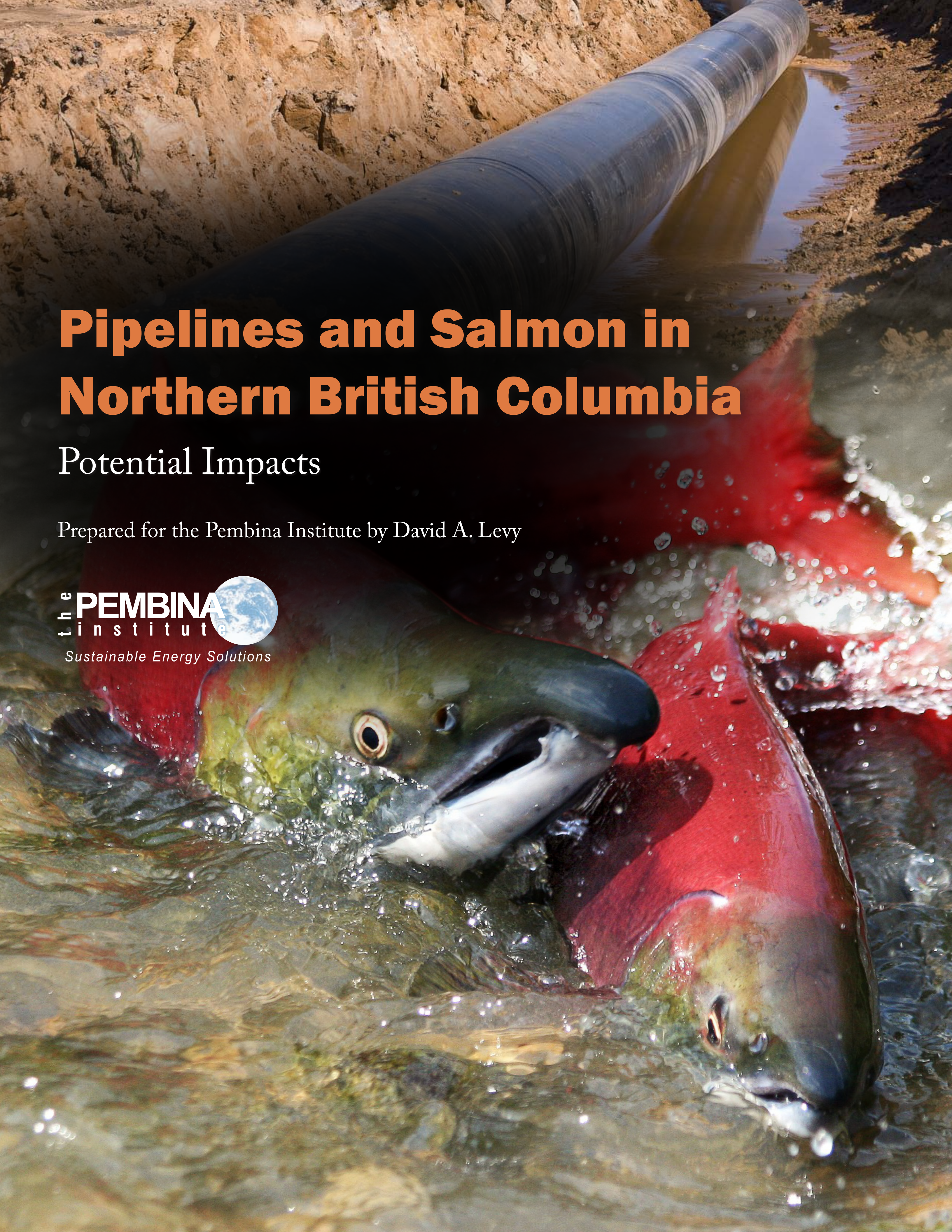

# Pipelines and Salmon in Northern British Columbia

## Potential Impacts

Prepared for the Pembina Institute by David A. Levy

the PEMBINA institute
*Sustainable Energy Solutions*

# Pipelines and Salmon in Northern British Columbia

Prepared for:

**The Pembina Institute**

Prepared by:

**David A. Levy**
**Levy Research Services Ltd.**
**315 Lonsdale Ave.**
**North Vancouver, B.C.**
**V7M 2G3**

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the PEMBINA institute
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Production management: Laura Fauth
Editor, Design/Layout: Roberta Franchuk
Cover design: Taylor Bachrach
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The Pembina Institute
Box 7558
Drayton Valley, Alberta
Canada  T7A 1S7
Phone: 780-542-6272
Email: info@pembina.org

Additional copies of this publication may be downloaded from the Pembina Institute website: www.pembina.org.

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# Pipelines and Salmon in Northern British Columbia

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# Pipelines and Salmon in Northern British Columbia

The health and abundance of salmon is critical to the well being of Northern British Columbia. There are currently four pipeline projects proposed to traverse northern B.C. that could threaten the health of the Fraser, Skeena, and Kitimat watersheds and the salmon they are home to.

Of these four proposals, Enbridge's Northern Gateway pipeline project has generated the most interest and concern for a number of reasons. Communities and First Nations along the proposed route have expressed concern about the risks posed to northern watersheds by the more than 700,000 barrels per day of highly toxic petroleum products that would be transported in the proposed twin pipelines. Looking more broadly, additional concerns have been raised because of project's role in expanding Alberta's oil sands and bringing supertankers to B.C.'s coast. Questions about this project are also timely, because it will be subjected to environmental review in the near future.

All of these proposed pipelines would cross and at times run parallel to the critically productive salmon habitats of the Upper Fraser, Skeena and Kitimat Watersheds. If all five proposed pipelines were built, they would extend over 4,000 km stretched end to end. They would cross more than one thousand rivers and streams in some of Canada's most productive salmon habitat. If the Enbridge pipeline is built, the salmon and their ecosystems may be negatively impacted by its construction, operation, and potential failures.

Salmon habitats in the vicinity of the pipelines are vulnerable to numerous construction effects, particularly at stream crossings. The primary construction impacts of the proposed pipelines would be increased sedimentation and higher water temperatures from diminished riparian habitat; salmon and trout are highly sensitive to increases in each of these parameters.

The greatest concerns are the risks to salmon and freshwater habitat from pipeline failures that cannot be entirely prevented. Two types of pipeline failure exist: leaks and ruptures. Ruptures can result from third party damage, natural events (e.g. landslides) or general pipeline degradation. Failures that occur adjacent to stream crossings or where pipelines run parallel to streams are the greatest risk to salmon. As evidenced by industry performance, pipeline ruptures are an ongoing hazard of pipeline operations.

In Canada, there have been two recent major oil spills into freshwater habitats: the Pine River spill and the Lake Wabamun spill. The Pine River spill of 1 million litres of petroleum severely affected the freshwater habitat and caused a massive fish kill that extended for over 20 km downstream from the spill site. Spill responses were inadequate and eventually cost the operator $30 million in clean-up costs — though the affected area has not yet fully recovered. The Wabamum Lake event demonstrated that the behavior of diluted heavy oil in freshwater environments is poorly understood.

The terrain where the proposed Enbridge pipelines would cross, particularly the Coast Range, does nothing to ease these concerns. This project would be constructed and operated in areas of steep, unforgiving and dangerous terrain. Heavy precipitation events and significant avalanche and landslide dangers are the norm. Indeed, major landslides in northern B.C. have occurred along existing and proposed pipeline routes. These events have resulted in pipeline ruptures, knocked out roads and various infrastructure including major highways, and resulted in several deaths in the last few years alone.

The impacts from proposed pipelines would add to numerous stressors on salmon ecosystems — some existing and some expected in the future. These include forestry, hydro developments and climate change. Within northern B.C., current and historic land-use practices have detrimentally affected salmon habitats. There have been widespread environmental impacts that will likely persist into the future. These must be taken into consideration when evaluating the merits of pipeline proposals.

In summary, approving, constructing, and operating pipelines in Northern B.C. will expose salmon habitat in the Upper Fraser, Skeena, and Kitimat watersheds to increased impacts. Even the best pipeline construction and operating practices are insufficient to eliminate all risks. Approving a pipeline proposal such as Enbridge's Gateway project would expose salmon to those risks and the potential impacts. Any such decision should obviously not be taken lightly.

# 1. Introduction

The health and abundance of salmon is critical to the well-being of Northern British Columbia. First Nations have always depended on salmon for food, social and ceremonial purposes. Wild salmon support recreational tourism, sport, commercial fishing and value-added processing. Their health is also an indicator of the overall health of the ecosystems they support.

In Northern B.C., the Upper Fraser, Skeena and Kitimat provide some of Canada's best salmon habitat. There are currently four proposed pipeline projects that would traverse these watersheds and potentially threaten the salmon they are home to. Of these four proposals, Enbridge's Northern Gateway pipeline project has generated the most interest and concern for a number of reasons. Of note are the sheer volume of highly toxic petroleum products that would be transported in the proposal's twin pipelines (more than 700,000 barrels per day[1]), as well as the role of the project in expanding production in Alberta's oil sands and bringing supertankers to B.C.'s coast. Questions about the project are also timely, because the proponent is planning to submit the project to regulatory review in the near future.

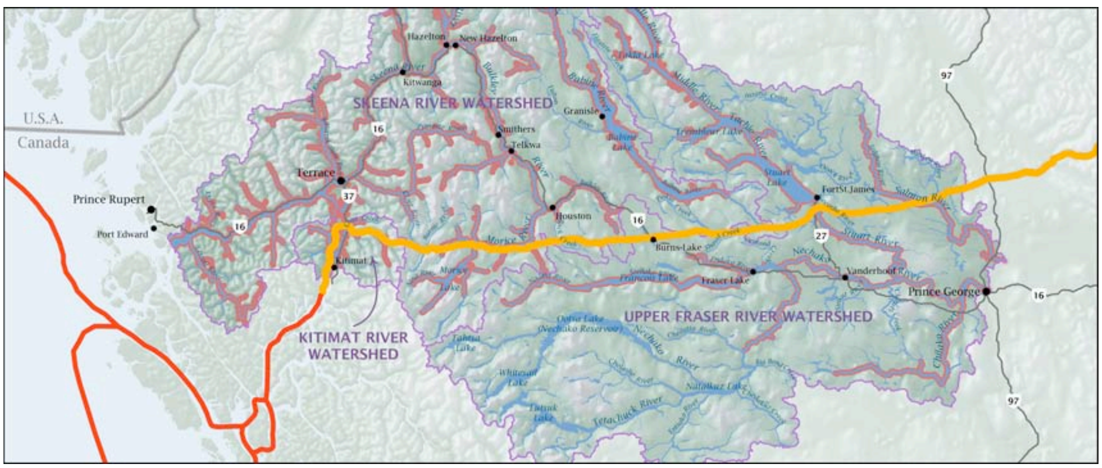


**Figure 1. Proposed Enbridge Northern Gateway pipeline route in relation to the Upper Fraser, Skeena and Kitimat Watersheds.**
Map: Eliana Macdonald

Some of the questions being asked include: How would construction of the project impact salmon and their habitat? What is the likelihood of minor or catastrophic spills? What would the impacts of an oil sands petroleum and condensate spill be for salmon and their habitat? Could the salmon and their habitat be protected when those pipeline failures happen?

These questions are especially relevant because the ecosystems in question have already been stressed, and will be further stressed by impacts such as mining, forestry, and climate change.

[1] The proposed 36-inch diameter westward line would export an average of 525,000 barrels a day of petroleum product. The proposed 20-inch diameter eastward line would import an average of 193,000 barrels a day of condensate.

This report was prepared to begin evaluating those questions. Having robust answers will help communities understand the potential impacts of Enbridge's proposed pipeline on the five species of salmon (sockeye, pink, chum, Chinook and coho) and steelhead. The report is structured as follows:

- Section 2 describes the salmon resources in the three affected watersheds, to identify the salmon populations that could be potentially affected by pipelines.
- Section 3 provides summary descriptions of the proposed Enbridge pipeline and other pipeline projects proposed for similar routes.
- Section 4 presents the impacts that pipeline construction and operation would have on salmon and other fish species using freshwater habitat.
- Section 5 discusses the impacts that pipeline failure would have on salmon and other fish species using the same freshwater habitat.
- Section 6 considers potential pipeline failure mechanisms and presents some examples of failures that affected aquatic resources in Northern B.C. and Alberta.
- Section 7 analyzes the combined risks to salmon from pipelines and other human activities in Northern B.C. and provides a preliminary cumulative impact evaluation.
- Section 8 summarizes the key conclusions.

# 2. Salmon Resources in Affected Watersheds

For thousands of years, the culture and well-being of the peoples of the Pacific Northwest have been inextricably linked to Pacific salmon. These fish return annually from the ocean bringing their gift of food, as well as enormous quantities of marine nutrients. Salmon define human and natural history in the northeast Pacific Ocean. B.C. salmon form part of the North Eastern Pacific salmon ecosystem, which is one of Earth's most productive biological communities, sustaining diverse terrestrial and aquatic life. The major salmon-bearing watersheds of the upper Fraser (including the Salmon, Takla-Stuart, and Nechako), the Skeena (including the Morice and Zymoetz), and the Kitimat are no exceptions. By any measure, salmon are a vital component of B.C.'s ecology, culture, economy and social fabric.

Figure 2 shows a map of the freshwater salmon habitats in B.C., while Figures 3, 4 and 5 show the Upper Fraser, Skeena, and Kitimat watersheds in relation to the proposed Enbridge pipeline. In total, the project would need to cross more than 780 waterways in these three watersheds.

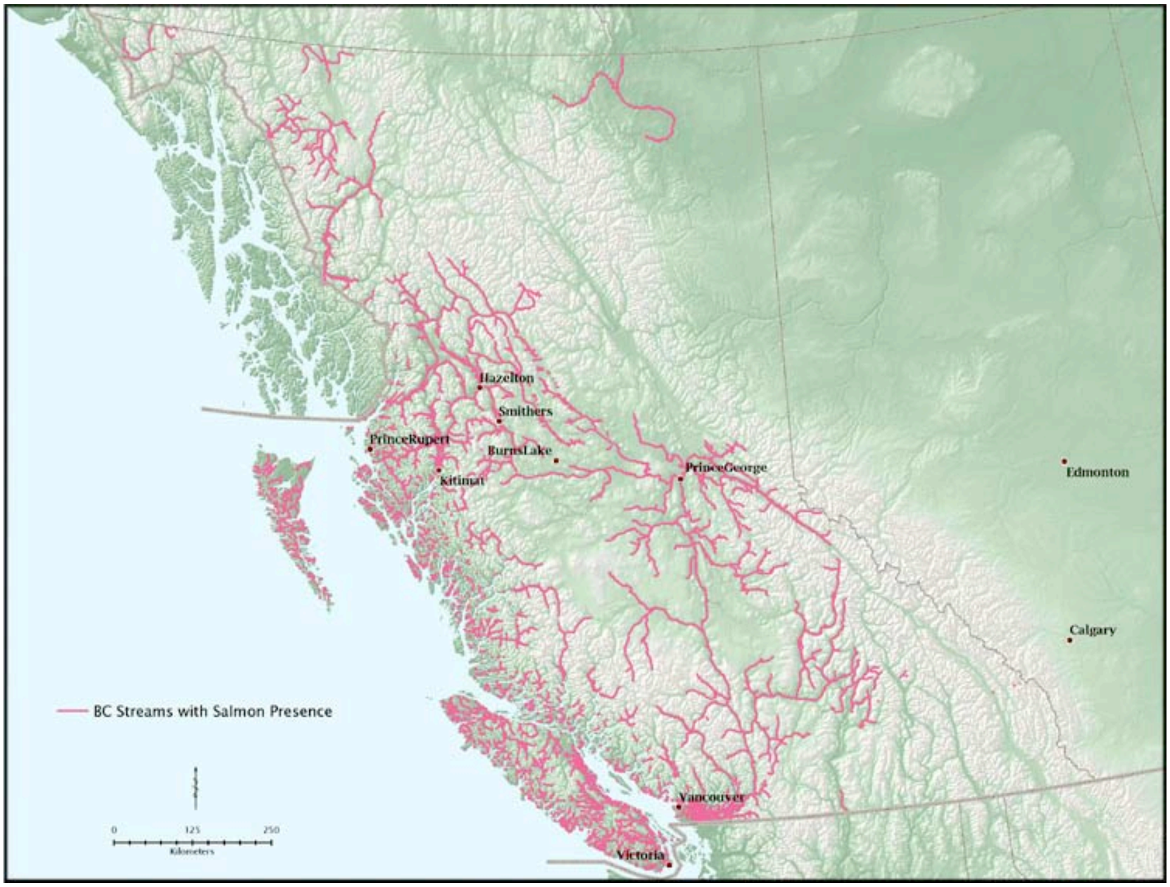


**Figure 2. Salmon habitats in B.C.**

Map: Eliana Macdonald

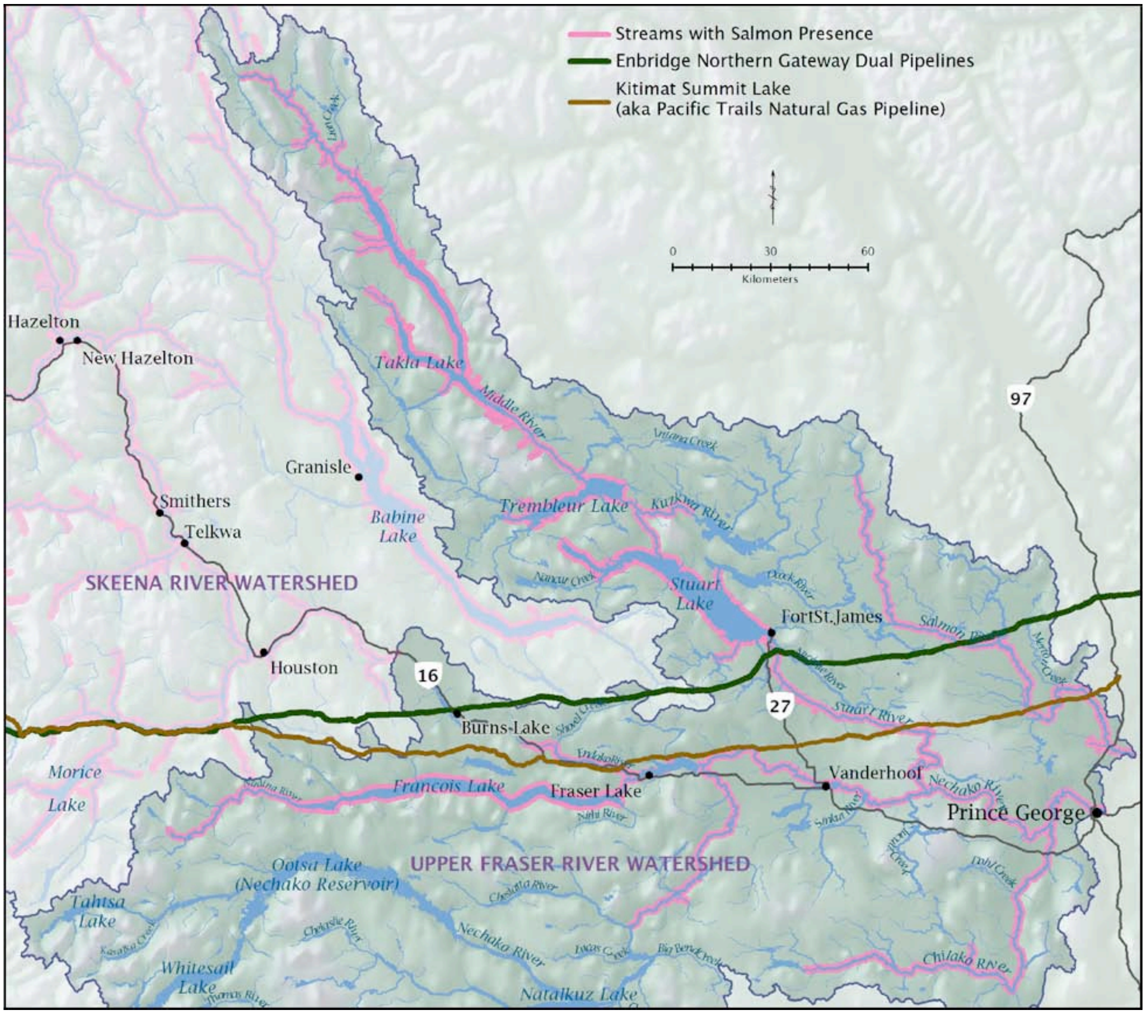


**Figure 3. Upper Fraser River Watershed in relation to proposed pipelines.**

Map: Eliana Macdonald

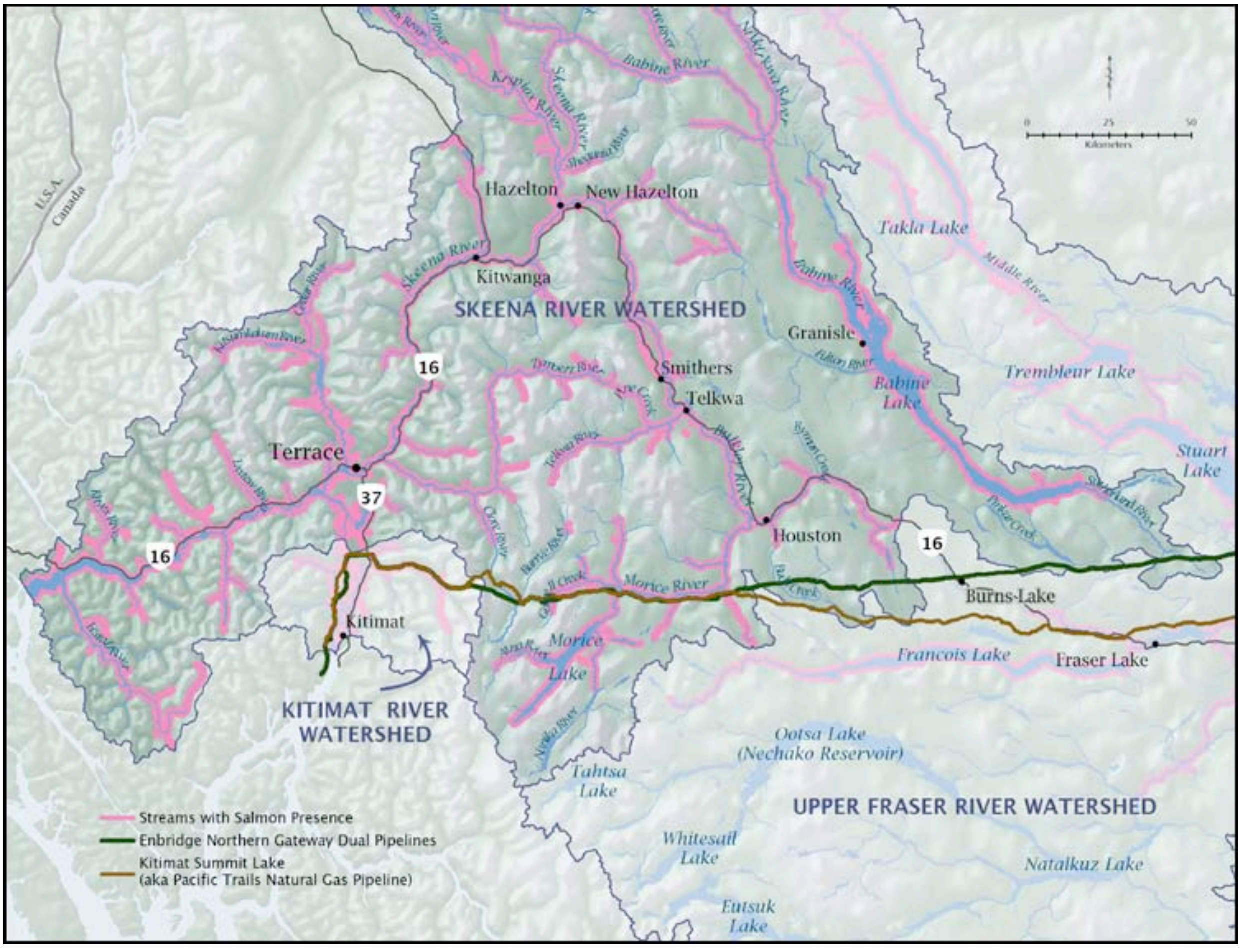


**Figure 4. Skeena River Watershed in relation to proposed pipelines.**

Map: Eliana Macdonald

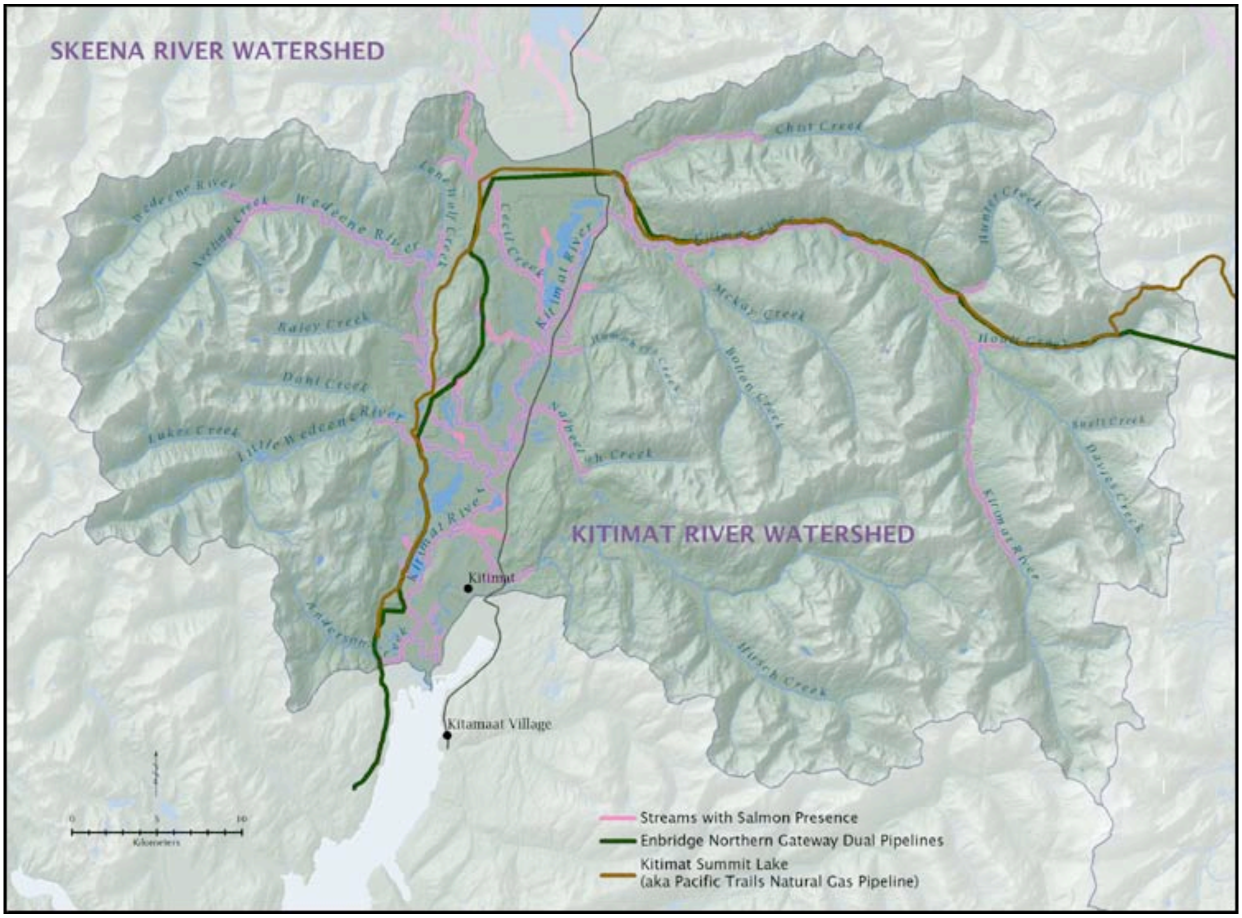


**Figure 5. Kitimat River Watershed in relation to proposed pipelines.**
Map: Eliana Macdonald

## 2.1 Salmon and First Nations

The remarkable salmon and steelhead which annually return from the sea serve as a cultural and economic foundation of many B.C. First Nations. In the Upper Fraser River, the Carrier fishery has taken place for millennia. Tl'az'ten, Nak'azdli and Takla Lake First Nations as well as other Carrier Sekani communities are highly dependent on the Stuart sockeye runs to meet their needs. The Kitamat river watershed has long been part of the ancestral homeland of the Haisla peoples. In the past, salmon, eulachon, and other species of fish were abundant and played a central and integral role in the Haisla's well-being.

In the Skeena River, the Gitxsan and Wet'suwet'en extensively relied upon the upper Zymoetz River watershed. The aboriginal fishery relied on a weir at the outlet of McDonell Lake, as well as spearing sites in the lower river. The Wet'suwet'en have also fished Morice-Nanika sockeye at Hagwilget and Moricetown Canyons for at least 6,000 years. The sockeye are critically important for food, social and ceremonial needs. Stock restoration is a high priority for the Wet'suwet'en, as Morice-Nanika sockeye are the last significant anadromous sockeye salmon population remaining on their traditional territory.

## 2.2 Salmon and B.C.'s Economy

In an average year, the commercial sector harvests around 28 million salmon, of which 75% are pink and sockeye.[2] The total landed value of the commercial catch is approximately $250 million. There are 350,000 recreational tidal water licenses issued in B.C. and a portion of the 300,000 non-tidal license holders also fish for salmon; collectively, fishers generate approximately $550 million in direct expenditures.[3] Nature tourism activities based on salmon are estimated to contribute hundreds of millions of dollars to the B.C. economy.[4]

The Zymoetz is considered one of the top ten steelhead rivers in B.C. for recreational fishing. The estimated annual steelhead catch, including guided angling, is 1,700 fish. The Morice is one of B.C.'s most significant streams for Chinook and is also considered to be a world-class summer steelhead stream. Coho are also fished in the Morice. Salmon and steelhead populations in both rivers are already stressed and various bans have been implemented to protect those populations.[5] A study of the Skeena Wild Salmon economy reported that it contributed $110 million to the regional economy[6].

The Kitimat River also provides some of B.C.'s finest recreational fishing for salmon, steelhead, and trout. The fishery is characterized by its ease of access for short-duration angling, as well as the large number of fish (augmented with hatchery releases).

## 2.3 Salmon Diversity and Abundance

Pacific salmon habitat extends from the freshwater rivers and streams in which they are born all the way to the Pacific Ocean, and back again where they spawn and die. The duration and timing of the migrations depend on the species and stock. Degradation in any part of that habitat will be detrimental to salmon health. In B.C., the five species of salmon are all present in the watersheds affected by the proposed Enbridge pipeline, as are steelhead (rainbow trout that migrate between freshwater and ocean habitats).

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[2] Fisheries and Oceans Canada, "Underwater World: Pacific Salmon," 2002, http://www.dfo-mpo.gc.ca/zone/underwater_sous-marin/salmon/salmon-saumon-eng.htm

[3] Fisheries and Oceans Canada, Fisheries Renewal, *A Vision for Recreational Fisheries in British Columbia 2008-2012: Draft Document for Discussion,* May 2008, http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/consultations/sfab/rec_fish_vision-documents/Recreational_Fisheries_Vision_Document_2008.pdf

[4] Wilderness Tourism Association of BC, *The Value of Wild Salmon to BC's Nature Based Tourism Industry and the Impacts of Open Net Cage Salmon Farming,* April 30, 2008, http://www.wilderness-tourism.bc.ca/docs/WTApositionpaper-salmon_farms-wild.pdf

[5] For the past several years, a kill ban has been instituted for the entire Skeena River watershed to protect steelhead runs from harvest. Throughout Morice River there is no angling from boats between August 15 and December 31 and a bait ban year-round.

[6] Northwest Institute for Bioregional Research *Valuation of the Wild Salmon Economy of the Skeena River Watershed*, prepared by IBM Business Consulting (2006), http://northwestinstitute.ca/downloads/IBM_skeena_report_06.pdf

Under the Wild Salmon Policy, the Department of Fisheries and Oceans (DFO) has grouped B.C. salmon into 423 "conservation units".[7] Conservation units are "groups of wild salmon sufficiently isolated from other groups that, if lost, would be unlikely to re-colonize naturally within an acceptable time frame." The areas of the Skeena, Kitimat, and upper Fraser that would be crossed by the Enbridge pipeline are home to at least 76 conservation units. This represents a huge range of unique and irreplaceable salmon biodiversity and some of Canada's most important salmon habitat (Table 1).

**Table 1. Conservation units in contact with proposed B.C. pipelines**

**The Skeena Watershed shows the greatest biodiversity, providing habitat for 55 conservation units.**

| | Conservation Units | | | | | | |
|---|---|---|---|---|---|---|---|
| Watershed | Pink | Chinook | Sockeye | Coho | Chum | Steelhead | Total |
| Upper Fraser | 1 | 1 | 9 | 2 | 0 | 0 | 13 |
| Skeena | 5 | 8 | 32 | 4 | 4 | 2 | 55 |
| Kitimat | 2 | 1 | 1 | 1 | 1 | 2 | 8 |
| Total | 8 | 10 | 42 | 7 | 5 | 4 | 76 |

While the number of unique salmon populations within these watersheds is significant, their resiliency varies from population to population. In general, the combination of a 150-year legacy of high fishing rates, increased industrial activity and human settlement in the watersheds, and reduced marine survival has led to diminished salmon abundance and lower-productivity habitats.

Table 2 summarizes the average runs by species and watershed, including some historical information where available. Some of the runs have variable returns, some reporting highs in the hundreds of thousands of fish in some years (e.g. Kitimat River pink and chum salmon). Other runs have experienced significant declines from historical numbers, including the sockeye run of the Morice River and the sockeye runs of the Stuart River.

Appendix 1 provides more detailed information on the salmon population in each of these watersheds.

[7] Fisheries and Oceans Canada, *Canada's Policy for Conservation of Wild Pacific Salmon,* June 2005, http://www.pac.dfo-mpo.gc.ca/publications/pdfs/wsp-eng.pdf

**Table 2. Average salmon runs by species and watershed**

| Watershed | Species | | | | | |
|---|---|---|---|---|---|---|
| | Pink | Chinook | Sockeye | Coho | Chum | Steelhead |
| **Upper Fraser** | Numbers of pink salmon are very low. They are expanding their ranges into Upper Fraser habitats. | The mean Chinook escapement in the Stuart River over the period 1995-2001 was 4200, with a range of 1900 to 7400. Over the period 1995–2008, mean Chinook escapement to the Salmon River was 920, with a range between 430 and 2400. | Populations are presently depressed due to adult migration difficulties and warm water temperatures encountered during migration. | Numbers of coho salmon are very low. They are expanding their ranges into Upper Fraser habitats. | None present. | None present. |
| **Zymoetz (Skeena)** | Over the past two decades there have been escapements of approximately 2000 pinks annually. | The annual Chinook escapement has ranged between 300 to 1000 spawners. | The average annual sockeye escapement has fluctuated between 1500 to 4000 spawners. | There are two distinct run components to the Upper and Lower river. There has been a long term decline in coho escapements. | The average annual chum escapement has ranged between 50 and 350 spawners. | Very high value recreational steelhead fishery. Predominantly summer run, with roughly 16% repeat spawners. |
| **Morice (Skeena)** | Insuffient information on Morice River pink salmon. | Morice River Chinook are the single most important Chinook population in the Skeena Watershed, constituting as much as 40% of the Skeena escapement in recent years. Escapements have ranged between 5,000 and 15,000 spawners. | Historically, Morice sockeye have comprised as much as 10% of the total Skeena River escapement. Levels in the 1940s and mid-1950s averaged around 40,000 spawners. Between the mid-1950s and the early 1990s the run collapsed to around 2,500 spawners. After 2000, the run has ranged from 3,000 to 10,000. | Morice River system coho comprise approximately 4% of the total Skeena coho escapement, however, absolute and relative abundance is declining. Escapements have fluctuated between 500 to 11,000 fish. Present escapement level is in the low thousands. | Very small run that historically had a few hundred spawners. Only a few are presently observed and these may be strays from the Kispiox system. | The Bulkley-Morice accounts for 30–40% of the Skeena steelhead escapement. These are summer run fish that enter the Morice system in mid-August and overwinter in the Morice mainstem, particularly downstream of Gosnell Creek. |
| **Kitimat** | Escapement has varied from 750 in 1971 to a high of 300,000 in 2003. Since 2003 there have been no annual stream inspections by DFO. | Escapement has fluctuated between 50,000 in the 1930s to a low of 1,000 in some years. The mean annual escapement for the 1990s was 13,400 spawners. | Escapement peaked at 15,000 in 1938. Since 1980, the mean annual escapement has been 3,000 spawners. | Escapement has varied from around 4,000 in the mid-1970s to a high of 75,000 in 1999. The mean annual escapement post-1980 has been 22,400 spawners. | The escapement is highly variable and has ranged from a high of 250,000 in 2003 to a low of 22,230 in 1990. A major component of the escapement is enhanced chum produced from the Kitimat Hatchery. Since 2003 there have been no annual stream inspections by DFO. | Kitimat winter-run steelhead are found throughout the watershed, migrating into the river between late March and early May. The peak spawning occurs in the first week of May. A small summer run is believed to spawn in the upper reaches of the mainstem and its tributaries. |

# 3. Pipelines in Northern British Columbia

Northern British Columbia currently has one major natural gas pipeline (operated by Pacific Northern Gas between Summit Lake and Prince Rupert) and no major liquid petroleum pipelines. Proposals exist for a total of four liquid fuel pipelines and one additional natural gas pipeline.

## 3.1 Proposed Northern Gateway Pipeline

As discussed, Enbridge's Northern Gateway pipeline has recently attracted considerable attention because of the profound scope of its environmental impacts.

Enbridge's proposed project would transport petroleum products across Northern B.C. between Alberta's oil sands and the B.C. coast. To accomplish this, Enbridge proposes to build twin pipelines that would cross the Upper Fraser, Skeena, and Kitimat watersheds. The pipelines would connect an inland terminal near Edmonton and a marine terminal near Kitimat to transfer petroleum products and condensate into and out of large oil tankers.[8] The proposed route is shown in Figure 6.


**Figure 6. Approximate route of the proposed Northern Gateway pipeline**

Source: http://www.northerngateway.ca/project-info/route-map

The east-flowing pipeline would most likely carry condensate, which is used as a thinning agent that permits high density petroleum products, such as bitumen, to flow in a pipeline. Condensate is a relatively light hydrocarbon that is acutely toxic to aquatic and terrestrial environments and is highly flammable in high concentrations. Despite the fact that condensate volatizes quickly in comparison to bitumen, it can cause substantial damage in the immediate spill location and

[8] Details of the project come from Enbridge Northern Gateway Pipelines, "Project Info: Northern Gateway at a Glance," http://www.northerngateway.ca/project-info/northern-gateway-at-a-glance

adjacent areas. Approximately 193,000 barrels of condensate per day would be carried in a 20-inch pipeline.

The most probable contents of the west-flowing pipeline are oil products from the oil sands, including diluted bitumen. Bitumen is the raw product from tar sands extraction that has not been upgraded to synthetic crude oil or further refined into petroleum products. Bitumen is an extremely toxic mixture of organic liquids that is highly viscous, black, sticky and composed primarily of highly condensed polycyclic aromatic hydrocarbons. Bitumen needs to be diluted with a lighter petroleum product (condensate or naphtha) in order to reduce its viscosity so that it can flow in a pipeline. Approximately 525,000 barrels of oil sands oil per day would travel through a 36-inch pipe. In comparison, the Exxon Valdez spill leaked 240,000 barrels of crude into Prince William Sound.

The right-of-way for the dual pipelines would be about 1170 km long and 30 m wide. It would cross at least 785 watercourses in British Columbia of which around 80 have high fisheries sensitivities or constructability issues. Large stream and river crossings, from east to west, include Kinuseo Creek, Murray River, Parsnip River, Wicheedo River, Crooked River, Muskeg River, Salmon River, Stuart River, Endako River, Morice River and Thautil River.

The project has generated concerns from First Nations and communities in Northern B.C. and beyond.[9] There are concerns that pipeline ruptures would affect fish abundance and habitat, and that oil tanker spills on the north or central B.C. coast will adversely affect marine life including B.C. salmon production in coastal waters. As well, the pipeline’s link to Alberta’s oil sands will hasten the land, water, and climate impacts already being caused by that development.[10]

## 3.2 Other Proposed Pipelines

The one new natural gas pipeline being proposed is the Pacific Trails Pipeline, which would carry gas west from Summit Lake to Kitimat. The pipeline would share the same right-of-way as the Pacific Northern Gas (PNG) pipeline between Endako (west of Fraser Lake) and Summit Lake, and require a new right-of-way between Endako and Kitimat.

All four proposed liquid pipelines (the twin Enbridge pipelines, and individual pipelines under evaluation by Kinder Morgan and Pembina Pipelines) are connected to the expansion of Athabasca oil sands in northern Alberta. Two would export oil sands products (most likely diluted bitumen), and two would import condensate (Table 3). Appendix 2 provides more information on the specific pipelines.

[9] Some of these concerns have been documented at http://landkeepers.ca/pipelines.

[10] Additional information can be found at http://www.oilsandswatch.org.

**Table 3. Existing and proposed pipelines in northern B.C.**

| Pipeline Project | Number of Pipelines | Product and Volume (per day) | Length of Right of Way | Linked to Oil Sands | Additional Tankers Required | Project Status |
|---|---|---|---|---|---|---|
| **Enbridge Northern Gateway** | 2 | 525,000 barrels of oil products including diluted bitumen<br>193,000 barrels of condensate | 1,170 km per pipeline | Yes | Yes | Proposed – Joint Review Panel process by the NEB and CEAA |
| **Pembina Pipeline Corporation** | 1 | 100,000 barrels of condensate | 465 km | Yes | Yes | Filed with the B.C. Environmental Assessment Office. Currently on hold. |
| **Kinder Morgan Canada** | 1 | 400,000 barrels of oil products including diluted bitumen | 760 km | Yes | Yes | Internal planning stages. |
| **Pacific Trail Pipelines** | 1 | 885 million cubic feet of natural gas | 470 km | No | Yes | Approved by CEAA and BCEAO. |
| **Pacific Northern Gas** | 1 | 115 million cubic feet of natural gas | ? | No | No | In operation |

If all five proposed pipelines were built, they would extend over 4,000 km stretched end to end. They would cross more than one thousand rivers and streams in some of Canada's most productive salmon habitat. These watersheds are national assets that provide food and shelter for aquatic and terrestrial wildlife and water for human consumption and other uses. If built, the salmon and their ecosystems may be negatively impacted by the construction and operation of the pipelines and from their possible failures. The remainder of this report further analyzes these impacts.

# 4. Impacts on Fish from Pipeline Construction and Operations

The construction and operation of pipelines is well understood and based on a large body of experience. While the steep and mountainous terrain of Northern British Columbia is a complicating factor, best practices and anticipated impacts are relatively well known. This section maps out those anticipated impacts for the construction and operation of pipelines. The most significant impacts would occur during construction at stream crossings, where increased sedimentation can cause adverse impacts ranging from increased mortality to changes in salmon behavior.

## 4.1 Construction Effects

Pipeline construction effects occur primarily at stream crossings[11]. They are characterized by acute physical and water quality impacts of relatively short duration. The main physical impacts are related to sedimentation and increases in total suspended solids (TSS) due to trench excavation, disposal of fill, erosion and run-off from adjacent upland worksites. Additionally, water discharge from hydrostatic pipe testing and trench dewatering also contributes sediment. Salmon are highly sensitive to sedimentation increases.

Fish responses to sedimentation are related both to the duration of exposure and the suspended sediment concentration[12]. The higher the sediment concentration and the longer the exposure, the more detrimental the impacts will be to fish populations. Analysis of the severity of sediment-related effects on six groups of fish (including salmonids) were rated in order of increased sediment loading as shown in Table 4.

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[11] Lucie M. Lévesque and Monique G. Dubé, "Review of the Effects of In-Stream Pipeline Crossing Construction on Aquatic Ecosystems and Examination of Canadian Methodologies for Impacts Assessment," *Environmental Monitoring and Assessment* 132 (2007): 395-409, http://www.ncbi.nlm.nih.gov/pubmed/17674136

[12] C.P. Newcombe and J.O.T. Jensen, "Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk and Impact," *North American Journal of Fisheries Management* 16 (1996): 693-727.

**Table 4. Analysis of the severity of sediment-related effects on fish[13]**

| Ranking of Sedimentation Effects | Fish Response |
|---|---|
| 1. behavioral effects | alarm, abandonment of cover, avoidance |
| 2. sublethal effects | short term reduction in feeding success, moderate physiological stress, cough and increased respiration rate, habitat degradation, impaired homing, long term reduction in feeding success, poor condition |
| 3. lethal and paralethal effects | reduced growth, delayed hatching, reduced density, increased predation and moderate to severe habitat degradation, with mortality increasing incrementally from > 20 to 100% |

The Canadian water quality guidelines define the safe level of TSS for the protection of aquatic life. The guidelines were developed using toxicity measurements from a suite of freshwater fish, including salmonids. The guideline is a maximum 25 mg/l increase over background levels during low flow over a period up to 24 hours, and a maximum 5 mg/l above background levels over a period between 24 hours and 30 days[14]. During pipeline construction, TSS can exceed 2500 mg/l[15].

The effects of high TSS from pipeline crossing construction on rainbow trout physiology were determined in cage experiments[16]. Measured effects of high TSS included increased respiration time and shorter times until loss of equilibrium. Differences in blood cell concentrations were attributed to sediment concentration and particle size.

Sedimentation effects on adult spawners may be very different than effects on fry. Behavioral impacts during migration or spawning may be more important for the former, and prey availability or physiological limitations may be more important for the latter.

Benthic invertebrates are also very susceptible to TSS increases. Drift invertebrate biomass was altered by winter pipeline crossing construction in Hodgson Creek, Northwest Territories in response to a pulse of sedimentation[17]. Elevated TSS caused an increase in invertebrate drift density from 2.6 to 37.6 per 100 $m^3$ downstream, and an increase in standing crop that lasted over 5 weeks. The increase was likely a reflection of sediment plume avoidance by the drift invertebrates.

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[13] Ibid.

[14] Canadian Council of Ministers of the Environment, *Canadian Environmental Quality Guidelines* (Winnipeg, MB: 1999).

[15] Scott M. Reid and Paul G. Anderson, "Suspended Sediment and Turbidity Restrictions Associated With Instream Construction Activities in The United States: An Assessment of Biological Relevance," *International Pipeline Conference 1998*: 1031–1035. http://aplwww.alliance-pipeline.com/contentfiles/30____TSS_Criteria.pdf

[16] Scott M. Reid, G. Isaac, S. Metikosh and J.I.M. Evans, "Physiological response of rainbow trout to sediment released during open-cut pipeline water crossing construction," *Water Quality Research Journal of Canada* 38 (2003): 473-481, http://cat.inist.fr/?aModele=afficheN&cpsidt=15025864

[17] Lucie M. Lévesque, *Method and Design for Assessment of Aquatic Impacts Associated with Pipeline Crossing Construction,* unpublished report prepared for Dr. Monique Dubé, National Water Research Institute, 2005.

One week after pipeline construction, the downstream benthic invertebrate community in Findlay Creek, Ontario was generally limited to only sediment-tolerant species of oligochaetes (aquatic earthworms)[18]. In contrast, at upstream control sites, the benthic invertebrate fauna was characterized as very diverse with over 26 species comprised of chironomids, caddisflies, stoneflies, mayflies, and dragonflies. Changes in observed benthic invertebrate communities tend to be transient. Full recovery of benthic invertebrate communities generally occurs within six months to a year after construction.

The amount of increased sedimentation and its duration depends largely on the method of stream crossing construction, and whether the crossing is below-ground or above-ground (i.e. a bridge)[19]. Construction impacts on salmon can also be partially mitigated by scheduling construction activities in specified timing windows. These windows are designed to avoid sensitive life history stages thereby minimizing salmon exposure to impacts. However, some stream-dwelling salmonids such as coho, Chinook and steelhead are present throughout the year, making these exposed fish vulnerable to short-term construction impacts all year round. Even following best practices, pipeline construction regularly results in TSS levels exceeding the Canadian water quality guidelines. While these guidelines provide a defensible biological basis for protecting salmon, they have no current legal status.

**An Enbridge Case Study in Construction Impacts[20]**

In early 2009, Enbridge Energy Limited Partnership was found liable for environmental damages incurred during the construction of two parallel pipelines in Wisconsin known as the Southern Access Expansion. The state lawsuit was settled after Enbridge paid $1.1 million in damages over violations of the conditions of their wetland and waterway protection permit. The Civil Complaint was filed by the Wisconsin Department of Justice and documented over 500 violations, including 282 wetland violations (soil mixing, rutting, unauthorized clearing, improper restoration), and 176 land disturbance and erosion control violations near navigable waters and wetlands. All of the violations were documented by independent environmental monitors hired by the Wisconsin Department of Natural Resources.

## 4.2 Operational Effects

After a pipeline has been installed and its associated road network has been developed, human access to streams is greatly enhanced at pipeline stream crossings in remote areas. This can promote activities, including fishing, that affect resident and migratory fish populations. In

[18] Scott M. Reid and Paul G. Anderson, "Effects of Sediment Released During Open-Cut Pipeline Water Crossings," *Canadian Water Resources Journal* 24 (1999): 235-251. http://aplwww.alliance-pipeline.com/contentfiles/45____EffectsofSediment.pdf

[19] Canadian Association of Petroleum Producers, Canadian Energy Pipeline Association and Canadian Gas Association, *Pipeline Associated Watercourse Crossings*, prepared by TERA Environmental Consultants and Salmo Consulting Inc. (Calgary, AB: 2005), http://www.neb.gc.ca/clf-nsi/rsftyndthnvrnmnt/nvrnmnt/rfrncmtrl/pplnwtrcrssngs2005-eng.pdf. This paper discusses watercourse crossing construction techniques and evaluates the environmental advantages and disadvantages of different pipeline crossings. A total of 43 pipeline construction methods were evaluated.

[20] Wisconsin Department of Justice, "Enbridge Energy Settles State Lawsuit Over Environmental Violations For $1,100,000," media release, January 2, 2009, http://www.doj.state.wi.us/absolutenm/anmviewer.asp?a=24&z=3

effect, the pipeline becomes a conduit for human contact at stream locations which were formerly difficult to access. Pipeline operations can thereby indirectly increase fish mortality via fishing or other human-induced secondary impacts.

In addition to concerns related to increased access, the clearing of trees around streams for pipelines and service roads can also affect salmon habitats. Deforestation frequently leads to decreased stream shading, which results in increased stream temperatures.

# 5. Impacts on Fish from Pipeline Failures

Pipeline failures and the resulting impact of spilled petroleum products are one of the main concerns associated with pipeline operations. A failure can be classified as a leak (where a pipeline may be losing product but continues to operate), or a rupture (where a pipeline has been compromised to the point where it cannot continue to operate). The Alberta Energy and Utilities Board (EUB) lists the following potential causes of pipeline failure: construction damage, damage by others, earth movement, external corrosion, internal corrosion, joint failure, excess pressure, pipe failures, valve failures, and weld failures[21].

The volume of a spill will depend on the volume of petroleum product being shipped in the pipeline, the size of the failure relative to the pipeline's capacity, and the time that passes until the pipeline is turned off. For example, in the Pine River spill near Chetwynd, B.C. (see Section 6), it took 55 minutes before a ruptured pipeline was shut down. The anticipated flow rate for the proposed Enbridge pipeline would be approximately 20,833 barrels per hour or roughly 350 barrels per minute.

Regardless of the cause, the end result of a pipeline failure is the same — petroleum products being spilled into the surrounding environment. The consequences to salmon are most severe if the pipeline failures occur in proximity to stream crossing locations and associated habitat. It is important to understand how spills will impact fresh water aquatic environments and salmon health. The remainder of this section assesses these consequences.

## 5.1 Behaviors of Different Petroleum Products in Fresh Water

The chemical properties of different petroleum products vary significantly in fresh water environments. Heavier oils may become associated with sediments and structures such as woody debris and boulders. After sticking to a substrate, the oil can become immobile, releasing contaminants slowly over a prolonged period.

Lighter materials (such as condensate) float along the surface and, depending on conditions such as wind speed and temperature, can persist for one to three days before breaking down or evaporating. However, during this period, the effects of condensate on salmon, aquatic biota, and other freshwater users can be acutely toxic.

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[21] Alberta Energy and Utilities Board, *Pipeline Performance in Alberta, 1990-2005*, (Alberta EUB, 2007), http://www.ercb.ca/docs/documents/reports/r2007-a.pdf

If a spill of diluted bitumen occurs, its properties change rapidly as the light condensate evaporates[22]. If the diluted bitumen enters into water, it partitions and releases the condensate fraction. The physical behaviors of heavier materials, such as bitumen, are less well understood than crude oil under spill conditions. They tend to sink in fresh water, are slower to dissolve in the water column, and will not evaporate.

Failures in natural gas pipelines would result in only minor aquatic impacts because the gas itself is non-toxic and would likely dissipate quickly. Gas from a submerged rupture would quickly bubble to the surface.

## 5.2 Hydrocarbon Toxicity

There is a large literature on the chronic and acute toxicity of petroleum compounds on fish, including salmonids. Condensate and diluted bitumen are highly toxic to all species of salmon, and particularly for the egg and alevin stages. There can be little doubt that exposure to these contaminants would have a severely detrimental impact on salmon populations in northern B.C. In the three watersheds of concern, Kitimat, Skeena and Upper Fraser, stream rearing juvenile steelhead, coho and Chinook are present all year round and are therefore susceptible to spilled petroleum products and condensate.

A range of impacts has been measured in salmon and other fish species from exposure to oil and other petroleum products. These include lethal as well as sublethal effects on growth[23], gene expression[24] and defects in cardiac function, edema, spinal curvature and reduction in the size of the jaw and other craniofacial structures[25].

Polycyclic aromatic hydrocarbons (PAHs) that are dissolved in water from either floating or submerged petrochemicals are the most toxic components for fish and invertebrates. Chronic toxicity increases with higher concentrations of alkyl PAHs. These compounds are found in trace concentrations in condensates, about 0.1% to 2.0% in crude oils and light refined oils (eg. diesel), and up to 6–10% in heavier oils (i.e. heavy bunker oils). Typically, early life stages and developing embryos (Figure 7) are the most sensitive to the toxic effects of petroleum products.

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[22] H.M. Brown and P. Nicholson, "The Physical-Chemical Properties of Bitumen in Relation to Oil Spill Response," *Proceedings, Fourteenth Arctic and Marine Oilspill Program* (1991).

[23] R.A. Heintz, S.D. Rice, A.C. Wertheimer, R.F. Bradshaw, F.P. Thrower, J.E. Joyce and J.W. Short, "Delayed Effects on Growth and Marine Survival of Pink Salmon *Oncorhynchus gorbuscha* After Exposure to Crude Oil During Embryonic Development," *Marine Ecology Progress Series* 208 (2000): 205–216.

[24] R.M. Stagg, J. Rusin, M.E. McPhail, and A.D. McIntosh, "Effects of Polycyclic Aromatic Hydrocarbons on Expression of CYP1A on Salmon (*Salmo salar*) Following Experimental Exposure and After the Braer Oil Spill," *Environmental Toxicology and Chemistry*, 19 (2000): 2797–2805.

[25] J.P. Incardona, T.K. Collier and N.L. Scholz, "Defects in Cardiac Function Precede Morphological Abnormalities in Fish Embryos Exposed to Polycyclic Aromatic Hydrocarbons," *Toxicology and Applied Pharmacology* 196 (2004): 191–205.


**Figure 7. Salmon embryos after oil exposure**

**Deformed pink salmon embryo (lower) exposed to oil compared to an unexposed fry (upper).**

Source: Dr. Mark Carls, NOAA, Alaska Fisheries Science Center, http://www.afsc.noaa.gov/

Chronic toxicity is usually the result of prolonged exposure to contaminants and depends on the persistence of the spilled material. In streams and rivers, oil entrained in bottom sediments can destroy spawning habitat. If spilled material contaminates sediments of a spawning bed, salmon embryos in the spawning gravel would be highly vulnerable. Chronic toxicity to embryos will reduce the number of fish that survive to the adult population.

The chronic toxicity of petroleum contaminants for fish and aquatic life has been clearly demonstrated. In separate studies, exposure to toxic fractions of Alaska North Slope Crude[26] and contaminated wastewaters from the Athabaska oil sands area[27] had detrimental impacts on fish health. Compared to control fish populations, the contaminated fish showed higher mortality, malformations, growth reductions and enzyme induction that could cause deleterious reproductive effects.

Acute lethality effects are due primarily to the components that readily dissolve in water like benzene, toluene, ethylbenzene and xylene. Toxic effects vary with the degree of evaporation and dilution which in turn depend largely on temperature and wind velocity. Acute lethality usually occurs within 24 hours and can be manifested as a fish kill.

[26] P.V. Hodson et al., "Alkyl PAH in Crude Oil Cause Chronic Toxicity to Early Life Stages of Fish" in: *28th Arctic and Marine Oilspill Program (AMOP) Technical Seminar,* Environmental Science and Technology Division, Environment Canada, Proceedings of the 2007 AMOP Symposium, Edmonton, AB, June 4–7 (2007): 291–300.

[27] M.V. Colavecchia, P.V. Hodson and J.L. Parrott, "CYP1A Induction and Blue Sac Disease in Early Life Stages of White Suckers (*Catostomus commersoni*) Exposed to Oil Sands," *Journal of Toxicology and Environmental Health Part A*, 69 (2006): 267–994.

# 6. History of Pipeline Failures

The previous section demonstrated the significant adverse impacts on salmon health that can be precipitated by pipeline failures that occur near stream crossings. Two obvious questions stem from this conclusion. What is the likelihood of significant pipeline failures? What can be done to limit the damages if such a spill occurs?

An analysis of pipeline failures suggests there is a significant probability that proposed pipeline projects in Northern B.C. will ultimately fail. In Alberta, the oil and gas industry had 377,000 kilometres of pipeline in 2005, and averaged 762 pipeline failures per year between 1990 and 2005 for a total of 12,191 failures. Six percent of these (758) were ruptures and 94% (11,433) were leaks[28]. The 1990–2005 data for pipelines in Alberta indicate the following release volumes: 96.0% of the pipeline failures resulted in releases of less than 100 $m^3$ of liquid, 3.5% were between 100 $m^3$ and 1000 $m^3$, and 0.5% were greater than 1000 $m^3$.

Along the 43,000 km of pipelines regulated by the National Energy Board (NEB), there were 46 ruptures over a 20-year period, or 2.3 ruptures per year[29]. A 1,000 km section of liquid pipeline would be expected to experience a rupture every 16 years. No ruptures were recorded in pipelines that had operated for less than 12 years, which was attributed to a number of factors, including the quality of materials, construction methods and effective pressure testing. According to the same study, large diameter oil pipelines — such as the ones proposed by Enbridge — experience failures from corrosion and stress after 28 years on average.

Oil products from these types of failures persist in freshwater, contaminating aquatic ecosystems for an indefinite period of time. Planning for spill emergency responses can help limit the damages, however there is an inevitable time lag before responses can be mobilized and adequate responses in dynamic river ecosystems will be challenging. Based on the likelihood of failure, coupled with the highly toxic nature of pipeline contents and unresolved questions about spill responses, failures represent the most serious threat from pipelines on Northern B.C. salmon populations.

## 6.1 Sabotage and Natural Disasters

While steps can be taken to minimize the risk of pipeline failure, there is little that an operator can do to avoid damage from outside forces such as sabotage and natural disasters. Indeed, pipelines in northern B.C. may fail more frequently than the pipelines regulated by the National

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[28] Alberta EUB, *Pipeline Performance in Alberta*.

[29] Franci Jeglic, "Analysis of Ruptures and Trends on Major Canadian Pipeline Systems," *Global Pipeline Monthly* 1 (2005), http://www.neb-one.gc.ca/clf-nsi/rsftyndthnvrnmnt/sfty/pplnrptrs/nlssrptrtrndmjrcndnppln-eng.pdf

Energy Board[30] because of the mountainous terrain and frequency of heavy precipitation events, landslides and avalanches.

Figure 8 shows a small portion of landslides that have occurred in areas adjacent to the proposed pipeline routes[31]. Within northern B.C., at least 38 catastrophic landslides larger than 500,000 $m^3$ of rock or with runouts longer than 1 km have occurred since 1973[32]. Adding to these risks, climate change is predicted to induce hydrological changes and potential flooding (i.e. rain on snow events) that could increase the frequency and severity of landslides[33].

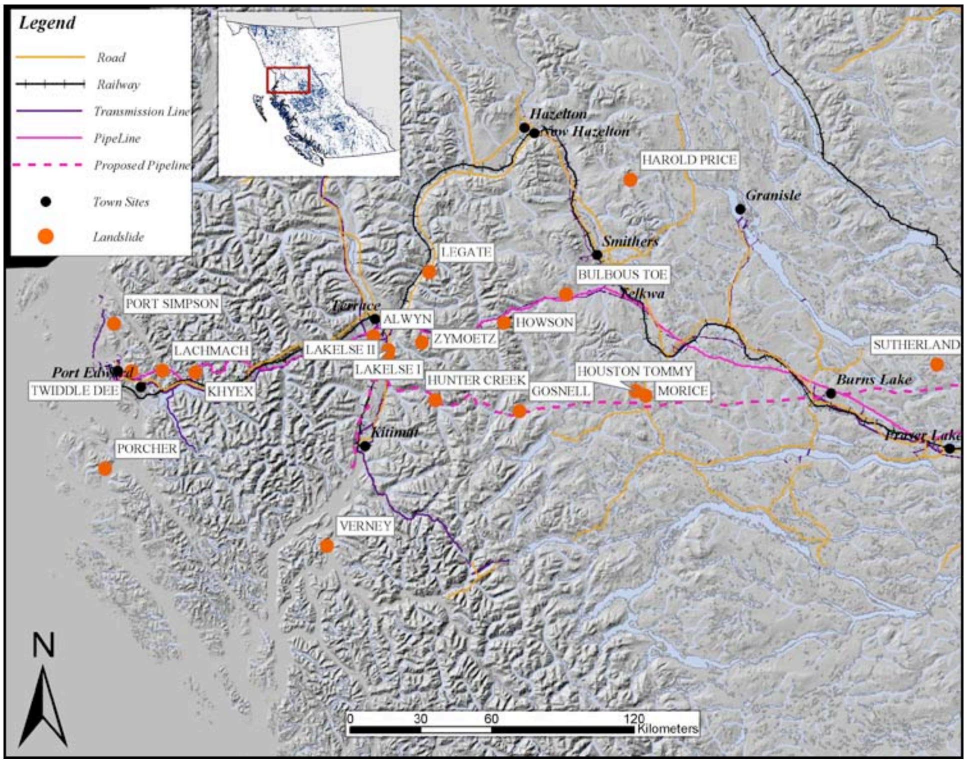


**Figure 8. Landslides and linear infrastructure in northern B.C.**

**The landslides (shown in boxes on the map) represent a small proportion of actual landslides in the area. The solid purple line is the PNG pipeline and the dashed purple line is the proposed Enbridge Northern Gateway right-of-way.**

Source: Geertsema et al., "Landslides and Linear Infrastructure."

Landslides ruptured natural gas pipelines in northern B.C. in 1978, 1999, 2002 and 2003. Two examples include the Howson rock avalanche and the Zymoetz landslide. The Howson rock

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[30] Ibid.

[31] M. Geertsema, J.W. Schwab and A. Blais-Stevens, "Landslides and Linear Infrastructure in West-Central British Columbia," *Natural Hazards* 48 (2009): 59–72.

[32] M. Geertsema, J.J. Clague, J.W. Schwab and S.G. Evans, "An Overview of Recent Large Catastrophic Landslides in Northern British Columbia, Canada," *Engineering Geology* 83 (2006): 120–143.

[33] Ibid.

avalanche[34] (Figure 9) travelled a distance of 2.7 km and dropped 1,300 metres in elevation. The avalanche tore through mature forest covering an area 1,200 metres long and up to 400 metres wide. Trees were blown over by the air blast, and large boulders, some the size of a small house, were strewn along the landslide path. In total, the avalanche displaced up to 5 million cubic metres of rock.


**Figure 9. Howson rock avalanche.**

**Left: The path of the avalanche showing cliffs (1), pipeline (2), powerline (3) and new lake (4).**

Source: Geertsema et al., "Recent Large Catastrophic Landslides."

**Upper right: View toward the ice valley showing rock avalanche width, forest removed, and gully on the left of photograph. Lower right: Helicopter next to a house-sized boulder carried down in the avalanche.**

Source: B.C. Forest Service, "Catastrophic Rock Avalanche."

The Zymoetz landslide[35] (1.6 million $m^3$) travelled a distance of 4.3 km and dropped 1,255 m in elevation over this distance. This landslide ruptured a gas pipeline interrupting service to Kitimat, Terrace and Prince Rupert and also blocked access to a 3,000 $km^2$ basin for more than a year due to the flooding of the road adjacent to the river. Similar types of barriers to access could seriously hinder the ability to respond to a pipeline failure, especially if exacerbated by severe winter conditions.

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[34] British Columbia Forest Service, Forest Sciences Prince Rupert Forest Region, "Catastrophic Rock Avalanche: Howson Range, Telkwa Pass," *Extension Note #46,* March 2002, http://www.for.gov.bc.ca/rni/research/Extension_Notes/Enote46.pdf

[35] Geertsema et al., "Recent Large Catastrophic Landslides."

Intentional human-caused damage is a further potential cause of failure. Figure 10 provides a graphic example of a pipeline failure that created significant environmental impacts. This 2001 incident adjacent to the Copper River in Alaska occurred when a bullet fired from a high-powered rifle put a 1/3-inch hole through the half-inch steel, 48-inch diameter pipe. Over 1.1 million litres of oil discharged into the environment before the hole could be plugged.

**Figure 10. An intentional breach of an Alaskan pipeline.**

Source: Joint Pipeline Office[36]

## 6.2 Canadian Case Studies: Freshwater Oil Spills

The two largest oil spills in Canada this century have occurred in freshwater environments[37]: the Pine River spill and the Wabamun Lake spill. Both spills offer important lessons in terms of the potential damages that could be expected from similar spills and the difficulties that would be encountered in attempting to mitigate the damage.

### 6.2.1 The Pine River Spill

A pipeline owned by Pembina Pipeline Corporation that transports light crude oil from Taylor to Kamloops ruptured on August 1, 2000 near the Pine River, 120 km upstream of Chetwynd. Operators of the pipeline detected a loss of pressure at 1:20 a.m., but both valves weren't manually shut off until 2:15 a.m. In that time 1 million litres of oil spilled into the Pine River, producing the largest inland oil pipeline spill in Canadian history.

The environmental impact included mortality to fish, benthic invertebrates and some wildlife.[38] Fish populations in the first 20 km were heavily impacted. A rough estimate by the B.C. Ministry

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[36] Joint Pipeline Office, *2001/2002 Annual Report*, http://www.jpo.doi.gov/Publications/Annual/2001-2002%20Report.pdf

[37] Ron Goodman, "Wabamun: a Major Inland Spill" (paper presented at Freshwater Spills Symposium, Portland, OR, May 1–4, 2006), http://www.epa.gov/OEM/docs/oil/fss/fss06/goodman.pdf

[38] Carrier Sekani Tribal Council, *Aboriginal Interests and Use Study on the Enbridge Gateway Pipeline: an assessment of the impacts of the proposed Enbridge Gateway Pipeline on the Carrier Sekani First Nations* (Prince

of Environment indicated tens of thousands of mountain whitefish and sculpins killed in the spill affected zone. The river water supply to the District of Chetwynd was also shut off and the use of many groundwater wells near the river was discontinued.

Clean-up costs for the spill were over $30,000,000 making it the most expensive inland oil spill clean-up in Canadian history. Clean-up efforts recovered 450,000 litres from the river and 415,000 litres from contaminated soil[39], leaving about 80,000 litres that spread through the environment. In 2002 Environment Canada laid charges against the corporation for depositing a deleterious substance into the Pine River.

The impacts on the river sediment included increased hydrocarbon concentrations over the first 25 km downstream. Physical cleanup of the river bottom was not possible due to the impact it would create, so the residual oil was left to be physically broken down over time. A survey undertaken in 2005, five years after the spill event, showed that residual oil has persisted in some bottom substrates of the Pine River[40].

The Saulteau and West Moberly First Nations expressed major concerns about the spill and its biophysical impacts, the environmental monitoring and evaluation of environmental damage, the impacts on their Treaty and Aboriginal rights, and the lack of a meaningful consultation process in regards to the potential infringements on their Treaty and Aboriginal rights.

### 6.2.2 The Wabamun Lake Spill

On August 3, 2005, a Canadian National Railway freight train derailed on the shore of Lake Wabamun, west of Edmonton, spilling about 750 $m^3$ of Bunker C fuel oil and 75 $m^3$ of a pole-treating agent on the lakeshore. The spilled materials covered about 12 km of shoreline, and demonstrated complex behaviors over time such as submergence, neutral buoyancy, resurfacing and formation of several types of oil aggregates[41,42]. These varied and unpredicted spill behaviors (shown in Figure 11) were influenced by sediment uptake or loss, temperature change, photo-oxidation and weathering.

George, B.C., 2006) 59, http://www.cstc.bc.ca/downloads/Oil%20&%20Gas/AIUS%20COMPLETE%20FINAL%20inc.%20maps.pdf

39 B.C. Ministry of the Environment, Environmental Emergency Management Program, "Pine River Oil Spill," http://www.env.gov.bc.ca/eemp/incidents/pembina_00.htm

40 H. Goldberg, "Pine River: 2005 Assessment — Residual Oil Survey and Snorkel Survey," Arc Environmental Ltd. Kamloops, B.C., 2006.

41 Merv Fingas, Bruce Hollebone and B. Fieldhouse, "The Density Behavior of Heavy Oils in Freshwater: the Example of the Lake Wabamun Spill" (paper presented at Freshwater Spills Symposium, Portland, OR, May 1–4, 2006) http://www.epa.gov/oem/docs/oil/fss/fss06/fingas_1.pdf

42 Ron Goodman, "Wabamun: a Major Inland Spill."

**Figure 11. Oil spill behavior in Lake Wabamun.**

**Left: Oil seeping along shoreline. Middle: Floating tar ball releasing sheen. Right: Tar log about 2 x 0.08 m.**

Source: Fingas et al, "Density Behavior of Heavy Oils."

In general, the spill's behavior in a freshwater environment was more complex than anticipated. As a result, the spill response and contingency planning was largely inadequate, and governments were not prepared to provide response assistance. The spill demonstrated the low level of understanding of oil spill behavior in freshwater environments. In particular, little was known about the dynamics of neutral density oil, the spillage and flow of hot product, the interaction of oil and fine sediments, and appropriate clean-up procedures[43]. Heavy oils still persist at the bottom of the lake.

## 6.3 Enbridge Accidents

While Enbridge has indicated that it will follow best practices, the company is not immune to pipeline failures, having experienced a number of pipeline ruptures during their operations including:

- on January 24, 2003, a leak released at least 380,000 litres of oil into the Nemadji River, a tributary of Lake Superior.[44]
- in February 2007, when workers ruptured a Wisconsin pipeline, releasing 300,000 litres of oil.[45]
- on April 15, 2007, a pipeline rupture near Glenavon Saskatchewan released 990,000 litres of oil.[46]

A study undertaken by the Carrier Sekani Tribal Council relating to aboriginal interests on the Enbridge Gateway pipeline documented eight pipeline ruptures that have occurred on Enbridge

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[43] Ibid.

[44] United States Environmental Protection Agency, "Oil Spill Program Update", July 2003, http://www.docstoc.com/docs/593974/EPA-Oil-Program-Update

[45] Enbridge, "2007 Corporate Responsibility Report," http://www.enbridge.com/csr2007/environmental-performance/spills-and-releases/

[46] National Energy Board, "Departmental Performance Report," March 31, 2008, http://www.tbs-sct.gc.ca/dpr-rmr/2007-2008/inst/ENR/ENR02-eng.asp

pipelines since 1992.[47] Data were obtained from records collected by the National Energy Board. The failures resulted in spills ranging from 50,000 to 4,000,000 litres of petroleum products, with an average of 1.8 million litres per rupture. An updated list of Enbridge failures to 2007 is documented in Table 5.

**Table 5. Enbridge pipeline ruptures since 1992**

| Date | Nearest Centre | Year Installed | Product | Immediate Cause | Volume Released (Litres) | Note |
|---|---|---|---|---|---|---|
| Jan 2007 | Clark County, WN | Not Specified | Crude Oil | Not Specified | 200,000 | Note 1 |
| Feb 2007 | Rusk County, WN | Not specified | Crude Oil | 3rd Party Damage | 475,000 | Note 1 |
| 15 Apr 2007 | Glenavon, SK | 1968 | Crude Oil | Corrosion | 990,000 | Note 2 |
| 22 Dec 2006 | Sheridan County, MT | Not Specified | Crude Oil | Failure at Pump Station | 300,000 | Note 1 |
| 2006 | Cromer, MB | Not specified | Crude Oil | Not Specified | 126,000 | Note 3 |
| 24 Jan 2003 | Nemadji River, WN | Not specified | Crude Oil | Not Specified | 375,000 | Note 4 |
| 4 July 2002 | Cohasset, MN | 1967 | Crude Oil | Cracking/Fatique | 950,000 | Note 5 |
| 29 Sep 2001 | Binbrook, ON | 1972 | Crude Oil | Metal Loss/ External Metal Loss | 50,000 | Note 6 |
| 17 Jan 2001 | Hardisty, AB | 1968 | Crude Oil | Cracking/Fatigue | 3,800,000 | Note 6 |
| 20 May 1999 | Regina, SK | 1968 | Crude Oil | Cracking/Fatigue | 3,123,000 | Note 6 |
| 27 Feb 1996 | Glenavon, SK | 1968 | Crude Oil | Metal Loss/ External Metal Loss | 800,000 | Note 6 |
| 13 Nov 1995 | Langbank, SK | 1965 | Crude Oil | Cracking/Fatigue | 768,000 | Note 6 |
| 16 Jun 1995 | Widthorst, SK | 1968 | Condensate | Metal Loss/ External Metal Loss | Not specified | Note 6 |
| 03 Oct 1994 | St. Leon, MB | 1963 | Oil & products | Improper Operation | 4,000,000 | Note 6 |
| 02 Jan 1992 | Cromer, MB | Not specified | Low Vapour Pressure Hydrocarbon | Metal Loss/ External Metal Loss | 125,000 | Note 6 |

[47] Carrier Sekani, *Aboriginal Interests and Use Study.*

Note 1: Source: Enbridge[48]

Note 2: Source: National Energy Board[49]

Note 3: Source: National Energy Board[50]

Note 4: Source: U.S. EPA[51]

Note 5: Source: U.S. National Transportation Safety Board[52]

Note 6: Carrier Sekani, *Aboriginal Interests and Use Study.*

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[48] Enbridge, “2007 Corporate Responsibility Report”.

[49] National Energy Board, “Departmental Performance Report,” March 31, 2008.

[50] National Energy Board, “Departmental Performance Report,” March 31, 2007, http://www.tbs-sct.gc.ca/dpr-rmr/2006-2007/inst/ENR/ENR02-eng.asp

[51] United States Environmental Protection Agency, “Oil Spill Program Update”, July 2003.

[52] United States National Transportation Safety Board, *Rupture of Enbridge Pipeline and Release of Crude Oil Near Cohasset, Minnesota, July 4, 2002*, Pipeline Accident Report NTSB/PAR-04/01, http://www.ntsb.gov/publictn/2004/PAR0401.pdf.

# 7. Cumulative Environmental Impacts on Salmon

The health of Skeena, Kitimat, and Upper Fraser watersheds have already been compromised to varying degrees by past impacts, and the proposed pipelines pose an additional threat. Forestry, hydro-electricity, transportation, agriculture, mining, mountain pine beetle, climate change and coalbed methane illustrate the breadth of stresses that salmon are already experiencing or could be faced with in the future. Their combined (or cumulative) impact will dictate the long-term health and viability of salmon.

If allowed to proceed, the proposed Enbridge pipeline and the anticipated impacts from its construction, operation, and eventual failures would be incremental to these existing and proposed stressors. As a result, the anticipated impacts from the proposed Enbridge pipeline need to be understood and assessed on a cumulative basis. The combined effect of multiple impacts won't necessarily be additive. Interactions between environmental stressors can result in a total impact greater than the sum of the parts.

Providing a detailed cumulative impact assessment is beyond the scope of this report, but this needs to be a critical element of any process considering whether or not to approve future pipeline projects. The following sub-sections provide a high-level overview of the other important impacts in the Skeena, Kitimat, and Upper Fraser watersheds.

## 7.1 Forestry

Historically, past forest practices greatly impacted salmon populations and degraded habitat. Logging directly affects stream habitats in a number of ways. Stream volumes, flow rates and turbidity are altered because snow melt and rainfall runoff flow faster across logged areas. Stream channels can be changed because of road construction. Stream temperatures can also increase because of reduced riparian vegetation. Each of these factors influences salmon populations and habitats, and many have strong parallels to the construction practices needed for a pipeline project. Though practices have been improved, logging remains the predominant industrial activity in the Upper Fraser, Skeena and Kitimat watersheds.

## 7.2 Hydro Electricity

Large storage reservoirs and flow controls frequently create adverse impacts on salmon. In British Columbia and the Pacific Northwest, large scale hydro developments have left a lasting and profound legacy of decimated salmon populations e.g. Columbia River Watershed. Of note in the Upper Fraser watershed is the Kemano Reservoir in the Nechako drainage. The project was developed by Alcan in the early 1950s to convey water into the Kemano watershed to generate electricity on the coast. Since 1987 there has been a Settlement Agreement between B.C., Alcan, and DFO that established the Nechako Fisheries Conservation Program to manage the impacts of the project on Chinook and sockeye salmon.

Within the Skeena and Kitimat watersheds there are also a number of proposals for smaller scale run-of-river hydro development. Run-of-river projects in B.C. have been controversial in part due to their potential impacts on salmon populations. Considerable scientific research is required to accurately assess the merits and impacts of these projects; such a detailed review is beyond the scope of this report. However, based on projects that have been approved elsewhere in B.C., it is reasonable to assume that some of these proposed run-of-the-river hydro projects could pose additional risks for Skeena and Kitimat salmon.

## 7.3 Transportation

Both rail and road alignments can block salmon access and alter fish habitats. These effects are prevalent in the lower Skeena watershed and the upper Bulkley floodplains because of poor design and construction of culverts and other drainage structures[53]. The most common problems are barriers to salmon migration, such as culverts with large outfall drops or culverts installed with excessive slope. These barriers create problems for returning adult spawners and also alienate the habitats for juvenile freshwater rearing. An example of alienated habitat is the 70% loss of the floodplain downstream of the Highway 16 Bridge crossing the Zymoetz River.[54]

## 7.4 Agriculture

The majority of agricultural impacts are associated with cattle grazing and the runoff of animal effluent as well as fertilizers and pesticides. Agricultural activity is significant in the Upper Fraser and there is also notable activity in the upper Bulkley of the Skeena. Agriculture is largely absent in the Kitimat watershed. Freshwater environmental impacts from grazing can be extensive. Unrestricted livestock access can negatively affect water quality, quantity, hydrology, riparian zone soils, instream and streambank vegetation, and aquatic and riparian wildlife.[55] In many cases, there can be reductions in fish production and biomass.

## 7.5 Mining

The reaches of the mid and upper Skeena plus the upper Fraser are dotted with various mineral deposits that have attracted mining exploration and development for the past century. Examples include three large open pit mines previously operated adjacent to Babine Lake in the Skeena watershed, the Duthie Mine in the Zymoetz drainage, the Silver Queen mining property east of

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[53] Allen Gottesfeld and Ken Rabnett, *Skeena River Fish and Their Habitat* (Skeena Fisheries Commission, 2008).

[54] Ibid.

[55] Belsky, A.J., A. Matzke and S. Uselman, "Survey of Livestock Influences on Stream and Riparian Ecosystems in the Western United States," *Journal of Soil and Water Conservation* 54 (1999): 419–431.

Owen Lake in the Skeena drainage, and the Equity Silver Mine in the Bulkley drainage. In some of these mines, inadequate controls on mining effluent have resulted in historical degradation of salmon habitat. While current mining operations do not present significant risks to salmon habitat, the development of large-scale mines in the future could change those risks depending on the nature of the project.

## 7.6 Climate Change and Warming Temperatures

Regardless of how successful efforts are to reduce greenhouse gas emissions, some degree of human-induced climate change is now inevitable. For these reasons, climate change is seen as a major threat to salmon survival. Small increases in water temperature can negatively affect salmon on their migratory spawning journey, as well as the viability of incubating eggs and juvenile salmon during the freshwater stages of their life cycle. Scientific studies have shown that prolonged exposure of several days in temperatures between 22–24°C can be fatal, and that at above 24°C death is almost certain within hours.[56] Of the five species of Pacific salmon, sockeye are the most sensitive and vulnerable to higher water temperatures.[57]

In recent years, temperatures in excess of 20°C have already being recorded on the Fraser River. Climate models predict temperature increases of 1.5–3.2°C by 2050. These higher temperatures will increase water temperatures to dangerously high levels for salmon.[58]

In addition to the direct impacts on salmon from increased water temperatures, changing weather patterns will impact salmon in several other ways:

- Higher temperatures can also increase the amount of organic materials present in freshwater ecosystems, raising the possibility for toxic algae blooms and leading to higher rates of bacterial infection.[59]
- Climate change will cause snow packs to melt earlier, resulting in stronger, more frequent spring flooding and reduced summer run-off. In the spring, increased volume, higher velocity and the mixed debris associated with heavy flooding and variable stream flows could scour existing redds and destroy incubating eggs.[60] Low summer flows could also isolate and destroy the rearing habitats of juvenile salmon.[61]

## 7.7 Mountain Pine Beetle

As shown on the distribution map of mountain pine beetle (Figure 12), Upper Fraser and Skeena areas along the proposed pipeline route have been subject to the beetle infestation. Infested

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[56] M. Ferrari, et al., "Modeling Changes in Summer Temperature of the Fraser River During the Next Century," *Journal of Hydrology* 342 (2007): 337.

[57] Ibid.

[58] James Battin et al., "Projected Impacts of Climate Change on Salmon Habitat Restoration," *Proceedings of the National Academy of Science* 104, no.16 (2007): 6722, www.pnas.org/cgi/doi/10.1073/pnas.0701685104

[59] Ibid., 6729

[60] Ibid., 6720

[61] Ibid., 6721

forests have higher water tables and faster snowmelt, resulting in higher spring floods and more flash flooding and erosion. Each of these changes in stream flow can stress salmon habitat.

The salvage logging associated with mountain pine beetle also introduces an additional layer of forestry impacts, with road building and stream crossing activities that can significantly impact salmon habitats.

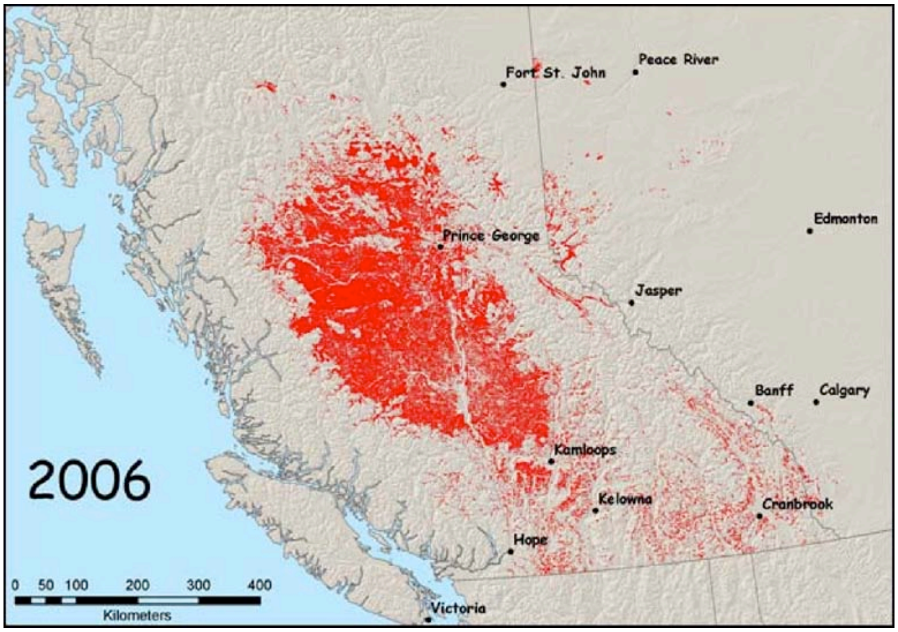


**Figure 12. Distribution of mountain pine beetle**
Source: Natural Resources Canada[62]

## 7.8 Coalbed Methane

Commercial coalbed methane has never been attempted in a salmon-bearing watershed and initial analysis suggests that it could have significant impacts on salmon habitat.[63] Coalbed methane requires a much higher density of wells, roads and pipelines than conventional gas. Each of these terrestrial impacts can influence stream volumes, flow rates and turbidity, which in turn can degrade salmon habitat. In addition, groundwater must often be removed before coalbed methane can be produced. Consequently, water tables could drop and ground water flow into streams could be reduced or stopped. The reduced groundwater inflow would alter overall stream flow and temperature, which could potentially reduce the stream's suitability for salmon. There are two areas in the Skeena that have been considered for coalbed methane development: one in the headwaters of the Skeena, Stikine and Nass rivers, and one area near Telkwa in the Bulkley watershed.

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[62] Natural Resources Canada, "Total Area Affected by Mountain Pine Beetle in Western Canada," http://mpb.cfs.nrcan.gc.ca/map_e.html

[63] The Pembina Institute, *Coalbed Methane and Salmon: Assessing the Risk*, prepared by GW Solutions, (Calgary, AB: The Pembina Institute, 2008), http://pubs.pembina.org/reports/cbmandsalmon-rpt.pdf

# 8. Conclusions

Each of the five proposed pipelines that could potentially traverse northern B.C. could threaten the health of the Fraser, Skeena, and Kitimat watersheds and the salmon they are home to. If all five proposed pipelines were built, they would extend over 4,000 km stretched end to end. They would cross more than one thousand rivers and streams in some of Canada's most productive salmon habitat. Any of the proposed pipeline projects in Northern B.C. will expose salmon to risks on a number of fronts.

During construction, pipeline stream crossings in particular are vulnerable to increased sedimentation, which can degrade salmon habitat. While many construction impacts can be minimized by adopting proven mitigation methods and environmental management plans, the best intentions do not always translate to the best practices as evidenced by Enbridge's 2009 pipeline construction violations in Wisconsin.

Of greater concern is the threat of pipeline failures in liquid pipelines and the resulting spills. The condensate and oil sands products that would be carried in the pipelines are highly toxic to salmon and if spilled into stream habitats, they have acute and chronic effects. Northern B.C. is mountainous and remote terrain, and whether failure is the result of normal pipeline decay over time or more sudden events like landslides or sabotage, the risk cannot be fully eliminated.

The experience of the Pine River and the Wabamun Lake spills also show that the complexity of oil spills in freshwater environments can be easily underestimated and emergency responses to those spills can be inadequate. Over the proposed life of these pipelines, the scenario of a failure that spills into the Upper Fraser, Skeena or Kitimat watersheds is real. Depending on the contaminant discharge volume and the spill location relative to stream crossings, serious and lasting adverse impacts on salmon habitats could occur. Any decision to approve such a pipeline should be made in recognition of these risks.

The risk of impacts from pipeline construction and failures should not be assessed and managed in isolation of other environmental impacts. If approved and constructed, the risks from pipelines would be in addition to existing and other new impacts such as forestry, mining, hydro-electric projects and climate change. The cumulative impacts of potential pipeline development must be evaluated to understand the contribution of numerous direct and indirect effects that over time combine to pose a serious and multi-tiered threat to salmon habitat and freshwater ecosystems.

# Appendix 1 – Description of Salmon Resources

## Upper Fraser River

The proposed pipeline routes would cross a number of important salmon-producing watersheds in the Upper Fraser (Figure 3) including the Salmon River and Stuart River systems. The Stuart River is a tributary that drains a network of large lakes (Stuart, Trembleur, and Takla) and flows into the Nechako River. The Salmon River joins the Fraser River northeast of Prince George. These two watersheds provide important salmon spawning, rearing and migratory habitats. The conservation units[64] in the Upper Fraser watersheds potentially affected by future pipelines include one pink, one Chinook, nine sockeye (eight lake-type and one river-type), and two coho.

Numbers of pink and coho salmon in the Upper Fraser are very low although both species are expanding their ranges into Upper Fraser habitats.

### Chinook

Stuart River Chinook are summer-run. Spawning usually occurs in September. While some juveniles take up residency in the Stuart River for one year, others out-migrate for juvenile rearing into the Fraser mainstem and downstream tributaries for juvenile rearing. Age of returning adults is 3–6 years, with the majority returning at age five. The mean Chinook escapement in the Stuart River over the period 1995-2001 was 4200, with a range of 1900–7400.

Most of the Salmon River serves as rearing habitat for juvenile Chinook. Salmon River Chinook are spring-run: they enter the lower Fraser from February to early July, and show peak spawning activity around the third week of August. Over the period 1995–2008, mean Chinook escapement to the Salmon River was 920, with a range of 430–2400.

### Sockeye

Two major Upper Fraser sockeye stocks are supported in the Stuart River watershed. These include the Early Stuart and Late Stuart populations. Adults migrate to spawning grounds in the summer (Early Stuart) and fall (Late Stuart) and spawn in tributaries adjacent to Stuart, Trembleur and Takla Lakes. Both of these populations are presently depressed due to adult migration difficulties and warm water temperatures encountered during migration.

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[64] Salmon Conservation Units in this Appendix were identified from maps developed by DFO. http://www.pac.dfo-mpo.gc.ca/consultation/wsp-pss/2008/docs-eng/CUsummlist.pdf

### Fisheries

The Carrier fishery has taken place for millennia. Salmon has long been the most important food staple. Tl'az'ten, Nak'azdli and Takla Lake First Nations are highly dependent on the Stuart sockeye runs to meet their needs.

## Skeena River

The Skeena watershed (Figure 4) provides extensive spawning and rearing habitat for all five salmon species, steelhead, and at least 22 other fish species[65,66] . The list of conservation units for Skeena salmon includes 32 sockeye CUs (30 lake-type and two river-type), eight CUs for Chinook, four for coho, four for chum, and five for pink salmon. There are two steelhead CUs for the Skeena watershed that are distinguished based on adult run-timing (summer-run and winter-run). There are important enhancement facilities in the Skeena Watershed including two major sockeye spawning channels adjacent to Babine Lake. The Zymoetz (Copper) and Morice Rivers, major Skeena tributaries with high fisheries values that would be crossed by future pipelines, are described below. [67]

### Zymoetz River

#### Chinook

The annual Chinook escapement to the Zymoetz River has ranged between 300–1000 spawners. Chinook enter the Zymoetz River in late June, and spawning occurs from the end of August to the end of September. Critical spawning habitat occurs in patches throughout the mainstem and in the lower reaches of two tributaries: Limonite Creek and the Clore River.

#### Chum

The average annual chum escapement to the Zymoetz River has ranged between 50 and 350 spawners. Chum enter the river in August and spawn in September and October in an unconfined reach in the lower river. Habitat loss in the Zymoetz due to repositioning of the Highway 16 bridge and channelization efforts below the bridge may have contributed to recent low chum returns.

#### Sockeye

The average annual sockeye escapement to the Zymoetz River has fluctuated between 1500 to 4000 spawners. Sockeye enter the river in July and spawn in the upper watershed during August and September. McDonnell, Dennis and Aldrich Lakes serve as rearing areas for sockeye fry.

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[65] Gottesfeld and Rabnett, *Skeena River Fish.*

[66] C.J. Walters, J.A. Lichatowich, R.M. Peterman, and J.D. Reynolds, *Report of the Skeena Independent Science Review Panel*, report to the Canadian Department of Fisheries and Oceans and the British Columbia Ministry of the Environment, 2008, http://www.psf.ca/sisrp.pdf

[67] Fisheries information for these two watersheds was summarized from Gottesfeld and Rabnett, *Skeena River Fish.*

### Pink

Over the past two decades there have been escapements of approximately 2000 pinks annually. Adults enter the river in August and spawn in September/October within the largely unconfined lower reaches. Pink fry migrate to the ocean directly following emergence.

### Steelhead

Adult steelhead enter the Zymoetz River between July and November and spawn the following May to June. Zymoetz River steelhead are believed to include both summer-run and winter-run fish, though summer-run predominates. Repeat spawners comprise 16% of the steelhead population. Steelhead spawn primarily in the upper watershed particularly at the outlet of McDonell Lake. Steelhead overwinter in McDonell Lake and in mainstem areas upstream of the Clore River confluence.

### Fisheries

Traditional use of the upper Zymoetz River watershed by Gitxsan and Wet'suwet'en was extensive and there is a network of trails, village sites and fish houses in the watershed. The aboriginal fishery relied on a weir at the outlet of McDonell Lake, as well as spearing sites in the lower river.

The Zymoetz is considered one of the top-ten steelhead rivers in B.C. for recreational fishing. Estimated annual steelhead catch is 1,700 fish which includes guided angling effort. For the past several years, a kill ban has been instituted for the entire Skeena River watershed to protect steelhead runs from harvest.

## Morice River

### Chinook

Morice River Chinook are the single most important Chinook population in the Skeena watershed, constituting as much as 40% of the Skeena escapement in recent years. Escapements have ranged between 5,000 and 15,000 spawners. Peak spawning takes place in mid-September. Spawning occurs primarily in the 2 km downstream of the Morice Lake outlet in large gravel dunes that are constructed during redd excavation. Chinook fry are displaced downstream upon emergence and then rear throughout the Morice river mainstem and its side channels. Downstream migration of one-year-old smolts peaks in early June.

### Sockeye

The Morice-Nanika sockeye population is the largest in the Bulkley basin. Historically, Morice sockeye have comprised as much as 10% of the total Skeena River escapement. There are two run components: Nanika River spawners and Morice Lake and Atna Lake beach spawners. Historic levels in the 1940s and mid-1950s averaged around 40,000 spawners. Between the mid-1950s and the early-1990s the run collapsed to around 2,500 spawners. After 2000, the run has averaged around 5,000 fish (range: 3,000–10,000). Morice Lake serves as the juvenile rearing lake. Due to the very low productivity of Morice Lake, over 85% of the sockeye spend two years in the lake.

### Coho

Morice River system coho comprise approximately 4% of the total Skeena coho escapement; however, absolute and relative abundance is declining. Escapements have fluctuated between 500–11,000 fish. Present escapement level is in the low thousands. Coho enter the Morice system in mid-August through mid-September and then hold in the mainstem or in Morice Lake. They spawn in the tributaries in late October and November during fall freshet periods. Juvenile coho are widely distributed throughout the Morice River mainstem as well as in its tributaries and lakes. Pipeline proposals in the Gosnell are in the heart of the coho spawning and rearing habitats.

### Pink

There is not much information available for pink salmon. Colonization of the Morice system by pink salmon was facilitated by rock blasting in the Hagwilget Canyon in 1959.

These fish occur in the mainstem Morice and Gosnell in the vicinity of proposed pipeline activity and in some years the escapements can be large. Pink salmon are particularly vulnerable in the mid-reaches of the Morice, since much of their spawning is in extensive sidechannels of the main river downstream from the Thautil. This is below potential pipeline stream crossings of Morice tributaries which could be impacted by a rupture of a petroleum or condensate pipeline.

### Steelhead

The Bulkley-Morice accounts for 30–40% of the total Skeena escapement, making it the single largest component of the population. Morice are summer-run steelhead that begin to move into the river in mid-August. Overwintering occurs throughout the mainstem, Morice Lake and in Gosnell Creek. Spawning occurs in May to June throughout the mainstem and its tributaries. Steelhead fry emergence occurs between August and September. Most steelhead remain in the river for three or four winters prior to downstream migration.

### Fisheries

The Wet'suwet'en have fished Morice-Nanika sockeye at Hagwilget and Moricetown Canyons for at least 6,000 years. The sockeye are critically important for food, social and ceremonial needs. Stock restoration is a high priority for the Wet'suwet'en as Morice-Nanika sockeye are the last significant anadromous sockeye salmon population remaining on their traditional territory.

The Morice is one of the most significant streams, provincially, for Chinook and steelhead angling. The river is considered to be a world class summer steelhead stream. Coho are also fished. Throughout Morice River there is no angling from boats between August 15 and December 31 and a bait ban year-round.

## Kitimat River

The Kitimat watershed (Figure 5) supports a relatively low-diversity complement of CUs including one (each) CU of river sockeye, Chinook, chum, coho, odd-year pink and even-year pink. There are two steelhead CUs: summer-run and winter-run.

## Chinook

Chinook salmon concentrate in the Kitimat River mainstem, as well as in most of the larger tributaries including Wedeene River, Little Wedeene River, Chist Creek, and Hirsch Creek. Escapement has fluctuated between 50,000 in the 1930s to a low of 1,000 Chinook in some years. The mean annual escapement for the 1990s was 13,400 spawners. Upstream migration occurs from May to September with the heaviest spawning in July and August.

## Chum

Most chum spawn in the Kitimat River with lesser numbers in the tributaries. The escapement is highly variable and has ranged from a high of 250,000 in 2003 to a low of 22,230 in 1990. A major component of the escapement is enhanced chum produced from the Kitimat Hatchery. Spawning begins in July, peaks in August, and is usually over by the end of September.

## Sockeye

Sockeye in the Kitimat system are a river-type population. Sockeye spawn mainly in mainstem groundwater channels downstream of Hunter Creek. Sockeye escapement peaked at 15,000 in 1938. Since 1980, the mean annual escapement has been 3,000 spawners. After emerging from the gravel, sockeye fry migrate to the estuary where they rear for the summer.

## Pink

The Kitimat River pink run is predominantly an even-year run. Most adult pink distribute in the Kitimat mainstem with additional spawning in the tributaries. By the first week of September most spawning is completed. Escapement has varied from 750 in 1971 to a high of 300,000 in 2003. Juveniles emerge from the gravel in late March and early April and spend their first summer in the Kitimat Estuary.

## Coho

Coho salmon are distributed throughout the watershed. Tributaries are also important producers. A major portion of the escapement spawns in or adjacent to the Kitimat River. Cecil Creek provides the largest amount of high quality spawning habitat. The Kitimat River is especially important for rearing due to the relatively large amount of high-quality coho habitat. Coho escapement has varied from around 4,000 in the mid-1970s to a high of 75,000 in 1999. The mean annual escapement post-1980 has been 22,400 spawners. Most coho fry enter the estuary during spring of their second year and remain there until the end of August.

## Steelhead

Kitimat winter-run steelhead are found throughout the watershed, migrating into the river between late March and early May. The peak spawning occurs in the first week of May. A small summer-run is believed to spawn in the upper reaches of the mainstem and its tributaries. The mainstem absorbs the majority of spawners and a number of tributaries are also important. Steelhead juvenile age at outmigration is variable, ranging from age two to age four.

## Fisheries

The Kitimat river watershed has long been part of the ancestral homeland of the Haisla peoples. In the past, salmon, eulachon, and other species of fish were abundant and played a central and integral role in the Haisla's well-being.

Kitimat River provides some of B.C.'s finest recreational fishing for salmon, steelhead, and trout. The fishery is characterized by the ease of access for short-duration angling, as well as the large number of fish, which are augmented with hatchery releases. Angler effort is primarily by shoreline fishing and drift boats. The majority of anglers fish the lower mainstem in April through October. Principal species fished are Chinook, steelhead, coho, chum, and sea run cutthroat trout.

# Appendix 2 – Detailed Pipeline Routes

## Liquid Petroleum Pipelines

### Enbridge Northern Gateway[68]

Enbridge proposes to build an export petroleum pipeline and an import condensate pipeline between an inland terminal near Edmonton and a marine terminal near Kitimat (Figure 6). Enbridge also proposes to construct and operate marine infrastructure at Kitimat to transfer petroleum products and condensate into and out of large oil tankers. The marine infrastructure would be an integral component of the pipeline terminal near Kitimat, all of which, together with the pipelines, are collectively referred to as the Enbridge Northern Gateway Project.

Bitumen (diluted, most likely with condensate) is the most probable petroleum product to be transferred via the pipeline to Kitimat. A right-of-way, about 1170 km in length and 30 m wide, would be constructed between the Edmonton area and the Gateway marine terminal near Kitimat. Both the petroleum (525,000 barrels per day, 36-inch pipe) and condensate (193,000 barrels per day, 20-inch pipe) pipelines will be located in this right-of-way.

The project will cross at least 785 watercourses in British Columbia of which around 80 have high fisheries sensitivities or constructability issues. Large stream and river crossings include, from east to west, Kinuseo Creek, Murray River, Parsnip River, Wicheedo River, Crooked River, Muskeg River, Salmon River, Stuart River, Endako River, Morice River and Thautil River. The latter five systems are salmon bearing, as are many hundred smaller streams that would need to be traversed by the pipeline.

The Enbridge Gateway project has initiated a Joint Review Panel process through the National Energy Board and the Canadian Environmental Assessment Agency. CEAA is currently reviewing the terms of reference for the review, after the 60 day public comment period. It is anticipated that Enbridge will file their application some time in 2009.

Additional pipeline capacity is due to planned expansion of the Alberta tar sands. If allowed to proceed, the pipeline will further facilitate the destruction of the Boreal forest and pollution of

[68] The description of the Enbridge Northern Gateway Project comes from the Preliminary Information Package (PIP) that was filed with the National Energy Board in November, 2005, and from Enbridge Northern Gateway Pipelines, "Project Info: Northern Gateway at a Glance," http://www.northerngateway.ca/project-info/northern-gateway-at-a-glance

the Athabasca River and will lead to greater expansion of highly toxic tailing ponds and increased GHG emissions.[69]

## Kinder Morgan Canada

Kinder Morgan Canada has initiated internal planning on the northern leg of their Trans Mountain Pipeline.[70] The company is examining the viability of connecting Canadian producers and refining customers in Asia. In B.C., the proposed northern leg would connect to the existing Trans Mountain Pipeline at Valemont and extend 760 km to a deep-water port at Kitimat, passing north of Prince George. The pipeline would carry 400,000 barrels per day, transporting petroleum products including diluted bitumen. Although there is limited information available on the routing, it is assumed that the routing would follow the Pacific Trails Pipeline right-of-way. The existing Trans Mountain Pipeline connects Edmonton to Burnaby and Washington State and has a capacity of 300,000 barrels per day.

## Pembina Pipeline Corporation

Pembina Pipeline Corporation has proposed to transport about 100,000 barrels per day of condensate from Kitimat to Pembina's existing Western System at Summit Lake via a 16-inch pipeline[71]. The condensate would be used in the development of the Alberta oil sands as a thinner for heavy oil, such as bitumen. The Canadian Environmental Assessment Act requires a federal screening environmental assessment. Preliminary routing information (Figure 13) indicates that the routing would follow the Pacific Trails Pipeline right-of-way.

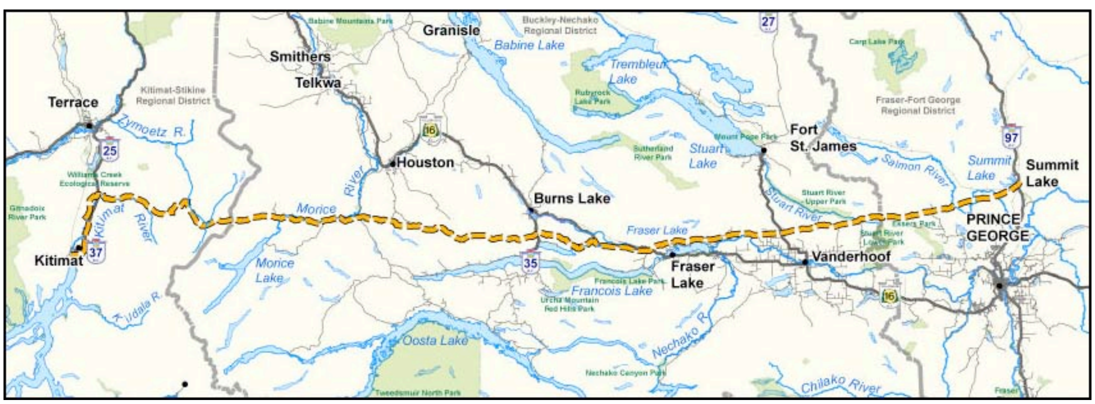


**Figure 13. Kitimat to Summit Lake corridor proposed by Pembina Pipeline Corporation.**

Source: Pembina Pipeline Corporation, *Project Description*

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[69] Dan Woynillowicz, Chris Severson-Baker, Marlo Reynolds, *Oil Sands Fever: The Environmental Implications of Canada's Oil Sands Rush* (Drayton Valley, AB: The Pembina Institute, 2005).

[70] Kinder Morgan Canada, *Trans Mountain Expansion (TMX) Proposal*, 2008, www.kindermorgan.com/business/canada/TMX_Documentation/brochure_single_page.pdf

[71] Pembina Pipeline Corporation, *Proposed Kitimat to Summit Lake Condensate Pipeline Project: Project Description*, filed June 14, 2006, at the B.C. Environmental Assessment Office: http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_project_home_280.html

# Natural Gas Pipelines

## Pacific Northern Gas

Pacific Northern Gas Ltd. (PNG) currently owns and operates a gas transmission and distribution system that delivers natural gas in a westerly direction from the Spectra Energy Transmission (formerly Duke Energy) gas pipeline system near Summit Lake to Kitimat and Prince Rupert on the west coast of British Columbia (Figure 14). The gas transmission line was constructed in 1968, with service commencing in 1969 for large industrial customers. Service was later provided to communities adjacent to the transmission line.

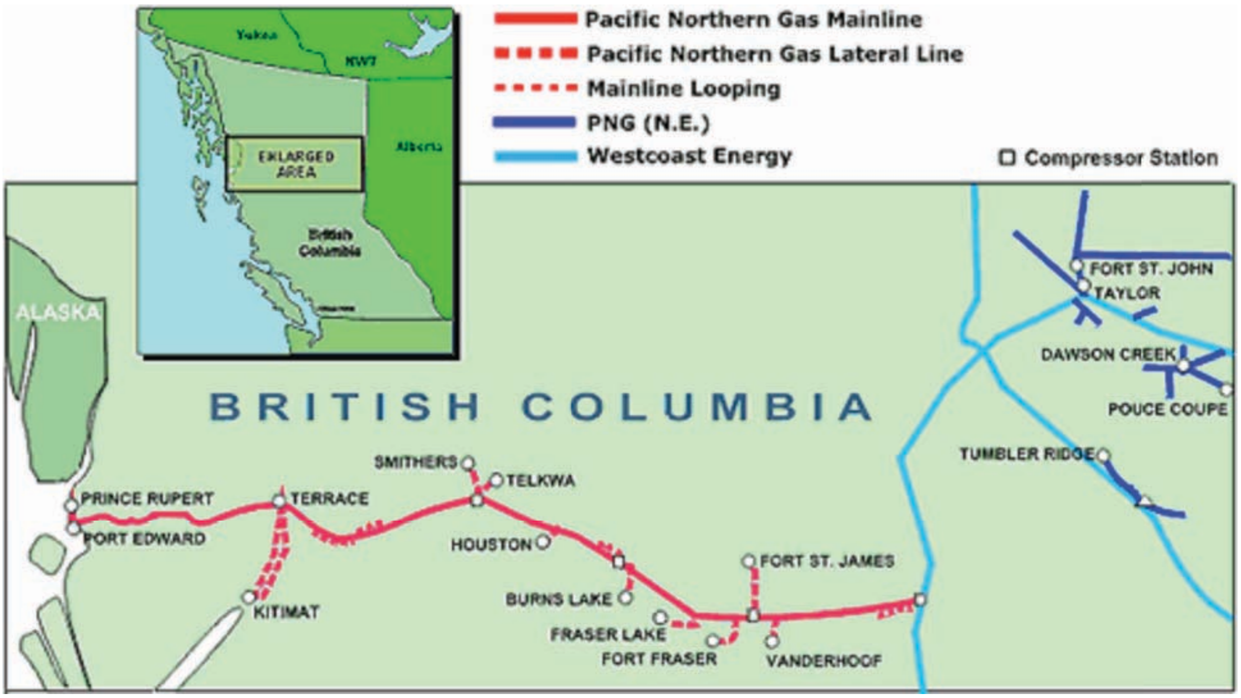


**Figure 14. Location of Pacific Northern Gas pipeline system in Northern B.C.**

Source: Pacific Northern Gas[72]

## Pacific Trail Pipelines

Pacific Trail Pipelines, a 50/50 partnership between Galveston LNG Inc. and Pacific Northern Gas Ltd. (PNG) plans to construct the Kitimat to Summit Lake Pipeline Looping Project (KSL Project) a new 470 km, 30-inch natural gas pipeline between Summit Lake and Kitimat B.C. along current and new rights-of-way[73] (Figure 15). The eastern portion of the pipeline is proposed for construction primarily within, or adjacent to, the right-of-way of the existing PNG

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[72] Pacific Northern Gas, "Company: Systems Map," http://www.png.ca/company_map.cfm

[73] Pacific Trail Pipelines, *Kitimat-Summit Lake (KSL) Pipeline Looping Project: Project Description (Revised February 2006)*, filed February 24, 2006, at the B.C. Environmental Assessment Office: http://a100.gov.bc.ca/appsdata/epic/html/deploy/epic_project_home_270.html

pipeline system between Summit Lake and Endako (west of Fraser Lake). The western half of the project would be constructed primarily within a new right-of-way between Endako and Kitimat. The divergence, in the western section, from the existing PNG right-of-way has been proposed to avoid difficult terrain through the Telkwa Pass, as well as environmentally sensitive areas in the Zymoetz (Copper) River valley. The project may also include one or more new compressor stations along the pipeline. Recently, the company announced that they would use Kitimat LNG Inc.'s liquified natural gas terminal near Kitimat as a component of an export operation.

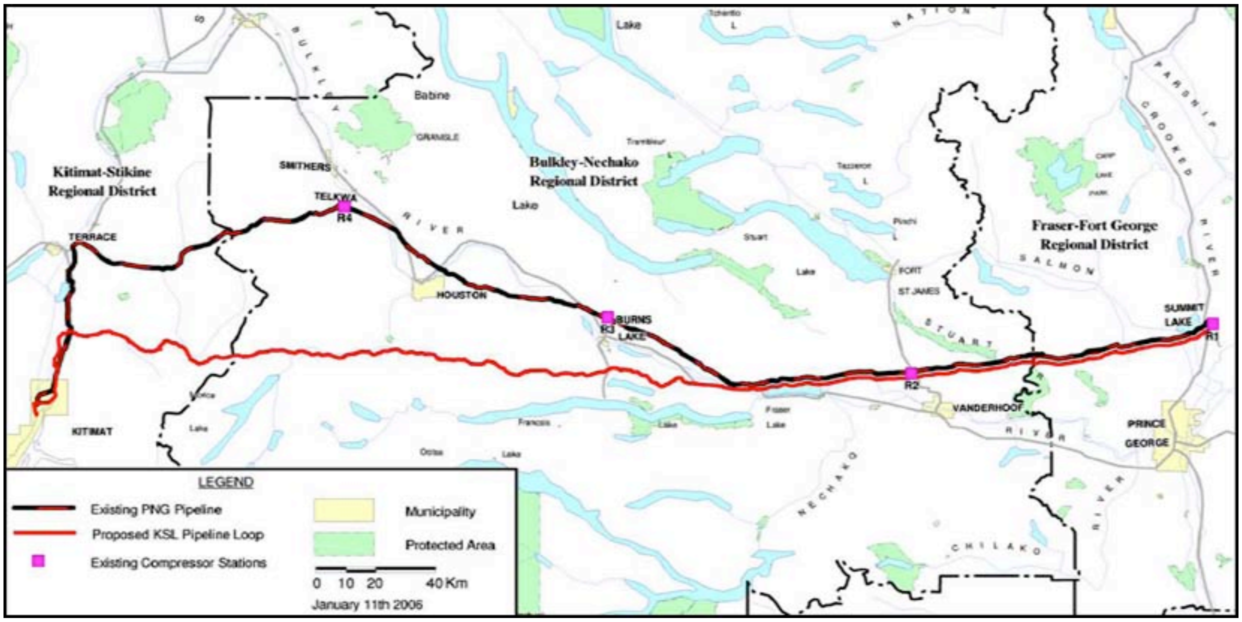


**Figure 15. Kitimat to Summit Lake Pipeline Looping Project (KSL Project) under development by Pacific Trail Pipelines.**

Source: Pacific Trail Pipelines, *Project Description*