oceans Canada (DFO) may authorize a HADD under Section 35(2) of the *Fisheries Act* if it is satisfied that the proponent has avoided the HADD to the maximum extent possible and has developed a compensation plan to offset the unavoidable losses of fish habitat such that a “no net loss” (NNL) of fish habitat productive capacity will be achieved.

As part of the Joint Review Panel process, Northern Gateway committed, in response to an Information Request from the Federal Government, to provide a detailed compensation plan in respect of freshwater fish habitat. This document meets this commitment. It provides a conceptual fish habitat compensation plan for the Enbridge Northern Gateway Project (Project) that is consistent with the NNL guiding principle and the Policy for Management of Fish Habitat in Canada (DFO 1986).

The plan is conceptual at this point because 1) the proposed pipeline route has not been finalized and, as a result, the number and magnitude of HADDs that would actually occur cannot be determined; 2) it does not explicitly identify where, how many or which of the different habitat creation or enhancement or restoration techniques available as “on-site” compensation options would be used; 3) it does not explicitly identify where or how many “off-site” compensation options would be necessary; and 4) it does not include the detailed design drawings, monitoring plans or cost estimates necessary before DFO can issue a Section 35(2) authorization for the HADD. This conceptual fish habitat compensation plan will form the framework for the development of the detailed fish habitat compensation plan that would be necessary prior to issuance of any Section 35(2) authorization(s) for the Project.

This conceptual fish habitat compensation plan updates the conceptual plan submitted in the May 2010 Application (Volume 6A, Appendix 11B). It does so by: 1) updating the potential HADD estimate based on updated route alignment and stream crossing techniques; 2) providing a description of the various on-site and off-site options available as compensation for the likely HADD; 3) providing a description of pilot projects that could be initiated prior to construction of the proposed pipelines to develop a habitat bank, validate the effectiveness of various enhancement techniques, and reduce the time lag likely to occur before habitat compensation projects become fully functional; and 4) providing a description of the instream and riparian habitat restoration or enhancement techniques likely to be used for different targeted fish species in streams of different sizes and geomorphology.

1.2 Objectives

The objectives of this plan are three-fold. First, the plan describes the methods that will be used to quantify the amount of compensatory fish habitat needed to offset the HADDs resulting from the Project. Second, the plan describes a framework that Northern Gateway intends to use to identify and prioritize the compensation options that may be used in the final compensation plan should the Project be approved by the Joint Review Panel. Third, the plan provides a description of the types of fish habitat creation or restoration or enhancement techniques that would most likely be used at various locations along the proposed pipeline route (i.e., on-site) or in other high-priority areas (i.e., off-site) identified during consultations with federal and provincial regulators and local First Nations. These techniques include, but are not necessarily limited to, those that have been used successfully in Alberta and British Columbia to increase the productive capacity of stream and lake habitats for recreationally, commercially and traditionally important fish species such as salmon, trout and walleye.

2 Regulatory Context

Section 35(1) of the federal *Fisheries Act* prohibits the HADD of fish habitat in Canada. Fish habitat is defined in Section 34 of the *Fisheries Act* as "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes." By this definition, fish habitat includes areas that currently produce fish, areas that could potentially produce fish, or areas that provide the nutrients, water or food supply to fish-bearing habitat downstream.

Pursuant to Section 35(2) of the *Fisheries Act*, DFO may issue an authorization for the HADD of fish habitat if it is satisfied that habitat losses can be compensated such that there is NNL of productive capacity of fish habitat, as outlined in the *Policy for the Management of Fish Habitat*[1]. DFO makes a decision on whether a Section 35(2) Authorization will be issued by taking into account public consultations, economic and environmental benefits and costs associated with the development of alternative solutions.

DFO's *Habitat Conservation and Protection Guidelines*[2] outlines a hierarchy of preferred management options to be followed by development proponents whose projects may cause a HADD of fish habitat. From most preferred to least preferred, these options include:

- **Relocation and Redesign -** "DFO normally prefers relocation or redesign, especially if the project represents a substantial risk to critical habitats, the habitats' productive capacity is high, or the habitat is particularly important to critical life stages of a fish species."
- **Mitigation -** "Project relocation and/or relocation are not always feasible and, when feasible, they may not be sufficient to completely eliminate impacts on fish habitat productivity. In these situations, mitigative measures have to be implemented during the project's planning, design, construction and/or operation, mostly when critical or important habitats are threatened."
- **Compensation** – "Habitat compensation is an option when residual impacts of projects on habitat productive capacity are still deemed harmful after relocation; redesign or mitigation options have been implemented. Compensation is not recommended as an option for loss of critical habitats and should only be considered where compensation for the loss of critical habitats is achievable." (DFO 1998)

Before a Section 35(2) Authorization is issued by DFO, the proponent must demonstrate that potential environmental effects on fish and fish habitat have been avoided to the maximum extent possible through refinement of the project design and implementation of technically feasible mitigation measures. Only when no further changes to the project or implementation of additional mitigation can be made will DFO consider compensation for unavoidable HADDs of fish habitat.

[1] Fisheries and Oceans Canada (DFO). 1986. *Policy for the Management of Fish Habitat*. Communications Directorate. Department of Fisheries and Oceans Canada. Ottawa, Ontario.
[2] Fisheries and Oceans Canada (DFO). 1998. *Habitat Conservation and Protection Guidelines.* Second Edition. Communications Directorate. Department of Fisheries and Oceans Canada. Ottawa, Ontario.

When compensation is still required to achieve NNL, DFO's hierarchy of preferred compensation options are as follows (DFO 2007):

1. create or increase the productive capacity of "like-for-like" habitat in the same ecological unit
2. create or increase the productive capacity of "unlike" habitat in the same ecological unit
3. create or increase the productive capacity of habitat in a different ecological unit
4. as a last resort, use artificial production techniques to maintain a stock of fish, deferred compensation, or restoration of chemically contaminated sites

For this hierarchy, an ecological unit is defined as "populations of organisms considered together with their physical environment and the interacting processes amongst them" (DFO 2007).

Achieving NNL has inherent uncertainties. These uncertainties are due to 1) the largely unknown relationship between fish habitat and fish production, 2) the uncertainty of successful habitat compensation, 3) the variability in the quality of the fish habitat being replaced, and 4) the likely time lag before habitat compensation reaches its maximum productive capacity (Minns 1997; Minns and Moore 2003; Minns 2006; DFO 1998). To address these uncertainties, DFO typically requires proponents to complete compensation at the higher levels of the hierarchy before considering compensation options lower down (DFO 2007) and typically requires compensation ratios (habitat gains to losses) greater than 1:1. Compensation options higher up in the hierarchy have a greater likelihood of providing habitat benefits to the fish populations most directly affected by the HADD. Higher compensation ratios, such as the recommended 2:1 ratio (Minns and Moore 2003), reduce the risks associated with the uncertainties described above. Together, these two mechanisms increase the likelihood of achieving NNL. However, the goal of NNL of productive capacity is applied not as a rigid quantitative rule but as a guiding principle (DFO 1998).

3 Environmental Setting

3.1 Overview

The right-of-way (RoW) crosses seven major drainages in Alberta and British Columbia (see Figure 3-1). From east to west, these include North Saskatchewan River, Athabasca River and Peace River drainages in Alberta, and Peace River, Fraser River, Skeena River and Kitimat River drainages in British Columbia. The proposed pipelines also cross into smaller tributary watersheds of the Douglas Channel on the British Columbia coast.

The proposed pipelines' summit elevations, estimated from 1:50,000 National Topographic Service (NTS) maps, vary from about 700 m above sea level (asl) in the North Saskatchewan River drainage in Alberta to 4,300 m asl in the Skeena River drainage in British Columbia. At their end points, the proposed pipelines are at sea level in Kitimat and 625 m asl in Bruderheim.

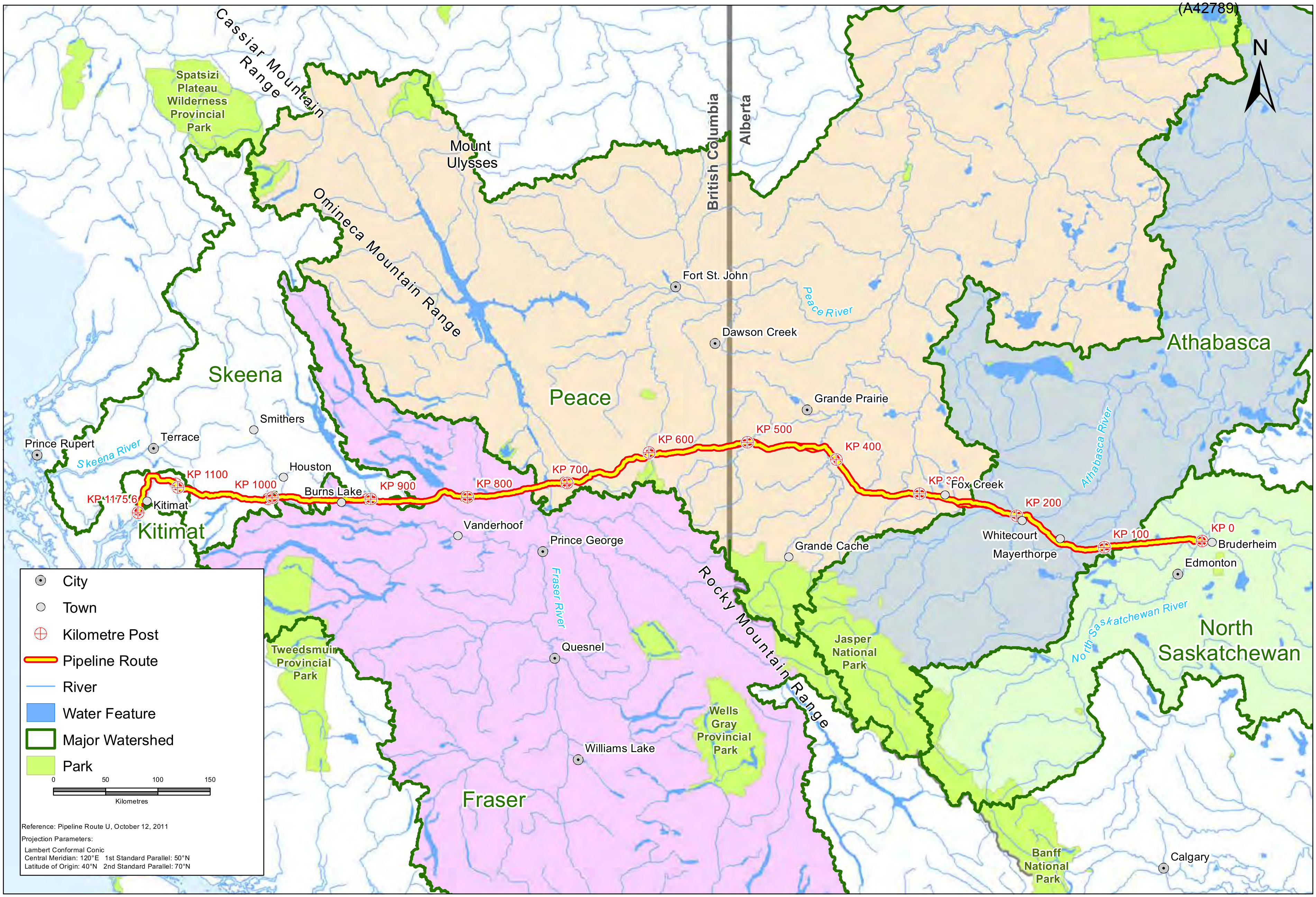
The proposed pipelines will cross the Eastern Alberta Plains and Southern Alberta Uplands physiographic regions in Alberta. Within these two regions are the Central Parkland, Lower Foothills and Dry and Central Mixed-wood natural sub-regions. In British Columbia, the proposed pipelines will cross the Alberta Plateau, Rocky Mountains, Interior Plateau and the Coast Mountains physiographic regions. Within these regions are the Sub-Boreal Spruce, Engelmann Spruce/Subalpine Fir, Boreal White and Black Spruce, Alpine Tundra, Coastal Western Hemlock, Mountain Hemlock and Interior Cedar Hemlock zones of the

Biogeoclimatic Ecosystem Classification (BEC) (British Columbia Ministry of Forests and Range [BC MoFR] 2009). The most common BEC zones, Sub-Boreal Spruce and Engelmann Spruce/Subalpine Fir, occur in the Peace, Fraser and Skeena River watersheds.

3.2 Drainages

3.2.1 North Saskatchewan River Drainage

Major watersheds in this drainage include North Saskatchewan and Sturgeon Rivers. This section of pipeline route crosses flat terrain associated with boreal forest, agricultural zones and low-gradient watercourses in the North Saskatchewan River and the Sturgeon River valleys (Allan 1984). The climatic region for the drainage is characterized predominantly by Central Parkland conditions, which include mostly grasslands and aspen and balsam poplar forests. A small region of Boreal Forest is found on the eastern and western sections of the RoW in the North Saskatchewan River drainage and is characterized mainly by aspen forests. Most of the land in this section of the proposed pipeline route is used for agriculture.



REFERENCES: NTDB Topographic Mapsheets provided by the Majesty the Queen in Right of Canada, Department of Natural Resources. All rights reserved.

CONTRACTOR: AMEC Environment & Infrastructure	ENBRIDGE NORTHERN GATEWAY PROJECT	FIGURE NUMBER: 3-1	DATE: May, 2012
PREPARED BY: gem / PREPARED FOR: ENBRIDGE NORTHERN GATEWAY PIPELINES	Major Drainages Crossed by the RoW in Alberta and British Columbia	SCALE: 1:5,000,000	AUTHOR: MY / APPROVED BY: KB
		PROJECTION: LCC	DATUM: NAD 83

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3.2.2 Athabasca River Drainage

With the Athabasca River drainage, the proposed pipeline route crosses flat terrain associated with forested and agricultural sections separated by low-gradient watercourses in the Pembina, Paddle and Athabasca River valleys (Wallace and McCart 1984). The climatic region is characterized by dry mixed-wood conditions, which include mainly aspen forests. In the western portion of the drainage, the climatic region is characterized by Foothills conditions dominated by white spruce, black spruce and birch forests. A transition zone between the two climatic regions occurs between kilometre post (KP) 160 and KP 200. A substantial amount of the land base in the Athabasca River drainage has been cleared for agriculture and logging. Oil and gas developments are also scattered through the western portion of the drainage.

3.2.3 Peace River Drainage (Alberta Portion)

The proposed pipeline RoW in the Alberta portion of the Peace River drainage crosses Foothills terrain associated with forested sections separated by low-gradient watercourses in the Little Smoky, Simonette, Smoky and Wapiti River valleys (Paetz 1984). The climatic region is characterized as a transitional zone between Foothills and Boreal forest conditions. Mixed forests of aspen, white spruce, black spruce and birch are found throughout the drainage. Most of the land use in this drainage is dedicated to logging and oil and gas lease developments.

3.2.4 Peace River Drainage (British Columbia Portion)

The proposed pipeline RoW in the British Columbia portion of the Peace River drainage crosses rugged terrain associated with the Rocky Mountains, Rocky Mountain Foothills, Hart and Misinchinka Ranges. The western section of the proposed pipeline route in the Peace River drainage crosses the Parsnip River in the Rocky Mountain Trench and ascends the McGregor and Interior plateaus. Most of the land in this drainage is undeveloped. However, some land has been used for mining, forestry, and oil and gas exploration and distribution.

3.2.5 Fraser River Drainage

Within the Fraser River drainage, the proposed pipeline RoW will be almost entirely within the Nechako (Interior) Plateau, a feature with relatively moderate-relief terrain. Unlike the steeper, wetter drainages associated with the proposed pipeline route in coastal areas of British Columbia, the climate within the Fraser River drainage has hotter and drier summers and colder winters. As a result, flows are generally lower during summer and there are more ephemeral tributaries. The primary land uses along the proposed pipeline RoW within the Fraser River drainage include agriculture, ranching and logging.

3.2.6 Skeena River Drainage

Within the Skeena River drainage, the proposed pipeline RoW crosses the rolling topography of the Nechako Plateau in the eastern region. The western section of the proposed pipeline route crosses western Morice River drainages before crossing high-relief terrain associated with Zymoetz River. The western section of the Skeena River drainage is primarily logged or remains undeveloped. In the eastern section, logging, agriculture and ranching account for the majority of land use along the proposed pipeline route.

3.2.7 Kitimat River Drainage

The headwaters of the Kitimat River system originate in the Kitimat Range of the Coast Mountains in west-central British Columbia. The river discharges into the Pacific Ocean at the head of Douglas Channel near the town of Kitimat. This section of the proposed pipeline route crosses steep terrain associated with the Coast and Kitimat Mountain ranges, separated by low-gradient watercourse crossings in the Kitimat River valley. A substantial amount of land in this watershed group has been logged.

3.2.8 Douglas Channel Drainage

The proposed pipeline route extends along the west side of Kitimat Arm in Douglas Channel to the Kitimat Terminal approximately 2 km north of Bish Cove. Watercourses in this section of the proposed pipeline route are part of the Kitimat River watershed group described above, but have been delineated as the Douglas Channel area for discussion.

The Kitimat Terminal includes both land-based facilities (tank terminal that is located inside the security fence and is 220 ha) and marine facilities (marine terminal). The land-based facilities drain to Douglas Channel. There will be 258 ha outside the tank terminal that will be used for storing material removed during construction of the tank and marine terminals (e.g., rock, marine clays and topsoil).

3.3 Fish Communities

It is estimated that 58 fish species reside or seasonally utilize habitat in streams along the proposed pipeline route. These species include 27 sport fish species, eight coarse fish species and 23 forage fish species (see Table 3-1). In Alberta, sport fish species include walleye, yellow perch, sauger, mooneye, goldeye, lake sturgeon, Arctic grayling, rainbow trout, bull trout, mountain whitefish, northern pike and burbot, as well as introduced brown trout and brook trout. In British Columbia, sport fish species include all five Pacific salmon species and steelhead, rainbow trout, bull trout, coastal cutthroat trout, Dolly Varden, kokanee, lake trout, pygmy whitefish, mountain whitefish and burbot, and in the Peace River watershed, northern pike, Arctic grayling, brook trout, bull trout and lake whitefish. All of these species, plus white sturgeon in the Fraser River watershed, are commonly targeted by recreational anglers. Rainbow trout and burbot are the only sport fish species present in every major watershed along the proposed pipeline route.

All five Pacific salmon species (chinook, coho, sockeye, pink and chum) and steelhead are found in the Skeena and Kitimat River watersheds in British Columbia. Chinook, sockeye and coho salmon are also present in the Fraser River watershed. Dolly Varden occur in the Kitimat River drainage and occur sympatrically with bull trout in the Skeena drainage (McPhail 2007; Feldoff 2009, pers. comm.; Baxter et. al. 1997). Both species are thought to be present from the Morice River (Skeena tributary) east to the Stuart River (Fraser drainage). Only bull trout occur east of the Stuart River and no Dolly Varden are present in the Peace River drainage.

Table 3-1 Fish Species in Watercourses Crossed by the Right-of-Way

Species	Scientific Name	Species Code AB	Species Code BC	Alberta Major Drainage			British Columbia Major Drainage			
				N. Sask.	Athabasca	Peace	Peace	Fraser	Skeena	Kitimat
Sport Fish										
Arctic grayling	*Thymallus arcticus*	ARGR	GR		X	X	X			
Brook trout	*Salvelinus fontinalis*	BKTR	EB		X	X	X			
Brown trout	*Salmo trutta*	BNTR	GB	X	X					
Bull trout	*Salvelinus confluentus*	BLTR	BT		X	X	X	X	X	X
Burbot	*Lota lota*	BRBT	BB	X	X	X	X	X	X	
Coastal cutthroat trout	*Oncorhynchus clarki clarki*	CTTR	CT						X	X
Chinook salmon	*Oncorhynchus tshawytscha*		CH					X	X	X
Chum salmon	*Oncorhynchus keta*		CM						X	X
Coho salmon	*Oncorhynchus kisutch*		CO					X	X	X
Dolly Varden	*Salvelinus malma*		DV					X	X	X
Goldeye	*Hiodon alosoides*	GOLD	GE	X	X					
Kokanee	*Oncorhynchus nerka*		KO					X	X	X
Lake whitefish	*Coregonus clupeaformis*	LKWH	LW				X			
Lake sturgeon	*Acipenser fulvescens*	LKST		X						
Lake trout	*Salvelinus namaycush*		LT				X	X	X	
Mooneye	*Hiodon tergisus*	MOON		X						
Mountain whitefish	*Prosopium williamsoni*	MNWH	MW	X	X	X	X	X	X	
Northern pike	*Esox lucius*	NRPK	NP	X	X	X	X			

Table 3-1 Fish Species in Watercourses Crossed by the Right-of-Way (cont'd.)

Species	Scientific Name	Species Code AB	Species Code BC	Alberta Major Drainage			British Columbia Major Drainage			
				N. Sask.	Athabasca	Peace	Peace	Fraser	Skeena	Kitimat
Sport Fish (cont'd)										
Pink salmon	*Oncorhynchus gorbuscha*		PK					X	X	X
Pygmy whitefish	*Pygmy whitefish*	PGWH	PW				X		X	
Rainbow trout	*Oncorhynchus mykiss*	RNTR	RB	X	X	X	X	X	X	X
Sauger	*Stizostedion canadense*	SAUG		X						
Sockeye salmon	*Oncorhynchus nerka*		SK					X	X	X
Steelhead	*Oncorhynchus mykiss*		ST						X	X
Walleye	*Sander vitreus*	WALL	WP	X	X	X				
White sturgeon	*Acipenser transmontanus*		WSG					X		
Yellow Perch	*Perca flavescens*	YLPR	YP	X	X	X				
Coarse Fish										
Bridgelip sucker	*Catostomus columbianus*		BSU					X		
Largescale sucker	*Catostomus macrocheilus*	LRSC	CSU			X	X	X	X	
Longnose sucker	*Catostomus catostomus*	LNSC	LSU	X	X	X	X	X	X	
Mountain sucker	*Catostomus platyrhyncus*	MNSC	MSU	X						
Quillback	*Carpiodes cyprinus*	QUIL		X						

Table 3-1 Fish Species in Watercourses Crossed by the Right-of-Way (cont'd.)

Species	Scientific Name	Species Code AB	Species Code BC	Alberta Major Drainage			British Columbia Major Drainage			
				N. Sask.	Athabasca	Peace	Peace	Fraser	Skeena	Kitimat
Coarse Fish (cont'd)										
Shorthead redhorse	*Moxostoma macrolepidotum*	SHRD		X						
Silver redhorse	*Moxostoma anisurum*	SLRD		X						
White sucker	*Catostomus commersoni*	WHSC	WSU	X	X	X	X	X	X	
Forage Fish										
Brassy minnow	*Hybognathus hankinsoni*	BRMN	BMC				X	X		
Brook stickleback	*Culea inconstans*	BRST	BSB	X	X	X	X			
Coastrange sculpin	*Cottus aleuticus*		CAL						X	X
Emerald shiner	*Notropis atherinoides*	EMSH	ESC	X	X	X				
Fathead minnow	*Pimephales promelas*	FTMN	FM	X	X					
Finescale dace	*Phoxinus neogaeus*	FNDC	FDC	X	X	X	X			
Flathead chub	*Platygobio gracilis*	FLCH	FHC	X	X	X				
Iowa darter	*Etheostoma exile*	IWDR		X						
Lake chub	*Couesius plumbeus*	LKCH	LKC	X	X	X	X	X	X	
Leopard dace	*Rhinichthys falcatus*		LDC					X	X	
Longnose dace	*Rhinichthys cataractae*	LNDC	LNC	X	X	X	X	X	X	
Northern redbelly dace	*Phoxinus eos*	NRDC	RDC	X	X	X	X			

Table 3-1 Fish Species in Watercourses Crossed by the Right-of-Way (cont'd.)

Species	Scientific Name	Species Code AB	Species Code BC	Alberta Major Drainage			British Columbia Major Drainage			
				N. Sask.	Athabasca	Peace	Peace	Fraser	Skeena	Kitimat
Forage Fish (cont'd)										
Northern pikeminnow	*Ptycheilus oregonensis*	NRPM	NSC			X	X	X	X	
Pacific lamprey	*Lampetra tridentata*		PL						X	X
Pearl dace	*Margariscus margarita*	PRDC	PDC	X	X	X	X			
Peamouth	*Mylocheilus caurinus*		PCC				X	X	X	
Prickly sculpin	*Cottus asper*	PRSC	CAS				X	X	X	X
Redside shiner	*Richardsonius balteatus*	RDSH	RSC			X	X	X	X	
River shiner	*Notropis blennius*	RVSH		X						
Slimy sculpin	*Cottus cognatus*	SLSC	CCG			X	X	X		
Spoonhead sculpin	*Cottus ricei*	SPSC	CRI	X	X	X				
Spottail shiner	*Notropis hudsonius*	SPSH	STC	X	X	X				
Threespine stickleback	*Gasterosteus aculeatus*		TSB						X	X
Troutperch	*Percopis omiscomaycus*	TRPR	TP	X	X	X	X			
SOURCE: FISS (BC MoE 2009a); FWMIS (ASRD 2009); McPhail 2007; Nelson and Paetz 1992; Scott and Crossman 1998.										

Coarse fish species include bridgelip, longnose, largescale, mountain and white suckers, quillback, shorthead redhorse, and silver redhorse. Longnose sucker and white sucker are commonly found in the watersheds along the pipeline route. Bridgelip suckers are only found in the Fraser River watershed in BC while mountain sucker, quillback, silver redhorse and shorthead redhorse are only found in the North Saskatchewan River in Alberta.

Forage fish species are small freshwater fish that serve as prey for larger fish. Forage fish species in streams potentially crossed by the pipeline route include chubs, shiners and dace, sculpins, sticklebacks, and darters. Longnose dace and lake chub are found in most watersheds along the proposed pipeline route. Coastrange sculpin, Pacific lamprey, and threespine stickleback are only found in the Skeena and Kitimit River drainages with access to the ocean. Iowa darter and river shiners are only found in the North Saskatchewan River in Alberta.

3.4 Fish Species at Risk

There are 14 fish species of conservation concern with distributions that overlap the proposed pipeline route in Alberta (see Table 3-2). These include the endangered lake sturgeon population in North Saskatchewan River and the critically imperilled population of northern pikeminnow in Peace River. The North Saskatchewan River lake sturgeon population is currently being considered for listing on Schedule 1 of the *Species at Risk Act* (*SARA*) by the Federal Government. Doing so would provide this population and its critical habitat with legal protection under *SARA*. Other fish species are either on a fish tracking list (provincial ranking of S1 or S2) or a fish watch list (provincial ranking of S3 or S4). Inclusion on these lists does not provide legislated protection.

In British Columbia, there are seven fish species of conservation concern in streams along the proposed pipeline route (see Table 3–2). These include the red-listed (i.e., extirpated, endangered or threatened) Arctic grayling populations in the Williston Lake sub-watershed of Peace River and the red-listed white sturgeon population in the Nechako River (Fraser River watershed). Blue-listed (i.e., special concern) populations of bull trout exist in the four British Columbia watersheds potentially crossed by the pipelines, as well as blue-listed populations of coastal cutthroat trout (Skeena and Kitimat River drainages), Dolly Varden (Fraser, Skeena and Kitimat River drainages) and pearl dace (Peace River drainage only). Yellow-listed (i.e., secure) chinook salmon are included in this list as their status is currently under review because they are an important prey species for the endangered southern Orca population in British Columbia.

Table 3-2 Fish Species of Conservation Concern

	Species	Ocean Drainage	Provincial Status[1,2,3]	Federal Status[4,5]
Alberta	Lake sturgeon	Arctic	Tracking List (SU)	*SARA* – endangered (G3G4)
	River shiner	Arctic	Tracking List (SU)	G5
	Largescale sucker	Arctic	Watch List (S3)	G5
	Silver redhorse	Arctic	Tracking List (SU)	G5
	Rainbow trout	Arctic	Track List (S1)	G5
	Arctic grayling	Arctic	Watch List (S3S4)	G5
	Bull trout	Arctic	Watch List (S3)	G3
	Northern redbelly dace	Arctic	Watch List (S3)	G5
	Pearl dace	Arctic	Watch List (SU)	G5
	Finescale dace	Arctic	Watch List (SU)	G5
	Quillback	Arctic	Watch List (SU)	G5
	Spoonhead sculpin	Arctic	Track List (S3)	G5
	Sauger	Arctic	Watch List (S3)	G5
	Northern Pikeminnow	Arctic	Tracking List (S1)	G5
British Columbia	Coastal cutthroat trout	Pacific	Blue-listed (S3S4)	G5
	Bull trout	Arctic, Pacific	Blue-listed (S3 Coastal lineage; S3S4 interior lineage)	G4T3T4 Coastal Lineage; G4T4 interior lineage
	White sturgeon (Nechako River population)	Pacific	Red-listed (S1)	*SARA* – Endangered (G4T1Q)
	Williston watershed Arctic grayling	Arctic	Red-listed (S1)	–
	Northern redbelly dace	Arctic	Blue-listed (S3)	G5
	Chinook salmon	Pacific	Yellow-listed (S4)	G5
	Pearl dace	Arctic	Blue-listed (S3)	G5

Table 3-2 Fish Species of Conservation Concern (cont'd)

NOTES:

[1] Tracking List = Alberta Fish Tracking List (Alberta Natural Heritage Information Centre [ANHIC] 2008)

[2] Watch List = Alberta Fish Watch List, (ANHIC 2008)

- SU Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
- S1 – 5 or fewer occurrences or only a few remaining individuals. May be especially vulnerable to extirpation because of some factor of its biology
- S2 – 6 to 20 or fewer occurrences or with many individuals in fewer locations
- S2/S3 – 6 to 20 or fewer occurrences or with many individuals in fewer locations / 21 to 100 occurrences, may be rare and local throughout its range, or in a restricted range (may be abundant in some locations)
- S3 – 21 to 100 occurrences, may be rare and local throughout its range, or in a restricted range (may be abundant in some locations)
- S3/S4 – 21 to 100 occurrences, may be rare and local throughout its range, or in a restricted range (may be abundant in some locations) / Typically more than 100 occurrences
- S5 - Typically more than 100 occurrences

[3] British Columbia Provincial Listed Species of Concern (British Columbia Conservation Data Centre [BC CDC] 2008)

- Blue-listed = Special concern (formerly vulnerable)
- Red-listed = Extirpated, endangered or threatened

[4] Government of Canada Species at Risk Public Registry (Committee on the Status of Endangered Wildlife in Canada [COSEWIC] 2008; Government of Canada 2009)

- Endangered = a wildlife species facing imminent extirpation or extinction. (Accepted by COSEWIC before May 2003)
- G – global
  - G1 – critically imperilled
  - G1G2 –critically imperilled/imperilled
  - G3 – special concern, vulnerable to extirpation or extinction
  - G3G4 – special concern, vulnerable to extirpation or extinction/apparently secure.
  - G4 – apparently secure
  - G5 - secure
- N – national
- Q – questionable taxonomy
- S – subnational
- T – number - intra-specific taxon (subspecies or variety)

4 Project Description, Potential Effects and Mitigation

4.1 Project Description

The pipeline route will extend approximately 1,177 km between Bruderheim, Alberta to the marine terminal in Kitimat, British Columbia. In addition, the Project includes access roads necessary for pipeline construction and maintenance, a powerline to provide electricity for pump stations, and a marine terminal in Kitimat.

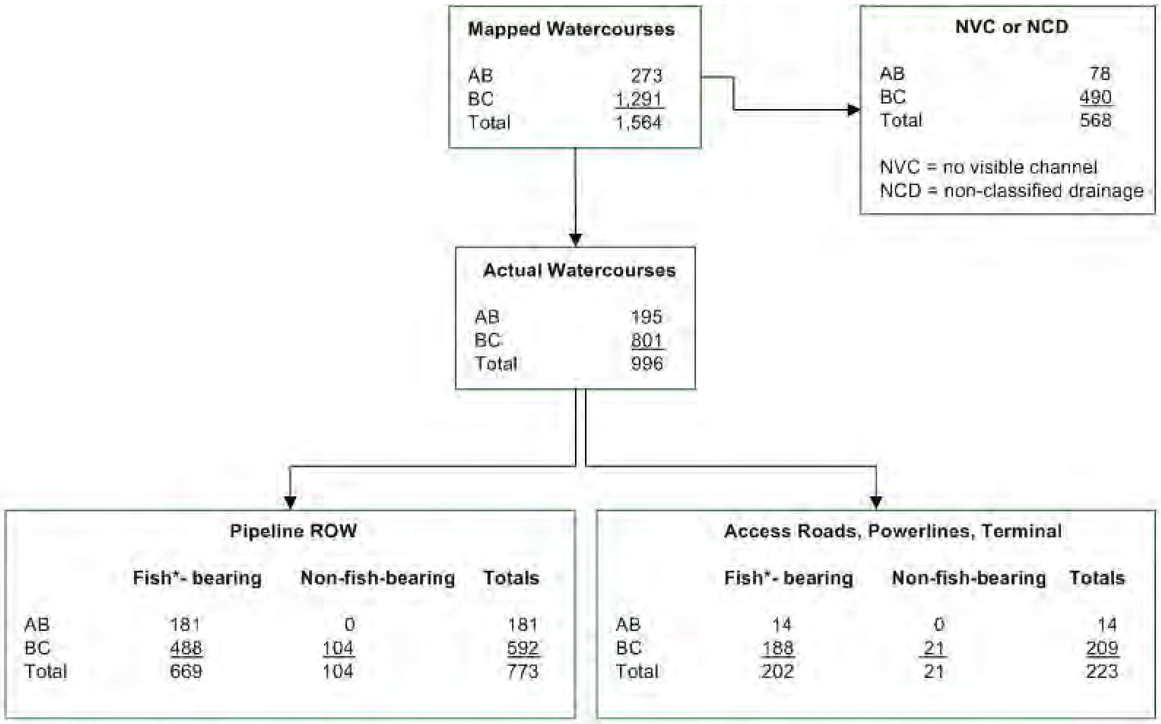
With the exception of several stream crossings where local geological conditions preclude underground construction, the pipelines will be buried underground at a depth of approximately 1 m. The larger (91.4 cm diameter) of the pipelines will transport up to 525,000 barrels per day of synthetic crude oil from northern Alberta westward to a new marine terminal in Kitimat, British Columbia. There, the oil will be loaded onto tankers for export to international markets. The smaller (50.8 cm diameter) of the pipelines will transport natural gas condensate unloaded from tankers at Kitimat eastward across British Columbia and Alberta to Bruderheim, Alberta. The condensate will be used to thin the heavier crude oil so that it can flow more easily through the westbound pipeline.

4.2 Watercourse Crossings

The Project will cross 1,564 mapped watercourses in Alberta and British Columbia (see Figure 4–1). However, not all of these mapped watercourses are actual streams or are fish bearing, and not all of these watercourses will be crossed by the pipeline route. Of the 1,564 mapped watercourses identified in a GIS at the 1:20,000 scale, field surveys only identified 996 as actual or inferred watercourses. The remaining 568 watercourses were identified in the field as no visible channel (NVC) or non-classified drainages (NCD). Of the 996 actual or inferred watercourses, 773 will be crossed by the proposed pipeline RoW, while 223 will be crossed by access roads, powerlines or the Kitimat marine terminal.

All 181 watercourses crossed by the proposed pipeline RoW in Alberta were determined to be fish-bearing. In British Columbia, however, 104 of the 592 watercourses crossed by the pipeline RoW were determined to be non-fish-bearing. Therefore, the proposed pipeline RoW crosses 669 fish-bearing watercourses along the proposed pipeline RoW in Alberta and British Columbia (see Table 4-1).

In Alberta, the proposed pipelines will potentially cross 24 fish-bearing streams in the North Saskatchewan River watershed, 65 fish-bearing streams in the Athabasca River watershed and 92 fish-bearing streams in the Peace River watershed. In British Columbia, the pipelines will cross 197 fish-bearing streams in the Peace River watershed, 92 fish-bearing streams in the Fraser River watershed, 124 fish-bearing streams in the Skeena River watershed, 70 fish-bearing streams in the Kitimat River watershed, and five fish-bearing streams in the Douglas Channel drainage.



*Fish-bearing streams includes non-fish-bearing streams where the zone of influence extends downstream into fish bearing waters.

Figure 4-1 Mapped and Actual Watercourses Crossed by the Pipeline Route

Table 4-1 Number and Distribution of Potential Pipeline Crossings by Major Drainage in Alberta and British Columbia

Province	Major Drainage	Fish-bearing	Non-fish-bearing	Totals
AB	North Saskatchewan	24	0	24
	Athabasca	65	0	65
	Peace AB	92	0	92
BC	Peace BC	197	58	255
	Fraser	92	6	98
	Skeena	124	16	140
	Kitimat	70	23	93
	Douglas Channel	5	1	6
	Totals	669	104	773

Eight different pipeline crossing methods will be used at the 669 fish-bearing watercourses to be crossed in Alberta and British Columbia. These methods will include four trenching methods (open cut, isolated dam and pump, isolated flumes, or isolated superflumes), two trenchless methods (horizontal directional drill or bore crossings), and one aerial crossing method. The type of crossing method used at any given site will depend on the size of the stream and its discharge, any specific engineering (e.g., geo-technical, design and constructability) issues, and the sensitivity of the habitat and fish species present. Northern Gateway will continue to consult with stakeholders, including appropriate regulatory agencies before the final crossing methods are selected.

4.3 Potential Environmental Effects and Mitigation

4.3.1 Potential Environmental Effects

Potential environmental effects on freshwater fish and fish habitat due to construction, operation and decommissioning of the proposed Project were identified and assessed in the May 2010 Application, Volume 6A, Section 11. The potential pathway of effects (PoE) assessed were those identified by DFO's PoE model for pipeline watercourse crossings:

- erosion and sediment deposition
- changes in instream habitat structure and cover including overwintering habitat, spawning and rearing habitat
- changes in riparian habitat
- changes in water temperature
- changes in food supply and nutrient contributions
- changes in migration and access to habitats

4.3.2 Mitigation

Mitigation of these potential PoEs followed DFO's hierarchy of preferred management options as described in its *Habitat Conservation and Protection Guidelines* (DFO 1998), namely: 1) relocate and redesign; 2) mitigate during project design and implementation; and 3) compensate as a last resort. Avoidance of potential effects through relocation and redesign and mitigation measures incorporated into the project design is discussed in the sections below. Compensation planning for unavoidable HADDs of fish habitat is the focus of the remainder of this document.

4.3.2.1 Relocate and Redesign

Analysis of alternative pipeline routes was the first and principle method used to avoid or reduce potential effects on fish habitat for the Project. These analyses have been assisted by:

- detailed fish habitat survey data collected between 2005 and 2009 to identify streams and waterbodies with high fish habitat values

- engineering assessments of each proposed crossing
- site-specific crossing assessments at difficult crossings or crossings with sensitive fish species and fish habitat by a multi-disciplinary team (i.e., Sensitive Watercourse Assessment Team or SWAT) consisting of a fisheries biologist, geotechnical engineer, pipeline engineer and a pipeline construction specialist.

This work has resulted in the relocation of 109 proposed pipeline stream crossings or 40% of the 271 difficult or sensitive stream crossings identified to date. These have included relocation of the proposed pipelines away from sensitive bull trout habitat in Morice River and sensitive chinook salmon spawning habitat in Stuart River in British Columbia, and away from geotechnically unstable ground near Smoky River in Alberta. These evaluations also provided input into site-specific design and mitigation techniques (e.g., sediment control measures, access constraints) at the other 162 difficult or sensitive stream crossings. Relocation of the pipeline route and refinement of the crossing techniques used at each crossing is likely to continue until the final Project design is complete.

4.3.2.2 Mitigate During Project Design

The type of watercourse crossing technique to be used at different stream crossings is an important part of the Project design and planning. This has been an iterative process involving project engineers and fisheries biologists with the objective of mitigating potential effects on fish and fish habitat.

As mentioned above, there are a number of possible crossing techniques available for construction of the Project. These include trenching techniques such as open cuts and various isolation methods (e.g., dam and pump) and trenchless techniques such as horizontal directional drilling, bore drilling and aerial crossings Trenching techniques involve the alteration of instream habitat and, therefore, would result in a temporary HADD of fish habitat, according to DFO’s definition of a HADD. Trenchless techniques avoid an instream HADD by placing the pipes below or above the stream channel without disturbing flows, fish or sediments or altering any habitat. For this reason, trenchless techniques are the preferred technique at sites with high fisheries values, sensitive fish species or habitat and/or engineering constraints that preclude the use of trenched techniques.

A watercourse crossing technique screening was developed to determine which pipeline crossing technique would be initially screened for use at different stream crossings along the proposed pipeline route. This process is described in detail in the May 2010 Application, Volume 6A, Section 11.3.2 and is shown graphically in Figure 4–2. In brief, the process assigned a recommended crossing technique for each watercourse based on:

- fish habitat sensitivity
- fish-bearing status
- ephemeral or permanent flow
- discharge volume
- stream width
- site-specific engineering constraints

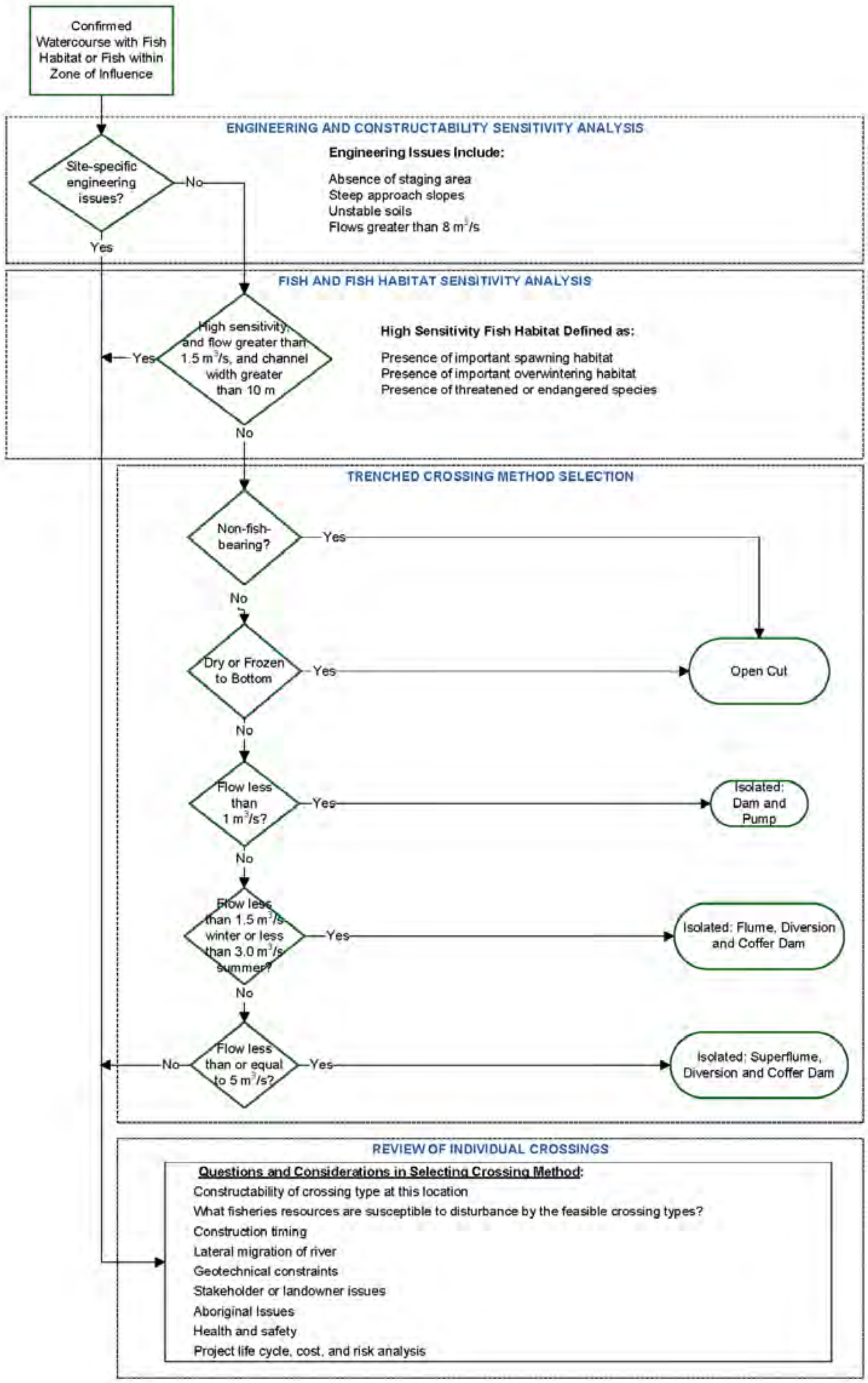


Figure 4-2 Decision Process for Pipeline Watercourse Crossing Technique

Using Figure 4–2 as a screening tool, open cut techniques are appropriate for sites that are non-fish-bearing, ephemeral or frozen to the bottom in winter. Isolation techniques are appropriate for fish-bearing streams with low to moderate fish and fish habitat sensitivity and discharges up to, but not exceeding, 5 m^3/sec. Site-specific crossing decisions were conducted for sites where:

- trenching techniques were not feasible from an engineering perspective (i.e., geotechnical, construction issues)
- trenching techniques were not feasible due to potential health and safety issues during construction
- fisheries values and the sensitivity of fish habitat were high, mean discharge was greater than 1.5 m^3/sec and channel width was greater than 10 m
- potential for lateral migration or down-grading of the stream channel was high
- stakeholder or landowner issues existed
- First Nations concerns were high

Trenchless techniques will be used for sites where any of these criteria preclude use of trenching techniques.

Results of this watercourse crossing technique decision process are shown in Figure 4–3. To date, open-cuts will be used at 97 of the fish-bearing watercourses along the proposed pipeline RoW. These include two crossings in Alberta and seven crossings in British Columbia that require further evaluation due to habitat sensitivities or engineering issues. By far, the most common watercourse crossing technique will be isolated trenching; these techniques will be used at 540 fish-bearing watercourses. These include 40 sites that will require site-specific evaluations due to habitat sensitivities or engineering issues. Finally, trenchless crossing techniques will be used at 32 watercourses: six in Alberta and 26 in British Columbia. These include proposed crossings of North Saskatchewan River in Alberta and Morice River in British Columbia. Although not shown in Figure 4–3, open cuts will be used at all NCD/NVC and non-fish-bearing watercourses along the proposed pipeline RoW.

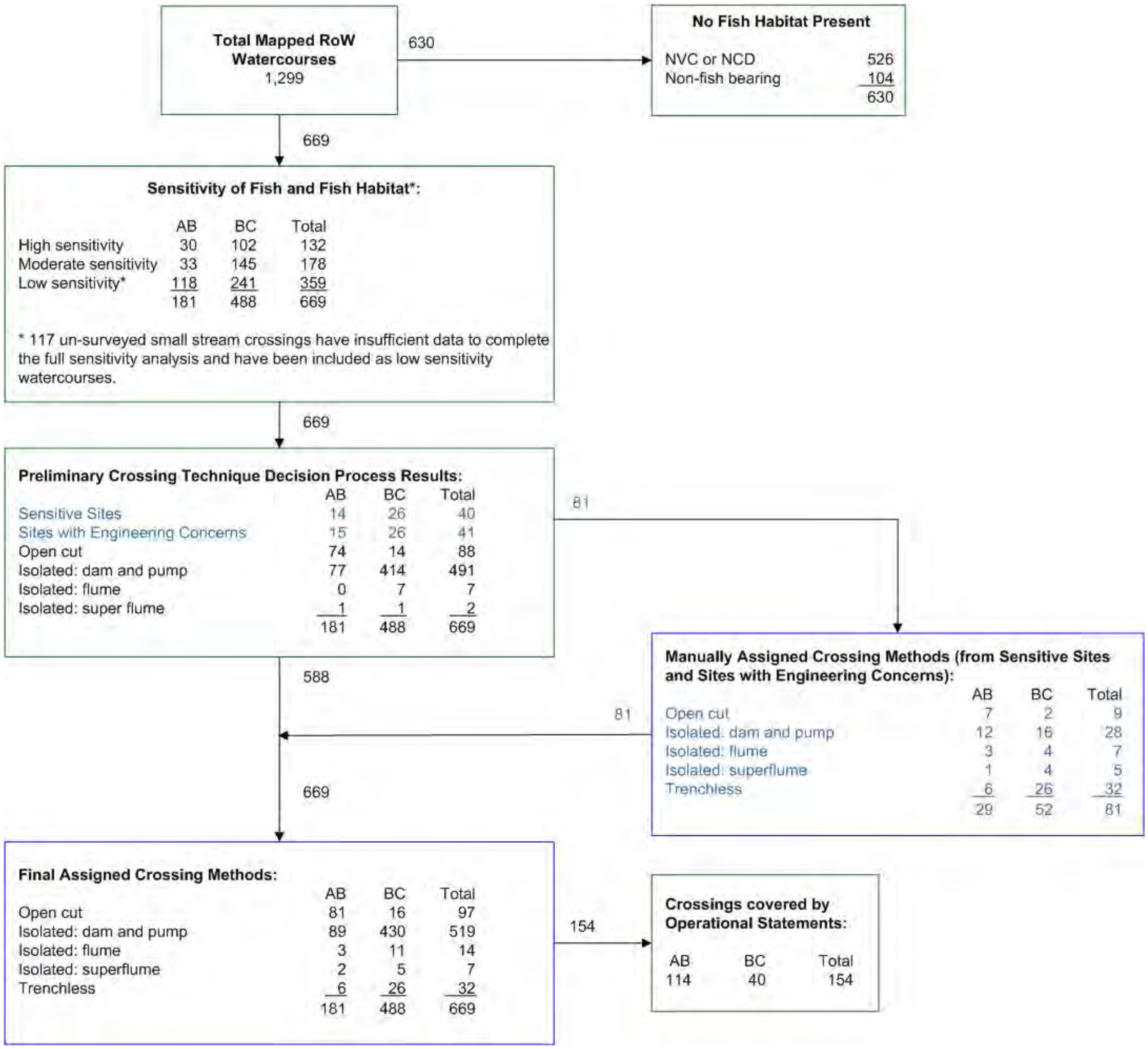


Figure 4-3 Watercourse Crossing Technique Decision Process

4.3.2.3 Mitigate During Project Implementation

Best Management Practices (BMPs) and Environmental Management Plans (EMPs) will be developed and implemented during construction, maintenance, and decommissioning of the Project to further mitigate potential effects on fish and fish habitat. Centreline surveys will be conducted in support of developing and refining the EMPs, including the preparation of separate sets of alignment sheets for RoW clearing and construction.

The over-arching objectives of these BMPs and EMPs will be to:

- limit the riparian disturbance area near fish-bearing waters
- limit the potential for bank erosion and downstream sedimentation into fish-bearing waters
- limit instream work activities to the least risk periods (LRPs) for the fish species present in the watersheds
- reduce the potential for the deposit of deleterious substances from entering fish-bearing watercourses during all phases of the Project
- promote the re-establishment of natural instream and riparian function and productivity as quickly as possible

To achieve these objectives, the following EMPs will be developed and implemented:

- Erosion and Sediment Control Plan
- Environmental Protection and Management Plan
- Hazardous Waste and Spill Prevention Plan
- Riparian Vegetation Management Plan

Details of each of these EMPs are provided in the May 2010 Application, Volume 7A, Construction Environmental Protection and Management Plan.

Mitigation measures in these EMPs will include BMPs included in industry, provincial and federal guidelines such as:

- British Columbia Standards and Best Management Practices for Instream Works (British Columbia Water, Land and Air Protection [BC WLAP] 2004)
- British Columbia's Riparian Management Area Guidebook (BC MoE and BC MoF 1995)
- British Columbia Land Development Guidelines (Chilibeck 1992)
- Alberta's Timber Harvesting Planning and Operating Ground Rules Framework for Renewal (Alberta Sustainable Resource Development [ASRD] 2005)
- Alberta's Pipeline Watercourse Crossing Guide
- Pipeline Associated Watercourse Crossings, 3rd edition (CAPP 2005)

- DFO Pacific Region and Central and Arctic Region Operational Statements including, but not limited to:
  - isolated or dry open-cut stream crossings
  - maintenance of riparian vegetation in existing RoWs
  - overhead line construction
  - punch and bore crossings
  - directional drilling
  - temporary stream crossings
  - clear-span bridges
  - bridge maintenance
  - culvert maintenance

Stream crossings for the access roads and powerlines needed for the Project have been assumed to meet the criteria of at least one of the above DFO Operational Statements. No HADD of fish habitat would occur at any of these stream crossings because the mitigation measures included in these Operation Statements would be followed. In addition to Project design, mitigation measures to be employed at stream crossings during construction and operations include sediment and erosion control plans, riparian restoration plans, and spills and emergency plans.

5 Risk Management Framework

5.1 Risk Management Framework Description

A risk-based approach (DFO 1986, 2007; CAPP et. al. 2005) was used to categorize all Project-related watercourse crossings into high, medium and low risk based on the sensitivity of fish and fish habitat and on the severity of potential negative effects caused by the proposed crossing method. The primary tool for this assessment is referred to as the Northern Gateway Fish Habitat Risk Management Framework (RMF) (see the May 2010 Application, Volume 6A, Section 11.5). The RMF includes the following four major components:

- an initial screening that confirms the presence of fish habitat, considers the proposed pipeline crossing technique, and determines if the project activity is covered under DFO Operational Statements
- an effects assessment that uses the DFO Pathways of Effects model to identify potential effects on fish mortality and fish habitat productivity, and opportunities to apply mitigation measures
- a risk assessment that considers the sensitivity of the fish species and fish habitat present, and the scale of negative effects associated with site-specific construction activities (after applying mitigation), plotted together on a risk assessment matrix
- a risk management decision for habitat compensation to offset reductions in habitat productive capacity where the overall risk to fish and fish habitat is moderate to high

The RMF is designed as an iterative process for relocating crossings, revising crossing techniques and modifying mitigation measures. For example, if a particular crossing is found to have a high risk level and alternate crossing techniques or additional mitigation could be applied, the RMF would be re-assessed to determine the new risk rating. This approach fulfills the relocate, redesign and mitigation requirements of the Policy for the Management of Fish Habitat (DFO 1986). The final assessment of the RMF identifies the overall level of risk to fish habitat productive capacity at each watercourse crossing and carries that risk forward to the compensation planning phase. Refer to the May 2010 Application, Vol. 6A, Figure 11-7, Risk Management Framework Flowchart for Freshwater Fish and Fish Habitat.

5.2 Results of Sensitivity Analysis

Fish and fish habitat sensitivity analyses were completed for the 669 pipeline watercourse crossings and the two tributaries affected by the Kitimat Terminal. Detailed results are available in the May 2010 Application, Volume 6A, Appendix 11C, Table 11C-1. In summary, out of the 669 pipeline crossings:

- 132 watercourses (20%) have a high sensitivity
- 178 watercourses (27%) have a moderate sensitivity
- 242 watercourses (36%) have a low sensitivity
- 117 small stream crossings had insufficient data to allow completion of the full sensitivity analysis but, for the purpose of the RMF analysis, are assumed to be low sensitivity due to their small size and low calculated flow.

Finally, the two tributaries affected by the Kitimat Terminal are both rated as moderate sensitivity watercourses.

5.3 Results of Scale of Negative Effects Analysis

The results of the scale of negative effects score for the pipeline watercourse crossings not covered by an Operational Statement are presented below:

- 16 crossings (3%) have a high score
- 147 crossings (29%) have a moderate score
- 263 crossings (51%) have a low score
- 89 crossings (17%) were un-surveyed and have insufficient data to determine their score

High scores for the scale of negative effects are largely due to the high risk to downstream habitats from sedimentation, construction windows for the crossing works that fall outside of defined LRPs, and/or the longer estimated time for habitat restoration success. All watercourse crossings with a high score for the scale of negative effects have zones of influence that extended more than 300 m downstream and, in many cases, more than 1,000 m downstream. These result in a larger habitat area that can be affected by sedimentation.

Of the 16 watercourse crossings with a high score for the scale of negative effects, 13 are proposed outside the LRP, or are in watercourses without a defined LRP; therefore, spawning fish and developing eggs could be affected. An additional two crossings have an open cut crossing technique, which results in a score of high for the scale of negative effects. The remaining high-risk crossing is a result of a large zone of influence and a medium- to long-term expected duration of effects. More details on the calculations of scale of negative effects for each crossing are available in the May 2010 Application (Volume 6A, Appendix 11C).

5.4 Output from Risk Management Framework

The risk assessment is based on the fish habitat sensitivity analysis determined at each crossing site and on the scale of negative effects score due to the site-specific conditions and the crossing technique proposed at each site. Table 5–1 provides a summary of the number of watercourse crossings in each risk category.

Table 5–1 Summary of the Number of Crossings in Each Risk Category

Risk Category	Total Crossings
High	29
Medium-High	14
Medium	26
Medium-Low	29
Low	330
Unsurveyed (low)	89
Total	**517**

Watercourse Crossings with a High Risk Rating

A total of 29 high-risk watercourse crossings exist along the proposed pipeline route, including 13 crossings in Alberta, 14 crossings in British Columbia, and the two tributaries affected by the Kitimat Terminal (Figure 5-1). All proposed pipeline watercourse crossings with a high risk rating have the potential to affect the productive capacity of fish habitat at the crossing and within the downstream zone of influence (ZOI). Habitat sensitivity ratings of watercourses in this group range from 11.5 to 14.8. The scale of negative effects scores for the proposed crossing methods range from 5.0 to 10.0. The high habitat sensitivities are primarily attributable to the presence of good to excellent quality spawning and overwintering habitat, or habitat characteristics that tend to have a lower resilience to disturbance. In most cases, this habitat is used by sensitive species (i.e., salmonids, sturgeon and burbot) and species of conservation concern. In Alberta, the five watercourse crossings with the highest risk are Little Smokey River and North Saskatchewan River. In British Columbia, the three watercourses with the highest risk ratings are Missinka River, Anderson Creek and the tributary to Gosnell Creek at KP 1,060.8. See the May 2010 Application, Volume 6A, Sections 11.1 to 11.6 for a discussion of risks to fish health and mortality risk.

The habitat sensitivity ratings for the two tributaries at the Kitimat Terminal are moderate because of habitat characteristics that tend to have a lower resilience to disturbance. However, the construction works will result in a habitat loss within the area of the Kitimat Terminal and in excess cut disposal areas. The scale of negative effects score for both watercourses is 11. No fish were observed in either watercourse; however, there is connectivity to known fish-bearing reaches of Renegade Creek. As a result, there is potential for fish to utilize these streams. Both watercourses provided flow and nutrients to downstream habitats in Renegade Creek and Bish Creek.

Watercourse Crossings with a Medium-High Risk Rating

Fourteen proposed pipeline watercourse crossings are considered medium-high risk, all of which are located in British Columbia. Most of these crossings have a moderate score for the scale of negative effects (between 5 and 8) (Figure 5-2). However, these watercourses are generally characterized by high or moderate habitat sensitivity (ranging from 10.4 to 13.8) due to the presence of salmonids, burbot or sturgeon, and one or more species of conservation concern.

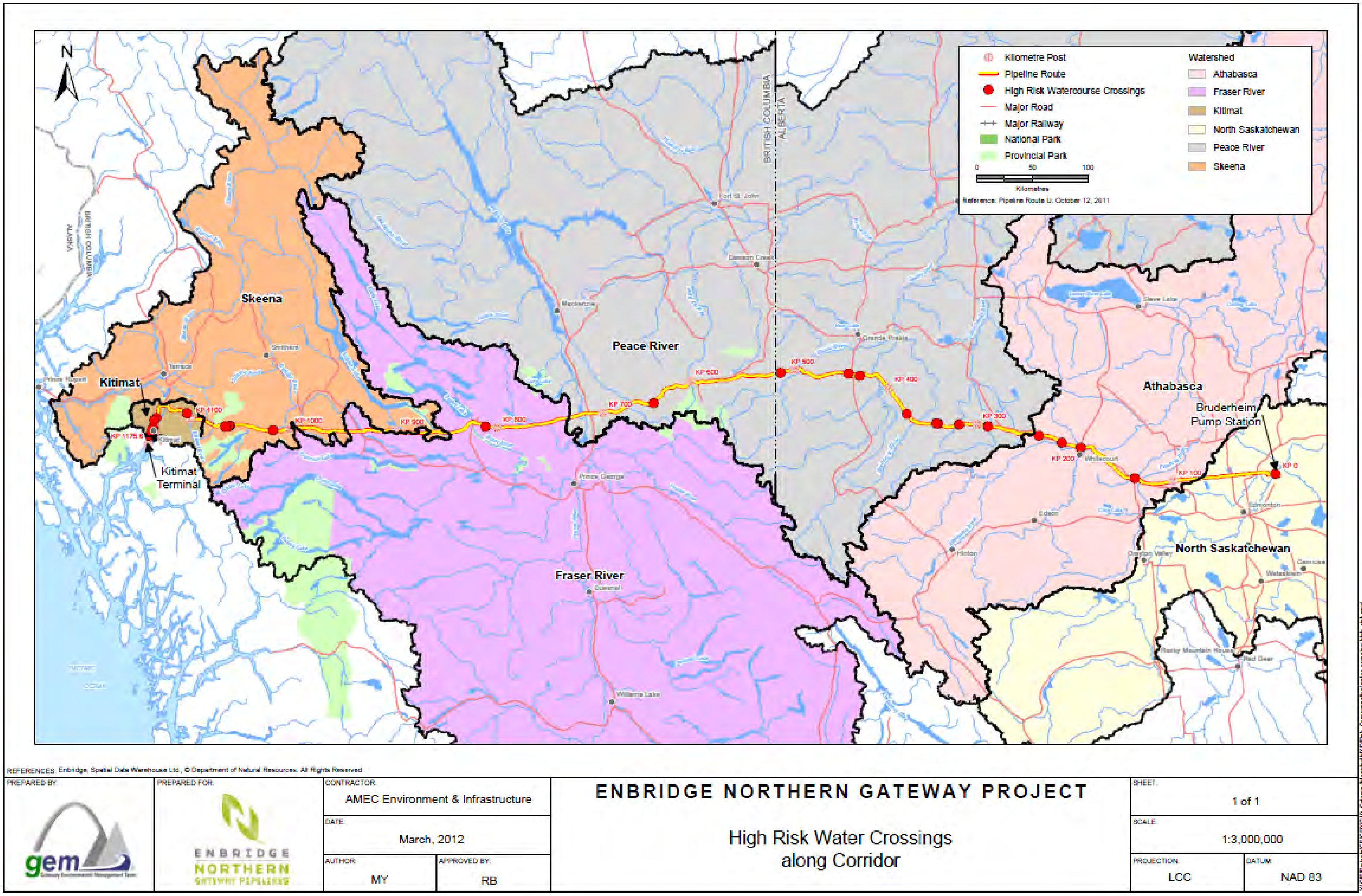


Figure 5-1 Map of High Risk Crossings along the Proposed Pipeline Corridor

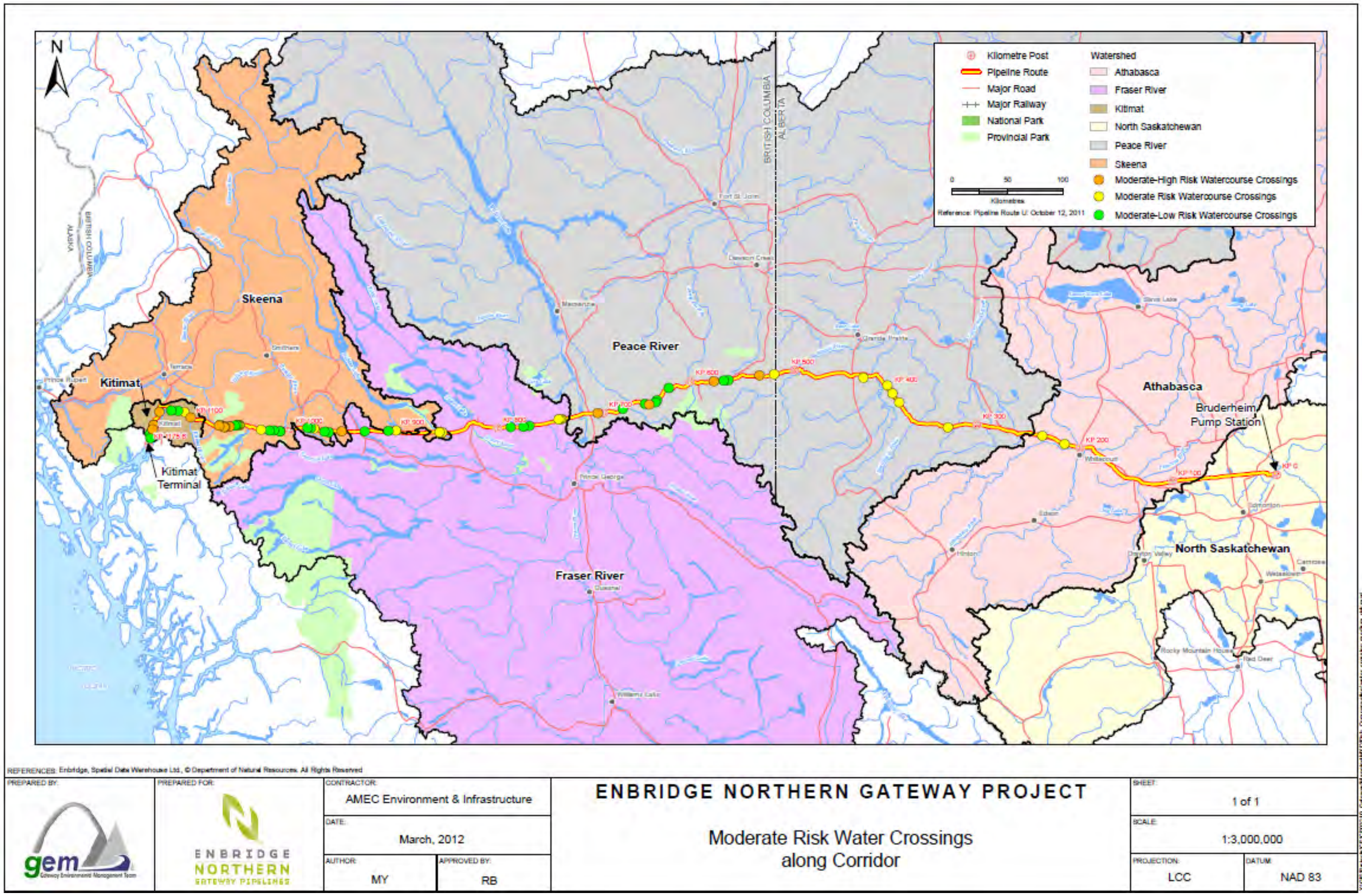


Figure 5-2 Map of Medium-Low, Medium, and Medium-High Risk Crossings Along the Proposed Pipeline Corridor

Watercourse Crossings with a Medium Risk Rating

A total of 26 watercourses crossed by the proposed RoW are assessed as having an overall medium RMF risk rating: 7 in Alberta and 19 in British Columbia. Habitat sensitivity and the scale of negative effects scores cover a wide range (9.6 to 14.7 and 3.0 to 7.0, respectively) (Figure 5-1). Watercourses with higher sensitivities are associated with crossings that have been assigned lower scores for the scale of negative effects and vice-versa. The overall RMF risk rating in these circumstances is medium.

All but three of the watercourses in this medium risk category have salmonids, burbot or sturgeon present. This contributes to their higher-than-average sensitivity rating. In addition, 18 crossings have threatened or endangered species present near the proposed pipeline route. For specific channel characteristics and details for sensitivity and scale of negative effects calculations for these crossings, see the May 2010 Application, Volume 6A, Appendix 11C.

Isolated crossing techniques are proposed for all of the watercourses within this RMF risk category. The higher score for the scale of negative effects for these crossings is primarily attributable to the absence of an LRP for construction or construction window outside the established LRP, moderate to large zones of influence, and longer duration of effects associated with the crossing construction methods and flow regime.

Watercourse Crossings with a Medium-Low Risk Level

Twenty nine watercourse crossings are rated as medium-low overall risk, all of which are located in British Columbia. Isolated crossing techniques are proposed for all of these crossings. Proposed crossing techniques combined with general mitigation procedures are unlikely to result in a loss of habitat productive capacity.

Watercourse Crossings with a Low Risk Level

The remaining 419 watercourses have been assessed as having a low overall risk rating. This includes 89 crossings that have not yet been surveyed and therefore have insufficient data to complete the full risk analysis. Due to the small size and low flows of these un-surveyed watercourses, it is uncertain whether they support fish; therefore, the risk to productive capacity is assumed to be low. These sites will be surveyed and the analysis will be updated when permitting occurs. Proposed crossing techniques combined with general mitigation procedures for low risk crossings are unlikely to result in loss of habitat productive capacity. No HADD is anticipated to occur at these sites.

Watercourse Risk Summary

The 98 watercourse crossings rated as high (29), medium-high (14), medium (26), and medium-low (29) are expected to result in temporary or permanent reductions for habitat productive capacity. These losses of habitat capacity will be offset by the implementation of a fish compensation plan that when fully functional will result in NNL of fish habitat productive capacity.

6 Methods to Estimate HADD and Quantify Compensation Requirements

The first step toward achieving NNL is to quantify the residual effects on productive capacity that cannot be feasibly avoided or mitigated; this will define the amount of compensation that is required. This section summarizes the method used to quantify the fish habitat compensation requirements for the Project. Details on this approach are presented in the May 2010 Application, Volume 6A, Section 11.

At low-risk sites, no HADD is anticipated because effects can be fully mitigated and are not expected to affect fish and fish habitat productivity. Crossings that are classified as medium to high risk, even after mitigation has been considered, are likely to be designated by DFO as a HADD. The risk rating determines the compensation ratio that will be applied to the HADD to calculate the amount of required compensation.

Compensation ratios reflect the level of risk assigned to each watercourse crossing where a HADD may result. Ratios reflect the certainty of success, variance in the quality of the fish habitat being replaced, and recognition of the lag time required for the new habitat to become functional. Thus, high-risk crossings require higher compensation ratios than medium and low-risk crossings. This strategy is consistent with the precautionary approach and will be applied to potentially affected habitats to quantify habitat losses from construction activities that are offset by habitat gained through compensation.

6.1 Quantification of Harmful Alteration, Disruption or Destruction

Potential HADDs in freshwaters include all permanently lost or altered habitat, all temporary losses or alterations of habitat occurring at medium and high-risk crossings, and any HADDs at lower-risk crossings identified by DFO after application of all other available mitigation. The precise extent of potential HADDs will remain unknown until the final watercourse crossing designs are complete during the detailed design phase of the Project. Final HADD values for watercourse crossings will be determined prior to submission of applicable permits.

The RMF analysis designated the watercourse crossings into the following four risk management categories:

- low risk – no HADD likely after mitigation
- medium risk – HADD likely and a streamlined authorization process can be used
- high risk – HADD likely and site-specific authorizations will be needed
- significant risk – HADD will occur and DFO policy to redesign or relocate is applied

A preliminary estimate was prepared for the compensation plan to scale the HADD for discussion purposes. This estimate assumes that all watercourse crossings will result in a HADD and represents a “worst case” value.

6.1.1 Methods

If DFO determines that a HADD will occur, habitat compensation will be implemented to offset any loss of habitat productivity. Since demonstrating losses to productive capacity is difficult (e.g., Minns 1995, 1997), common practice has been to use the disturbed area as the basis for determining the scope of any compensatory work needed to offset the loss and to achieve NNL. For watercourse crossings determined to be a HADD, the disturbed areas (instream and riparian) will be quantified as follows:

1. Amount of instream area affected will be calculated according to the formula:

   BFW x (TW*Elevation)

   Channel bank full width (BFW) will be multiplied by trench width (TW) disturbance and final elevation (Elevation) to define the HADD to instream habitat (Bonnington and Boag 2006). Trench disturbance width is estimated at 7 m for isolations and 10 m for open cut crossings (large watercourse crossings only). Elevation is assumed to be 3 m.

2. Amount of riparian area affected will be calculated according to the formula:

   RoW(m) x 30 m + EAWR

   The riparian disturbance area estimated for compensation consists of the construction RoW width (m) multiplied by 30 m (from high high-water mark up to 15 m on each bank, when loss of canopy closure results) plus estimated additional workspace required (EAWR), which may include areas for temporary vehicle crossings.

The RoW width for the Project is 25 m. The estimated riparian area affected by the RoW for each crossing is 750 m^2. This exercise is intended to scale the HADD. Actual measurements will vary with bank configuration and angle at which the pipeline RoW intersects the watercourse. The EAWR will also be identified during the detailed design phase. For the purposes of this exercise, each crossing will include an additional 150 m^2 of EAWR. The total value of the riparian HADD for each crossing is 900 m^2.

6.1.1.1 Assumptions

The following assumptions are used in calculating the HADD:

- Low-risk crossings result in a HADD.
- Road crossings result in a HADD. All road crossings required riparian clearing of a 50 m construction ROW. No instream works are required.
- Transmission line crossings result in a HADD. All transmission lines required riparian clearing of a 50 m construction ROW. No instream works are required.
- Trenchless crossings can not be completed and trenched methods are utilized instead.

6.1.2 Preliminary HADD Estimate

6.1.2.1 Permanently Lost or Altered Habitat

Construction of the Kitimat Terminal and disposal of waste rock next to the terminal will result in substantial modification or infilling of approximately 1,500 m of two fish-bearing tributaries to Renegade Creek (a tributary to Bish Creek). Both streams are small first-order watercourses less than 2 m in width. One originates in the southwest corner of the Kitimat Terminal footprint while the other is located within the excess cut disposal area north of the security fence at the Kitimat Terminal. This is the only direct loss of freshwater habitat identified as a result of proposed Project activities (Table 6–1).

Table 6-1 Estimated HADD for Permanently Altered Streams

Watercourse	Length (m)	Stream Width (m)	HADD Estimate (m^2)		
			Instream	Riparian	Total
Two Tributaries to Renegade Creek	1,500	2	3,500	45,000	48,500

6.1.2.2 Permanently Lost or Altered Habitat

A worst-case scenario is used to calculate the total estimated HADD (Table 6-2). This value is preliminary and includes potential disturbance areas.

Table 6-2 Summary of Estimated HADD for Temporary Losses or Alterations of Habitat

Crossing Method	RMF Result	No. of Watercourse Crossings	HADD (m^2)		
			Instream	Riparian	Total
Open Cut	High	2	8,110	3,000	11,110
Isolate: Flume	High	7	2,250	10,500	12,750
	Medium High	1	250	1,500	1,750
	Medium	3	350	4,500	4,850
Isolate: Super Flume	High	4	1,710	6,000	7,710
	Medium High	1	160	1,500	1,660
	Medium	1	350	1,500	1,850
Isolate: Dam and Pump	High	14	3,860	21,000	24,860
	Medium High	12	1,320	18,000	19,320
	Medium	22	2,910	33,000	35,910
	Medium Low	29	2,070	43,500	45,570
Low Risk Crossings[1]		402	17,570	604,500	622,070

Table 6-2 Summary of Estimated HADD for Temporary Losses or Alterations of Habitat (cont'd)

Crossing Method	RMF Result	No. of Watercourse Crossings	HADD (m^2)		
			Instream	Riparian	Total
Road Crossings		26		39,000	39,000
Transmission Line Crossings		172		258,000	258,000
Trenchless Contingency Methods		28	51,070	42,000	93,070
Totals		724	91,980	1,087,500	1,179,480

NOTE:
[1] 93 Low-risk sites did not have channel widths, thus instream HADD could not be determined.

6.1.3 Detailed Quantification of HADD and Compensation

To achieve NNL, it is essential to establish a transparent system for quantifying the losses (HADD) and gains (compensation) of fish habitat productive capacity. Although NNL is a common requirement, there is no single, officially recognized system for such quantification due to the unique nature of each project and the level of design detail that is available during permitting. In the case of this Project, the large number of watercourse crossing sites, the area involved, and the lack of detailed design drawings typical for pipeline construction make it difficult to accurately predict the total amount of HADD that will be caused by the Project. Similarly, the habitat enhancement techniques proposed as compensation have been shown to be effective in general, but will be implemented in response to site-specific conditions, with widely varying zones of influence.

This compensation plan proposes two methods for quantifying HADD and compensation. Method 1is simplistic but has been used with existing data to roughly estimate the total compensation requirement. It is based exclusively on habitat quantity–more precisely, on square metres of instream and riparian habitat calculated using simple area formulas–and does not address habitat quality. This method is useful for generating a "ballpark" estimate for compensation planning purposes.

Method 2 involves a more accurate accounting of losses and gains in fish habitat productivity. The method is based on a survey that evaluates the habitat quality of each reach and converts the score into a multiplier that is then applied to the habitat area. The units of measure resulting from this approach are simple square metres; therefore, the method is not comparable to the estimates resulting from Method 1. Both HADD and required compensation will not be known until immediately prior to construction when baseline habitat assessments will be performed. Similarly, the value of compensation techniques will not be easily estimated until they have been installed and the relative habitat value of the reach is assessed.

To track the net change of habitat productive capacity, a habitat balance sheet will be created and updated throughout the construction and monitoring phase. The habitat balance sheet will include the following elements:

- list of each affected reach and area of potential HADD of fish habitat
- time series of habitat quality scores (starting with baseline conditions pre-Project) for each construction and compensation reach with which to calculate net change
- time-weighted approach for comparing compensation benefits over time

6.2 Quantifying Compensation Requirements

The amount of compensation required has not been calculated at this time. Northern Gateway, together with DFO, will determine compensation ratios that will be applied to the Project. A conceptual flowchart showing the decision process for the compensation ratio of each site is shown in Figure 6-1.

6.2.1 Compensation Ratios

Compensation ratios reflect a precautionary approach to compensation planning that accounts for the varying level of risk assigned to each watercourse crossing where a HADD may result. Applying a higher compensation ratio, and thus requiring more compensation, for higher-risk sites addresses:

- the greater uncertainty of success
- the greater variance in the quality of the fish habitat being replaced
- the longer lag time required for the new habitat to become functional (DFO 2006)

A precautionary approach is also used to address cumulative effects and the ecological consequences of multiple watercourse crossings on fish communities. Because cumulative effects are poorly understood (Tchir et al. 2004) and do not warrant a more quantitative approach, the required compensation ratio for a watercourse or local watershed containing five or more watercourse crossings on that watercourse or in that local watershed is simply elevated to the next higher level.

6.2.1.1 Compensation Level 1

Compensation Level 1 is proposed for sites that have medium-low and medium risk to fish habitat productive capacity. The compensation ratio for Level 1 watercourse crossings is 1.5:1. If more than five medium-risk watercourse crossing sites occur on a particular watercourse or local watershed, then the compensation ratio may be increased to 2:1, and these sites will then be under Compensation Level 2. Compensation options follow the DFO hierarchy.

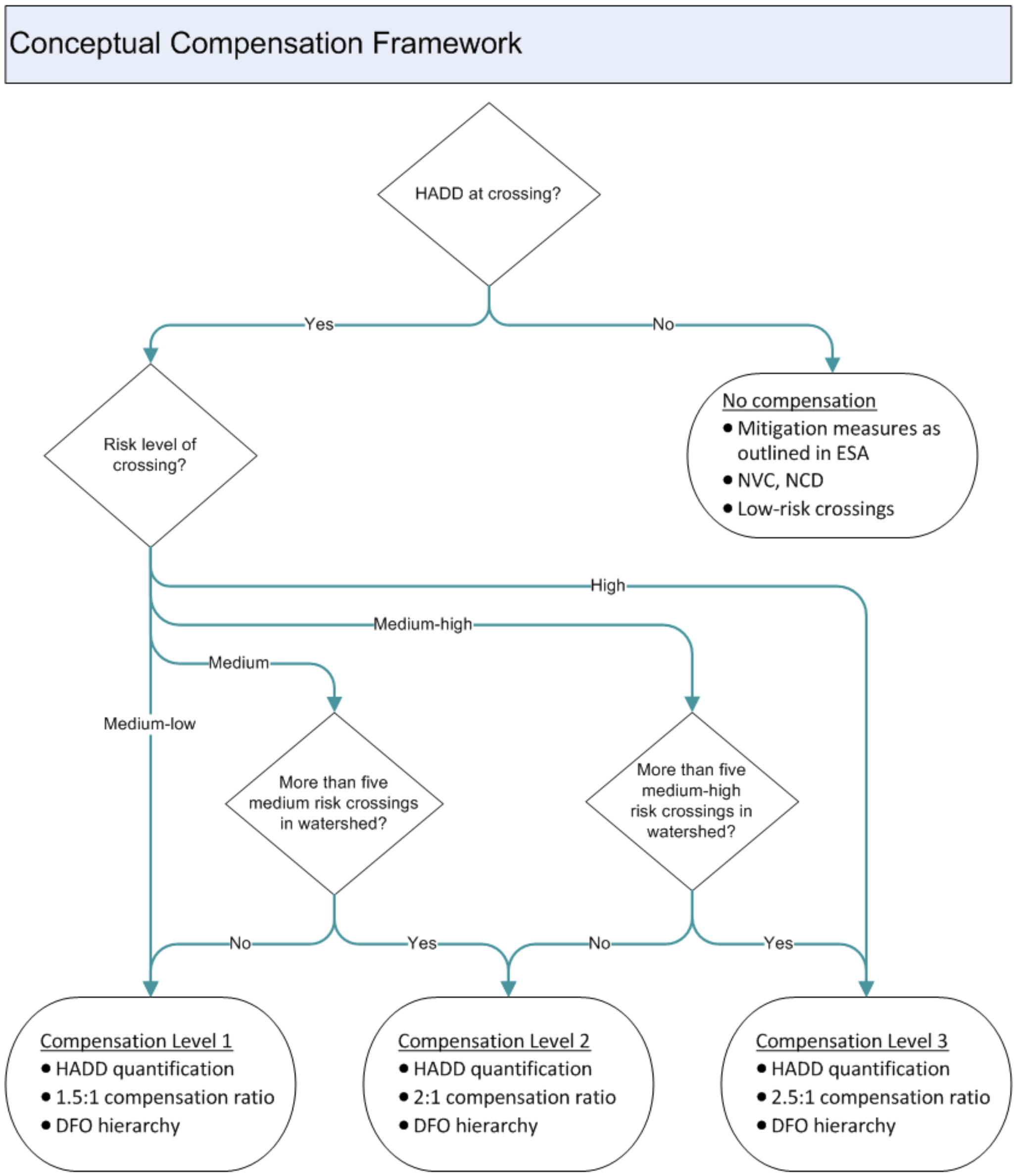


Figure 6-1 Conceptual Compensation Framework Flowchart

6.2.1.2 Compensation Level 2

Compensation Level 2 is proposed for sites that have medium-high risk to fish habitat productive capacity and for sites where more than five Level 1 watercourse crossings occur within the same watercourse or local watershed. The compensation ratio for Level 2 watercourse crossings is 2:1. If more than five medium-high risk watercourse crossing sites occur on a particular watercourse or local watershed, then the compensation ratio may be increased to 2.5:1, and these sites will then be under Compensation Level 3. Compensation options follow the DFO hierarchy.

6.2.1.3 Compensation Level 3

Compensation Level 3 is proposed for sites that have a high risk to fish habitat productive capacity, and for sites where more than five Level 2 watercourse crossings occur within the same watercourse or local watershed. The compensation ratio for Level 3 watercourse crossings is 2.5:1. Compensation options follow the DFO hierarchy.

6.2.2 Low-Risk Sites

Crossings at sites designated as low risk are not expected to result in a HADD of fish habitat because the crossing is not expected to have water and/or fish present during the construction season. Region-specific Operational Statements (OSs) will be applied during construction at low-risk sites to avoid HADD. Low-risk sites are not considered further in the compensation plan; however, if engineering problems occur or field conditions change at low-risk sites, additional mitigation or further risk analysis may be applied to re-evaluate the risk level.

6.2.3 Medium-Risk Sites

Medium-risk sites, which include medium-low, medium, and medium-high risk categories, are likely to result in a HADD that would require compensation. Losses may include direct losses of instream habitat and indirect losses as a result of alterations in the adjacent riparian vegetation. Medium-low and medium risk sites would be grouped in Compensation Level 1, which applies a compensation ratio of 1.5:1. Medium-high risk sites fall under Compensation Level 2 and receive a compensation ratio of 2:1. Compensation for HADD of fish habitat at most medium-risk sites will be achieved on-site using the toolbox approach, a screening process for applying common habitat restoration and enhancement techniques.

6.2.4 High-Risk Sites

High-risk sites will require detailed site-specific designs and HADD authorization from DFO. High-risk sites fall under Compensation Level 3 and receive a compensation ratio of 2.5:1. While the toolbox approach may be useful for an initial approach to choosing compensation options at high-risk crossings, the streamlined approach is not appropriate for final compensation design.

6.3 Identifying Compensation Opportunities

Compensation requirements will be met through a combination of off-site and on-site options. Section 7 describes the methods for identifying off-site compensation opportunities. Section 8 describes the methods for identifying and prioritizing on-site compensation opportunities.

6.3.1 Off-Site Compensation Opportunities

High value, priority habitat projects outside of the RoW were identified through consultation with DFO, provincial agencies, First Nations and stakeholder groups. A subset of these projects was identified as potential pilot projects that could be implemented prior to construction and would create an opportunity to bank compensation credit. Off-site compensation efforts focused on listed fish species, species of commercial, recreational, or First Nations importance, and species and populations most likely to be affected by this Project.

6.3.2 On-Site Compensation Opportunities

Opportunities for on-site compensation were identified at several crossings during field surveys. Figure 6–2 is a map showing the locations of these opportunities along the proposed pipeline corridor. In addition, a toolbox approach was developed to identify and screen habitat enhancement opportunities at each site in parallel with pipeline construction. The toolbox approach refers to a screening process and a collection of commonly applied habitat enhancement techniques that can be used in a variety of stream settings. This approach is intended to streamline the authorization process for medium-risk crossing sites. It considers the geomorphic context, biological relevancy, management objectives and technical feasibility constraints at each site to determine which techniques provide an optimal Authorization of Harmful Alteration, Disruption or Destruction improvement in fish habitat productivity.

The final determination of the number of HADDs, which crossings constitute a HADD and the compensation requirements will be determined by DFO. However, the Risk Management Framework (DFO 2007) provides guidance on which risk levels require a *Fisheries Act* authorization. As discussed previously, only medium and high-risk crossings are considered to result in a HADD requiring compensation.

The RMF (DFO 2007) also provides guidance on how *Fisheries Act* authorizations are issued by DFO for medium and high-risk sites. For example, authorization of HADDs for medium-risk crossings involves a streamlined process (see Figure 6–1). This streamlined process is assumed to entail blanket authorization of HADDs at medium-risk sites, where watercourse enhancement procedures commonly used in western Canada and the United States can be readily applied. These types of enhancements include, for example, installing large woody debris (LWD) structures and boulder clusters. They can be designed and built using relatively standard procedures, such as those outlined in the following documents:

- *Alberta Fish Habitat Enhancement Designs* (Alberta Environmental Protection 1996), for Alberta
- *Fish Habitat Rehabilitation Procedures* (Slaney and Zaldokas 1997), for British Columbia.

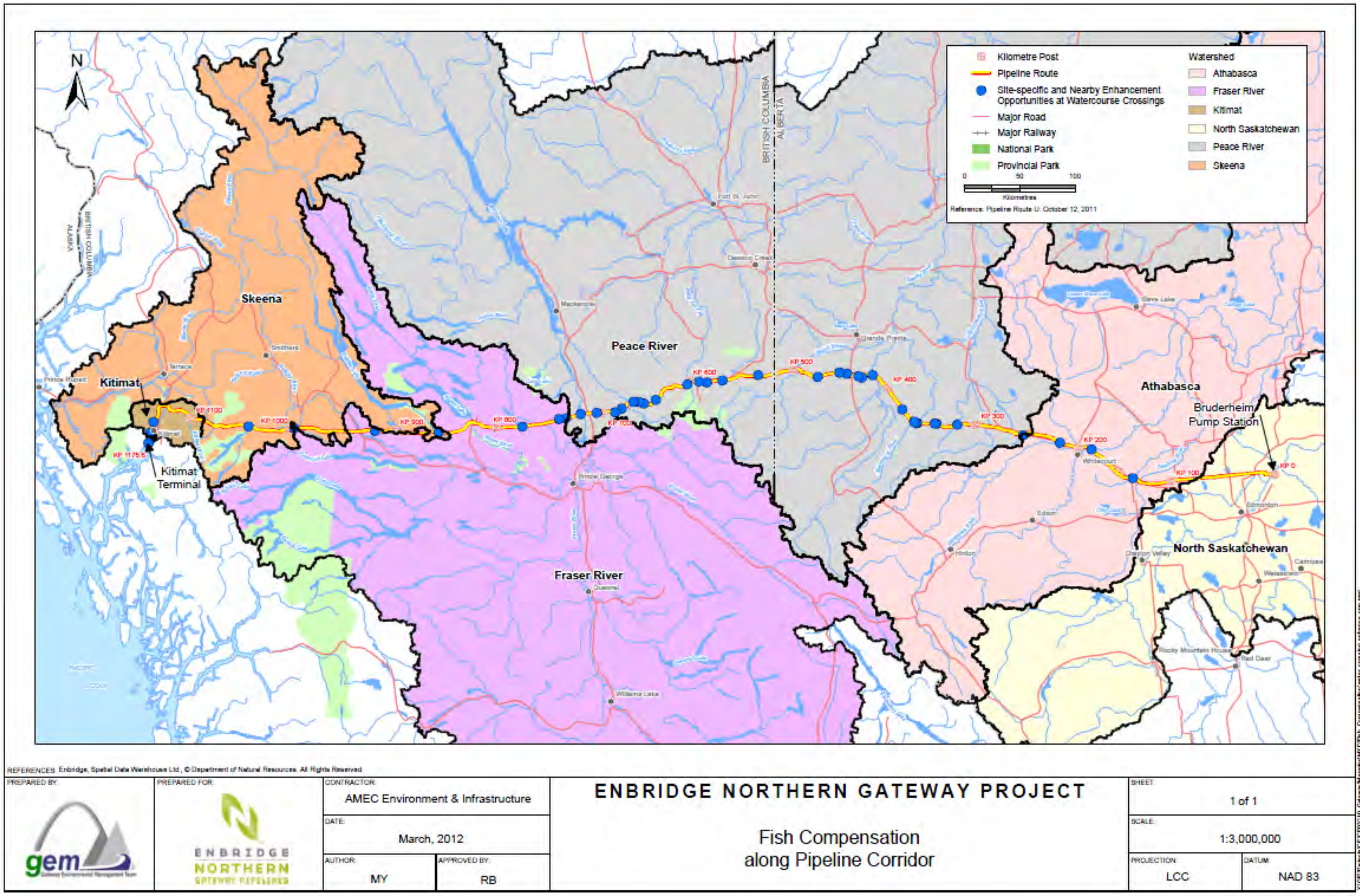


Figure 6-2 Map Showing Locations of Fish Compensation Opportunities Identified Along the Proposed Pipeline Corridor

HADDs for high-risk crossings are likely to involve site-specific authorizations. These authorizations will specifically quantify the amount and quality of habitat lost or altered, and will prescribe specific types of on-site or off-site habitat compensation at specified quantities. The detailed designs for compensation works that are required to offset habitat losses at these high-risk sites will be incorporated into the authorizations.

6.4 Implementing Project Habitat Compensation Plans

This conceptual compensation plan is contingent on the final level of risk applied to each watercourse crossing. The final level of risk depends on:

- the final centreline location of watercourse crossings
- the watercourse crossing methods used
- when crossings are completed (i.e., inside or outside the least risk periods)

Determination of HADD sites will be further quantified during detailed engineering. Any HADDs identified may be suited to off-site compensation before pipeline construction and HADD occurrence. A complete determination of compensation requirements will be possible only after post-construction surveys have been completed. Post-construction HADD determination will quantify habitat losses, apply any compensation measures before construction to offset these losses, and calculate the final total compensation required.

Compensation works may be completed by Northern Gateway during pipeline construction, or through agreements with participating Aboriginal groups, communities and other third parties before, during or after pipeline construction. Any compensation conducted before construction will be considered part of habitat banking. Compensation completed during construction is most likely to include on-site habitat enhancement or creation or fish passage improvements. Off-site options are more likely to be conducted by participating Aboriginal groups, communities, provincial or federal regulatory bodies (e.g., BC Ministry of Environment) or other third parties.

All on-site and off-site compensation activities (i.e., post-construction) conducted by Northern Gateway are expected to be completed soon after Project cleanup. On-site or off-site habitat compensation activities by others may extend beyond this period, depending on the project type and funding arrangements.

6.5 Post-Construction Monitoring

Post-construction monitoring will evaluate the compliance to design drawings and datasheets and compare the post-construction habitat value of the Project area to the baseline conditions. More detailed monitoring plans will be developed at the *Fisheries Act* authorization stage. These plans will identify the objectives of each compensation works activity and the parameters that will be measured to determine success (e.g., water quality objectives, hydraulic habitat objectives, fish species and life stage use). These plans will include study designs (e.g., before, after, control, impact (BACI)-designed experiments) for determining success. These studies may also provide information that can be used to adapt existing compensation works or to design additional compensation works. Post-construction monitoring will extend for five years after compensation is completed.

6.6 No Net Loss Threshold

Forecasted HADD has been quantified for each site, and the amount of compensation that is proposed should result in the confirmation of NNL of fish habitat within the proposed monitoring timeline. After construction, the amount of disturbance and the area of habitat improvements will be measured. However, to adequately document that NNL of fish habitat has been achieved, a habitat assessment method is proposed that compares the value of the habitat before and after construction. The habitat values will be multiplied by the area affected to result in a net habitat loss or gain over time at each site, whether it is on or off site.

7 Methods to Identify and Prioritize Off-Site Compensation Options

The proposed pipelines will pass through rural and wilderness areas with minimal development and relatively undisturbed fish habitats. As a result, opportunities for large-scale, on-site or "like for like" compensation are limited and off-site opportunities must be considered. Off-site compensation options can be completed at any time before or during construction. They can be utilized to mitigate temporal reductions in productive capacity and develop partnerships with local community groups and First Nations in the identification, design and implementation of the works.

7.1.1 Off-Site Opportunities

In developing potential pilot projects, the specific concerns of Aboriginal organizations, stakeholders, fish species in the Project area and geographic characteristics of the regions have been considered. Potential projects include the removal of barriers to increase upstream access to habitat, creation of habitat for fish species of concern and habitat restoration. Each opportunity will need to be further developed with input from civil engineers and environmental professionals to consider the feasibility, benefits and costs for the potential project. The following are specific opportunities that have been identified as potential pilot projects:

- Toboggan Creek Culvert Replacement
- Station Creek Culvert Replacement
- creation of off-channel habitat for spawning sockeye on the Morrison River between Morrison Lake and Babine Lake
- Johnny David Creek Culvert Replacement
- Garner Creek Culvert Replacement
- Kakwa Watershed Culvert Replacements
- North Saskatchewan River sturgeon spawning

Other opportunities near the pipeline route will likely be developed through consultation with regulatory and stakeholder groups. Pilot projects will require consultation between Northern Gateway, regulators, Aboriginal organizations, community groups and stakeholders as a prelude to detailed planning, design and construction of the off-site compensation projects. Considerations for off-site compensation would include:

- construction timing of the habitat banks such that the temporal loss of productive capacity within the Project watershed is offset to the extent feasible.
- construction timing such that the environmental effect on migrating fish is reduced
- implementation of BMPs for construction and temporary habitat disturbance to mitigate environmental effects from construction

- minimal disturbance of mature vegetation and prompt re-vegetation with local native species
- monitor the site and engage in adaptive management

After construction, a plan is needed whereby deficiencies in implementation or function could be quickly recognized and addressed while compensation projects could continue to move forward toward achieving the overall NNL goal. These project-specific strategies will incorporate contingency planning, management objectives, ongoing monitoring and the Northern Gateway's commitment to achieving benchmark goals at specified timelines.

A compliance monitoring program will be used to verify that the compensation measures have been properly constructed. Baseline and follow-up monitoring will be used to verify the benefits accrued from the compensation works. Compliance monitoring for each of the pilot projects will be integrated into the supervision of the construction work and will be in compliance with the conditions of the required *Fisheries Act* authorizations. To ensure the compensation works are constructed to design specifications, baseline conditions will initially be documented, then monitoring will be scheduled at regular intervals throughout construction of the various Project components, and again afterward to document the Project's function, until the point in time when it is clear that the compensation measure will not require maintenance, or until NNL is reached for the major basin in which the site is located. The construction monitoring schedule will generally follow recommendations described in the *British Columbia Standards and Best Practices for Instream Works* (BC MWLAP 2004).

8 Identify and Prioritize On-Site Opportunities

This section describes the process that Northern Gateway and its contractors will use to identify smaller-scale, local compensation options at each watercourse pipeline crossing. Each crossing is referred to as an on-site compensation opportunity. This Plan emphasizes the *process* that will be used to identify and design optimum on-site compensation, rather than the *results* of the process, because it is intended to be an adaptive approach and implemented in conjunction with on-site conditions during pipeline construction.

Compensation for an HADD of fish habitat will be achieved on-site at the crossing or as near as possible to the affected watercourse. This approach is consistent with the DFO hierarchy (DFO 1986) that prefers like-for-like compensation. On-site opportunities will be identified and prioritized on a case-by-case basis, using an established screening process and approved set of habitat enhancement techniques, as described below.

The screening process offers a streamlined approach to HADD authorization that can be applied to most of the small- to medium-sized watercourses. It is intended primarily for watercourse crossings ranked as low-medium, medium, or medium-high risk. The screening process may still be useful for other crossings; however, the high-risk crossings will likely require site-specific designs and separate permit approvals, and the low-risk crossings are not expected to create a HADD.

This streamlined screening process and the design typical for each rehabilitation technique are referred to as the toolbox approach. While no two watercourses are the same, the toolbox approach is intended to address common construction impacts and pre-existing habitat degradation in surrounding watersheds using a common suite of restoration and enhancement techniques

8.1 Initial In-Field Observations for Watercourse Enhancements

Potential watercourse enhancement options were identified during field assessments. These serve as a valuable starting point for planning on-site compensation measures because they reflect first-hand observations of the sites. The May 2010 Application, Volume 6A, Section 11, Appendix 11B, Table 11B-7 contains examples of the potential habitat enhancement opportunities identified during baseline surveys at or near watercourse crossings. Opportunities identified include:

- instream placements of LWD and boulder clusters
- cover enhancements, e.g., creating deep pools
- fish passage enhancements, e.g., repairing culverts
- erosion protection, e.g., using LWD for undercut banks

The size of the enhancement area at each site including those already identified will require further assessment and will depend on the type of enhancement applied. Additional opportunities will be added to the list as they are identified. Preferred options will be selected through discussions with DFO, and will be reviewed with affected Aboriginal organizations and stakeholders.

8.2 Habitat Restoration and Enhancement Methods

The stream habitat restoration and enhancement techniques that are included in the proposed toolbox can be categorized into the following four groups:

- bank stability and habitat
- instream habitat
- off-channel habitat
- culvert replacement

Qualified personnel will be needed to finalize the design and appropriately install these features at the site.

Bank Stability and Habitat

Where the banks and riparian areas have been disturbed by construction activities, appropriate BMPs will be employed to reduce the risk of soil erosion into the adjacent water body. Beyond that, basic function, bank stability and habitat restoration consists of actions that can be taken to create banks that are able to withstand reasonable threats of erosion from flows in the watercourse with the addition of fish habitat features, primarily using vegetative and bio-engineering methods. Generally, these practices will be most appropriate when the proposed pipelines have been installed in an open cut method, where the replaced bank is relatively steep and contains fairly erodible soils. Open cut crossings require the removal of vegetation and roots, and proper restoration of the site includes restoring the topography to a stable configuration for the benefit of fish and the longevity of the pipelines. The soils to be backfilled must be free of roots and other organic matter. The banks will therefore lack the root structure that may have existed before the clearing, grubbing and excavation occurred.

These measures are meant to restore the bank stability that would have previously been provided from the riparian vegetation and its root structure, and do so with approaches that emphasize the use of vegetative materials. Bank vegetation will provide shade, habitat for terrestrial insects that become food for the fish, inputs to support the aquatic food web, and woody mass which may eventually be recruited into the watercourse. The vegetative materials to be used will generally be sourced locally, from within the RoW to the extent possible, or from other sources as needed. Soil backfill will be obtained from within the RoW, but other materials needed, such as coir logs and geotextile would have to be imported.

A list of the restoration techniques that fit into this category include:

- coir logs and grass rolls
- shrub restoration and live stakes
- brush layering
- coniferous tree revetment
- vegetated crib walls

Instream Habitat

In watercourses, fish habitat improvements can be accomplished using rock and/or wood. Rock will be most appropriate where CWD is generally unavailable and is not naturally be present. Immobile rocks can be placed in the stream bed to create local variations in water velocity and scour pools.

It has been determined that in Alberta, there are areas where riffle spawning habitat is lacking for fish like walleye and northern pike. Riffles can be created to provide habitat that may not be abundantly present or have been degraded because of siltation or other effects. Wood structures provide habitat conditions for fish and structure for a watercourse that are not possible with rock. Generally, wood structures have been shown to have a higher level of use as rearing habitat than rock structures. It therefore should be considered a valuable tool in restoring habitat, and pursued where it is appropriate. Wood structures can be very small and simple, such as a single log with root wad, to very large and complex, such as installing an engineered log jam. Given the relative benefit, risk and cost of installing large, complex structures as compensation measures, these structures will may not be considered, in part because of the high level of design and installation expertise. The lowest level of risk is anticipated by selecting several basic types of CWD and rock structures that can be installed properly and efficiently, as a result of the need to construct these structures in many locations within relatively short work windows. The risks of installing wood structures should be considered in the vicinity of downstream bridges or culverts or stream-side land uses, which could be affected if the wood becomes mobilized. The use of rocks may also be a better choice in watercourses that have a high potential to scour wood from the stream bed and banks, and move it downstream. Rocks can also be used as ballast on wood pieces to increase their stability.

A list of appropriate restoration techniques include:

Rock-based structures

- boulder clusters
- resting pools
- excavated fish runs
- full riffle structures
- walleye spawning riffles
- v weirs
- opposing rock wing deflectors
- spurs and groynes

Wood-based structures

- root wad structures
- log/root balls
- submerged shelters
- engineered log jams

- log sills
- log v weirs
- log k dams
- single log wing deflectors
- large wood and rock spurs
- log channel constructions
- deflectors with cover logs

The above practices can be used to improve conditions for fish to compensate for instream HADD effects.

Off-channel habitat

Off-channel habitat includes establishing riparian zone vegetation, adding habitat features to the floodplain, and creating off-channel habitat features. The riparian zone improvements generally entail establishing shrubs and/or trees as seedlings or cuttings. Generally, when native woody vegetation is removed during construction, the same species should be replanted. In cases where woody vegetation is not present or lacks diversity in age class or species because of anthropogenic causes, native woody plant species that are appropriate for the site should be planted. The intent is to plant a mix of plant species that are native and adapted to local conditions so that they require a minimum amount of effort to become established and will become an integral part of a healthy and functional riparian corridor.

Floodplain features can be added in situations where there is a lack of diversity in the riparian topography and/or where there is a lack of CWD on the surface of the floodplain. Downed wood can be added where there is a lack of mature standing trees that could be recruited by the nearby watercourse. The wood should be brought from nearby upland areas of the RoW where it exists. The wood will provide substantial benefits to terrestrial wildlife most of the time. During floods, the floodplain habitat can help to slow down overland flows, provide refuge for fish and help increase sedimentation of fine-particles from floodwaters.

Off-channel habitat features can be improved by re-connecting remnant side channels, old oxbows, or other topographic features, which can serve as refuge, rearing or spawning areas, but do not carry the main flow of the watercourse. Some of these features may have previously existed, but may be naturally cut off from the main channel or they their function may be less than ideal from sedimentation.

A list of the restoration techniques that fit into this category include:

- woody plantings
- herbaceous plantings
- CWD placement
- connections to remnant side channel
- development of gravel side channel
- creation of northern pike spawning habitat

Culvert replacement

Improvements to fish productivity could also include addressing fish passage problems and correcting problems caused by livestock access to the watercourses. In certain areas, the greatest potential increase in fish productivity may be gained from the removal of man-made fish passage barriers. Various potential projects have been identified, and efforts to locate other potential projects will continue. Off-site fish passage projects should be implemented in advance of pipeline construction, with the possible exception of those blockages that alone prevent fish access to a proposed pipeline crossing. Otherwise, implementing fish passage improvements prior to construction will likely give fish more places within the local basin to go to get away from construction activities.

Each replacement structure, whether it is a culvert or bridge, must be designed by a qualified professional. The structure not only needs to adequately provide for water, sediment, debris, and fish movement, but also needs to accommodate the intended traffic and any utilities that may exist in the road fill. The design will vary depending on the slope, hydrology and hydraulics of the stream, as well as the anticipated sediment and debris loading in the system. In portions of the pipeline route, ice may also be an important consideration.

Some opportunities have been identified to improve fish passage at beaver dams or culverts that have been affected by beaver dams. The size of the culvert being dammed should be evaluated. It is not uncommon to find out that a culvert with recurring beaver dam problems is undersized. Adding “beaver deceiver” fencing is generally effective when installed in appropriate situations. These projects should be considered where a substantial amount of habitat can be gained and where the existing culvert is not otherwise a fish passage problem.

A list of the restoration techniques that fit into this category include:

- culvert/bridge replacement
- installation of beaver management structures at culverts

Figure 8–1 presents the available habitat restoration techniques within each category and family of practices.

List of Stream Habitat Technique Data Sheets

BANK STABILITY / HABITAT			ID	Type
Vegetated Bank			A1	Coir Logs and Grass Rolls
			A2	Shrub Restoration and Live Stakes
			A3	Brush Layering
Native Material Revetment			B1	Coniferous Tree Revetment
			B2	Vegetated Crib Wall

INSTREAM HABITAT			ID	Type
Rock		Boulder Placement	C1	Boulder Clusters
			C2	Resting Pool
			C3	Excavated Fish Run
		Riffle Structure	D1	Riffle Structure
		Rock Drop Structure	E1	Rock V Weir
		Rock Current Deflector	F1	Rock Wing Deflector
			F2	Rock Spurs and Groynes
Wood	Single	Bank Log Structure	G1	Root Wad
			G2	Bank Cover Log
		Submerged Shelter	H1	Weighted Log and Root Balls
			H2	Fallen Tree Shelter
	Multiple	Engineered Log Jam	I1	Engineered Log Jam
		Wood Drop Structure	J1	Log Sill
			J2	Log V Weir
			J3	Log K Dam
		Log Current Deflector	K1	Log Wing Deflector
			K2	Log Vane
			K3	Log Channel Constrictor

OFF-CHANNEL HABITAT	ID	Type
Riparian Zone Plantings	L1	Woody Plantings
	L2	Herbaceous Plantings
Floodplain Habitat	M1	Floodplain Wood Debris Placement
Side Channel Construction	N1	Natural Side Channel Restoration
	N2	Temporary Gravel Side Channel

SPECIALTY ACTIONS	ID	Type
Culvert Replacement	O1	Culvert Replacement

Figure 8-1 Available Habitat Restoration Techniques Within Each Category and Family of Practices

8.3 Assessment for Stream Compensation

The stream compensation assessment encompasses four primary components:

- existing stream conditions
- fish presence within streams
- management objectives based on regulations and guidelines
- technical feasibility of specific compensation measures based on stream conditions

Each of these components is assessed to determine preferred habitat types on a site-specific basis (Figure 8-2). Stream physical criteria and preferred habitat types are inputted into a decision matrix to identify appropriate compensation techniques that are the most effective in habitat enhancement and restoration (Toolbox Approach – Section 8.4).

8.3.1 Existing Stream Habitat Conditions

Preliminary physical data for each crossing site was collected between 2005 and 2009, including parameters such as: channel width, gradient, residual pool depth, bankfull depth and average flow. In addition, the watercourses were assigned stream types according to the relevant provincial system. Stream classifications, such as those developed by Rosgen (1994) or Montgomery and Buffington (1997), are useful for summarizing these geomorphic characteristics and can help guide the selection of compensation options by ruling out options that are not relevant or feasible for a given stream type. This data can then be used to identify optimum engineering and fish habitat attributes for pipeline crossing compensation. For example, channel morphology is dictated by the topography, flow of water, supply and movement of sediment and organic debris, and the level of prior anthropogenic alterations (*reference*). Most rehabilitation techniques are applicable for gravel-bedded pool-riffle streams, but for watercourses with steeper or shallower slopes, many of the techniques become less effective or create instability in the stream.

8.3.2 Existing Fisheries Use

While the fish species that use a given reach as habitat will correlate with the geomorphic characteristics of a site (subject to a lack of migration barriers), it remains important to confirm which species and life stages are present at the location where compensation is proposed. The need for specific habitat types and hydraulic features will help decide which compensation options are biologically relevant. Northern Gateway has conducted fisheries field surveys and reviewed relevant literature to determine which species occur at each of the crossing sites. Figure 8-3 describes preferred habitat attributes (low to high value) for construction sensitive fish species. By comparing species habitat preferences in the matrix, a priority list of habitat types for restoration or enhancement can be determined. The types of habitat that are most important to restore or enhance will be closely related to, and further refined by, the management objectives as described in the following section.

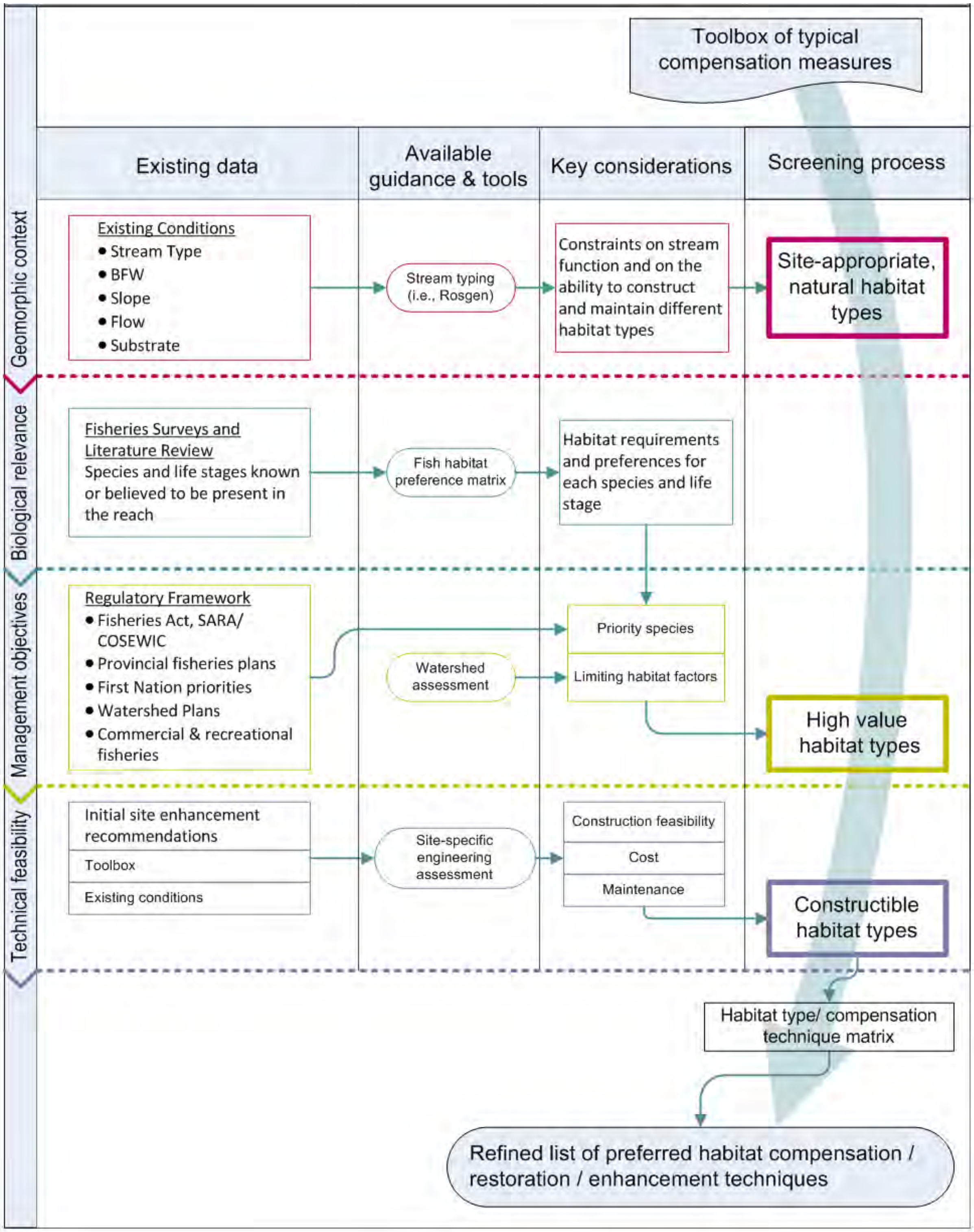


Figure 8-2 Screening Process to Develop List of Preferred Habitat Compensation Techniques

Status	Species	Lifestage	**0-20 cm**	**20-60 cm**	**60-100 cm**	**100-200 cm**	**>200 cm**	**pool (<0.25 m/s)**	**run (0.25-0.50 m/s)**	**riffle (0.50-1.00 m/s)**	**rapid (>1.00 m/s**	**river margin** (habitat along banks of mainstem channel, often low velocity)	**off-channel** (any habitat outside the mainstem flow including side channels, backwaters, often low or no velocity)	**bedrock**	**boulder** = >25 cm	**cobble** = 17-25 cm	**rubble** = 6.4-17 cm	**gravel** = 0.2-6.4 cm	**sand** = <0.2 cm	**silt/clay** = finer than sand with fine organic content	**muck(detritus)** = mud with coarse organic content	**hard-pan clay** = clay	**pelagic** = open water, no substrate	**none** = no cover	**submergent vegetation** = aquatic plants that grow entirely below the water's surface	**emergent vegetation** = aquatic plants that are rooted within submerged areas but stem and leaves above surface	**algae** = aquatic algae on bottom or within water column	**wood** = large (LWD) or small woody debris (SWD)	**in situ** = submerged cavities and crevices, undercut banks	**substrate** = interstitial spaces between any size of substrate (boulder-sand)	**overhead** = cover originating in the riparian zone that overhangs stream or banks
	Northern pike	young-of-the-year	H	H	H								H								H				H	M					
		juvenile				H	H						H						L		H				H	H					
		adult				H	H						H						L		H				H	H					
		spawning	H	H	M								H						M	M	H				H	H					
	Lake sturgeon	young-of-the-year					H										M	M	H	H	H				L	L					
		juvenile					H											H	L	H	H										
		adult					H											L	L	H	H										
		spawning	H	H	H	H	H								H	H	H	H	H			H							H		
	Walleye	young-of-the-year			M	H	H																								
		juvenile																													
		adult						H																H	H			H		H	
		spawning			H	H	H	H	H	H	H	H	H											H				H		L	
	Arctic grayling	young-of-the-year	H	H									H		H	H	H	H	H	M					H	H		H		H	H
		juvenile		H	H			H	H	H			H			H															
		adult	M	H	H	H	H	H	H	H			H	H	H			H													
		spawning						H									H	H			L										
	Bull trout	young-of-the-year	H	H	M			H					H		H	H				M								H	H	H	H
		juvenile	H	H	H			H	H						H	H	H		M	M			M					H	H	H	H
		adult							H	H					H	H	H											H	H	H	H
		spawning		H				H	H	L							H	H										H	H		H
	Dolly varden	young-of-the-year																													
		juvenile																													
		adult								H			M																		
		spawning							H									H													
	Anadromous dolly varden	young-of-the-year						L	H	H							H														
		juvenile						L	H	H																					
		adult																													
		spawning															H														
	Rainbow trout	young-of-the-year																													
		juvenile						M	H	H					H	H	H	H										M		M	H
		adult						M	H	H					H	H	H	H										M		M	H
		spawning								H								H										M			M
	Resident coastal cutthroat trout	young-of-the-year	H	H	H	H		H				H			H													H		H	
		juvenile			H	H		H		H			H															H			
		adult			H	H		H		H			H															H			
		spawning																H													
	Amphidromous coastal cutthroat trout	young-of-the-year						H	M	L					H	H	H	H	H	H	H							H	M	H	
		juvenile						H	M	L					H	H	H	H	H	H	H							H	M	H	
		adult						H																				H		H	
		spawning	H	H														H													
	Pearl dace	young-of-the-year																													
		juvenile																													
		adult																													
		spawning	H	H														H	H												
	Steelhead	young-of-the-year	H	H	M	M				H		H												H				M		H	L
		juvenile		H	H	H		H	M	H		M			L	M	H	H	M	M				M				H		M	M
		adult													M	H	H	H	H	M											
		spawning	H	H	H	H				H																					
	Coho salmon	young-of-the-year		H				H				H	H															H	H		H
		juvenile	H	H	H			H		M			H			H	H	M	M									H	H		H
		adult																													
		spawning	H	H				H		H								H													
	Chinook salmon	young-of-the-year	H	H	H	H	H					M	H												M	M				H	
		juvenile	H	H	H			H	H	M			H		H	H	H	M	M						M	M					
		adult																													
		spawning	H	H	H	H	H	H		H						H	H	H													
	Sockeye salmon	young-of-the-year	H	H	H	H							H																		
		juvenile																							M						
		adult																													
		spawning	H	H	H													H													
	White sturgeon	young-of-the-year		L	L	H	H		H	H					L	L	L	L	H	L		L								H	
		juvenile				M	H		H	M	L		L		L	M	M	M	H	L		L								H	
		adult					H						H																		
		spawning		L	L	H	H		H				H	M	H	H	H	H	H	M											
	Mountain whitefish	young-of-the-year	H	H					M	H		H	H		H	H	H	H	H	H											
		juvenile						M	H	H						H	H	H							H	H		H			
		adult						M	H	H						H	H	H							H	H		H			
		spawning	M	H	H	H	H								H	H	H	H													

Figure 8-3 Preferred Habitat Attributes (Low, Medium, High) by Fish Species and Age

8.3.3 Management Objectives

In addition to fish presence and preferred habitat attributes, it is important to consider the regulatory framework and management objectives developed by federal, provincial, Aboriginal, and public stakeholder groups. The *Fisheries Act* requires no-net-loss of fish production, primarily related to species that are important to commercial and recreational fisheries. This may not include other species that are part of the freshwater ecosystems but are rarely harvested. The *Species at Risk Act* provides additional protection for species that have been severely affected by human activities, regardless of fisheries value. Aboriginal groups may have culturally important species for which management priorities are established. In general, salmonids and sport fish species are usually given a high priority; however, valued species do vary between different regions.

Wherever relevant watershed assessments and other regional or reach-scale planning efforts are recommendations are available, these preferences will be used to aid in the selection of habitat restoration and enhancement measures (Roni et. al 2002). In most cases, these documents have been developed by a cooperative partnership of interested parties who defined the most valued stocks and species, summarized current factors limiting those populations, and prioritized habitat restoration or enhancement measures.

8.3.4 Technical Feasibility

The prior three topics are useful for determining what habitat features are either missing or will be affected in a given reach and what habitat features should be restored or created to maximize benefits to fish. In contrast, a similar analysis is needed that considers the feasibility to design and install certain hydraulic conditions and habitat types. From the list of possible enhancement measures identified during site visits and refined by the screening criteria, only some will be preferred based on technical constraints such as construction feasibility, cost, need for maintenance, etc.

8.3.5 Final Screening and Selection Process

The high value habitat types identified through the geomorphic, biological, and management screening criteria will need to be balanced with the feasible habitat types identified through the technical feasibility screening criteria. The overlap between these two assessments creates a list of habitat types that should be considered for compensation measures at each site. The final step is then to refer to the Habitat Compensation Technique Matrix to link the habitat types with the compensation measures that will achieve them. Finally, a refined list of preferred habitat compensation measures is available and typical design drawings for each can be found in the toolbox. Despite this formulaic approach, experienced engineers and other restoration professionals should oversee the final design and construction phases and monitor the installations after construction.

8.4 Toolbox Approach

The “toolbox” is a compendium of typical in-stream and riparian habitat manipulation techniques that can be used either alone or in combination to restore or enhance certain stream and riparian functions that provide habitat for fish and other aquatic life. These typical designs have been developed by various groups in Canada and the U.S. (WDFW SHRG, etc.; Slaney and Zaldokas; AB Trans) and have been proven effective in a wide range of situations. The “toolbox approach” refers to the proposed screening process used to integrate site-specific information and select which techniques will be most effective at improving habitat conditions at any given site. This approach is intended to streamline the HADD authorization process by establishing strict guidelines for compensation planning rather than developing individual designs for the multitude of sites.

When is the Toolbox Applicable?

The toolbox approach is particularly suited to smaller streams with relatively straightforward habitat needs that can be improved on-site. Therefore, the toolbox approach is proposed primarily for medium-low, medium and medium-high risk crossings. High risk sites will likely require more detailed planning, site-specific design work, and regulatory review while low risk sites are expected to avoid HADD by employing sufficient mitigation measures.

The toolbox approach does not negate the need for an experienced biologist and/or engineer to consider site specific conditions at each watercourse crossing. Successful application of these techniques requires them to be customized to the fish species that use the site, watercourse conditions, available materials, season of construction, and other factors. The design process is necessary for determining the appropriate structure size, orientation, elevation, and use of materials. Qualified restoration professionals will be engaged in the final selection and installation of the compensation measures during pipeline construction. The screening process and typical designs are described generally to allow for comment by regulatory agencies and stakeholders.

8.4.1 Screening Process for Instream Compensation Opportunities

The screening process is based on inputting physical characteristics along with engineering and fish habitat attributes into a stream habitat compensation techniques matrix (Figure 8-4). From this matrix, a suite of appropriate compensation measures can be derived.

Stream Habitat Compensation Techniques Matrix

Relative Condition and Attribute Assessment:

●	Good, ideal
▲	Fair, effective
◆	Poor, ineffective
-	Not applicable

		Bank Stability / Habitat		Instream Habitat									Off-Channel Habitat			
				Rock				Large Wood								
								Single		Multiple						
		Vegetated Bank	Native Material Revetment	Boulder Placement	Riffle Structure	Rock Drop Structure	Rock Current Deflector	Bank Log Structure	Submerged Shelter	Engineered Log Jam	Wood Drop Structure	Log Current Deflector	Riparian Zone Plantings	Floodplain Habitat	Side Channel Construction	Culvert Replacement
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Bankfull Width	Small (< 3 m)	●	●	▲	●	●	◆	●	▲	◆	●	●	●	▲	◆	●
	Medium (3 to 10 m)	●	●	●	●	●	▲	●	●	▲	▲	●	●	▲	▲	●
	Large (> 10 m)	▲	●	●	●	●	●	▲	●	●	◆	▲	●	●	●	●
Reach Geomorphology (Typical Bed Material, Gradient)	Braided (Variable, s < 0.03)	◆	◆	◆	◆	◆	◆	◆	▲	▲	◆	◆	▲	●	-	●
	Dune-Ripple (Sand, s < 0.001)	●	▲	◆	◆	◆	▲	▲	●	▲	▲	◆	●	●	▲	●
	Pool-Riffle (Gravel, 0.001<s<0.02)	●	●	●	●	●	●	●	●	●	▲	●	●	●	▲	●
	Plane-Bed (Gravel/Cobble, 0.01<s<0.04)	●	●	●	●	●	●	●	●	●	●	●	●	●	▲	●
	Step-Pool (Cobble/Boulder, 0.02<s<0.08)	▲	▲	●	◆	●	◆	▲	●	◆	●	●	●	▲	▲	●
	Cascade (Boulder, 0.04 s<0.25)	◆	◆	-	-	◆	◆	-	◆	-	-	◆	▲	◆	▲	▲
	Bedrock (N/A, s = Variable)	-	-	-	-	-	-	-	-	-	-	-	▲	-	-	◆
	Colluvial (Variable, s > 0.20)	◆	◆	-	-	-	-	-	-	-	-	-	◆	-	-	▲
Engineering Attributes	Stabilize Bank Erosion	●	●	◆	◆	▲	▲	▲	-	▲	▲	▲	▲	-	-	-
	Promote Bedload Retention	-	-	◆	▲	●	-	-	-	▲	●	-	-	-	▲	-
	Increase Sediment Transport	-	-	◆	-	-	●	-	-	▲	-	●	-	-	◆	▲
	Maintain Channel Capacity	●	▲	▲	●	▲	◆	●	●	▲	▲	◆	-	-	●	●
	Improve Floodplain Connectivity	◆	◆	◆	◆	▲	◆	◆	◆	●	▲	◆	-	-	●	-
	Prevent Channel Avulsion	▲	▲	◆	-	▲	▲	▲	-	▲	▲	▲	●	▲	◆	-
	Recruit Wood Debris	-	▲	◆	-	◆	◆	▲	◆	●	◆	◆	▲	▲	◆	-
Fish Habitat Attributes	Create Pool/Riffle Morphology	-	▲	▲	●	◆	▲	▲	-	●	◆	●	-	-	-	-
	Create Deep Pools	-	▲	▲	▲	●	▲	▲	-	●	●	●	-	-	-	-
	Provide Cover - Overhead	●	●	▲	-	-	◆	▲	-	●	-	▲	▲	-	-	-
	Provide Cover - Submerged	-	●	●	-	◆	◆	●	●	●	◆	◆	-	-	-	-
	Create Holding Areas	-	▲	●	▲	●	◆	▲	●	●	●	▲	-	-	●	-
	Provide High-water Refugia	◆	▲	▲	◆	▲	▲	◆	◆	●	▲	▲	▲	●	●	-
	Recruit/Reveal Gravel Substrates	-	▲	▲	▲	●	▲	◆	◆	●	●	▲	-	-	◆	-
	Create Overwintering Areas	-	◆	-	◆	▲	▲	-	-	▲	◆	◆	-	-	●	-
	Provide Nutrient Supply	●	●	-	-	-	-	▲	●	●	●	●	●	◆	-	-
	Increase Habitat Connectivity	-	-	▲	▲	●	-	-	-	-	▲	-	-	-	●	●

Figure 8-4 Stream habitat compensation techniques matrix

Stream habitat compensation techniques were ranked for effectiveness based on four primary criteria:

- bankfull width
- reach geomorphology
- engineering attributes
- fish habitat attributes

Bankfull width and reach geomorphology capture the physical characteristics of the site that may limit the use of certain compensation techniques. These physical criteria are utilized to help guide the selection of compensation techniques by ruling out options that are not relevant or feasible for a given stream type.

Engineering and fish habitat attributes define objectives for the enhancement or restoration of habitat. Engineering attributes are processes that promote channel stability and function. Fish habitat attributes are processes to create specific habitat types based on species presence, life stage requirements and management objectives. The need for specific habitat types and hydraulic features will help decide which compensation options are biologically relevant.

After identifying the physical characteristics along with engineering and fish habitat attributes in the stream habitat compensation matrix, the results are "rolled up" to identify the most effective compensation techniques to meet the aforementioned criteria (as identified by green circles in the matrix). These compensation techniques can then be refined further by looking at technical constraints such as construction feasibility, cost, and need for maintenance.

Compensation techniques for each category are summarized in Figure 8-1.

8.4.2 Example Application of Toolbox Approach

A medium-sized stream in Alberta is presented with BFW of 8 m and average depth of 1.5 m. At the crossing site, the stream comprises pool-riffle-run habitat types and the slope is approximately 1%. Bed and bank substrate is mixed, with a relatively high proportion of fines. Residual pool depths are shallow. The crossing site is in a moderately confined forested valley, although the immediate riparian zone is primarily shrubs. Beaver activity is evident nearby.

Fish species present in this stream include suckers, stickleback, dace, sculpins, chub and two species that are of management concern: bull trout and Arctic grayling. No initial site enhancement recommendations are available, but it is noted that good habitat complexity exists downstream of the site with functioning LWD jams. The estimated HADD reflected a much higher degree of effect to riparian areas than to instream habitats.

Using the screening process described above existing information about the site can be used in an organized way to help select a refined list of compensation techniques. First, the geomorphic data such as slope, channel dimensions, and substrates indicate that the reach can either take the form of a plane-bed or pool-riffle type stream (Montgomery and Buffington 1997). These constraints discourage the use of techniques such as wood drop structures and side channel construction. Second, the biological data suggest that a wide variety of species are present. Because these species prefer different habitat attributes, it would be impractical to attempt to design a site specific compensation approach to meet every need.

Established management objectives that identify the species of importance (bull trout and arctic grayling) and narrow the range of desired habitat types accordingly are employed. Both species make use of pool-riffle-run habitat types, prefer coarse substrate and would benefit from instream and overhead cover (Figure 8-5). Pool depth and the deposition of fine sediment from the eroding stream bank are considered limiting factors in this reach and represent the high-value habitat types that could be enhanced through compensation techniques. Finally, the constraints of cost and technical feasibility are considered.

			Depth					Velocity						Substrate										Cover							
Status	**Species**	**Lifestage**	**0-20 cm**	**20-60 cm**	**60-100 cm**	**100-200 cm**	**>200 cm**	**pool (<0.25 m/s)**	**run (0.25-0.50 m/s)**	**riffle (0.50-1.00 m/s)**	**rapid (>1.00 m/s**	**river margin**	**off-channel**	**bedrock**	**boulder**	**cobble**	**rubble**	**gravel**	**sand**	**silt/clay**	**muck(detritus)**	**hard-pan clay**	**pelagic**	**none**	**submergent vegetation**	**emergent vegetation**	**algae**	**wood**	**in situ**	**substrate**	**overhead**
	Arctic grayling	young-of-the-year	H	H									H		H	H	H	H	H	M					H	H		H		H	H
		juvenile		H	H			H	H	H			H			H															
		adult	M	H	H	H	H	H	H	H			H	H	H			H													
		spawning						H									H	H			L										
	Bull trout	young-of-the-year	H	H	M			H					H		H	H				M								H	H	H	H
		juvenile	H	H	H			H	H						H	H	H		M	M			M					H	H	H	H
		adult							H	H					H	H	H											H	H	H	H
		spawning		H				H	H	L							H	H										H	H		H

Figure 8-5 Priority Species Habitat Preferences

The objectives for compensation are to create deeper pools, reduce bank erosion and create conditions to mobilize the fine sediments but retain gravel and cobble. Using the toolbox matrix (Figure 8–6), the installation of log current deflector structures can be effective at promoting pool-riffle morphology and, in particular, creating deep pools.

Each habitat category corresponds with a letter of the alphabet (Figure 8–8). The list of available stream techniques could include more than one datasheet, as shown in Figure 8-1. For log current deflectors, three are listed. Each technique has a unique identification code, which starts with the letter corresponding to the type of habitat feature. For this example, each of the three log current deflector techniques could be chosen, including:

- K1 – Log wing deflector
- K2 – Log vane
- K3 – Log channel constrictor

Relative Condition and Attribute Assessment:

- ● Good, ideal
- ▲ Fair, effective
- ◆ Poor, ineffective
- \- Not applicable

		Bank Stability / Habitat		Instream Habitat									Off-Channel Habitat			
				Rock				Large Wood								
								Single		Multiple						
		Vegetated Bank	Native Material Revetment	Boulder Placement	Riffle Structure	Rock Drop Structure	Rock Current Deflector	Bank Log Structure	Submerged Shelter	Engineered Log Jam	Wood Drop Structure	Log Current Deflector	Riparian Zone Plantings	Floodplain Habitat	Side Channel Construction	Culvert Replacement
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
BF W	Medium (3 to 10 m)	●	●	●	●	●	▲	●	●	▲	▲	●	●	▲	▲	●
Geomorph	Pool-Riffle (Gravel, 0.001<s<0.02)	●	●	●	●	●	●	●	●	●	▲	●	●	●	▲	●
	Plane-Bed (Gravel/Cobble, 0.01<s<0.04)	●	●	●	●	●	●	●	●	●	●	●	●	●	▲	●
Engr Attrib	Stabilize Bank Erosion	●	●	◆	◆	▲	▲	▲	-	▲	▲	▲	▲	-	-	-
	Increase Sediment Transport	-	-	◆	-	-	●	-	-	▲	-	●	-	-	◆	▲
Fish Habitat	Create Pool/Riffle Morphology	-	▲	▲	●	◆	▲	▲	-	●	◆	●	-	-	-	-
	Provide Cover - Deep Water	-	▲	▲	▲	●	▲	▲	-	●	●	●	-	-	-	-

Figure 8-6 Technique Selection Matrix Reduced to Show Only Relevant Rows and With Markup to Show Selection Process

In addition, these constrictions increase sediment transport that will help clear fines out of the bed. These structures are confirmed as appropriate for medium-sized plane-bed or pool-riffle streams. Because log current deflectors are only considered “fair” at reducing bank erosion, an additional technique in the “vegetated bank” or “native material revetment” category is integrated into the design. The techniques in these categories include:

- A1 – coir logs and grass rolls;
- A2 – shrub restoration and live stakes;
- A3 – brush layering;
- B1 – coniferous tree revetment
- B2 – vegetated crib wall

If the site conditions prohibit effective installation of these techniques, or if they are cost prohibitive, alternatives can be found on the same matrix. For example, a root wad structure may be appropriate for the site and help to create pools, but the pools may not be deep enough to avoid freezing in the winter, and the root wad is unlikely to help transport fine sediments from the reach.

In conjunction with bank and instream habitat enhancements, the riparian zone can be enhanced by adding native coniferous and deciduous species that are lacking along this section of stream. Given the observed nearby beaver activity, care should be taken to plant species that are relatively undesirable for beaver. Use of beaver fence or other means to keep beaver away from the saplings should be considered.

8.4.3 Riparian

Since the majority of the HADD of fish habitat along the pipeline route will occur to riparian areas, it is important to consider compensation opportunities that specifically address potential environmental effects on riparian areas. Unfortunately, there are few relevant resources that offer a prescriptive approach for improving riparian conditions. Furthermore, the ability to improve riparian conditions will either be limited by required inspection/maintenance buffers around the pipelines, or will rely on replanting with seedlings and salvaged plants from upland areas. Riparian restoration activities will be somewhat opportunistic, unless the compensation is completed off-site. Therefore, the first step and preferred method for achieving NNL is to mitigate and restore affected riparian areas to the greatest extent possible. The second step is to address residual effects using the compensation techniques described in Figure 8–4.

Step 1 - Mitigation and Restoration

Changes to riparian areas will be reduced by using the following mitigation measures during construction:

- The removal of vegetation and disturbance of soil adjacent to watercourses and wetlands will be reduced.
- Woody riparian and wetland plants, shrubs and small deciduous trees will be cut, hydroaxed or walked-down at ground level, with the roots left intact where possible.
- Reduce the width of grubbing through wet and riparian areas during construction to facilitate the natural restoration of understory plants.
- To restore shrub cover on wetland or watercourse edges, willows (or other locally available shrub species) will be staked along the wetland edge.
- Grubbed areas will be re-contoured and drainage patterns re-established to promote natural regeneration of wetland plant species and to reduce the risk of erosion.
- The RoW will be monitored post-construction to assess the efficacy of the restoration program and proposed mitigation measures.
- Where HDD is not feasible, clearing of mature deciduous and coniferous trees in the riparian zone will be reduced, and the width of temporary workspaces will be narrowed to the extent practicable.
- Where grading is not required, trees will be cut at ground level and temporary workspaces will not be grubbed to allow for coppicing and to keep root systems intact.
- To retain stream bank stability and reduce erosion potential, bio-engineering will be implemented along stream banks using appropriate vegetation species and techniques.
- Where appropriate, coarse woody debris will be distributed on riparian and flood plain ground surfaces during the final clean-up and restoration phase to restore the structural complexity and wildlife habitat functions of riparian and floodplain forest, in areas where this activity does not create forest health concerns.
- Cleared riparian and floodplain forest will be seeded with appropriate seed mixes, and riparian shrubs and trees will be planted, as outlined in the Restoration Plan.

Disturbed riparian habitat will be restored with the intent of replicating or improving pre-existing conditions. The streambed and banks will also be restored to a stable configuration to produce similar or improved habitat conditions. In addition, natural drainage and slope configurations will be maintained or restored through the riparian areas. To mitigate for the loss of riparian vegetation, instream cover for fish species may be improved by adding rock clusters and large woody debris. Bank stabilization will also be improved using a combination of techniques found in the toolbox.

Riparian zones will be replanted to mitigate for the potential effects from disturbing the soil and removing vegetation. The emphasis will be to stabilize disturbed slopes and replant them with native vegetation. Grasses, with the possible addition of legumes, can be seeded to provide nearly immediate soil cover and stabilization. Trees and shrubs can also be planted in an effort to establish or restore more robust root systems and overhead cover. Additionally, in areas where mature trees were present prior to construction, the addition of coarse woody debris can provide mitigation for the loss of those materials from the riparian zone.

Since the riparian vegetation is proposed to be removed in a narrow strip at each crossing, the relative effect on the food supply for fish will be small. The riparian zones are proposed to be replanted to restore the food supply for fish in the longer term.

Step 2 - Compensation

A conceptual decision tree is proposed for identifying opportunities for riparian compensation (Figure 8-7). If the existing riparian areas contain invasive or non-native species, the undesirable plants first need to be controlled. Then, after examining the conditions of the root systems, soil, the plants present, and their maturity, the characteristics that can be improved by the addition of plants.

If the root systems of the existing vegetation are weak because the plants are not well suited to the conditions, plant species that are more suitable for the environment could be planted. If the weak root systems occur due to inherent soil or water table conditions at the site, planting additional plants may not be appropriate.

If a lack of deep, organically rich soils is encountered, appropriate vegetation species can be planted to improve the production of organic detritus. The potential causes for the poor soil conditions will also need to be considered, such as fertility issues, erosion, or sediment deposition.
If a lack of vegetation species diversity is encountered, species that are representative of a healthy riparian system could be planted. If the species present are pioneer species and are located in a channel migration zone, on a gravel bar, or in an area of colluvium, the risk to the planted vegetation as a result of these normal processes should be considered in re-vegetation plans and activities.

If the riparian zone lacks understorey, an overhead canopy or grasses and forbs, species that can help establish the under-represented class of vegetation could be planted. Reasons for the class of vegetation being absent should be determined.

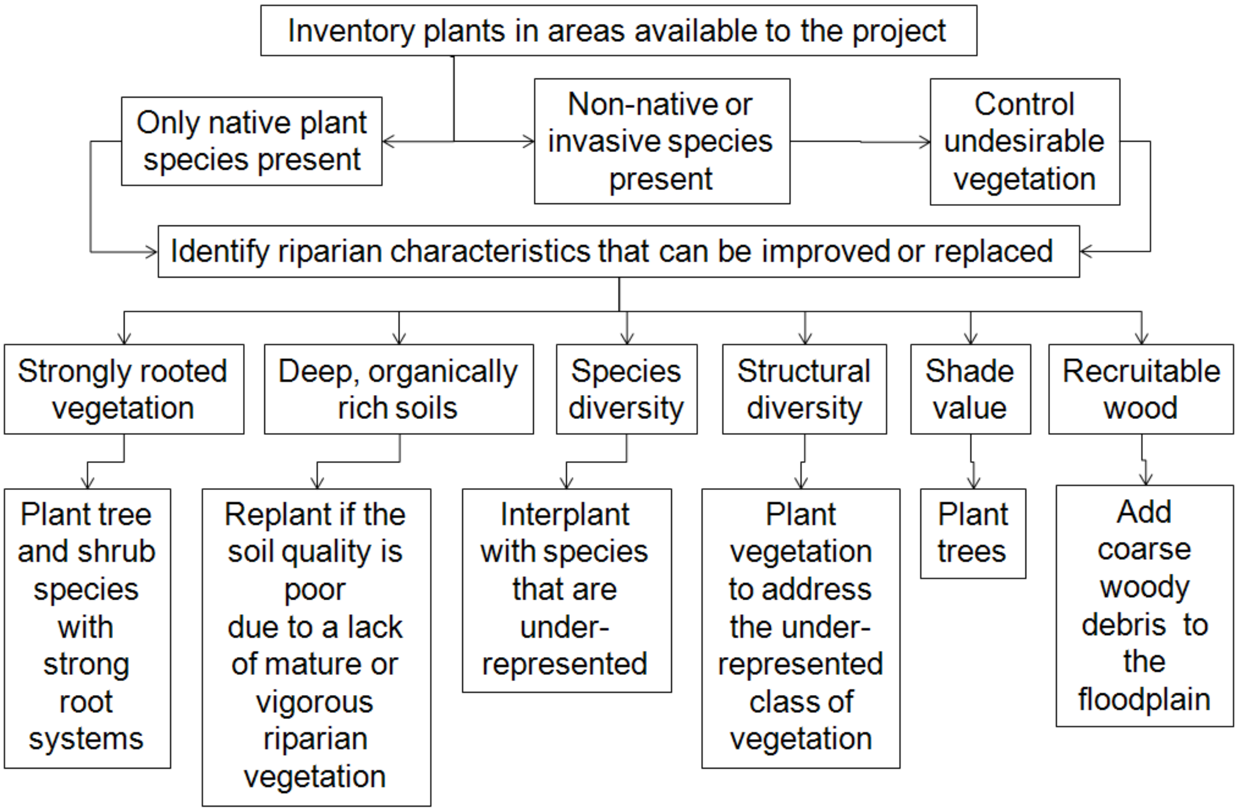


Figure 8-7 Flow Chart for Identifying Riparian Compensation Opportunities

If the riparian zone does not provide shade for the adjacent watercourse, trees could be planted if the soil and environmental conditions are favorable for their establishment. An assessment of whether the lack of shade trees is due to environmental conditions should be conducted. Potential damage to the tree seedlings by mammals should be included in the assessment when identifying the addition of potential species, establishment techniques, and protective measures.

If the riparian zone lacks CWD due to natural or human causes, the additional CWD can be planted in the floodplain or in riparian areas. In downstream areas where bridges, levees, or other infrastructure are located, it may be appropriate to add CWD to mitigate potential erosion effects downstream by employing techniques to reduce the potential movement of CWD.

- When consistent with site conditions and goals, re-vegetation of the ground layer should be allowed to occur naturally. If seeding or planting is necessary to reduce the potential for erosion or the potential spread of highly damaging alien species, native seeds or non-alien cover crops should be used for re-vegetation purposes.
- Plant materials that are site appropriate should be included in the selection process.
- Post-planting management of alien species should be included in vegetation management plans for the area.

8.4.4 Generic Application of Toolbox Approach to Select Habitat Compensation Techniques

The selection of compensation opportunities, whether on-site or off-site, will rely on a process that is informed by geomorphic and technical constraints, the type and severity of effect and established biological objectives. Therefore, compensation measures will be somewhat unique to each crossing and should thus be prescribed individually. However, due to the limited number of watershed/stream types and species in a given region, it is possible to group some of these measures and describe them generally. Examples of common techniques used to restore, enhance or create fish habitat are described below according to watershed type and fish species/communities. More detailed descriptions of the topography and land use types within the major drainages and the life history and habitat requirements of relevant fish species are provided in the Technical Data Reports.

8.4.4.1 Compensation Measures by Watershed Type

A certain subset of compensation measures may be more appropriate, depending on the location of the site. Whether the site is situated in coastal British Columbia, interior British Columbia or Alberta, there will be similarities in geomorphic context, land use and habitat degradation issues and biological communities within each of those areas. While a great degree of variability still exists within these regions, we describe the typical conditions in each area.

Alberta

In Alberta, the pipeline route crosses watercourses in the Peace River, Athabasca River and the North Saskatchewan River drainages, which all flow east to Hudson Bay and which do not support anadromous salmon species. Instead, important sport fish species include Arctic grayling, bull trout, burbot, mountain whitefish, northern pike and rainbow trout. In addition, longnose sucker, white sucker and brook stickleback are widely distributed across streams in this region.

In the North Saskatchewan River drainage, the pipeline route crosses flat terrain associated with boreal forest, agricultural zones and low-gradient watercourses. The climate and topography in this region resulted in a natural region referred to as Central Parkland, which includes mostly grasslands and aspen and balsam poplar forests. A small region of Boreal Forest is found on the eastern and western sections of the proposed RoW in the North Saskatchewan River drainage, and is mainly characterized by aspen forests. Most of the land in this section of the pipeline route is used for agriculture. Construction-sensitive species include lake sturgeon, northern pike and walleye.

In the Athabasca River drainage, the pipeline route crosses flat terrain associated with forested and agricultural zones with low-gradient watercourses throughout. The climate in this region is characterized by dry mixed wood conditions (mainly aspen forests) in the eastern portion of the drainage, and Foothills conditions in the western portion of the drainage (dominated by white spruce, black spruce and birch forests). A substantial amount of the land base in this drainage has been cleared for agriculture and logging. Construction-sensitive species include northern pike, walleye, bull trout, Arctic grayling, mountain whitefish and rainbow trout.

In the eastern Peace River drainage, the pipeline route crosses forested foothills and low-gradient watercourses. The climate and topography in this region resulted in a transitional zone between Foothills and Boreal Forest conditions and mixed forests, which are comprised of aspen, white spruce, black spruce and birch. Most of the land use in this drainage is dedicated to logging and oil and gas lease developments. Construction-sensitive species include arctic grayling, northern pike, walleye, bull trout and mountain whitefish.

The flat terrain along the pipeline route in Alberta indicates that the watercourse crossings will likely occur at transport limited reaches with low slope and finer substrates. These channel types (i.e., pool-riffle and dune-ripple [Montgomery and Buffington 1997]) are highly susceptible to altered sediment and flow regimes, and are also highly responsive to restoration measures. In areas where the land has been cleared for agriculture or grazing, the enhancement opportunities may include soft bank stabilization techniques and planting native vegetation in the riparian and floodplain zones. Many of the larger, channel spanning features may be inappropriate in unconstrained alluvial valleys and would increase the risk of avulsion. Engineered instream structures that rely on scouring processes to create habitat complexity may only be useful in larger rivers with sufficient stream power. Sourcing large wood may be difficult in these areas and supply may have been limited naturally; therefore, structures that rely on rock may be preferable considering the landscape and budget. Other opportunities may involve excluding cattle from access to the streams and providing alternate watering sources if their only source of water is from the stream.

BC Interior Region

In British Columbia, the pipeline route crosses watercourses in the Peace, Fraser, Skeena and Kitimat River drainages. Important sport fish species include: rainbow trout and bull trout, which are common to all four drainages; coho salmon, Dolly Varden and cutthroat trout, which were captured in both the Skeena and Kitimat River drainages; mountain whitefish, which were captured in the Peace and Fraser drainages; chinook, chum and pink salmon, which were only captured in the Kitimat River drainage; and arctic grayling, brook trout and burbot, which were only captured in the Peace River drainage.

In the eastern Peace River drainage, the proposed pipeline route crosses rugged terrain associated with the Rocky Mountains, Foothills and Interior plateaus. Most of the land in this drainage is undeveloped. However, some land has been used for mining, forestry and oil and gas exploration and distribution. Construction-sensitive species include northern pike, bull trout, Arctic grayling, rainbow trout, mountain whitefish and burbot.

Within the Fraser River drainage, the proposed pipeline route will be almost entirely within the Nechako (Interior) Plateau, a feature with relatively moderate relief terrain. Unlike the steeper, wetter drainages associated with the proposed pipeline route in coastal areas of British Columbia, the climate within the Fraser River drainage features hotter and drier summers, and colder winters. As a result, flows are generally lower during summer and there are more ephemeral tributaries. The primary land uses along the proposed pipeline RoW within the Fraser River drainage include agriculture, ranching and logging. Construction-sensitive species include rainbow trout, mountain whitefish and several species of anadromous salmon.

In the BC interior region, watercourses are more likely to have a morphology reflecting higher gradients – pool-riffle, plane-bed, and possibly step-pool channel types (Montgomery and Buffington 1997) – that can be forced toward other (possibly more preferable) channel types by installing instream structures. Valley walls are typically more constraining and thus channel spanning structures have a higher likelihood of success. These instream habitat structures may consist of a combination of wood and rock such as boulder clusters, rock drop structures, log weirs, dams and jams. Deep pool and off-channel habitats are important due to the freezing potential of streams during cold winters and the overwintering needs of the fish species. In the summer, these deeper areas provide refuge during low flows.

BC Coastal Region

The Skeena River system lies within west-central British Columbia and flows from its headwaters in the Skeena Range of the Coast Mountains to the ocean near Prince Rupert. The western section of the Skeena River drainage generally consists of forests which have either been logged or remain untouched. In the eastern section, logging, agriculture and ranching account for the majority of land use along the pipeline route. Construction-sensitive species include bull trout, Dolly Varden, cutthroat trout, rainbow trout, coho salmon and other anadromous salmonids.

The Kitimat River also originates in the Coast Mountains and discharges into the Pacific Ocean at the head of Douglas Channel near Kitimat. There are no impoundments or diversions in the Kitimat River drainage. This section of pipeline route crosses steep terrain associated with the Coastal and Kitimat Mountain ranges, separated by low-gradient watercourse crossings in the Kitimat River Valley. A substantial amount of the land in this watershed group has been logged. Construction-sensitive species include cutthroat trout, rainbow trout, Dolly Varden and several anadromous salmon species.

In the high-relief watersheds of coastal British Columbia, the pipeline route will likely cross a wide range of channel types. In areas where the stream habitat is relatively pristine, culvert replacement and improvement of habitat connectivity may provide the best opportunities for enhancing fish productivity, especially considering the predominance of anadromous salmonids that rely on extensive migration corridors. Where logging has been prevalent, hard bank stabilization and riparian planting techniques may be useful for reducing sediment loads into the watercourse. Large wood structures are appropriate given the landscape context and locally available materials. Log jams will be useful for creating localized areas of scour, retaining gravels, and increasing invertebrate food supply.

8.4.4.2 Compensation Options by Fish Species

The species mix in these regions also steers the identification of compensation opportunities. In Alberta, the opportunities to enhance fish habitat may be very different than in coastal BC watersheds because of the different species that are important. Sport fish species such as northern pike and walleye have very different habitat preferences than salmonids; namely deeper pools and off-channel areas of slow water and finer substrates. Opportunities for walleye may include the construction of riffles for spawning, bank stabilization to prevent siltation of the riffles, excavated pools and runs and off-channel areas. Opportunities for northern pike may include construction of off-channel spawning areas of shallow, low-flow conditions with submerged vegetation.

Mountain whitefish and arctic grayling have habitat preferences similar to trout and are discussed in the next section. Overwintering areas where water depth is sufficient to avoid freezing solid during the winter months are important for all species in this region. Thus, deep pools and/or connectivity to a larger waterbody are particularly important habitat attributes for non-anadromous species of Alberta and interior British Columbia.

In Interior British Columbia, the primary fish of concern are trout and other species that share similar stream habitat requirements. These include pool riffles, gravel substrates, vegetated banks that provide cover and cold clear water. Ideal habitat enhancement opportunities for trout include current deflectors that encourage natural meander patterns, pool-riffle morphology and undercut banks; rock or log weirs and dams to increase pool depth; boulder clusters or root wads placed in the stream to provide cover for juveniles; and bank planting to stabilize erosion, and provide cover and shade. Trout also require overwintering areas, such as deep pools, that do not freeze and maintain suitable dissolved oxygen levels and some degree of habitat connectivity, which allows them to respond to seasonal changes in water quality, flow conditions and food availability.

In coastal BC, anadromous salmon and steelhead have specific habitat requirements during different life stages (Fish Habitat Preference Matrix, Figure 8-3. Adult spawners require barrier-free migration corridors, cold clean water and gravel substrates for egg deposition. Juveniles that rear in the stream before migrating to sea require an adequate food supply, cover from predators and areas of appropriate depth and velocity where they can take refuge from high flows. Where land use practices and anthropogenic disturbances have degraded these habitat types, an opportunity exists to restore them. As noted above, the single most cost-effective habitat enhancement in coastal BC may be to remove barriers to fish passage. On-site opportunities that use the common techniques found in the toolbox include log weirs and dams that help create pool-riffle habitat and recruit spawning gravel; adding large wood jams with submerged root wads to increase overhead and submerged cover, and installing bank protection structures that also provide habitat complexity and refuge for juveniles during high flows. If feasible, construction and connection of off-channel areas represents a valuable opportunity to enhance habitat for rearing coho salmon.

9 Monitoring, Adaptive Management and Long-Range Compensation

The Northern Gateway freshwater fish habitat compensation plan will include a proposed monitoring program to ensure that the habitat compensation works are successful and meeting the objectives of the plan. The monitoring program will consist of compliance monitoring to ensure that compensatory habitats are constructed in accordance with the plan, and effectiveness monitoring to ensure that the compensatory habitats are functioning as intended.

In addition, further refinement using an adaptive management approach will be carried out during the construction and post-construction phases. This approach includes methods for evaluating the effectiveness of habitat compensation plans and if measures are found to be ineffective they will be adjusted and corrected.

10 References

10.1 Literature Cited

Alberta Environmental Protection. 1996. Fish habitat enhancement designs: typical structures. Water Resource Management Services, Technical Services and Monitoring Division, River Engineering Branch. 44 p.

Alberta Natural Heritage Information Centre (ANHIC). 2008. *Animal Tracking & Watch Lists*. Available at: http://www.tpr.alberta.ca/parks/heritageinfocentre/default.aspx

Alberta Sustainable Resource Development (ASRD). 2005. Alberta Timber Harvest Planning and Operating Ground Rules Framework for Renewal. Accessed February 2006. Available at: http://www.srd.gov.ab.ca/forests/pdf/Annex_4_draft_Jan_15_08Final.pdf

Alberta Sustainable Resource Development (ASRD). 2009. *Fisheries Management Information System (FWMIS)*. Available at: http://www.srd.gov.ab.ca/fishwildlife/guidelinesresearch/fwmis.aspx

Allan, J.H. 1984. An Overview of the Fish and Fisheries of the North Saskatchewan River Basin. Alberta Environment, Planning Division. Edmonton, AB.

Baxter, J.S., E.B. Taylor, R.H. Devlin, J. Hagen and J.D. McPhail. 1997. Evidence for natural hybridization between Dolly Varden (*Salvelinus malma*) and bull trout (*Salvelinus confluentus*) in a northcentral British Columbia Watershed. *Canadian Journal of Fisheries and Aquatic Sciences* 54: 421–429.

Bonnington, C.H. and T.D. Boag. 2006. Compensation Plan for the Terasen Pipelines (Trans Mountain) Inc. TMX – Anchor Loop Project. Prepared for Terasen Pipelines (Trans Mountain) Inc., Calgary, AB.

British Columbia Conservation Data Centre (BC CDC). 2008. *BC Species and Ecosystems Explorer*. Ministry of Environment, Victoria, BC. Accessed February 2008. Available at: http://www.env.gov.bc.ca/atrisk/toolintro.html

British Columbia Ministry of Environment (BC MoE) and British Columbia Ministry of Forests (BC MoF). 1995. *Forest Practices Code of British Columbia. Riparian Management Area Guidebook*. Forest Practices Branch. Victoria, BC. 75 pp.

British Columbia Ministry of Environment (BC MoE). 2009a. *Fisheries Information Summary System (FISS)*. Available at: http://a100.gov.bc.ca/pub/fidq/main.doc

British Columbia Ministry of Forests and Range (BC MoFR). 2009. British Columbia Mountain Pine Beetle Status Map 2008. Updated 24 March 2009. Accessed 08 June 2009. Available at http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/maps/Culm_kill_2008.jpg.

British Columbia Ministry of Water, Land, and Air Protection (BC MWLAP). 2004. *Standards and Best Management* Practices *for Instream Works.* Biodiversity Branch, Ecosystems Standards and Planning. Victoria, BC.

Canadian Association of Petroleum Producers (CAPP). 2005. Pipeline Associated Watercourse Crossings, 3rd Edition. Canadian Association of Petroleum Producers (CAPP) and Canadian Energy Pipeline Association (CEPA) and Canadian Gas Association (CGA). Prepared by TERA Environmental Consultants and Salmo Consulting Inc., Calgary, AB.

Chilibeck, B. 1992. Land Development Guidelines for the Protection of Aquatic Habitat. Fisheries and Oceans Canada and the Ministry of Environment, Lands and Parks, Integrated Management Branch.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2008. *COSEWIC Species Database*. Environment Canada. Available at: http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm

DFO (Fisheries and Oceans Canada). 1986. Policy for the Management of Fish Habitat. Ottawa, ON.

DFO. 1998. Decision Framework for the Determination of a Harmful Alteration, Disruption or Destruction of Fish Habitat. Fisheries and Oceans Canada. Ottawa, ON.

DFO (Fisheries and Oceans Canada). 2006. Practitioner’s Guide to Habitat Compensation. Ottawa, ON.

DFO (Fisheries and Oceans Canada). 2007. Practitioner’s Guide to the Risk Management Framework for DFO Habitat Management Staff. Ottawa, ON.

Government of Canada. 2009. *Species at Risk Registry*. Available at: http://www.sararegistry.gc.ca/default_e.cfm

McPhail, J.D. 2007. *The Freshwater Fishes of British Columbia*. University of Alberta Press. Edmonton, AB.

Minns, C.K. 1995. Calculating net change of productivity of fish habitats. Can. MS Rep. Fish. Aquat. Sci. 2282.

Minns, C.K. 1997. Quantifying “no net loss” of productivity of fish habitats. Can. J. Fish. Aquat. Sci. 54: 2463–2473.

Minns, C.K. 2006. Compensation ratios needed to offset timing effects of losses and gains and achieve no net loss of productive capacity of fish habitat. Can. J. Fish. Aquat. Sci. 63:1172-1182.

Minns, C.K., and J.E. Moore. 2003. Assessment of net change of productive capacity of fish habitats: the role of uncertainty and complexity in decision making. Can. J. Fish. Aquat. Sci. 60: 100-116.

Montgomery, D.R. and J.M. Buffington. 1997. Channel-reach morphology in mountain drainage basins. GSA Bulletin 109(5):596-611.

Nelson, J.S., and M.J. Paetz. 1992. *The Fishes of Alberta. 2nd edition*. The University of Alberta Press. Edmonton, AB.

Paetz, M.J. 1984. The Fish and Fisheries of the Peace River Basin: Their Status and Environmental Requirements. Alberta Environment Planning Division. Edmonton, AB.

Roni, P., T.J. Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollock and G.R. Pess. 2002. A review of stream restoration techniques and a hierarchical plan for prioritizing restoration in Pacific Northwest watersheds. North American Journal of Fisheries Management 22:1–20.

Rosgen, D. L. 1994. A classification of natural rivers. Catena, Vol. 22:169–199.

Scott, W.B. and E.J. Crossman. 1998. *Freshwater Fishes of Canada.* Galt House Publications Ltd. Oakville, ON. 966 pp.

Slaney, P.A. and D. Zaldokas. 1997. Fish Habitat Rehabilitation Procedures. Watershed Restoration Technical Circular No. 9. Watershed Restoration Program, BC Ministry of Environment, Lands and Parks. Vancouver, BC.

Tchir, J.P., P.J. Hvenegaard and G.J. Scrimgeour. 2004. Stream crossing inventories in the Swan and Notikewin River basins of Northwest Alberta: Resolution at the watershed scale. In G. J. Scrimgeour, G. Eisler, B. McCullock, U. Silins and M. Monita (eds.). Forest Land-Fish Conference II – Ecosystem Stewardship through Collaboration. Proc. Forest-Land-Fish Conf. II, April 26-28, Edmonton, AB. 53–62.

Wallace, R.R. and P.J. McCart. 1984. *The Fish and Fisheries of the Athabasca River Basin: Their Status and Environmental Requirements*. Prepared for Alberta Environment Planning Division. Edmonton, AB.

10.2 Personnel Communication

Feldoff, M. 2009. Kitimat Hatchery. Conversation.

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Technical Data Report

Conceptual Marine Fish Habitat Compensation Plan

ENBRIDGE NORTHERN GATEWAY PROJECT

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July 2012

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1 Introduction

Northern Gateway Pipelines Limited Partnership (Northern Gateway) proposes to construct and operate:

- an oil export pipeline and associated facilities
- a condensate import pipeline and associated facilities
- a tank terminal and marine terminal (the Kitimat Terminal) to be located near Kitimat, British Columbia

These project components and activities are collectively referred to as the Enbridge Northern Gateway Project (the Project).

Due to the need to modify the existing marine bottom profile in the vicinity of the marine terminal, construction of the Project will result in the harmful alteration, disruption, or destruction (HADD) of marine fish habitats. Habitat compensation planning is required to offset the adverse effects of the Project on fish habitat and to support issuance of a section 35(2) *Fisheries Act* authorization for Project HADD.

1.1 Objective

Northern Gateway retained Stantec Consulting Ltd. (Stantec) to prepare this conceptual marine fish habitat compensation plan, which describes the habitat compensation strategies that can be considered by the Project to meet DFO's policy of "net gain" and guiding principal of "no net loss" of productive capacity of marine fish habitats. This conceptual plan represents the first step toward the development of a detailed marine fish habitat compensation plan, which will be necessary prior to issuance of a Section 35(2) *Fisheries Act* authorization for the Project. This plan has been prepared, in part, as a response to Federal Government Information Request 2.8.

This report describes the Project activities that are expected to result in marine HADD, quantifies the areal extent of affected habitats, and describes options for the physical works that can be undertaken to compensate for this HADD. This report deals exclusively with marine fish habitats. Compensation strategies for freshwater fish habitats affected by the Project are discussed in the conceptual freshwater fish habitat compensation plan (Northern Gateway 2012).

The intent of this report is to provide an overview of the compensation options that can be used to offset marine HADD associated with the Project. The final compensation strategy will be determined through discussions with Fisheries and Oceans Canada (DFO), participating Aboriginal organizations and potentially-affected stakeholders. This strategy will likely include one or more of the options presented in this report, but may also incorporate additional compensation opportunities identified by the participants. Once the preferred compensation options have been selected, Northern Gateway will develop detailed design drawings for each of the compensation features and will include these in the final marine fish habitat compensation plan.

1.2 Regulatory Context

The legislative authority for the management and conservation of fish and fish habitat in Canada is provided by the federal *Fisheries Act*. Section 34 of the *Fisheries Act* defines fish habitat as:

> *"spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes."*

The main provision of the *Fisheries Act* dealing with protection of fish habitat is section 35. Section 35(1) states that: "no person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction (HADD) of fish habitat." However, Subsection 35(2) qualifies this prohibition, in that it allows for the authorization of a HADD to fish habitat by the Minister of Fisheries and Oceans, or through regulation.

The Policy for the Management of Fish Habitat (1986) provides direction for interpreting the broad powers mandated in the *Act*. It established DFO's long-term policy objective of an overall "net gain" of the productive capacity of fish habitats through habitat conservation, restoration and development. The policy framework around conservation of fish habitat, and its linkage to Sections 35(1) and 35(2) of the *Act*, establishes the guiding principle of "no net loss" of productive capacity. Under this principle, DFO works with project proponents and other government agencies to ensure projects are designed to maintain the productive capacity of fish habitat while recognizing the potential or existing land use value. All project plans that affect fish habitat must demonstrate that they meet the "no net loss" guiding principle and should achieve the "net gain" policy objective.

Proponents must pursue location, design and other mitigation options that avoid effects to fish habitat before DFO will consider authorizing habitat compensation to achieve "no net loss" of fish habitat. In cases where losses of fish habitat cannot be avoided, habitat replacement or enhancement, on a case-by-case basis, may be accepted as compensation for unavoidable losses.

DFO's Decision Framework for the Determination and Authorization of Harmful Alteration, Disruption or Destruction of Fish Habitat (1998) provides two key pieces of information that are important to understanding the authorization review process. First, it provides definitions for what a HADD is and second it provides guidance to DFO staff on how to determine what effects to fish habitat are acceptable (i.e., can a HADD be authorized under subsection 35(2) of the *Act*).

Definitions for HADD provided in the 1998 Decision Framework are as follows:

- **Harmful alteration -** any change to fish habitat that indefinitely reduces its capacity to support one or more life processes of fish but does not completely eliminate the habitat
- **Disruption -** any change to fish habitat occurring for a limited period which reduces its capacity to support one or more life processes of fish
- **Destruction -** any permanent change of fish habitat which completely eliminates its capacity to support one or more life processes.

Compensation plans are typically developed with substantial input from DFO and must balance construction feasibility and fiscal reality with fish habitat requirements. Each project poses specific challenges and opportunities; therefore, the process of developing the habitat compensation plan is unique to each new project.

1.3 Fisheries Resources of the Area

The objective of the habitat provisions of the *Fisheries Act* and the supporting policy is to manage fish habitats that support freshwater and marine fisheries—whether they are recreational, commercial, food or Aboriginal fisheries. As a result, the focus of this conceptual compensation plan is on fish habitat that supports a fishery.

The waters of Kitimat Arm support commercial, recreational and Aboriginal food, social and ceremonial (FSC) fisheries. Key species harvested for one or more fisheries include:

- pacific salmon (sockeye, chinook, coho, pink and chum)
- halibut
- rockfish (various species)
- lingcod
- herring
- eulachon
- sole
- crab (dungeness and red rock)
- prawns
- bivalves

1.4 Factors Involved in Habitat Compensation

Habitat compensation is the modification of existing habitat or the creation of new habitat to maintain or enhance the productive capacity of fish habitats and ensure compliance with the "no net loss" policy. Productive capacity is defined in the Policy for the Management of Fish Habitat as the maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend (DFO 1986). Because a quantitative value of productive capacity can rarely be measured with confidence, habitat loss and gain is often expressed as a measure of area. However, fish distribution and abundance across ecosystems are determined not only by the useable area, but also by the quality of the habitat available. Aside from the amount of physical space available for use by aquatic organisms, the productive capacity of habitat is influenced by a number of physical and biological features including:

- habitat complexity (number of ecological niches available)
- physical properties (water flow, currents, disturbance regimes, temperature, dissolved oxygen, pH, etc.)
- protection from predators

- primary productivity (algal biomass and turnover rate)
- prey production
- species diversity

Area-based habitat compensation ratios (i.e., the ratio of the habitat area created versus the habitat area affected) are often used in habitat compensation planning. However, by using a direct measure of area, the quality of the habitat is essentially dismissed and the actual productive capacity of the habitat may be overlooked. Thus, it is essential to consider both the areal extent and the quality of affected fish habitats.

When determining the amount of habitat compensation needed, the following factors must be considered:

- type and productive capacity of affected and compensation habitats
- temporal loss of productivity associated with the time required for compensation habitats to reach full productive capacity
- risk associated with failure of the proposed compensation habitat
- regional and local availability of affected habitats

2 Existing Marine Fish Habitats

Marine fish habitats within the project development area (PDA) and project effects assessment area (PEAA) were characterized during thirteen field surveys carried out between 2005 and 2011. Details on survey type, task, date and coverage are provided in Table 2-1. The spatial extent of the PDA and PEAA are shown in Figure 2-1.

Table 2-1 Marine field surveys undertaken in the PDA and PEAA

Survey Type	Task Completed	Date	Coverage
Intertidal habitat characterization	Reconnaissance survey	July 2005	PEAA
	Transect survey	June 2006	PDA
	Transect survey	July 2008	PDA
	Transect survey	August 2009	PDA
Subtidal habitat characterization	Qualitative subtidal survey	September 2005	PEAA
	Sediment and water sampling	February 2006	PDA
	Benthic invertebrate sampling	June 2006	PDA
	Quantitative subtidal video survey	June 2006	PDA
	Quantitative subtidal video survey	June 2007	PDA
	Kitimat Arm glass sponge survey	May 2011	PEAA
Nearshore fish survey	Beach seine	July 2005	PEAA
	Gillnet and longline	September 2005	PEAA
Nearshore crab survey	Crab traps	September 2005	PDA

The following sections provide an overview of the physical and biological characteristics of marine fish habitats identified during the field surveys. The focus is on habitats within the PDA that may be affected by Project construction. For a more detailed discussion of survey methodology and results, the reader is referred to the Marine Fish and Fish Habitat Technical Data Report (Beckett and Munro 2010).

2.1 Subtidal Habitat

Nearshore subtidal habitats within the PDA are composed primarily of bedrock with overlying surface sediments such as mud, pebbles, cobbles and boulders. The depth of the veneer varies from less than 1 cm in steeper areas to depths great enough to support a number of burrowing infauna. As is typical of fjord environments, the seafloor steepens with increasing distance from shore and the sediment veneer gives way to rock walls and ledges. Exposed bedrock was observed in the northern section of the PDA, where steep cliffs alternate with ledges covered with silt. Notable amounts of woody debris, ranging from bark to large logs, were found at the site, suggesting that some type of historical log booming activity took place at or near the site.

Algae at the site are present on a narrow, shallow shelf close to shore. Foliose and filamentous green algae (*Ulva* spp.) are the dominant species. Some brown algae (*Laminaria* spp. and *Fucus gardneri*) and small amounts of red algae (mostly foliose, with some coralline and encrusting species) are also present. Algal abundance declines rapidly with distance from the shoreline as a result of the rapid increase in depth and the associated decrease in light.

Overall, invertebrate diversity within the PDA is low. In areas where sediment has accumulated over bedrock, silt-dwelling infauna are the most abundant taxa. Sea anemones, sea cucumbers and parchment tubeworms are present throughout the site at low abundance. The steep rock faces in the northern section of the PDA provide habitat for tubeworms, particularly calcareous tubeworms, brachiopods and green sea urchins. Hexactinellid sponges (glass sponges) were observed in deeper areas, where they were generally associated with steep, rugged bedrock substrate. Sponges were particularly abundant at the southern end of the survey area, just outside the PDA. Less than 25% of sponge aggregations in the southern region of the PDA showed evidence of active growth and many of the remaining sponges were partially or completely buried in silt. Sponges were also present, although in much lower abundance, on the cliff faces in the northern region of the PDA.

In May 2011 a dedicated sponge survey was undertaken in Kitimat Arm. The purpose of this survey was to characterize the distribution of glass sponges in Kitimat Arm. Using a remote operated vehicle (ROV), forty-four transects were surveyed at eight sites located on both the west and east sides of Kitimat Arm. Sponges were observed in each of the survey areas and were common throughout Kitimat Arm. Consistent with sponge ecology, glass sponges were most abundant in relatively deep waters (31 to 60 m) with adequate water currents and hard substrate with little or no sediment accumulation. Most fish observed during the survey were found over soft-sediment substrates and were not associated with sponges. Detailed results of the sponge survey are presented in Appendix A.

During the subtidal surveys, several commercially harvested invertebrate species were observed in the PDA, including Dungeness crabs, tanner crabs, prawns and shrimp. Crabs and shrimp were most abundant in the southern portion of the PDA and prawns were most abundant in the northern portion. Fish were observed to be in relatively low to moderate abundance throughout the site. Common species observed over soft sediment habitats included gobies, sculpins, ratfish, flatfish, eelpouts and northern ronquils. Despite the abundance of steep bedrock habitat, only two rockfish were observed within the PDA: one copper rockfish and one quillback rockfish.

In addition to providing habitat for benthic fish and invertebrates, subtidal habitats within the PDA are presumably used in some capacity by migratory fish such as salmon, herring and eulachon. For example, Kitimat River supports large runs of chum, pink, sockeye, coho and chinook salmon. Some these fish pass through the PDA, either as adults bound for spawning habitats or juveniles bound for offshore waters. The extent to which these and other harvested fish species use the subtidal habitat within the PDA is unknown; however; the relatively low structural complexity and limited biotic diversity of this habitat suggests that its value as foraging and/or nursery habitat is limited.

2.2 Intertidal Habitat

Two intertidal habitat types were identified within the PDA: boulder and cobble, and rock wall and ramp. Both habitats are steep (25-35º for boulder and cobble, 70-100º for rock walls) and consist almost exclusively of rock. Finer sediments such as gravel, sand and shell debris are found in small pockets amongst the larger rocks in the mid to low intertidal zone. No sand beaches or mudflats occur within the PDA.

Intertidal habitats in the PDA show typical patterns of intertidal zonation. The high intertidal zone is dominated by rockweed (*Fucus gardneri*), which provides habitat for periwinkles (*Littorina* spp.) and limpets (*Tectura* spp.). Barnacles (*Balanus glandula*) are most abundant in the mid intertidal zone on rock walls and on the upper portions of large boulders. Mussel (*Mytilus* spp.) beds are found predominantly on rock walls in the mid to low intertidal zone. Algal diversity increases in the low intertidal zone, with a mix of reds (e.g., *Mastocarpus* spp., *Odonthalia* spp., *Halosaccion glandiforme*), greens (e.g., *Acrosiphonia coalita*, *Ulva* spp.), and browns (e.g., *Laminaria* spp., *Sargassum muticum*). Shore crabs (*Hemigrapsus* spp.) are common beneath cobble and in amongst boulders in the mid and low intertidal zones.

For a complete list of species identified during the intertidal field surveys, the reader is referred to the Marine Fish and Fish Habitat TDR, Appendix B (Beckett and Munro 2010). Overall, species diversity (algae and invertebrates) within the PDA is low. This is typical of north coast fjord environments, which are not exposed to the nutrient rich upwelling that occurs along the exposed coast. Intertidal habitats within the PDA are also subjected to large inputs of fresh water from nearby Kitimat River, as well as high concentrations of suspended solids. These stressors may act to limit the number of species that are able to survive in this environment.

Although not identified during the field surveys, juvenile fish such as salmon, herring and eulachon likely utilize intertidal habitats within the PDA. Juvenile fish typically forage in shallow waters and migrate along shorelines, making use of microhabitats created by rocks and algae. For example, rockweed, with its gas filled bladders, provides a floating three-dimensional matrix for juvenile fish to forage and avoid predation. Rockweed and other intertidal algae also support a diverse community of microinvertebrates that juvenile fish prey upon.

2.3 Marine Riparian Vegetation

Marine riparian systems are areas on land bordering tidewater and constitute the interface between terrestrial and aquatic systems (Brennan and Culverwell 2004). Riparian habitats provide a number of ecosystem services and functions in marine systems. These functions include maintaining water quality by stabilizing soils and reducing erosion; creating microclimates by providing shade and habitat structure; and enhancing local productivity through inputs of vegetative matter and terrestrial insects (Brennan and Culverwell 2004). Although most research has been done on freshwater riparian systems, evidence suggests that marine riparian vegetation plays an important role in fish health by improving habitat quality in the nearshore marine environment.

Marine riparian vegetation is considered to be any vegetation within 10 m of tidewater. In the PDA, marine riparian vegetation grows on a steep, rocky shoreline well above the high water mark. The marine riparian zone adjacent to the marine terminal is densely populated with western hemlock, western red cedar, Amabilis fir, Sitka spruce and some Douglas fir. Small shrubs occupy the understory environment and the shoreward limit of the riparian vegetation zone. Common shrub species include salmonberry, salal, Devil's club, and various species of fern and bramble.

3 Project Components that Will Affect Marine Fish Habitats

The Kitimat Terminal will be located on the west side of Kitimat Arm, approximately 5 km south of the existing Alcan facility. In-water infrastructure will include two tanker berths as well as a utility berth that will be used to support construction activities and service tugs during operations (Figure 3-1). On-shore infrastructure will include oil and condensate storage tanks, hydrocarbon transfer systems, a remote impoundment reservoir, and a variety of maintenance, storage and control room buildings (Figure 3-1).

The following sections describe the terminal components presented in the May 2010 Application, Volume 3, Section 9.6. Detailed design of in-water and on-shore terminal infrastructure has not yet been completed; therefore, the terminal components described here are subject to change. Any changes to the proposed design of the Kitimat Terminal, including structure types, layout and methods of construction, will be included in the final marine fish habitat compensation plan.

3.1 Tanker Berths

The two tanker berths will be designed to handle a range of tanker sizes, from Aframax (~80,000 DWT) to VLCCs (~320,000 DWT). The tanker berths will each have the following major components:

- loading platform with gangway tower
- access trestles and catwalks
- berthing and mooring structures

Several design options exist for the structure type and methods used to construct each of the major components of the tanker berths. For each component, two structural options indicative of the range of viable alternatives were evaluated and the preferred option was selected. A number of factors were considered when evaluating the potential options, including the amount of marine habitat that could be adversely affected, the geotechnical properties of the seafloor, and the cost of construction activities. The objective of this selection process was to ensure the stability of terminal structures while minimizing the loss or alteration of marine fish habitat.

3.1.1 Loading Platforms

The loading platform at each tanker berth provides the interface for moving hydrocarbons between the tanker and on-shore facilities. The loading platforms are designed as independent structures that support the loading arms, and may have a deck area of approximately 35 m wide by 58 m long. For the loading platforms, the two structural options evaluated were a jacket structure option and a pile and deck structure option.

For the jacket structure option, the concrete deck slabs of the loading platform are supported on modular steel framing and dual jacket structures. Each jacket structure consists of a four-legged, fully braced, tower-like steel assembly that is approximately 40 m high. The towers would sit on a level bench on the seabed excavated into the sloping bedrock and would be anchored to the rock to resist lateral forces.

For the pile and deck structure option, a composite concrete slab and box-girder deck is supported on individual steel piles and pile caps. The individual piles would all be vertical and may be either partially or entirely filled with concrete.

The pile and deck structure option was selected as the preferred option because it requires less rock blasting and will result in less disturbance of marine habitat. The pile and deck option also limits potential construction and operation issues associated with the quality of underlying bedrock.

3.1.2 Access Structures

Pile-supported access trestles will provide access from the shore to the loading platforms. The access trestles will be designed to accommodate a single lane roadway and the piping and utilities that extend from the shore onto the loading platform. A series of catwalks will also be in place to provide workers with access between the loading platforms and the berthing and mooring structures. Conventional pile and deck construction similar to the loading platform will be used for the access trestles.

3.1.3 Berthing and Mooring Structures

The berthing structures will be independent structures located on either side of the loading platform and will be fitted with rubber fenders designed to absorb the lateral forces from a berthing tanker. Four fender locations, two on each side of each loading platform, will accommodate the range of design vessels. For the berthing structures, the two structural options evaluated were a full jacket structure option and a buttressed (stiff-leg) structure option.

The full jacket structure option is similar to the jacket structure option evaluated for the loading platforms and uses the same member sizes and dimensions. The base of each jacket structure would be set on flat rock benches on the seabed excavated into the sloping bedrock and anchored to the rock. For the buttressed or “stiff-leg” structure option, instead of individual berthing structures as proposed in the full jacket structure option, each set of side-by-side berthing structures would be combined into one structure that is laterally supported by two stiff-leg space frames mounted to onshore concrete abutments.

The buttressed (stiff-leg) structure option was selected as the preferred option because it requires considerably less rock blasting and will result in less disturbance of marine habitat.

The decks of the berthing structures will consist of steel grating on a steel frame that is supported on the superstructure of the jackets or vertical piles. Mooring hardware will be anchored to a concrete slab cast into the deck frame of each structure. Alternative forms of construction could include either pre-cast or cast-in-place concrete caps, set on piles with mooring hardware anchored to the top surface.

Due to the proximity of the shoreline to the tanker berths, mooring structures may be located in the water, on-shore or a combination of both. An on-shore mooring structure option is preferred because it requires less rock blasting and will result in less disturbance of marine habitat. On-shore moorings will result in:

- mooring structures being located above the highest high water level (HHWL) with no disturbance of in-water marine habitats

- less drilling and blasting in intertidal and/or subtidal habitats
- less shading of intertidal and/or subtidal habitats

The mooring structures will use rock-anchored concrete abutments and the mooring hardware will be cast directly into the mass concrete of the mooring structures.

3.2 Utility Berth

The utility berth will be located to the immediate north of the two tanker berths. It will have facilities that can accommodate the mooring of harbour tugs and two utility work boats. The utility work boats are required primarily for maintenance of the tanker berths and deploying the containment boom. The berth may also be used for short-term docking of the whale spotting vessel or other small project vessels. A davit system will be used to launch the utility boats from the utility berth deck and retrieve the boats for stowage and maintenance.

Two options were considered for the berth construction: a concrete caisson and a floating structure. The concrete caisson was rejected on the basis that it entailed much more rock blasting and would result in more disturbance of marine habitat. The preferred option is a floating dock held in place by steel piles.

3.3 On-shore Terminal Components

The land-based components of the Kitimat Terminal will be constructed adjacent to the tanker berths and will occupy a land area of approximately 220 ha. Major on-shore components will include:

- 11 oil tanks and 3 condensate tanks
- hydrocarbon transfer systems
- a remote impoundment reservoir
- oil receiving facilities
- an initiating condensate pump station
- a variety of maintenance, storage, electrical and control room buildings

Construction of land-based terminal components will not affect intertidal or subtidal marine fish habitats. However, site preparation will involve the removal of most, if not all, of the marine riparian vegetation within the PDA.

4 HADD Quantification for Marine Fish Habitats

The anticipated areas of marine HADD attributable to the Project are calculated based on preliminary engineering and design plans for the marine terminal. For the purposes of these calculations, it is assumed that the tanker berths (loading platforms, access trestles, and berthing and mooring structures) will be constructed using the pile and cap option and that the utility berth will be constructed using a combination of caissons and piles. As noted previously, detailed design of the marine infrastructure has not yet been completed; therefore, the structure types and methods used to construct the terminal components may change. As a result, the areas of marine HADD presented here should be considered approximate. Once detailed design of the marine terminal is complete, the spatial extent of marine HADD will be re-quantified, and these values will be included in the final marine fish habitat compensation plan.

4.1 Calculating HADD

Areas of marine HADD are calculated separately for subtidal habitat, intertidal habitat and marine riparian habitat. This process reflects the value of each habitat type. In general, intertidal and subtidal habitats are considered more valuable to marine biota than marine riparian vegetation. Whereas riparian habitats provide only indirect benefits through the provision of shade and terrestrial organics, intertidal and subtidal habitats support diverse assemblages of macroalgae and invertebrates, and provide complex habitat for juvenile and adult fish.

To calculate the spatial extent of HADD for each of the three habitat types, terminal engineering drawings showing the footprint of in-water infrastructure and areas of physical works (e.g., rock blasting, dredging) were overlaid onto a base map with bathymetric contours. Habitat types are defined as follows:

- *Subtidal:* below 0 m chart datum
- *Intertidal:* between 0 m and the highest high water level (HHWL), which in Kitimat Arm is approximately +6.5 m
- *Marine Riparian:* between HHWL and 10 m inshore (horizontal distance)

ArcMap GIS software was used to calculate the spatial extent of affected habitats (m^2). Areas of marine HADD associated with the southern tanker berth, northern tanker berth and utility berth are shown on Figures 4-1, 4-2 and 4-3, respectively.

4.2 Subtidal HADD

Blasting and dredging will be required at each pile location to prepare the seafloor for pile installation. These activities will result in the physical alteration of subtidal habitat. Specifically, the removal of soft sediment overburden and the creation of rock benches will expose vertical and horizontal rock faces, increasing the amount of bare rock in the PDA. Although organisms currently inhabiting the work area will be lost, the exposed bedrock will be available for colonization as soon as the physical works are completed. Therefore, this effect is considered an alteration rather than a loss.

Based on the current terminal design, in-water site preparation will result in the physical alteration of approximately 16,040 m^2 of subtidal marine habitat. This includes 7,007 m^2 for the southern tanker berth, 7,752 m^2 for the northern tanker berth, and 1,281 m^2 for the utility berth.

Once blasting and dredging is complete, steel piles will be seated on the rock benches and drilled and grouted into the bedrock. The number and size of piles that will be installed to support the two tanker berths and the utility berth will not be known with confidence until detailed design has been completed. The current estimate is for a total of 155 piles: 74 for the southern tanker berth, 77 for the northern tanker berth, and 4 for the utility berth. The diameter of the piles will likely be approximately 1.5 m. In addition, three concrete caissons measuring 9 m x 9 m may be installed to support the utility berth. The installation of both piles and caissons will result in the permanent loss of subtidal habitat.

Based on the current terminal design, pile and caisson installation will result in the loss of approximately 353 m^2 of subtidal marine habitat. This includes 44 m^2 for the southern tanker berth, 66 m^2 for the northern tanker berth, and 243 m^2 for the utility berth.

Depending on the final layout of the tanker berths, some dredging and/or blasting may be required to provide adequate under-keel clearance for the large tankers. This will be confirmed during detailed design of the marine terminal.

4.3 Intertidal HADD

Some of the piles installed to support the access platforms and mooring structures will be located in the intertidal zone. At each of these locations, rock benches will be blasted into the bedrock to seat the piles for drilling. This will result in the loss of intertidal flora and fauna and the physical alteration of intertidal habitat. Given that the existing habitat is dominated by steep bedrock walls and large boulders, the alteration will not represent a drastic change to the physical character of the habitat. It is expected that intertidal organisms will begin recolonizing the affected areas as soon as construction activities are completed.

Based on the current terminal design, in-water site preparation will result in the physical alteration of approximately 3,757 m^2 of intertidal marine habitat. This includes 1,906 m^2 for the southern terminal berth, 1,229 m^2 for the northern terminal berth, and 622 m^2 for the utility berth.

The installation of large diameter steel piles will result in the permanent loss of approximately 29 m^2 of intertidal habitat. This includes 22 m^2 for the southern tanker berth, 4 m^2 for the northern tanker berth, and 3 m^2 for the utility berth.

4.4 Marine Riparian HADD

Marine riparian vegetation within the PDA will be cleared to provide construction access to the berth sites and to make room for land-based infrastructure. The total area of marine riparian vegetation within the PDA is 18,339 m^2. For the purpose of quantifying HADD, it is assumed that this entire area of marine riparian vegetation will be permanently lost. This is considered to be a conservative assumption, as it may be possible to preserve some segments of the existing vegetation.

4.5 Marine HADD Summary

The total areas of marine HADD associated with construction of the Kitimat Terminal are shown in Table 4-1, below. These values should be considered approximate, as they are based on preliminary engineering of terminal components. As soon as detailed design has been completed, marine HADD will be re-quantified and the final area calculations will be presented in the final marine fish habitat compensation plan.

Table 4-1 Type and amount of marine fish habitat affected by the Project

		Area of Affected Habitat (m^2)			
Habitat Type	**HADD Type**	**Total**	**Southern Tanker Berth**	**Northern Tanker Berth**	**Utility Berth**
Subtidal habitat	Alteration	16,040	7,007	7,752	1,281
Subtidal habitat	Loss	353	44	66	243
Intertidal habitat	Alteration	3,757	1,906	1,229	622
Intertidal habitat	Loss	29	22	4	3
Marine riparian vegetation	Loss	18,339	-	-	-
Total HADD		**38,518**	**8,979**	**9,051**	**2,149**

5 Habitat Compensation Strategy

The objective of this conceptual habitat compensation plan is to ensure that the Project does not diminish the productive capacity of existing marine fish habitats. A number of important fish species, including salmon (*Oncorhynchus* spp.), herring (*Clupea pallasii*), eulachon (*Thaleichthys pacificus*) and rockfish (*Sebastes* spp.) spawn and rear in the marine habitats of northern Kitimat Arm and in the freshwater habitats in the surrounding watershed. These species support valuable recreational, commercial and food, social and ceremonial (FSC) fisheries and are integral to the social and economic wellbeing of local communities.

Compensation for marine fish habitats affected by the Project should focus on the creation and/or enhancement of physical and biological habitats that support harvested finfish species. The compensation options presented in the following sections are based on well-established techniques that have been successfully implemented elsewhere in British Columbia and throughout North America. These options are presented according to DFO's goals of conservation, restoration and development of fish habitat in order to achieve 'no net loss' of productive capacity.

The final compensation strategy will be determined through discussions with Fisheries and Oceans Canada (DFO), participating Aboriginal organizations and potentially-affected stakeholders. This strategy will likely include one or more of the options presented in this report, but may also incorporate additional compensation opportunities identified by the participants. Northern Gateway is committed to working with all interested parties to identify the most appropriate means of compensating for marine fish habitats affected by the Project. The list of options presented in this report is not intended to be exhaustive; rather, it is a basis for initiating discussions with the various participating groups. Northern Gateway fully expects that these discussions may lead to the identification of additional compensation options, or at a minimum, the refinement of the options presented in this report.

5.1 Option 1: Subtidal Reef Creation

One of the most effective methods for increasing the productive capacity of marine fish habitat is through the creation of artificial reefs. Typically constructed of a hard material such as rock or concrete, artificial reefs increase the structural complexity of the marine environment and provide habitat for a diverse assemblage of marine biota. In Kitimat Arm, a subtidal reef located in the nearshore environment would provide foraging habitat and refuge for a number of harvested fish species, including juvenile salmon, herring, rockfish and possibly even eulachon.

In terms of DFO's hierarchy of compensation options, the creation of a subtidal reef would represent a Level 1 option because it involves replacing like-for-like habitat in the same ecological unit (DFO 2010). Most of the intertidal habitats affected by the Project are composed of boulders and bedrock, and the subtidal habitats are a mix of exposed bedrock and soft sediment overburden. A subtidal rock reef will have the same natural integrity, structure and function as these existing habitats. This type of compensation is favored because it is assumed to have the greatest likelihood of meeting the no net loss objective.

The solid rock foundations provide anchoring sites for algae and sessile invertebrates, enhancing primary productivity and biotic diversity. Crevices and interstitial spaces within a reef provide foraging habitat and refuge for a variety of mobile invertebrates and demersal fish. Fish are attracted to the structural complexity of the reef landscape and to the prey resources that a reef supports. It is well documented that subtidal reefs provide valuable habitat for many commercially and recreationally harvested species (Buckley and Hueckel 1985; Hueckel et al. 1989).

To maximize the ecological benefits of a subtidal reef, it should be constructed within the photic zone (i.e., the zone that receives incoming sunlight). In Kitimat Arm, this is likely no deeper than 20 m below the surface. Situating the reef in the photic zone will promote the establishment and growth of algae, which will provide food and habitat for fish and invertebrates. A shallow-water reef will also be exposed to subsurface wave energy, which will increase dissolved oxygen levels and food delivery (e.g., plankton) around the reef. To maximize the reef's value as finfish habitat, it should be constructed as close to shore as possible. Many juvenile fish rear in near-surface waters close to shore, including salmon, which are often encountered migrating along shorelines.

Ideally, the subtidal reef would be constructed as close as possible to the area of habitat loss (i.e., within the PDA); however, a number of factors must be considered when choosing a suitable location. The reef should be constructed on a relatively flat bottom that does not have a thick layer of soft-sediment overburden. Steep slopes will not support the rocks used to construct the reef, and thick sediments may cause the reef to subside. The location of the reef must also be chosen to ensure that the safe navigation of vessels in Kitimat Arm is not affected. For example, the reef cannot be constructed too close to the berth sites, as this could interfere with the movements of tankers. It is also important to ensure that there are no future development plans for a site that could affect the ecological value of the subtidal reef habitat.

Two potential locations for a subtidal reef have been identified based on a preliminary assessment of bathymetry in the upper Kitimat Arm: Emsley Cove and Moon Bay. Emsley Cove is located on the west side of Kitimat Arm, approximately 5 kilometers south of the PDA. Moon Bay is also located on the west side of Kitimat Arm, approximately 4 kilometers north of the PDA. Both locations appear to have suitable depth and seafloor slope and do not overlap with any known future developments. From a geotechnical perspective, Emsley Cove is the preferred site. This is due to concerns regarding the stability of overburden material in Moon Bay. In 1976, a large submarine landslide occurred at the north end of Moon Bay during the construction of a rip-rap breakwater. Although the volume of rock used to build a subtidal reef would probably be insufficient to trigger such an event, the possibility still exists.

From an ecological perspective, Emsley Cove is also the preferred location for a subtidal reef. Numerous eelgrass meadows are reported to occur in the shallow, nearshore waters of Emsley Cove. These meadows likely provide valuable nursery habitat for juvenile salmon migrating out of the Kitimat River, as well as juvenile herring and eulachon. Constructing a subtidal reef seaward of the existing eelgrass meadows would increase the complexity of nearshore habitats in Emsley Cove, providing additional habitat for fish. To ensure that Emsley Cove is indeed suitable for the construction of a subtidal reef, a subtidal habitat survey would have to be conducted by divers or an ROV with video capabilities.

Construction of a subtidal reef would entail the placement of large quantities of rock on the seafloor. Rocks used to construct a reef could be derived from marine blasting and dredging activities within the Project footprint. This beneficial re-use of materials is preferable to acquiring rocks offsite, as it reduces the amount of material that will be disposed of on land, and reduces the cost of the habitat compensation program. Using rocks from the marine environment also reduces the likelihood of introducing materials that could affect water and/or sediment quality (e.g., acid rock drainage). Alternatively, if Project construction activities do not produce rock of sufficient quality or quantity, rocks will be sourced from an on-land quarry. To maximize the structural complexity of the reef, the majority of rocks should be approximately 1.0 m in diameter. Rocks of this size will be of various shapes and not fit tightly together. This will ensure that crevices and interstitial spaces are created within the reef, which will provide habitat for a variety of fish and invertebrates.

If the subtidal reef option is selected to be part of the final compensation strategy, detailed design drawings will be developed. The design would have to take into account the effect of the reef on existing habitat (which would be included in the overall calculation of HADD and the eventual habitat compensation goal). Specific design variables such as the size, shape and height of the reef will be determined based on the results of the habitat survey and any geotechnical investigations that are considered necessary. These design drawings will be submitted along with a construction plan as part of the final marine fish habitat compensation plan.

5.2 Option 2: Eelgrass Transplants

Eelgrass meadows are among the most productive marine ecosystems. In the northeast Pacific, carbon fixation can range as high as 8 g C per m^2/day (McRoy 1970). This primary productivity forms the basis of important links in many marine food webs and ultimately supports both local and regional fisheries (Valentine *et al.* 2002). In British Columbia, eelgrass meadows provide extremely valuable habitat for a number of economically, culturally and ecologically important species including juvenile salmon (*Oncorhynchus* spp.), Pacific herring (*Clupea pallasii*), rockfish (*Sebastes* spp.), and Dungeness crab (*Metacarcinus magister*) (Wilson and Atkinson 1995; Nelson and Waaland 1997).

The rooted, rhizomatous basal system and canopy of eelgrass add structural complexity to simple mud and sand substrata, thus providing nursery and refuge habitat for infaunal and epifaunal organisms (Nelson and Waaland 1997; Heck et al. 1989). Eelgrass beds stabilize fine benthic sediments, thus restricting erosion and supporting a higher biomass and diversity of biota than would otherwise be present (Phillips 1984). The habitat complexity provided by eelgrass beds is important for predator avoidance by juvenile fish in the nearshore environment; for instance, eelgrass forms a hiding place for herring eggs and young, which is a major food source for salmon, seabirds, seals and other marine mammals.

Although no eelgrass meadows will be affected by the Project, eelgrass is commonly featured in compensation programs owing to its high productive capacity. Transplanting eelgrass involves the relocation of viable seedlings grown in aquaria, or mature plants taken from healthy donor beds, to a suitable restoration site. Standard planting techniques offer low to moderate risk, though they tend to be extremely labour intensive, requiring divers to plant the individual units by hand.

The establishment of a transplanted eelgrass meadow represents a Level 2 option on DFO’s hierarchy of compensation options because it involves creating unlike habitat in the same ecological unit (DFO 2010). However, given its high productive capacity and limited abundance in Kitimat Arm, an eelgrass meadow is probably more valuable than the habitat that will be affected by the Project.

Transplanted eelgrass meadows have been successfully established at a variety of sites along the coast of British Columbia. In a review of 15 eelgrass transplant projects completed between 1985 and 2000, seven were rated as successful and three as failures (Precision Identification 2002). The success of one site could not be determined due to the expansion of the surrounding natural population, and the remaining four sites were planted too recently to be evaluated. However, these sites demonstrated good development and were expected to be classified as successes within several years.

The success of a transplanted eelgrass meadow is predicated on the selection of a suitable transplant site. The primary environmental factors that affect the growth and survival of eelgrass include light availability, sediment type, current velocity and salinity (Phillips 1974). Most eelgrass meadows are found between 0 m chart datum (mean lowest low water level; MLLW) and -6.6 m chart datum. Desiccation at low tide limits the upper distribution of eelgrass in intertidal areas, and reduced light penetration at depth limits the lower distribution. Mixed sand and mud is a key requirement for eelgrass, as the shoots are rooted into the substrate. Healthy eelgrass shoots produce subsurface rhizomes, which allow the plants to spread through vegetative reproduction. Most eelgrass meadows are located in physically sheltered environments such as estuaries, bays and shallow inlets. Low to moderate currents may enhance eelgrass growth; however, strong currents break leaves and may scour the substrate from around the rhizomes, uprooting the plants. Eelgrass meadows are often found near the mouths of small streams, indicating that they are quite tolerant to changes in salinity. Research suggests that the optimum range of salinity is between 10 and 30 ppt (Phillips 1974).

To maximize the likelihood of successful establishment and growth of transplanted eelgrass, a restoration site should encompass one or more existing eelgrass meadows. Sites with existing meadows are more likely to have the appropriate physical attributes and experience suitable environmental conditions. Two potential transplant sites have been identified south of the PDA: Bish Cove and Emsley Cove. No eelgrass meadows are known to occur north of the PDA, likely due to the steep bathymetry of Kitimat Arm, the heavy sediment input from the Kitimat River, and historical contamination of marine sediments. Although both sites are known to contain intertidal and subtidal eelgrass meadows, Bish Cove is currently the site of an LNG terminal development project. Emsley Cove has no known future development plans and is therefore the preferred transplant site.

To identify the most appropriate location(s) in Emsley Cove for eelgrass transplants, both intertidal and subtidal habitat surveys would have to be conducted. If suitable unvegetated habitats exist, planting could be accomplished without the need for any physical habitat modifications. However, it may be necessary to add fine grained sediments along the outer margin of the existing eelgrass meadows to increase the area of suitable depth within the restoration site. To prevent this material from being eroded by currents and wave action, a rock berm would have to be constructed along the seaward edge. The need for these physical works would depend on the specific characteristics of the restoration site, which would be determined through the habitat surveys.

If the eelgrass transplant option is selected to be part of the final compensation strategy, detailed design drawings and construction plans will be developed and submitted along with the final marine fish habitat compensation plan.

5.3 Option 3: Freshwater Habitat Enhancement

The Kitimat River and its tributaries support a number of anadromous fish species that are harvested by commercial, recreational, and FSC fisheries. This includes all five species of Pacific salmon, steelhead, cutthroat trout, and eulachon. Despite the productivity of Kitimat River, habitats in its lower reaches have been severely degraded by a variety of anthropogenic activities, including forestry and urban development. The loss of natural spawning and rearing habitats in lower Kitimat River may be partly to blame for the historic declines in salmon escapement and the more recent decline in eulachon numbers.

Given the importance of Kitimat River as fish habitat and its proximity to the Project site, it may be appropriate to undertake freshwater/estuarine enhancement works as part of the marine compensation program. Recent precedents for applying in-stream compensation to marine HADD include the Kitimat LNG Project's proposal to restore side channel habitats in the Kitimat River floodplain. The plan involves the removal of two segments of the old Rio Tinto Alcan dyke to restore connectivity to salmonids rearing habitats. Boulders and large woody debris will also be introduced to enhance the productive capacity of in-stream habitats. This plan has received a high level of support from DFO and local First Nations.

The focus of any potential compensation projects in lower Kitimat River should be on improving salmonid and/or eulachon spawning and rearing habitats. These species have high economic and cultural importance and are integral to the health of marine and freshwater ecosystems. Although Northern Gateway has not yet identified any specific compensation projects in lower Kitimat River, First Nations and local DFO representatives may have insight into potential opportunities. If a suitable freshwater habitat enhancement project is identified, Northern Gateway will work with DFO to determine whether it is appropriate to be included in the marine fish habitat compensation plan.

Undertaking freshwater habitat enhancement represents a Level 3 option on DFO's hierarchy of compensation options because it involves increasing the productive capacity of fish habitat in a different ecological unit (freshwater vs. marine) (DFO 2010). This type of approach is generally less preferred than marine-for-marine compensation; however, there are circumstances in which a Level 3 option is considered appropriate. These include situations where limitations to productive capacity are known, such as is the case for lower Kitimat River. In addition, compensation in Kitimat River would benefit anadromous fish species such as salmon and eulachon, which also make use of nearshore marine habitats in Kitimat Arm.

5.4 Option 4: Partnership with Aboriginal Organizations or Non-aboriginal Local Stewardship Group

As part of one or more of the compensation options described above, it may be possible to partner with an external non-government organization that focuses on fish habitat restoration projects. Ideally, the partnership would involve an Aboriginal organization and/or a non-aboriginal stewardship group based in Kitimat or the surrounding region. Members of the organization could help develop and implement the compensation works and/or assist with habitat monitoring. Alternatively, funding and/or professional resources could be provided to the organization to support an existing program that involves marine or freshwater enhancement works.

Northern Gateway is committed to identifying fish habitat compensation opportunities that will not only meet DFO's no net loss objective, but also provide benefits to local users, especially participating Aboriginal organizations. Establishing a partnership with an Aboriginal organization and/or a non-aboriginal stewardship group would help to ensure that the compensation program is developed and implemented in a manner that is consistent with the values of local residents. In addition, integrating local knowledge and resources into the compensation program would undoubtedly increase the likelihood of success.

5.5 Timing of Compensation Works

Once constructed, a compensation habitat may take up to several years to reach its full productive capacity. This is generally attributed to the time it takes for biotic communities to become fully established, which varies by habitat type. For example, it may take 1-2 years for a transplanted eelgrass meadow to develop an infaunal community and 2-3 years for an artificial rock reef to become fully colonized by algae and invertebrates.

Most compensation habitats are not constructed until after a HADD has been incurred, resulting in a temporal loss of productive capacity. To minimize this loss, compensation measures should be implemented prior to Project construction whenever possible.

At a minimum, all compensation features should be in place within twelve months of the completion of in-water construction activities. If the Project is approved, Northern Gateway would prefer to identify, agree upon and construct appropriate habitat compensation features in advance of the start of operations of the Terminal. The exact timing will depend on which options are selected for the final compensation plan. For example, eelgrass transplants are best performed during the summer months, and freshwater in-stream works must comply with applicable work windows. The construction of a subtidal reef would also be timed to avoid potential interactions with sensitive life stages of marine species.

6 Marine Habitat Balance

Based on current engineering and design plans, construction of the Kitimat Terminal will result in the alteration or loss of approximately 38,518 m^2 of marine fish habitat. To compensate for this HADD and the associated loss of productive capacity, one or more of the compensation options presented in this report will be implemented. This will result in the creation of high value fish habitat that will provide direct and indirect benefits to a number of important fish species. Special attention will be given to maximizing benefits to salmon and eulachon, given their ecological, economic and cultural significance.

The amount of compensation provided will depend on the ultimate quantification of marine HADD as well as the type of compensation habitat(s) created. Once the final compensation features have been selected, compensation ratios will be developed in consultation with DFO. These ratios will reflect both the ecological value of affected habitats and the type of HADD incurred. Specifically, ratios will be higher for habitats that have high productive capacity and/or are permanently lost, and lower for habitats that have low productive capacity and/or are physically altered. This will ensure that the compensation balances the HADD and that there is no net loss of productive capacity.

7 Monitoring Program

Northern Gateway will implement a monitoring program to ensure that the habitat compensation works are successful and meet the objectives of the final marine fish habitat compensation plan. The monitoring program will consist of compliance monitoring, to ensure that compensatory habitats are constructed in accordance with the plan, and effectiveness monitoring, to ensure that the compensatory habitats are functioning as intended after construction.

7.1 Compliance Monitoring

Compliance monitoring for the compensation works will be integrated into the supervision of compensation habitat construction. A biologist will be on-site during start-up, at critical periods of the construction (e.g., eelgrass transplants, installation of subtidal reef components), and during any in-stream works. Information to be documented will include:

- written and photo-documented sequence of events during construction
- any changes in the design that are necessary to adapt to unanticipated conditions
- technical issues that arise during construction and how they were addressed
- confirmation that all habitat components meet the area and design requirements
- confirmation that all terms and conditions of the DFO Authorization are met.

7.2 Habitat Effectiveness Monitoring

Starting one year after completion of the marine habitat compensation measures, Northern Gateway will commence a five-year monitoring program to demonstrate the success of the compensatory habitat works as required by the DFO Authorization. Northern Gateway prefer participating Aboriginal organizations and non-Aboriginal stakeholders to participate in the monitoring program. The type and level of involvement would be determined as part of the planning process.

The specific methods used in this monitoring program will depend on the types of compensation habitats constructed. Success criteria will be established for each compensation feature and annual monitoring will be conducted to document progress toward these criteria. If success criteria are not achieved by year five, a work plan will be developed and additional works will be undertaken. Monitoring will continue until success criteria have been met.

7.3 Reporting

Results of compliance and effectiveness monitoring programs will be compiled annually and sent to DFO for review. The reports would also be provided to other participating organizations such as Aboriginal organizations and local stakeholders. After the fifth year of the effectiveness monitoring program, a summary report will be issued with recommendations based on the success of the compensation habitats.

8 References

Beckett, J., and Munro, K. 2010. *Marine Fish and Fish Habitat Technical Data Report; Enbridge Northern Gateway Project*. Report prepared by Jacques Whitford Ltd.

Brennan, J.S. and H. Culverwell. 2004. Marine Riparian: An Assessment of Riparian Functions in Marine Ecosystems. Published by Washington Sea Grant Program, UW Board of Regents, Seattle, WA. 34 p.

Buckley, R.M. and G.J. Hueckel. 1985. Biological processes and ecological development on an artificial reef in Puget Sound, Washington. *Bulletin of Marine Science*. 37(1): 50-69.

DFO. 1986. Policy for the management of fish habitat. Communications Directorate. Fish Habitat Management Branch. Ottawa, ON. 28 pp.

DFO. 1998. Decision framework for the determination and authorization of harmful alteration, disruption or destruction of fish habitat. Communications Directorate. Fish Habitat Management Branch. Ottawa, ON. 22 pp.

DFO. 2010. Practitioner's guide to habitat compensation for DFO habitat management staff. Version 1.1. Ottawa, ON. 20 pp.

Northern Gateway. 2010. Volume 3: Engineering, construction and operations. Enbridge Northern Gateway Project. 918 pp.

Northern Gateway. 2012. Conceptual fish habitat mitigation and compensation plan. Version 2.0. Enbridge Northern Gateway Project. 91 pp + appendices.

Hueckel, G.J., R.M. Buckley and B.L. Benson. 1989. Mitigating rocky habitat loss using artificial reefs. *Bulletin of Marine Science*. 44(2): 913-922.

Larkum, A.W.D., Orth, R.J., and Duarte, C.M. 2006. *Seagrasses: biology, ecology and conservation. Springer*.

McRoy, C.P. 1970. Standing stocks and other features of eelgrass (*Zostera marina*) populations on the coast of Alaska. Journal of Fisheries Research Board of Canada 27: 1811-1821

Nelson, T. and J. R. Waaland 1997. Seasonality of eelgrass, epiphyte and grazer biomass and productivity in subtidal eelgrass meadows subjected to moderate tidal amplitude. *Aquatic Botany* 56: 51-74

Phillips, R.C. 1974. Transplantation of seagrasses, with special emphasis on eelgrass, *Zostera marina*. L. Aquaculture 4:161-176.

Phillips, R. C. 1984. The ecology of eelgrass meadows in the Pacific Northwest: a community profile. US Fish and Wildlife Service. 85. Washington, DC

Precision Identification. 2002. A review and assessment of eelgrass transplant projects in British Columbia. DFO. 59 pp

Valentine, J.F., Heck Jr., K.L. and A. Cinkovich. 2002. Impacts of seagrass food webs on marine ecosystems: A need for a broader perspective. *Bulletin of Marine Science* 71: 1361-1368

Wilson, U.W. and J.B. Atkinson. 1995. Black brant winter and spring-stages use at two Washington coastal areas in relation to eelgrass abundance. *The Condor* 97: 91-98

9 Figures

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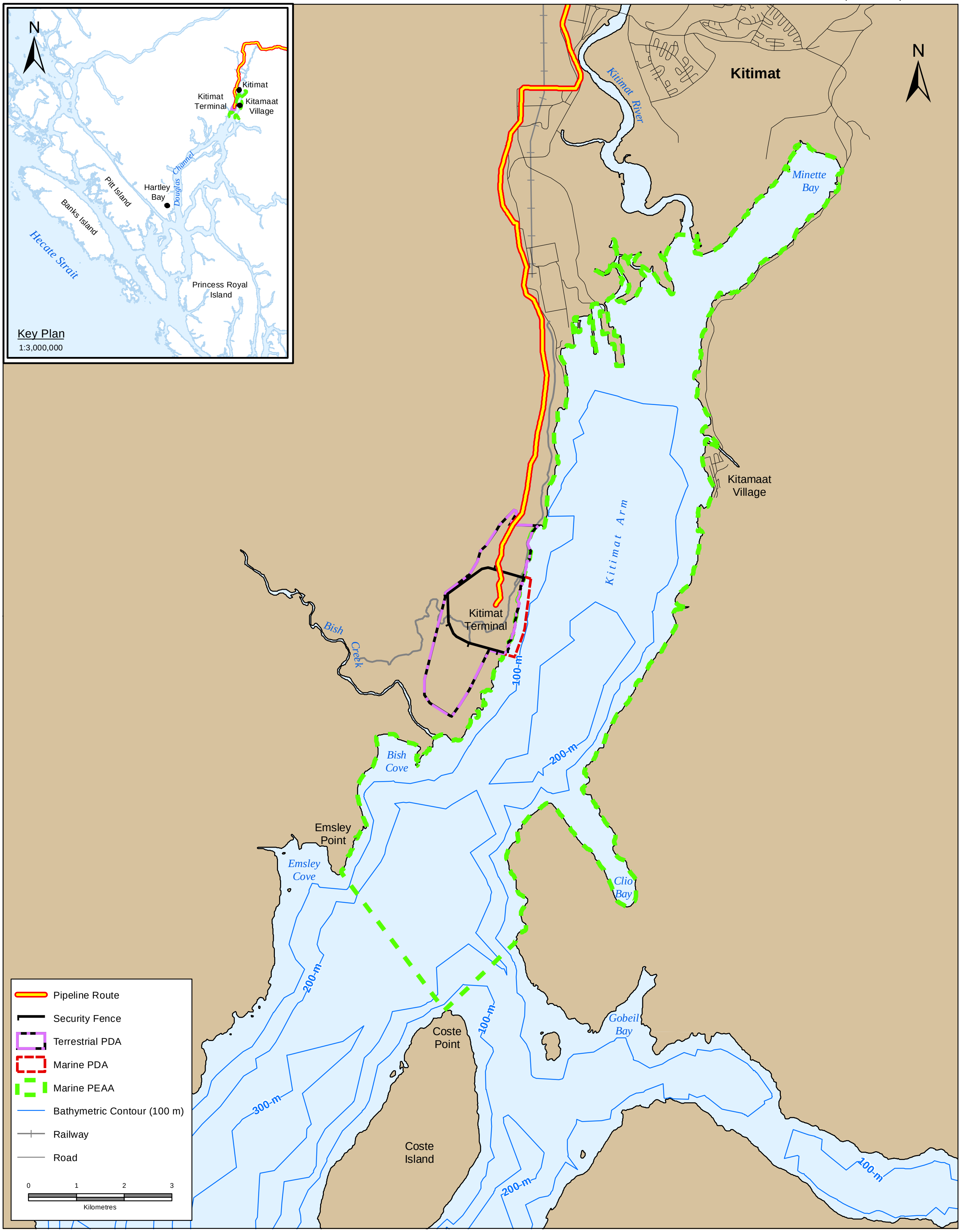

REFERENCES: NTDB Topographic Mapsheets provided by the Majesty the Queen in Right of Canada, Department of Natural Resources. All rights reserved.

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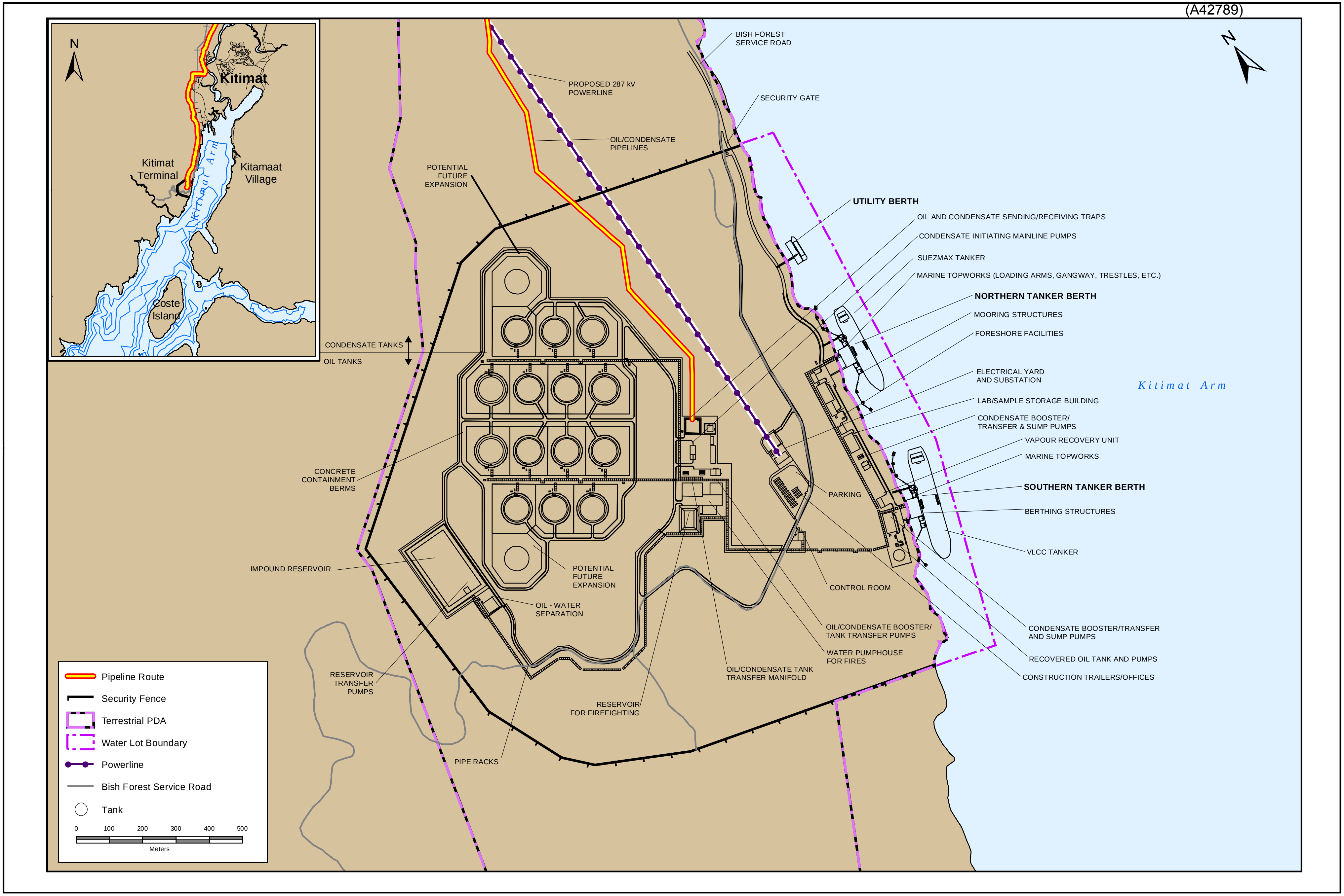
ENBRIDGE NORTHERN GATEWAY PIPELINES

MARINE PROJECT DEVELOPMENT AREA (PDA) AND PROJECT EFFECTS ASSESSMENT AREA (PEAA)

ENBRIDGE NORTHERN GATEWAY PROJECT
KITIMAT, BC

PROJECTION: UTM - ZONE 10	DRAWN BY: SS
DATUM: NAD 83	CHECKED BY: SD
DATE: 7/12/2012	FIGURE NO. 2-1



R:\2011Stantec\123510694_NorthernGateway\gis\figures\ConceptualMarineFishHabitatCompensationPlan\123510694 Fig 3-1_Preliminary Layout of the Kitimat Terminal.mxd

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ENBRIDGE NORTHERN GATEWAY PIPELINES

PRELIMINARY LAYOUT OF KITIMAT TERMINAL

ENBRIDGE NORTHERN GATEWAY PROJECT
KITIMAT, BC

PROJECTION	DRAWN BY
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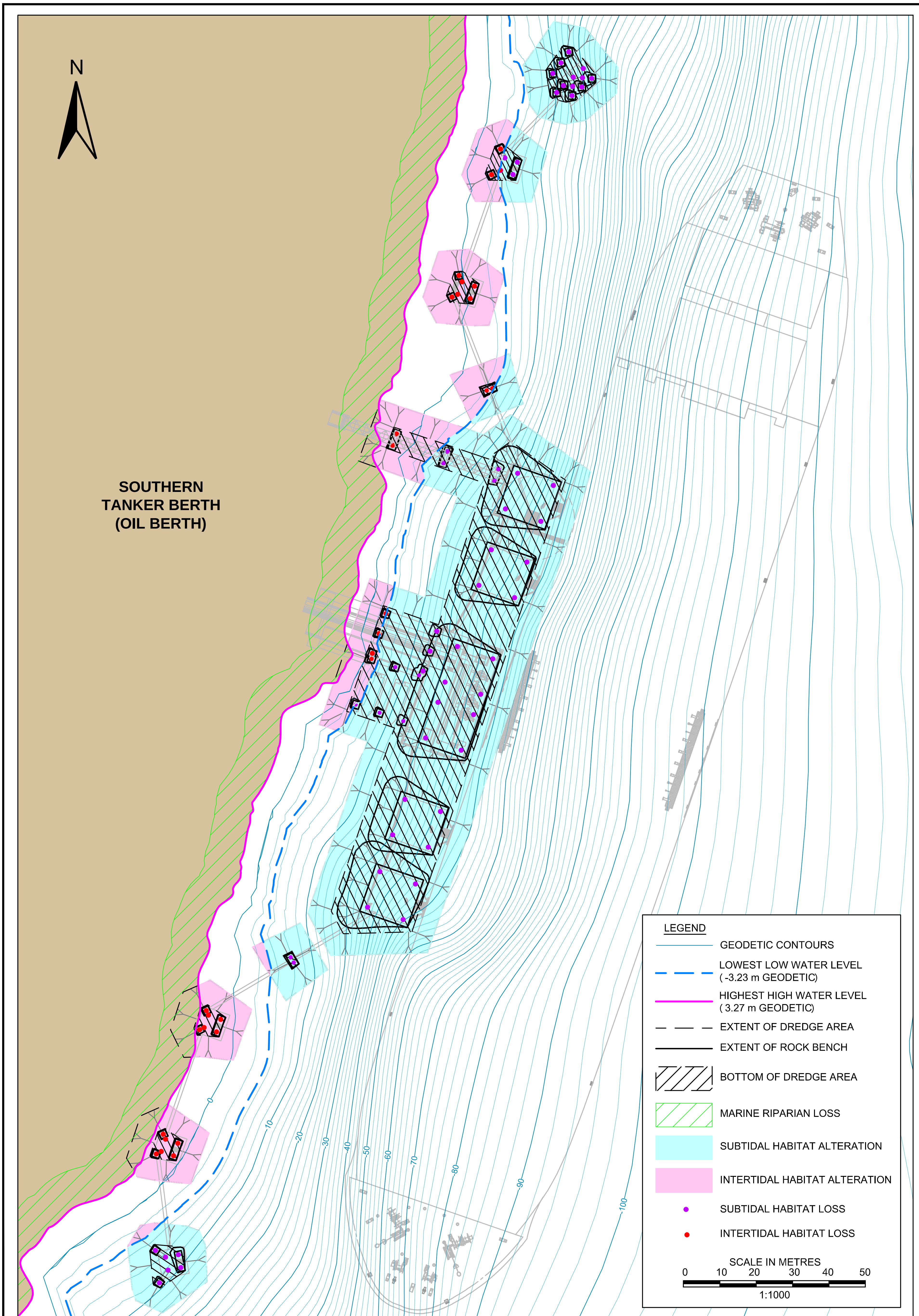

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ENBRIDGE NORTHERN GATEWAY PIPELINES

MARINE HADD - SOUTHERN TANKER BERTH
ENBRIDGE NORTHERN GATEWAY PROJECT
KITIMAT, BC

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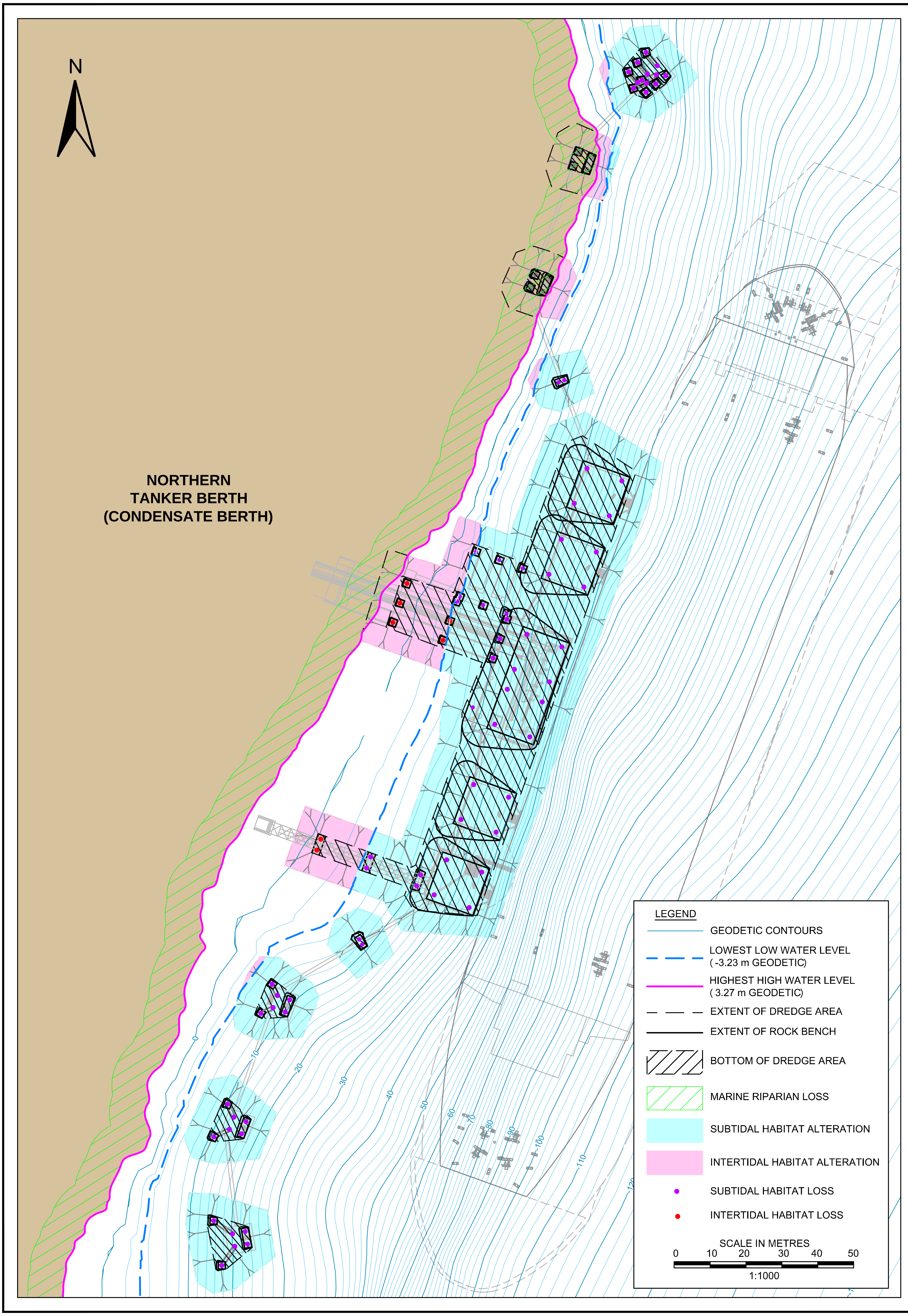

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ENBRIDGE NORTHERN GATEWAY PIPELINES

MARINE HADD - NORTHERN TANKER BERTH
ENBRIDGE NORTHERN GATEWAY PROJECT
KITIMAT, BC

PROJECTION	DRAWN BY
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DATUM	CHECKED BY
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DATE	FIGURE NO.
20-Jul-12	4-2

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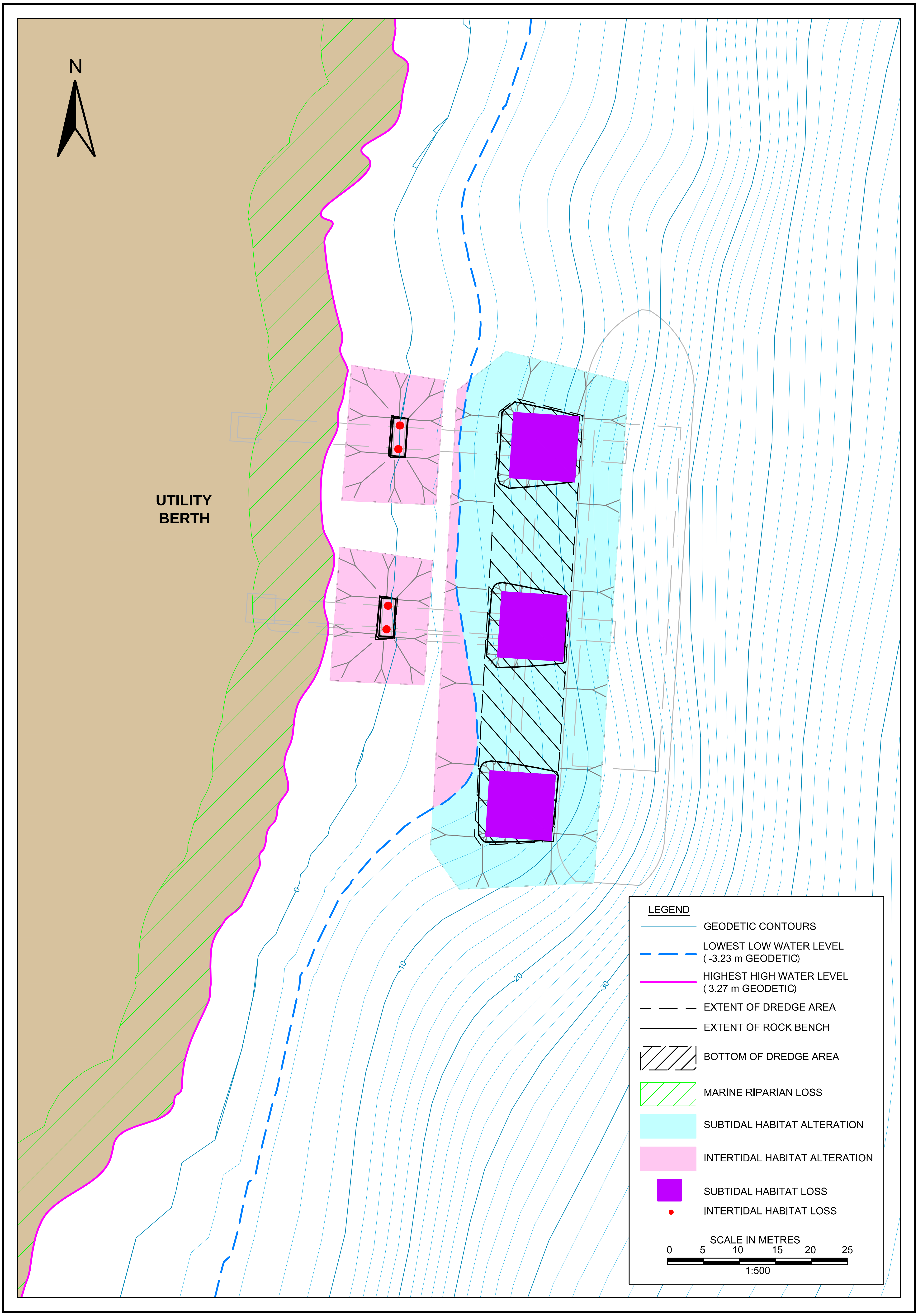

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MARINE HADD - UTILITY BERTH

ENBRIDGE NORTHERN GATEWAY PROJECT
KITIMAT, BC

PROJECTION	DRAWN BY
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20-Jul-12	4-3

Appendix A Abundance and Distribution of Sponges in Kitimat Arm

A.1 Introduction

Subtidal surveys conducted in the project development area (PDA) in June 2006 and June 2007 identified a number of sedentary invertebrate species inhabiting the steep rock walls just offshore of the Terminal site. Among these were Hexactinellid sponges, a class of sponges made of siliceous spicules, often referred to as glass sponges. These sponges are not uncommon in British Columbia; however, their biology, ecology and distribution remain poorly understood. To put the findings of these surveys in context and better understand potential effects to fish habitat, DFO requested additional information on sponges in the area and their importance to the marine ecosystem in Kitimat Arm (letter received from DFO dated December 10, 2010).

To characterize the abundance and distribution of sponges in Kitimat Ar m, Stantec contracted IUS International Underwater Surveyors and Ecostat Research Ltd. to complete a subtidal remotely operated vehicle (ROV) survey over three days from May 21 to May 23, 2011. The purpose of this study was to survey the variety of habitat types throughout Kitimat Arm and associate those characteristics with species presence, with a focus on sponges and finfish. However, these groups as well as other biota were included in the survey. Specific objectives of this survey were to:

- Estimate sponge and finfish distributions over a range of depths, hydrographic and deposition conditions and habitat types in Kitimat Arm; and,
- Estimate sponge and finfish distributions near the proposed Terminal site and place into context with findings elsewhere in Kitimat Arm.

This report provides a summary of the results of the May 2011 subtidal ROV survey.

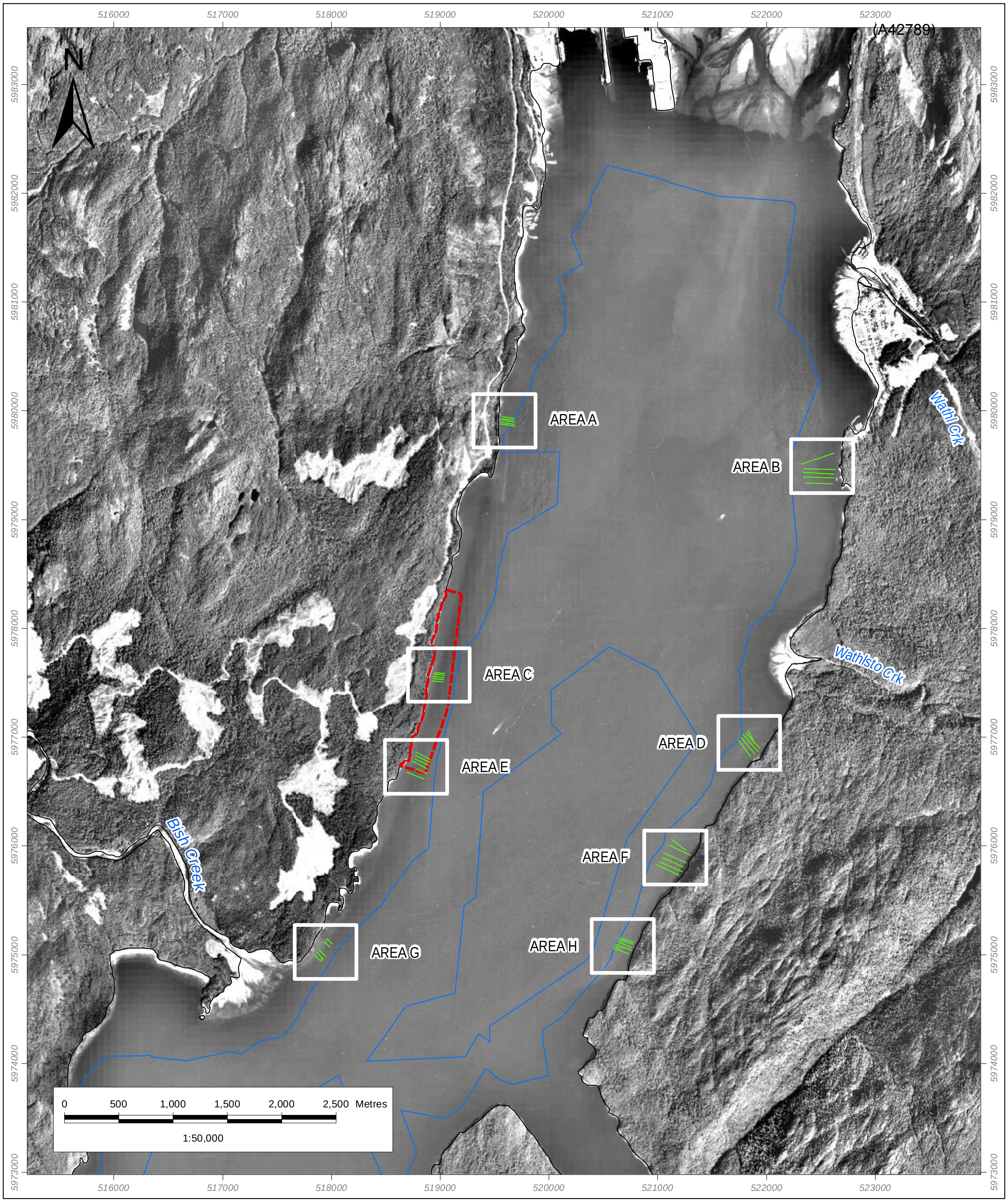
A.2 Methods

A.2.1 Field ROV Surveys

A remotely operated vehicle (ROV) with a high definition video camera was used to survey subtidal habitats in eight areas of Kitimat Arm (Figure 2.1-1). These areas were selected on the basis of steepness of slope, substrate type, surrounding topography and proximity to the Kitimat River. Seafloor slope and substrate type were inferred from nautical charts (Canadian Hydrographic Service) and multibeam bathymetry data provided by Natural Resources Canada (NRCan, Pacific Geoscience Center, Sidney, BC). The eight areas selected for the survey were selected deliberately to be representative of the various habitat types found within the PEAA.

Within each of the survey areas, 5-6 replicate transects were surveyed. Transects began at approximately 100 metres depth and extended shoreward to the shallowest practical depth. Replicate transects were spaced at least 20 metres apart to maximize coverage and to ensure there was no overlap among transects. Forty-four transects were surveyed overall. Exact positioning of transects, depth ranges and survey times are presented in Table 2.1-1.

The ROV was equipped with scaling lasers to obtain accurate specimen size data where possible. Subsequent video classification identified species of fauna and types of substrate observed along the transects. Some technical difficulties were encountered during the survey, including intermittent operation of the scaling lasers and loss of GPS positioning. In some cases, this made it difficult to determine accurate geo-referenced positions of individual sponges along transects; however, the quality of the video footage was not affected.



Legend

- Sponge Survey Transects
- Bathymetric Contour (100 m)
- Marine Project Development Area

ENBRIDGE NORTHERN GATEWAY PROJECT

2011 KITIMAT ARM SPONGE SURVEY OVERVIEW MAP

Sources:

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

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DRAWN BY:	N. PUREWAL	CHECKED BY:	M. BREWIS

PREPARED BY:
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PREPARED FOR:
ENBRIDGE NORTHERN GATEWAY PIPELINES

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Table 2-1 ROV Survey Dates, Times, Depth Ranges, and Locations

Transect ID	Date	Start Time	End Time	Start Latitude	Start Longitude	End Latitude	End Longitude	Start Depth (m)	End Depth (m)	Approximate Transect Area (m^2)*
A_1	23-May-11	1:31 PM	1:39 PM	53 58.011	128 41.998	53 58.022	128 42.112	119	7	169
A_2	23-May-11	1:38 PM	2:00 PM	53 58.022	128 41.998	53 58.033	128 42.107	111	8	159
A_3	23-May-11	2:09 PM	2:19 PM	53 58.031	128 41.997	53 58.041	128 42.106	99	5	153
A_4	23-May-11	2:25 PM	2:38 PM	53 58.040	128 41.997	53 58.049	128 42.100	103	17	143
A_5	23-May-11	2:55 PM	3:09 PM	53 58.001	128 41.992	53 58.013	128 42.114	118	7	175
B_1	24-May-11	12:48 PM	12:59 PM	53 57.715	128 39.550	53 57.709	128 39.326	100	8	262
B_2	24-May-11	1:11 PM	1:22 PM	53 57.744	128 39.572	53 57.738	128 39.316	100	11	294
B_3	24-May-11	1:34 PM	1:43 PM	53 57.766	128 39.573	53 57.758	128 39.312	100	11	299
B_4	24-May-11	1:59 PM	2:11 PM	53 57.786	128 39.576	53 57.780	128 39.303	100	11	312
B_5	24-May-11	2:23 PM	2:35 PM	53 57.807	128 39.585	53 57.863	128 39.309	101	12	331
C_1	23-May-11	10:07 AM	10:20 AM	53 56.758	128 42.598	53 56.764	128 42.692	118	6	152
C_2	23-May-11	10:30 AM	10:43 AM	53 56.769	128 42.595	53 56.775	128 42.680	106	6	137
C_3	23-May-11	10:52 AM	11:09 AM	53 56.778	128 42.592	53 56.783	128 42.672	119	8	142
C_4	23-May-11	10:24 AM	11:37 AM	53 56.748	128 42.602	53 56.753	128 42.694	131	5	162
C_5	23-May-11	11:47 AM	11:57 AM	53 56.737	128 42.607	53 56.742	128 42.695	107	7	139
D_1	23-May-11	4:18 PM	4:28 PM	53 56.453	128 40.102	53 56.371	128 39.990	102	3	219
D_2	23-May-11	4:37 PM	4:49 PM	53 56.441	128 40.126	53 56.359	128 40.027	113	5	216
D_3[1]	24-May-11	8:21 AM	8:29 AM	53 56.468	128 40.087			125	37	238
D_3[1]	24-May-11	8:53 AM	8:58 AM			53 56.384	128 39.963	70	7	
D_4	24-May-11	9:07 AM	9:10 AM	53 56.477	128 40.066	53 56.401	128 39.948	110	5	218
D_5[2]	24-May-11	9:29 AM						114		
D_5	24-May-11	11:29 AM	11:34 AM	53 56.487	128 40.044	53 56.424	128 39.990	102	5	163

Table 2-1 ROV Survey Dates, Times, Depth Ranges, and Locations (cont'd)

Transect ID	Date	Start Time	End Time	Start Latitude	Start Longitude	End Latitude	End Longitude	Start Depth (m)	End Depth (m)	Approximate Transect Area (m^2)*
E_1	22-May-11	10:50 AM	10:59 AM	53 56.256	128 42.768	53 56.289	128 42.916	100	8	196
E_2	22-May-11	11:10 AM	11:20 AM	53 56.283	128 42.752	53 56.305	128 42.836	104	30	125
E_3	22-May-11	11:43 AM	11:52 AM	53 56.306	128 42.741	53 56.345	128 42.866	96	7	178
E_4	22-May-11	1:33 PM	1:40 PM	53 56.324	128 42.731	53 56.354	128 42.841	98	11	159
E_5	23-May-11	8:46 AM	8:55 AM	53 56.338	128 42.724	53 56.373	128 42.839	105	7	172
E_6	23-May-11	9:05 AM	9:17 AM	53 56.351	128 42.716	53 56.389	128 42.836	109	3	183
F_1	21-May-11	4:36 PM	4:45 PM	53 55.885	128 40.762	53 55.834	128 40.571	89	11	242
F_2	21-May-11	4:59 PM	5:12 PM	53 55.923	128 40.719	53 55.870	128 40.534	110	13	245
F_3	21-May-11	5:22 PM	5:34 PM	53 55.951	128 40.691	53 55.895	128 40.572	100	11	189
F_4	22-May-11	2:31 PM	2:40 PM	53 55.829	128 40.826	53 55.773	128 40.631	98	8	254
F_5	22-May-11	2:54 PM	3:09 PM	53 55.838	128 40.787	53 55.792	128 40.605	102	7	237
F_6	22-May-11	3:59 PM	4:11 PM	53 55.862	128 40.777	53 55.813	128 40.594	100	7	239
G_1	21-May-11	9:23 AM	9:29 AM	53 55.378	128 43.603	53 55.412	128 43.659	130	91	96
G_2	21-May-11	9:51 AM	10:08 AM	53 55.358	128 43.632	53 55.368	128 43.643	133	11	124
G_3	21-May-11	10:23 AM	10:36 AM	53 55.424	128 43.567	53 55.452	128 43.611	115	10	127
G_4	21-May-11	10:49 AM	11:16 AM	53 55.440	128 43.545	53 55.467	128 43.596	122	10	135
G_5	22-May-11	8:57 AM	9:09 AM	53 55.354	128 43.641	53 55.389	128 43.698	117	8	141
G_6	22-May-11	9:22 AM	9:32 AM	53 55.364	128 43.622	53 55.399	128 43.676	126	8	147
H_1	21-May-11	12:56 PM	1:16 PM	53 55.415	128 41.189	53 55.383	128 41.054	110	7	190
H_2	21-May-11	1:30 PM	1:44 PM	53 55.423	128 41.177	53 55.411	128 41.127	103	80	63
H_3	21-May-11	1:56 PM	2:04 PM	53 55.433	128 41.171	53 55.401	128 41.033	106	10	189
H_4	21-May-11	2:49 PM	3:00 PM	53 55.445	128 41.149	53 55.415	128 41.036	103	8	166

Table 2-1 ROV Survey Dates, Times, Depth Ranges, and Locations (cont'd)

Transect ID	Date	Start Time	End Time	Start Latitude	Start Longitude	End Latitude	End Longitude	Start Depth (m)	End Depth (m)	Approximate Transect Area (m^2)*
H_5	21-May-11	3:13 PM	3:28 PM	53 55.456	128 41.143	53 55.433	128 41.021	108	13	169
H_6	21-May-11	3:42 PM	3:54 PM	53 55.464	128 41.133	53 55.443	128 41.021	106	13	159

NOTES:

1 Transect D_3 was completed in two segments due to technical difficulties encountered.

2 First attempt at transect D_5 was aborted due to technical difficulty.

* Transect length was inferred from the horizontal distance between the start and end coordinates of the transect and the difference between the start and end depths of the transect. While there was some variance in the field of view of the ROV, and thus the width of each transect at various points along it, the area of each transect was subsequently approximated assuming a constant width of one metre for all transects for comparative purposes

A.3 Results

A.3.1 Habitat Characteristics

The substrate and slope for each of the eight survey areas were characterized as follows:

- Area A: Dominated by a similar percentage of vertical cliff bedrock and mud with some mixed unconsolidated sediments. Slope was generally 45°.
- Area B: Primarily mud with no cliff bedrock or hard substrates. Slope was generally 30°.
- Area C: About 66% cliff bedrock with pockets of mud, and 33% mud with mixed unconsolidated sediments. Slope was 55 – 60º. Note that this area falls within the PDA.
- Area D: Similar to Area A, along with 10 – 25% primarily sandy substrate. Slope was 55 – 60º.
- Area E: Similar to Area A, but with a higher percentage of mud. Slope was 45º down to 100 m, then leveled off to about 30º to 150 m. Note that this area overlaps with the PDA.
- Area F: Similar to Area E, but with less bedrock and higher mud content and about 20% sandy substrate. Slope was 30 – 45º.
- Area G: Predominantly bedrock cliff with mud pockets and about 20% mud/mixed unconsolidated sediments. Slope was 30 – 40º.
- Area H: Primarily bedrock cliff with about 15% each of sand/mixed unconsolidated sediments and 15% mud with mixed coarse sediments. Slope was a consistent 50º.

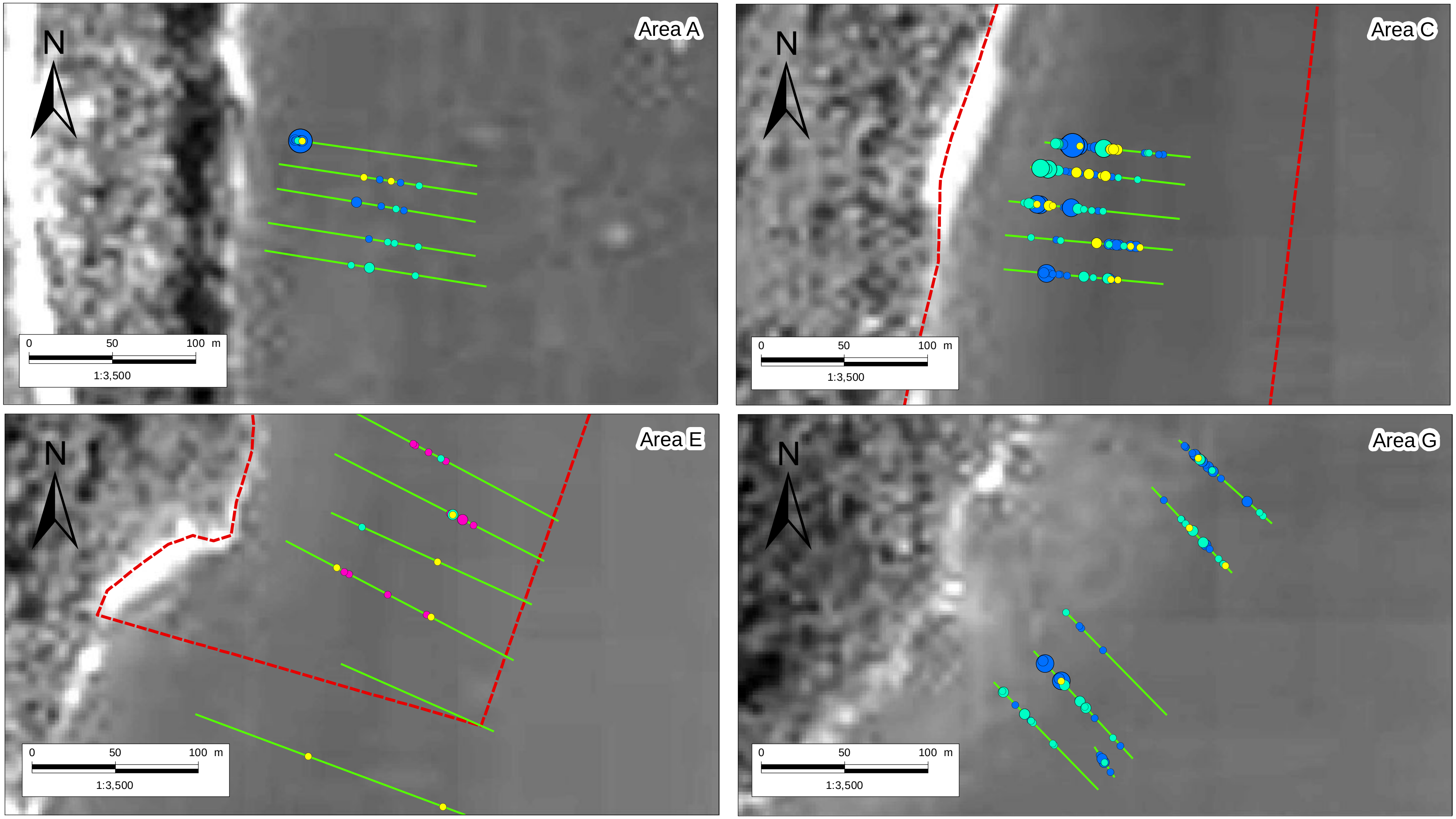
A.3.2 Sponge Distribution in Kitimat Arm

Species of sponges observed during the survey fell into two classes: Hexactinellida (glass sponges), which includes *Aphrocallistes vastus* (cloud sponges), *Heterochone calyx* (goblet sponges), and *Rossellidae* spp. (boot sponges); and Demospongiae. Cloud and goblet sponges were grouped together during video analysis due to difficulties distinguishing between the species visually. Raw sponge data, including sponge species, count, depth, time, geographic coordinates, and substrate category by transect are included in Attachment A1.

As shown in Figures 3.2-1 and 3.2-2, sponges were observed in each of the eight survey areas and were common throughout the PEAA. Cloud and goblet sponges were found in all survey areas except for Area E, and boot sponges were found in all survey areas except for Area B.

Individual sponges were typically less than 1 m in diameter and all sponges observed were growing independently. When larger sponges were encountered, the ROV was manipulated to allow the entire sponge to be in the frame of view. The scaling lasers were set to 15 cm distance, allowing accurate measurement of the organisms. Although some areas had several sponges in close proximity, no reefs were observed. Consistent with sponge ecology, most sponges were found in relatively deep waters (in this case 31 – 60 m) with adequate water currents and hard substrate with little to no sediment accumulation (Conway et al. 2005).

(A42789)



	Species	Number of Observations
Sponge Survey Transects	Boot Sponges (Rossellidae)	1
Marine Project Development Area	Demosponges (Demospongiae)	2-3
	Unidentified Glass Sponges (Hexactinellida)	4-5
	Cloud/Goblet Sponges *(Aphrocallistes vastus / Heterochone calyx)*	> 5

ENBRIDGE NORTHERN GATEWAY PROJECT

2011 KITIMAT ARM SPONGE SURVEY OBSERVATIONS WEST KITIMAT ARM

Sources:

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

PREPARED BY: gem

PREPARED FOR: ENBRIDGE NORTHERN GATEWAY PIPELINES

FIGURE NO: **3.2-1**

DATE: 12-JUL-12	PROJECTION: UTM 9	DRAWN BY: N. PUREWAL
FIGURE ID: 123510694	DATUM: NAD 83	CHECKED BY: M. BREWIS

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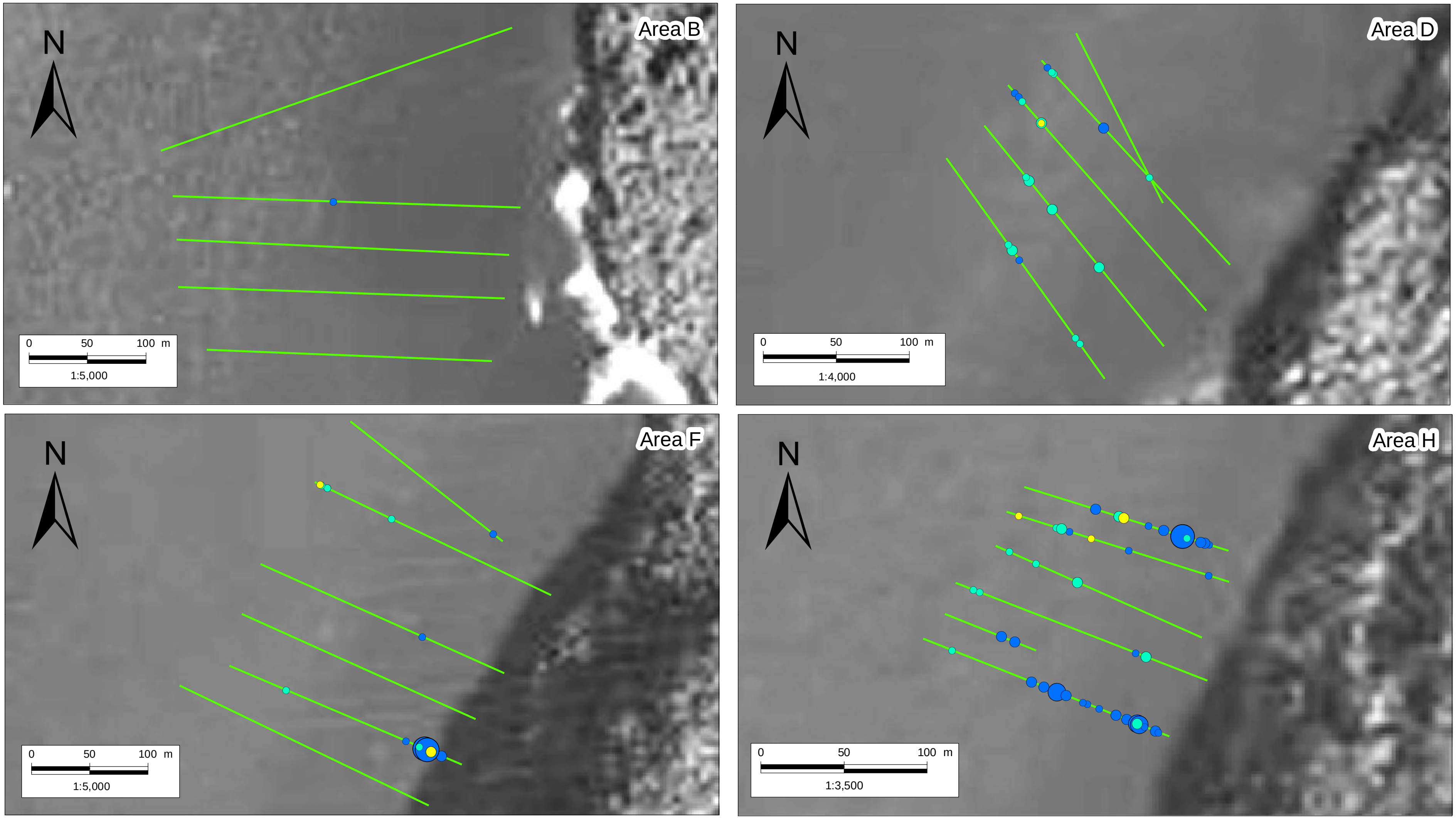
(A42789)



Sponge Survey Transects
Marine Project Development Area

Species
- **Boot Sponges (Rossellidae)**
- **Demosponges (Demospongiae)**
- **Unidentified Glass Sponges (Hexactinellida)**
- **Cloud/Goblet Sponges *(Aphrocallistes vastus / Heterochone calyx)***

Number of Observations
- 1
- 2-3
- 4-5
- > 5

ENBRIDGE NORTHERN GATEWAY PROJECT

2011 KITIMAT ARM
SPONGE SURVEY OBSERVATIONS
EAST KITIMAT ARM

Sources:

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

DATE: 12-JUL-12	PROJECTION: UTM 9	DRAWN BY: N. PUREWAL
FIGURE ID: 123510694	DATUM: NAD 83	CHECKED BY: M. BREWIS

PREPARED BY:

PREPARED FOR:

FIGURE NO:

3.2-2

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Sponge density (number of sponges per m^2) by survey area is shown in Figure 3.2-3. For Areas A through D, n=5 transects and for Areas E through H, n=6 transects. Sponge abundance is the sum of all sponge types. Transect lengths were inferred from the horizontal distance between the start and end coordinates and the difference between the start and end depths. There was some variance in the field of view distance (i.e. width of transect). The area of each transect was approximated assuming a constant width of 1 m.

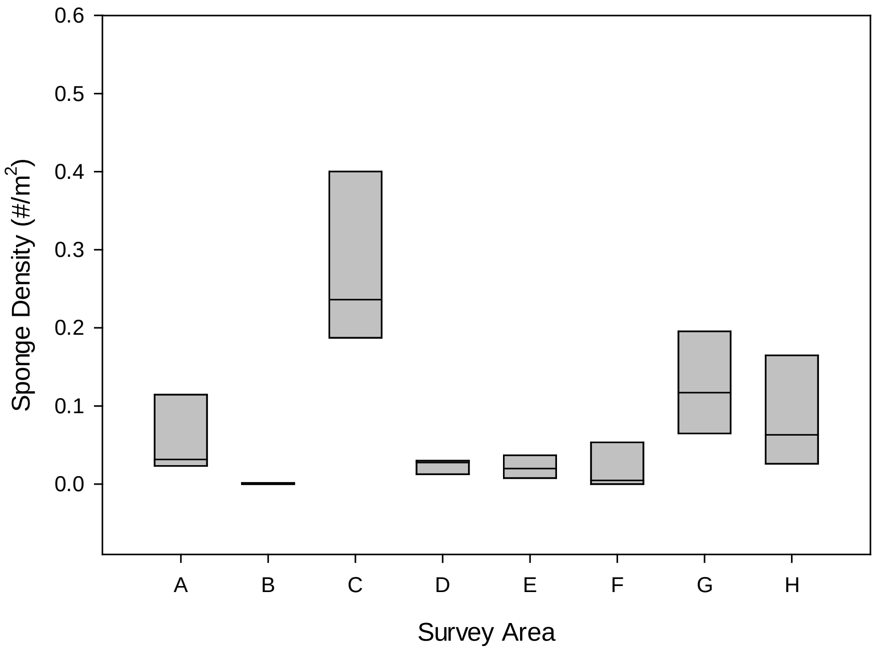

Figure 3.2-3 Sponge density by survey area in upper Kitimat Arm, BC[1]

Sponge density was highest in area C, intermediate in areas A, G, and H, and lowest in areas B, D, E, and F. In general, densities were higher on the west side of Kitimat Arm (areas A, C, E, G) than the east side of Kitimat Arm (areas B, D, F, H). These results likely reflect differences in substrate types among the survey areas. Specifically, higher sponge densities in areas C, G and H are associated with substrate that is mostly bedrock and fairly steep (highest sponge density in areas with 55-60^{o} incline), while lower sponge densities in areas A, B, D, E and F are generally associated with a higher proportion of mud and sand.

Freshwater inputs along the north and east sides of Kitimat Arm (Kitimat River, Wathl Creek, Wathlsto Creek) may also contribute to the lower numbers of sponges observed in these areas. These watercourses deposit large volumes of fine sediments in the nearshore marine environment, as evidenced by the alluvial fans clearly seen in Figure 2.1-1. Sponge larvae require hard substrate (e.g., boulders, bedrock) for attachment and will not persist in soft sediment habitats. In addition, sponges require relatively clear water (i.e., low turbidity) for effective growth and survival. This is because sponges rely on complex movement of water through canals to filter small food particles (e.g., bacteria) and to obtain oxygen for

[1] box plots: top and bottom represent first and third quartiles; bars represents medians

cellular respiration. Heavy sedimentation clogs this delicate system, which inhibits sponge growth and eventually leads to mortality.

A.3.3 Frequency of Sponges by Dominant Substrate Type in Kitimat Arm

Substrates observed during the ROV survey were categorized into the following six general types:

- category 1: primarily bedrock (mostly cliff face) with some mixed unconsolidated sediments
- category 2: primarily boulder or very coarse substrate with some mixed unconsolidated sediments
- category 3: primarily sand with mixed coarse sediments
- category 4: primarily mud (>75%) with mixed coarse sediments
- category 5: mixed mud and bedrock (mud pockets or flat patches on cliffs)
- category 6: equal mix of mud and unconsolidated coarse sediments

All sponges observed during the survey were attached to hard substrates (categories 1, 2, and 5). Of 531 sponges observed, 509 (96%) were observed on bedrock (category 1), 19 (3.5%) were observed on mixed mud and bedrock (category 5), and 3 (0.5%) were observed on boulder/coarse substrate (category 2). No sponges were observed on soft substrates comprised of coarse sediments and sand or mud (categories 3, 4, and 6).

A.3.4 Frequency of Sponges by Depth in Kitimat Arm

Sponge frequency (number of sponges per transect) by depth class (0-30 m, 31-60 m, >60 m) is shown in Figure 3.3-1. For all areas combined (n=44), sponge frequency was lowest in the 0-30 m depth class (Figure 3.3-1) and highest in the 31-60 m depth class. This is consistent with the results of a study by Leys et al. (2004), which found glass sponges to be most abundant between 20 and 260 m in coastal waters of British Columbia. The primary abiotic factor influencing the upper depth limit is water temperature, although light may also be an important factor (Leys et al. 2004). In Kitimat Arm, the observed decrease in sponge frequency below 60 m is likely related to a lack of suitable steep bedrock habitat at depth. On most transects, the steep fjordal walls gave way to more gently-sloping soft sediment habitats somewhere between 60 and 100 m depth. This habitat type is unsuitable for sponge colonization and growth.

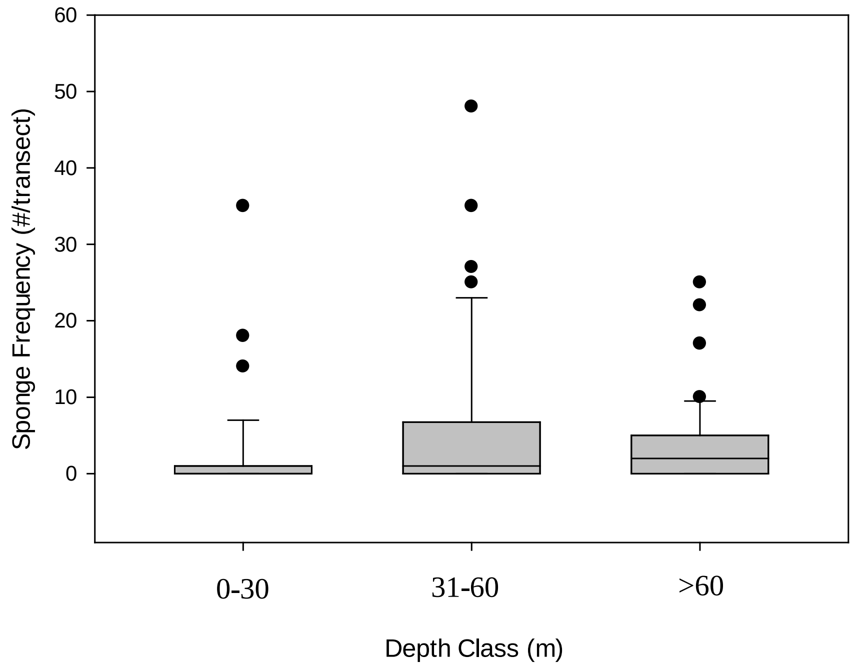

Figure 3.3-1 Sponge frequency by depth for all survey areas combined (n=44 transects)[2]

Consistent with the trend observed throughout Kitimat Arm, sponge frequency within the PDA was found to be lowest in the 0–30 m depth class and highest in the 31-60 m depth class (Figure 3.3-2). In-water activities associated with construction of the Kitimat Terminal will be focused in water depths of less than 40 m.

[2] (box plots: top and bottom represent first and third quartiles; bars represent medians; whiskers represent endpoints; dots represent outliers

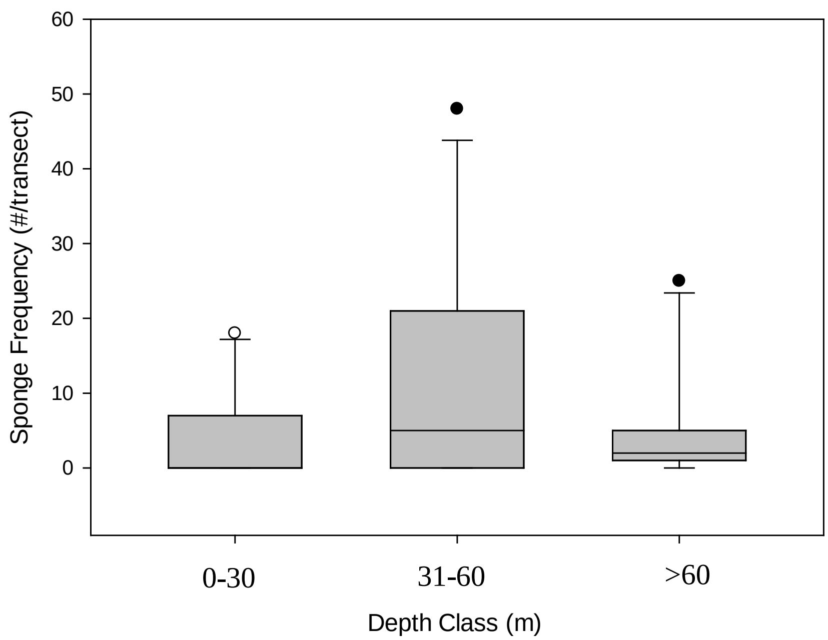

Figure 1.3-2 Sponge frequency by depth for survey areas C & E (n=11 transects)[3]

A.3.5 Frequency of Finfish in Kitimat Arm

Fish species most commonly observed during the survey include poacher (Agonidae family), eelpout (Zoarcidae family), and flatfish (Pleuronectidae family). Rex sole (*Errex* zachirus) were the most commonly identified flatfish species. Eight rockfish were also observed, including six quillback rockfish (*Sebastes maliger*), one darkblotched rockfish (*Sebastes crameri*), one pygmy rockfish (*Sebastes wilsoni*), and two unidentified rockfish.

Fish were not present in all transects, depth ranges, or associated with all substrate types in the survey areas. In contrast to sponges, fish were more commonly associated with softer, unconsolidated sediments. Most fish were found over substrate category 4 (primarily mud), in the deepest depth range (> 60m). Although sponges can provide complex habitat for some fish species (e.g. quillback rockfish), most of the fish observed during the survey were not in close proximity of sponges. Rather, the common species observed in Kitimat Arm (e.g., poacher, eelpout, flatfish) appear to prefer simple soft sediment habitats.

A.4 Conclusion

Habitat type is often an accurate proxy for species composition. The purpose of this study was to survey the variety of habitat types throughout Kitimat Arm and associate those characteristics with species presence. Habitat characteristics analyzed included substrate, depth, slope, and freshwater influence. All

[3] box plots: top and bottom represent first and third quartiles; bars represent medians; whiskers represent endpoints; dots represent outliers

organisms were recorded and analyzed according to habitat characteristics. Eight study areas in Kitimat Arm were chosen to represent the range of habitats present. A minimum of 5 transects were completed within each study area. While all invertebrates were recorded, the study focused on sponge and finfish abundance and distribution.

Sponges were recorded in all survey areas and were found to be fairly common throughout Kitimat Arm. Substrate type appears to be a major factor influencing sponge distribution; 96% of all sponges identified during the survey were associated with bedrock. Highest sponge densities were observed on hard substrates in deep water (31–60 m). Sponge frequency was lowest in shallow water (0–30 m), likely due to elevated temperature and light levels. All sponges observed during the survey were found to be growing independently. In optimal habitats (e.g. steep bedrock cliffs), it was not uncommon to find several sponges growing in close proximity; however, no sponge reefs were observed in Kitimat Arm. Consistent with the trend observed throughout Kitimat Arm, sponge frequency within the PDA was found to be lowest in the depth range that will be most affected by in-water construction activities (0-30 m).

Finfish were observed in relatively low abundance throughout Kitimat Arm. Common species included flatfish, poacher and eelpout. Most fish were found over soft sediments (e.g., mud, silt) in deep water (>60 m). Given their preference for habitats that are not well-suited to sponges, fish do not appear to be particularly associated with sponges in Kitimat Arm.

A.5 References

Beckett, J., Munro, K. 2010. Technical Data Report: Marine Fish and Fish Habitat. Enbridge Northern Gateway Project. Jacques Whitford Ltd. Calgary, Alberta.

Conway, K.W., Krautter, M., Barrie, J.V., Whitney, F. Thompson, R.E., Reiswig, H., Lehnert, H., Mungov, G., and Bertram, M. 2005. Sponge reefs in the Queen Charlotte Basin, Canada: Controls on distribution, growth, and development. *In* Cold-water Corals and Ecosystems. Edited by A. Freiwald and J.M. Roberts. Springer-Verlag, Berlin. pp. 605-621.

Leys, S.P., Wilson, K., Holeton, C., Reiswig, H.M., Austin, W.C. and Tunnicliffe, V. 2004. Patterns of glass sponge (Porifera, Hexactinellida) distribution in coastal waters of British Columbia, Canada. *Marine Ecology Progress Series* 283: 133-149.

Attachment A1 Raw Sponge Data

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
A_1	83	3	1:33:47 PM	53.96690063	-128.7004914	Demospongiae (C)	1	1
A_1	78	3	1:34:38 PM	53.96692146	-128.7007072	Demospongiae (C)	1	1
A_1	72	3	1:34:53 PM	53.96692758	-128.7007707	Demospongiae (C)	1	1
A_1	61	3	1:35:34 PM	53.96694432	-128.7009442	*Aphrocallistes vastus/Heterochone calyx*	1	1
A_2	71	3	1:52:30 PM	53.96709949	-128.7006222	*Aphrocallistes vastus/Heterochone calyx*	1	1
A_2	45	2	1:55:14 PM	53.96714307	-128.701054	*Aphrocallistes vastus/Heterochone calyx*	1	2
A_2	65	3	1:52:57 PM	53.96710667	-128.7006933	Demospongiae (C)	1	1
A_2	58	2	1:53:48 PM	53.96712022	-128.7008276	*Aphrocallistes vastus/Heterochone calyx*	1	1
A_3	61	3	2:13:35 PM	53.9672652	-128.7008424	*Aphrocallistes vastus/Heterochone calyx*	1	1
A_3	64	3	2:13:02 PM	53.96725556	-128.7007372	Rossellidae	1	1
A_3	68	3	2:12:35 PM	53.96724766	-128.7006512	*Aphrocallistes vastus/Heterochone calyx*	1	1
A_3	76	3	2:11:41 PM	53.96723187	-128.7004791	Demospongiae (C)	1	1
A_3	54	2	2:14:20 PM	53.96727836	-128.7009858	Rossellidae	1	1
A_4	69	3	2:31:07 PM	53.96747448	-128.7015654	Aphrocallistes vastus/Heterochone calyx	1	13
A_4	69	3	2:31:15 PM	53.96747464	-128.7015672	*Aphrocallistes vastus/Heterochone calyx*	1	2

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
A_4	39	2	2:34:54 PM	53.96747889	-128.7016158	*Aphrocallistes vastus/Heterochone calyx*	1	2
A_4	40	2	2:34:46 PM	53.96747873	-128.701614	*Aphrocallistes vastus/Heterochone calyx*	1	1
A_4	41	2	2:34:24 PM	53.96747831	-128.7016091	*Aphrocallistes vastus/Heterochone calyx*	1	1
A_4	54	2	2:32:58 PM	53.96747664	-128.70159	Demospongiae (C)	1	1
A_4	71	3	2:30:29 PM	53.96747375	-128.7015569	*Aphrocallistes vastus/Heterochone calyx*	1	1
A_4	73	3	2:30:11 PM	53.9674734	-128.7015529	*Aphrocallistes vastus/Heterochone calyx*	1	2
A_4	73	3	2:29:57 PM	53.96747313	-128.7015498	*Aphrocallistes vastus/Heterochone calyx*	1	2
A_4	75	3	2:29:51 PM	53.96747301	-128.7015485	Rossellidae	1	1
A_4	76	3	2:29:42 PM	53.96747283	-128.7015465	Demospongiae (C)	1	1
A_4	56	2	2:32:54 PM	53.96747656	-128.7015892	Demospongiae (C)	1	1
A_5	39	2	3:04:01 PM	53.96680538	-128.7011075	Demospongiae (C)	1	1
A_5	76	3	3:00:04 PM	53.96674765	-128.7005205	Demospongiae (C)	1	1
A_5	49	2	3:02:52 PM	53.96678857	-128.7009366	Demospongiae (C)	1	2
B_4	45	2	2:05:15 PM	53.96305381	-128.6574984	*Aphrocallistes vastus/Heterochone calyx*	5	1
C_1	38	2	10:17:05 AM	53.94604301	-128.7111627	Rossellidae	5	2

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
C_1	36	2	10:17:12 AM	53.94604395	-128.7111775	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_1	33	2	10:17:32 AM	53.94604664	-128.7112196	*Aphrocallistes vastus/Heterochone calyx*	1	2
C_1	32	2	10:17:45 AM	53.94604839	-128.711247	*Aphrocallistes vastus/Heterochone calyx*	1	4
C_1	31	2	10:17:58 AM	53.94605013	-128.7112743	*Aphrocallistes vastus/Heterochone calyx*	1	4
C_1	31	2	10:17:58 AM	53.94605013	-128.7112743	Rossellidae	1	1
C_1	28	1	10:18:17 AM	53.94605269	-128.7113143	*Aphrocallistes vastus/Heterochone calyx*	5	1
C_1	26	1	10:18:23 AM	53.94605349	-128.711327	Demospongiae (C)	1	3
C_1	22	1	10:18:52 AM	53.94605739	-128.711388	Demospongiae (C)	1	1
C_1	39	2	10:16:49 AM	53.94604086	-128.711129	Rossellidae	5	1
C_1	26	1	10:18:31 AM	53.94605457	-128.7113438	Demospongiae (C)	1	2
C_1	69	3	10:13:10 AM	53.94601142	-128.7106679	Demospongiae (C)	1	1
C_1	41	2	10:16:02 AM	53.94603454	-128.7110301	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_1	42	2	10:15:54 AM	53.94603347	-128.7110132	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_1	43	2	10:15:28 AM	53.94602997	-128.7109585	*Aphrocallistes vastus/Heterochone calyx*	1	4

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
C_1	46	2	10:14:58 AM	53.94602594	-128.7108953	Demospongiae (C)	1	2
C_1	53	2	10:14:34 AM	53.94602272	-128.7108448	Demospongiae (C)	1	1
C_1	56	2	10:13:58 AM	53.94601788	-128.710769	Demospongiae (C)	1	1
C_1	56	2	10:13:58 AM	53.94601788	-128.710769	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_1	39	2	10:16:49 AM	53.94604086	-128.711129	*Aphrocallistes vastus/Heterochone calyx*	5	1
C_1	62	3	10:13:32 AM	53.94601438	-128.7107142	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_2	49	2	10:40:04 AM	53.94621783	-128.7108776	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_2	45	2	10:40:19 AM	53.94622021	-128.7109113	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_2	45	2	10:40:19 AM	53.94622021	-128.7109113	Rossellidae	1	3
C_2	44	2	10:40:47 AM	53.94622464	-128.7109741	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_2	41	2	10:41:03 AM	53.94622718	-128.71101	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_2	33	2	10:41:32 AM	53.94623177	-128.7110751	Demospongiae (C)	1	3
C_2	26	1	10:42:09 AM	53.94623764	-128.7111582	Demospongiae (C)	1	3
C_2	25	1	10:42:14 AM	53.94623843	-128.7111694	Demospongiae (C)	1	4
C_2	24	1	10:42:18 AM	53.94623906	-128.7111784	Demospongiae (C)	5	2

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
C_2	51	2	10:39:27 AM	53.94621197	-128.7107945	Rossellidae	1	3
C_2	19	1	10:42:42 AM	53.94624287	-128.7112323	Demospongiae (C)	1	3
C_2	83	3	10:36:08 AM	53.94618043	-128.7103477	Demospongiae (C)	1	1
C_2	56	2	10:39:02 AM	53.946208	-128.7107384	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_2	58	2	10:38:38 AM	53.9462042	-128.7106845	Rossellidae	1	1
C_2	58	2	10:38:38 AM	53.9462042	-128.7106845	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_2	58	2	10:38:28 AM	53.94620261	-128.710662	Demospongiae (C)	1	1
C_2	58	2	10:38:28 AM	53.94620261	-128.710662	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_2	59	2	10:38:19 AM	53.94620119	-128.7106418	Rossellidae	1	2
C_2	62	3	10:37:54 AM	53.94619723	-128.7105857	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_2	67	3	10:37:27 AM	53.94619295	-128.7105251	Demospongiae (C)	1	1
C_2	51	2	10:39:27 AM	53.94621197	-128.7107945	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_2	19	1	10:42:45 AM	53.94624334	-128.711239	Demospongiae (C)	1	5
C_3	34	2	11:05:42 AM	53.94636305	-128.7108754	Rossellidae	1	1
C_3	34	2	11:05:42 AM	53.94636305	-128.7108754	*Aphrocallistes vastus/Heterochone calyx*	1	3

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
C_3	34	2	11:05:17 AM	53.94636077	-128.710839	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_3	35	2	11:04:45 AM	53.94635786	-128.7107924	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_3	37	2	11:04:37 AM	53.94635713	-128.7107808	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_3	34	2	11:05:51 AM	53.94636386	-128.7108885	*Aphrocallistes vastus/Heterochone calyx*	1	4
C_3	40	2	11:03:59 AM	53.94635368	-128.7107255	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_3	24	1	11:08:01 AM	53.94637569	-128.7110777	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_3	38	2	11:04:07 AM	53.9463544	-128.7107371	*Aphrocallistes vastus/Heterochone calyx*	1	2
C_3	32	2	11:06:17 AM	53.94636623	-128.7109263	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_3	30	1	11:06:59 AM	53.94637005	-128.7109875	*Aphrocallistes vastus/Heterochone calyx*	1	5
C_3	45	2	11:03:24 AM	53.94635049	-128.7106745	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_3	26	1	11:07:52 AM	53.94637487	-128.7110646	Demospongiae (C)	1	1
C_3	31	2	11:06:30 AM	53.94636741	-128.7109453	*Aphrocallistes vastus/Heterochone calyx*	1	12

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
C_3	24	1	11:08:01 AM	53.94637569	-128.7110777	Demospongiae (C)	1	3
C_3	23	1	11:08:07 AM	53.94637624	-128.7110865	Demospongiae (C)	1	2
C_3	22	1	11:08:15 AM	53.94637697	-128.7110981	Demospongiae (C)	1	2
C_3	26	1	11:07:52 AM	53.94637487	-128.7110646	*Aphrocallistes vastus/Heterochone calyx*	1	2
C_3	76	3	10:58:56 AM	53.94632611	-128.7102844	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_3	29	1	11:07:32 AM	53.94637305	-128.7110355	*Aphrocallistes vastus/Heterochone calyx*	1	2
C_3	91	3	10:56:58 AM	53.94631537	-128.7101127	*Aphrocallistes vastus/Heterochone calyx*	2	1
C_3	83	3	10:57:26 AM	53.94631792	-128.7101534	*Aphrocallistes vastus/Heterochone calyx*	2	1
C_3	47	2	11:03:14 AM	53.94634958	-128.71066	Demospongiae (C)	1	4
C_3	76	3	10:58:37 AM	53.94632438	-128.7102568	Demospongiae (C)	1	1
C_3	57	2	11:01:38 AM	53.94634085	-128.7105202	Demospongiae (C)	1	1
C_3	56	2	11:01:46 AM	53.94634158	-128.7105319	Rossellidae	1	2
C_3	55	2	11:02:08 AM	53.94634358	-128.7105639	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_3	53	2	11:02:32 AM	53.94634576	-128.7105988	Demospongiae (C)	1	1
C_3	55	2	11:02:12 AM	53.94634394	-128.7105697	*Aphrocallistes vastus/Heterochone calyx*	1	1

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
C_3	54	2	11:02:20 AM	53.94634467	-128.7105814	Rossellidae	1	1
C_3	50	2	11:02:42 AM	53.94634667	-128.7106134	Demospongiae (C)	1	1
C_3	53	2	11:02:27 AM	53.94634531	-128.7105916	Rossellidae	1	2
C_3	53	2	11:02:27 AM	53.94634531	-128.7105916	Demospongiae (C)	1	2
C_3	53	2	11:02:32 AM	53.94634576	-128.7105988	*Aphrocallistes vastus/Heterochone calyx*	1	2
C_3	55	2	11:02:12 AM	53.94634394	-128.7105697	Rossellidae	1	2
C_3	76	3	10:58:30 AM	53.94632374	-128.7102466	Demospongiae (C)	1	1
C_4	86	3	11:30:34 AM	53.94583164	-128.7106156	*Aphrocallistes vastus/Heterochone calyx*	1	3
C_4	86	3	11:30:34 AM	53.94583164	-128.7106156	Demospongiae (C)	1	1
C_4	80	3	11:31:22 AM	53.9458377	-128.7107269	Rossellidae	1	3
C_4	80	3	11:31:22 AM	53.9458377	-128.7107269	*Aphrocallistes vastus/Heterochone calyx*	1	2
C_4	51	2	11:33:45 AM	53.94585572	-128.7110586	Demospongiae (C)	1	1
C_4	31	2	11:35:41 AM	53.94587035	-128.7113277	Demospongiae (C)	5	1
C_4	89	3	11:29:55 AM	53.94582673	-128.7105251	*Aphrocallistes vastus/Heterochone calyx*	1	3
C_4	49	2	11:34:02 AM	53.94585787	-128.7110981	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_4	91	3	11:29:35 AM	53.94582421	-128.7104787	Demospongiae (C)	1	1

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
C_4	91	3	11:29:35 AM	53.94582421	-128.7104787	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_4	93	3	11:29:08 AM	53.9458208	-128.7104161	Rossellidae	1	1
C_4	93	3	11:29:08 AM	53.9458208	-128.7104161	*Aphrocallistes vastus/Heterochone calyx*	1	2
C_4	96	3	11:28:46 AM	53.94581803	-128.7103651	*Aphrocallistes vastus/Heterochone calyx*	1	3
C_4	97	3	11:28:31 AM	53.94581614	-128.7103303	Rossellidae	1	1
C_4	87	3	11:30:16 AM	53.94582937	-128.7105738	*Aphrocallistes vastus/Heterochone calyx*	1	2
C_4	88	3	11:30:05 AM	53.94582799	-128.7105483	*Aphrocallistes vastus/Heterochone calyx*	1	2
C_5	49	2	11:54:25 AM	53.94567767	-128.7111903	*Aphrocallistes vastus/Heterochone calyx*	1	4
C_5	72	3	11:52:09 AM	53.94565782	-128.710841	Demospongiae (C)	1	1
C_5	58	2	11:53:10 AM	53.94566673	-128.7109977	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_5	55	2	11:53:35 AM	53.94567037	-128.7110619	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_5	54	2	11:53:41 AM	53.94567125	-128.7110773	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_5	83	3	11:50:53 AM	53.94564673	-128.7106458	Demospongiae (C)	1	1

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
C_5	49	2	11:54:13 AM	53.94567592	-128.7111595	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_5	86	3	11:50:34 AM	53.94564396	-128.710597	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_5	51	2	11:54:01 AM	53.94567417	-128.7111287	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_5	83	3	11:50:53 AM	53.94564673	-128.7106458	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_5	84	3	11:50:47 AM	53.94564586	-128.7106304	Demospongiae (C)	1	3
C_5	86	3	11:50:34 AM	53.94564396	-128.710597	Rossellidae	1	1
C_5	87	3	11:50:25 AM	53.94564264	-128.7105739	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_5	86	3	11:50:10 AM	53.94564046	-128.7105353	*Rossellidae*	1	1
C_5	86	3	11:50:10 AM	53.94564046	-128.7105353	*Aphrocallistes vastus/Heterochone calyx*	1	1
C_5	48	2	11:54:34 AM	53.94567898	-128.7112135	*Aphrocallistes vastus/Heterochone calyx*	1	2
C_5	71	3	11:52:11 AM	53.94565811	-128.7108461	Demospongiae (C)	1	3
C_5	84	3	11:50:41 AM	53.94564498	-128.710615	*Aphrocallistes vastus/Heterochone calyx*	1	2
C_5	80	3	11:51:37 AM	53.94565315	-128.7107588	Demospongiae (C)	1	1
D_1	29	1	4:25:16 PM	53.94000656	-128.6671691	Demospongiae (C)	1	2

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
D_1	75	3	4:21:44 PM	53.94053915	-128.6678966	Demospongiae (C)	1	2
D_1	76	3	4:21:34 PM	53.94056428	-128.6679309	Demospongiae (C)	1	1
D_1	53	2	4:22:54 PM	53.9403633	-128.6676564	Demospongiae (C)	1	2
D_2	53	2	4:42:35 PM	53.94005175	-128.6680041	*Aphrocallistes vastus/Heterochone calyx*	1	1
D_2	58	2	4:42:07 PM	53.9401109	-128.6680756	Demospongiae (C)	1	2
D_2	62	3	4:41:50 PM	53.94014681	-128.6681189	Demospongiae (C)	1	1
D_2	25	1	4:46:41 PM	53.93953212	-128.6673768	Demospongiae (C)	1	1
D_2	28	1	4:46:23 PM	53.93957014	-128.6674227	Demospongiae (C)	1	1
D_3	104	3	8:23:22 AM	53.94108443	-128.6680445	*Aphrocallistes vastus/Heterochone calyx*	1	1
D_3	42	2	8:28:08 AM	53.94089794	-128.6677692	Demospongiae (C)	1	2
D_3	42	2	8:28:08 AM	53.94089794	-128.6677692	Rossellidae	1	1
D_3	94	3	8:24:03 AM	53.94105769	-128.668005	*Aphrocallistes vastus/Heterochone calyx*	1	1
D_3	88	3	8:24:44 AM	53.94103096	-128.6679655	Demospongiae (C)	1	1
D_4	49	2	9:12:21 AM	53.94055694	-128.6666388	Demospongiae (C)	1	1
D_4	80	3	9:10:22 AM	53.94086456	-128.6671165	*Aphrocallistes vastus/Heterochone calyx*	5	2
D_4	103	3	9:07:56 AM	53.94124197	-128.6677024	*Aphrocallistes vastus/Heterochone calyx*	1	1

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
D_4	100	3	9:08:12 AM	53.94120061	-128.6676382	Demospongiae (C)	1	1
D_4	100	3	9:08:08 AM	53.94121095	-128.6676543	Demospongiae (C)	1	1
E_1	61	3	10:55:14 AM	53.93791989	-128.7142346	Rossellidae	1	1
E_1	100	3	10:50:48 AM	53.9376454	-128.7130036	Rossellidae	5	1
E_3	71	3	11:46:58 AM	53.93866879	-128.7131047	Rossellidae	1	1
E_3	69	3	11:47:08 AM	53.93868131	-128.7131448	Hexactinellida (C)	1	1
E_3	60	2	11:48:37 AM	53.93879277	-128.7135021	Hexactinellida (C)	1	1
E_3	45	2	11:50:04 AM	53.93890173	-128.7138513	Hexactinellida (C)	1	1
E_3	45	2	11:50:16 AM	53.93891676	-128.7138995	Hexactinellida (C)	1	1
E_3	41	2	11:50:32 AM	53.9389368	-128.7139637	Rossellidae	1	1
E_4	69	3	1:37:02 PM	53.93896732	-128.7130413	Rossellidae	1	1
E_4	27	1	1:39:35 PM	53.93915575	-128.7137322	Demospongiae (C)	5	1
E_5	53	2	8:50:28 AM	53.93922048	-128.7129006	Rossellidae	1	1
E_5	56	2	8:50:04 AM	53.93919377	-128.7128128	Hexactinellida (C)	1	2
E_5	57	2	8:50:35 AM	53.93922828	-128.7129262	Hexactinellida (C)	1	1
E_5	53	2	8:50:28 AM	53.93922048	-128.7129006	Demospongiae (C)	1	3
E_5	61	3	8:49:37 AM	53.93916371	-128.7127141	Hexactinellida (C)	1	1
E_6	55	2	9:12:20 AM	53.93955864	-128.7131185	Hexactinellida (C)	1	1
E_6	50	2	9:13:00 AM	53.93959774	-128.713242	Hexactinellida (C)	1	1

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
E_6	59	2	9:11:30 AM	53.93950977	-128.7129642	Hexactinellida (C)	1	1
E_6	50	2	9:13:06 AM	53.9396036	-128.7132605	Hexactinellida (C)	1	1
E_6	57	2	9:11:44 AM	53.93952346	-128.7130074	Demospongiae (C)	1	1
F_1	41	2	4:42:30 PM	53.93085314	-128.6772562	*Aphrocallistes vastus/Heterochone calyx*	1	1
F_2	101	3	5:01:03 PM	53.93200272	-128.678485	Demospongiae (C)	1	1
F_2	101	3	5:01:03 PM	53.93200272	-128.678485	*Aphrocallistes vastus/Heterochone calyx*	1	1
F_2	104	3	5:00:45 PM	53.93202512	-128.6785631	Demospongiae (C)	1	1
F_2	105	3	5:00:41 PM	53.93203009	-128.6785805	Rossellidae	1	1
F_2	71	3	5:04:15 PM	53.93176385	-128.6776512	Demospongiae (C)	1	1
F_3	23	1	5:34:02 PM	53.93164136	-128.6763233	*Aphrocallistes vastus/Heterochone calyx*	1	1
F_5	22	1	3:07:09 PM	53.92997523	-128.6771795	*Aphrocallistes vastus/Heterochone calyx*	1	5
F_5	20	1	3:08:00 PM	53.92993231	-128.6770097	*Aphrocallistes vastus/Heterochone calyx*	1	3
F_5	80	3	2:57:51 PM	53.93044482	-128.6790375	Demospongiae (C)	1	1
F_5	22	1	3:06:33 PM	53.93000553	-128.6772994	*Aphrocallistes vastus/Heterochone calyx*	1	2
F_5	22	1	3:06:33 PM	53.93000553	-128.6772994	Demospongiae (C)	1	1

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
F_5	23	1	3:06:54 PM	53.92998785	-128.6772295	*Aphrocallistes vastus/Heterochone calyx*	1	10
F_5	22	1	3:07:03 PM	53.92998028	-128.6771995	*Aphrocallistes vastus/Heterochone calyx*	1	9
F_5	21	1	3:07:19 PM	53.92996681	-128.6771462	Rossellidae	1	2
F_5	21	1	3:07:19 PM	53.92996681	-128.6771462	*Aphrocallistes vastus/Heterochone calyx*	1	2
F_5	30	1	3:05:40 PM	53.93005013	-128.6774759	*Aphrocallistes vastus/Heterochone calyx*	2	1
G_1	113	3	9:26:51 AM	53.92331967	-128.7272981	*Aphrocallistes vastus/Heterochone calyx*	5	1
G_1	106	3	9:27:56 AM	53.92344044	-128.727497	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_1	106	3	9:28:02 AM	53.92345158	-128.7275154	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_1	105	3	9:28:42 AM	53.9235259	-128.7276378	Demospongiae (C)	1	1
G_2	53	2	10:03:47 AM	53.92275681	-128.7273358	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_2	85	3	9:59:36 AM	53.9227143	-128.7272891	Demospongiae (C)	1	1
G_2	85	3	9:59:40 AM	53.92271497	-128.7272898	Demospongiae (C)	1	1
G_2	83	3	9:59:52 AM	53.92271701	-128.727292	*Aphrocallistes vastus/Heterochone calyx*	1	2

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
G_2	64	3	10:01:44 AM	53.92273598	-128.7273129	*Aphrocallistes vastus/Heterochone calyx*	1	3
G_2	115	3	9:54:36 AM	53.92266348	-128.7272332	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_3	94	3	10:25:58 AM	53.92381051	-128.7262379	Demospongiae (C)	1	1
G_3	59	2	10:30:06 AM	53.92396003	-128.7264729	Demospongiae (C)	1	3
G_3	76	3	10:28:03 AM	53.92388587	-128.7263564	*Aphrocallistes vastus/Heterochone calyx*	1	2
G_3	22	1	10:34:48 AM	53.92413006	-128.7267401	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_3	45	2	10:32:00 AM	53.92402877	-128.7265809	Demospongiae (C)	1	1
G_3	45	2	10:31:53 AM	53.92402455	-128.7265743	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_3	53	2	10:30:38 AM	53.92397933	-128.7265032	Rossellidae	1	1
G_3	75	3	10:28:26 AM	53.92389974	-128.7263782	Demospongiae (C)	5	2
G_3	76	3	10:28:05 AM	53.92388708	-128.7263583	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_3	80	3	10:27:26 AM	53.92386357	-128.7263213	*Aphrocallistes vastus/Heterochone calyx*	5	1
G_3	101	3	10:25:16 AM	53.92378519	-128.7261981	Demospongiae (C)	1	1
G_3	101	3	10:25:11 AM	53.92378217	-128.7261934	Demospongiae (C)	1	1
G_3	103	3	10:24:55 AM	53.92377252	-128.7261783	Rossellidae	1	1

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
G_3	49	2	10:31:16 AM	53.92400224	-128.7265392	Demospongiae (C)	1	1
G_4	64	3	11:06:21 AM	53.92428359	-128.7262857	*Aphrocallistes vastus/Heterochone calyx*	1	2
G_4	78	3	11:04:01 AM	53.92424508	-128.7262129	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_4	114	3	10:51:46 AM	53.92404291	-128.7258311	Demospongiae (C)	1	1
G_4	106	3	10:52:48 AM	53.92405996	-128.7258633	Demospongiae (C)	1	1
G_4	43	2	11:11:12 AM	53.92436363	-128.7264369	*Aphrocallistes vastus/Heterochone calyx*	1	2
G_4	53	2	11:07:45 AM	53.92430669	-128.7263293	*Aphrocallistes vastus/Heterochone calyx*	1	3
G_4	51	2	11:08:33 AM	53.9243199	-128.7263542	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_4	51	2	11:09:08 AM	53.92432952	-128.7263724	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_4	47	2	11:09:36 AM	53.92433722	-128.726387	*Aphrocallistes vastus/Heterochone calyx*	1	2
G_4	47	2	11:10:10 AM	53.92434658	-128.7264046	Demospongiae (C)	1	3
G_4	45	2	11:10:11 AM	53.92434685	-128.7264052	Demospongiae (C)	1	2
G_4	81	3	10:56:27 AM	53.9241202	-128.725977	*Aphrocallistes vastus/Heterochone calyx*	1	2
G_4	44	2	11:11:05 AM	53.92436171	-128.7264332	*Aphrocallistes vastus/Heterochone calyx*	1	1

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
G_4	59	2	11:06:49 AM	53.92429129	-128.7263002	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_4	41	2	11:11:39 AM	53.92437106	-128.7264509	*Aphrocallistes vastus/Heterochone calyx*	1	3
G_4	41	2	11:11:44 AM	53.92437243	-128.7264535	*Aphrocallistes vastus/Heterochone calyx*	1	2
G_4	39	2	11:12:21 AM	53.92438261	-128.7264727	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_4	32	2	11:14:15 AM	53.92441397	-128.7265319	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_4	31	2	11:14:26 AM	53.92441699	-128.7265377	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_4	28	1	11:14:43 AM	53.92442167	-128.7265465	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_4	64	3	11:06:35 AM	53.92428744	-128.7262929	Demospongiae (C)	1	1
G_4	45	2	11:10:38 AM	53.92435428	-128.7264192	Rossellidae	1	1
G_5	86	3	9:02:46 AM	53.92281095	-128.7277478	Demospongiae (C)	1	1
G_5	22	1	9:08:36 AM	53.9230969	-128.7282135	Demospongiae (C)	1	2
G_5	41	2	9:06:09 AM	53.9229768	-128.7280179	Demospongiae (C)	1	2
G_5	41	2	9:06:09 AM	53.9229768	-128.7280179	*Aphrocallistes vastus/Heterochone calyx*	1	2
G_5	54	2	9:05:12 AM	53.92293023	-128.7279421	Demospongiae (C)	1	1

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
G_5	51	2	9:05:29 AM	53.92294412	-128.7279647	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_5	21	1	9:08:41 AM	53.92310098	-128.7282202	Demospongiae (C)	1	1
G_5	52	2	9:05:26 AM	53.92294167	-128.7279607	Demospongiae (C)	1	1
G_5	83	3	9:02:55 AM	53.9228183	-128.7277598	Demospongiae (C)	1	1
G_5	37	2	9:07:12 AM	53.92302827	-128.7281018	*Aphrocallistes vastus/Heterochone calyx*	5	1
G_6	91	3	9:25:57 AM	53.92295718	-128.7273787	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_6	111	3	9:24:04 AM	53.92285	-128.7272133	Demospongiae (C)	1	1
G_6	46	2	9:29:26 AM	53.92315542	-128.7276846	*Aphrocallistes vastus/Heterochone calyx*	1	5
G_6	46	2	9:29:26 AM	53.92315542	-128.7276846	Rossellidae	1	1
G_6	71	3	9:27:38 AM	53.92305298	-128.7275265	*Aphrocallistes vastus/Heterochone calyx*	5	1
G_6	49	2	9:29:02 AM	53.92313266	-128.7276494	Demospongiae (C)	1	2
G_6	73	3	9:27:28 AM	53.9230435	-128.7275119	Demospongiae (C)	1	2
G_6	115	3	9:23:16 AM	53.92280447	-128.7271431	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_6	81	3	9:26:52 AM	53.92300935	-128.7274592	Demospongiae (C)	1	2
G_6	45	2	9:29:38 AM	53.9231668	-128.7277021	*Aphrocallistes vastus/Heterochone calyx*	1	2

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
G_6	80	3	9:26:58 AM	53.92301504	-128.727468	Demospongiae (C)	1	1
G_6	30	1	9:30:48 AM	53.9232332	-128.7278046	*Aphrocallistes vastus/Heterochone calyx*	1	1
G_6	27	1	9:31:07 AM	53.92325122	-128.7278324	*Aphrocallistes vastus/Heterochone calyx*	1	4
G_6	25	1	9:31:19 AM	53.9232626	-128.7278499	*Aphrocallistes vastus/Heterochone calyx*	1	2
H_1	38	2	1:09:42 PM	53.92322748	-128.6849821	*Aphrocallistes vastus/Heterochone calyx*	1	1
H_1	83	3	12:58:44 PM	53.92352017	-128.6862169	Demospongiae (C)	1	1
H_1	52	2	1:05:11 PM	53.92334803	-128.6854906	*Aphrocallistes vastus/Heterochone calyx*	1	2
H_1	43	2	1:06:11 PM	53.92332134	-128.685378	*Aphrocallistes vastus/Heterochone calyx*	1	3
H_1	39	2	1:07:12 PM	53.9232942	-128.6852636	*Aphrocallistes vastus/Heterochone calyx*	1	5
H_1	26	1	1:15:12 PM	53.92308069	-128.6843628	*Aphrocallistes vastus/Heterochone calyx*	1	2
H_1	39	2	1:09:21 PM	53.92323682	-128.6850215	*Aphrocallistes vastus/Heterochone calyx*	1	1
H_1	22	1	1:15:28 PM	53.92307358	-128.6843328	*Aphrocallistes vastus/Heterochone calyx*	1	1
H_1	35	2	1:10:40 PM	53.92320168	-128.6848732	*Aphrocallistes vastus/Heterochone calyx*	1	1

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
H_1	39	2	1:12:02 PM	53.92316521	-128.6847194	*Aphrocallistes vastus/Heterochone calyx*	1	3
H_1	38	2	1:12:54 PM	53.92314208	-128.6846218	*Aphrocallistes vastus/Heterochone calyx*	1	2
H_1	34	2	1:13:36 PM	53.92312339	-128.684543	*Aphrocallistes vastus/Heterochone calyx*	1	2
H_1	34	2	1:13:44 PM	53.92311984	-128.684528	*Aphrocallistes vastus/Heterochone calyx*	1	4
H_1	34	2	1:13:44 PM	53.92311984	-128.684528	Demospongiae (C)	1	2
H_1	34	2	1:13:54 PM	53.92311539	-128.6845092	*Aphrocallistes vastus/Heterochone calyx*	1	5
H_1	32	2	1:14:21 PM	53.92310338	-128.6844585	*Aphrocallistes vastus/Heterochone calyx*	1	1
H_1	37	2	1:07:58 PM	53.92327374	-128.6851772	*Aphrocallistes vastus/Heterochone calyx*	1	3
H_2	83	3	1:34:03 PM	53.9235927	-128.6857668	*Aphrocallistes vastus/Heterochone calyx*	1	2
H_2	77	3	1:35:07 PM	53.92356321	-128.6856439	*Aphrocallistes vastus/Heterochone calyx*	1	3
H_3	35	2	2:02:11 PM	53.92347937	-128.6844412	Demospongiae (C)	1	2
H_3	99	3	1:57:22 PM	53.92383207	-128.6859623	Demospongiae (C)	1	1
H_3	101	3	1:57:11 PM	53.9238455	-128.6860202	Demospongiae (C)	1	1

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
H_3	36	2	2:01:53 PM	53.92350133	-128.684536	*Aphrocallistes vastus/Heterochone calyx*	1	1
H_4	72	3	2:53:50 PM	53.92388441	-128.6850674	Demospongiae (C)	1	2
H_4	87	3	2:51:39 PM	53.92398502	-128.6854464	Demospongiae (C)	1	1
H_4	97	3	2:50:15 PM	53.92404954	-128.6856894	Demospongiae (C)	1	1
H_5	81	3	3:16:48 PM	53.9241803	-128.6852585	Demospongiae (C)	1	1
H_5	54	2	3:21:42 PM	53.92405522	-128.6845951	*Aphrocallistes vastus/Heterochone calyx*	1	1
H_5	105	3	3:14:15 PM	53.92424539	-128.6856038	Rossellidae	1	1
H_5	79	3	3:17:09 PM	53.92417137	-128.6852112	Demospongiae (C)	1	2
H_5	71	3	3:19:10 PM	53.92411989	-128.6849381	Rossellidae	1	1
H_5	26	1	3:27:04 PM	53.92391822	-128.6838684	*Aphrocallistes vastus/Heterochone calyx*	1	1
H_5	71	3	3:17:42 PM	53.92415733	-128.6851367	*Aphrocallistes vastus/Heterochone calyx*	1	1
H_6	62	3	3:47:46 PM	53.9242299	-128.6846428	Rossellidae	1	2
H_6	26	1	3:52:45 PM	53.92408333	-128.6838611	*Aphrocallistes vastus/Heterochone calyx*	1	1
H_6	60	2	3:47:29 PM	53.92423824	-128.6846873	Demospongiae (C)	1	2
H_6	27	1	3:52:30 PM	53.92409069	-128.6839003	*Aphrocallistes vastus/Heterochone calyx*	1	3

Table A1-1 Sponge Species, Count, Depth, Time Recorded, Geographic Coordinates, and Substrate Category by Transect (cont'd)

Transect ID	Depth (m)	Depth Category	Time	Latitude	Longitude	Fauna ID	Substrate Category	Fauna Count
H_6	46	2	3:49:13 PM	53.92418725	-128.6844154	*Aphrocallistes vastus/Heterochone calyx*	1	1
H_6	42	2	3:50:06 PM	53.92416127	-128.6842768	*Aphrocallistes vastus/Heterochone calyx*	1	2
H_6	38	2	3:50:43 PM	53.92414314	-128.6841801	*Aphrocallistes vastus/Heterochone calyx*	1	1
H_6	37	2	3:51:12 PM	53.92412892	-128.6841042	*Aphrocallistes vastus/Heterochone calyx*	1	6
H_6	35	2	3:51:27 PM	53.92412157	-128.684065	Demospongiae (C)	1	1
H_6	27	1	3:52:16 PM	53.92409755	-128.6839369	*Aphrocallistes vastus/Heterochone calyx*	1	3
H_6	75	3	3:46:08 PM	53.92427794	-128.684899	*Aphrocallistes vastus/Heterochone calyx*	1	2