17. Assessment of Potential Wetlands Effects

17.1 INTRODUCTION

Wetlands are dynamic, depressional, or slightly sloping areas on the landscape that are saturated with water for a significant period of time during the growing season. The effect of this saturation is reflected in the soil development and vegetation community composition found within wetlands. They are important ecosystems, as they fulfill a wide range of ecological, hydrological, biochemical, and habitat functions and are valued by society for the services they provide (Milko 1998; Mitsch and Gosselink 2000; Hanson et al. 2008). They maintain water quality, regulate water flow, and provide erosion control. They also provide habitat for a wide variety of wildlife, including red- and blue-listed wetland dependant species (Cox and Cullington 2009) and many economically important species. In British Columbia (BC), wetlands comprise about 5.6% of the provincial land base.

Wetlands are present within the immediate vicinity of the Brucejack Gold Mine Project (the Project) footprint; thus the Project has the potential to affect wetlands, including effects on wetland extent and function. This chapter will identify, assess, and discuss the significance of residual effects of the Project on wetland extent and function after implementation of mitigation measures and management plans. The assessment will consider the magnitude of change from baseline conditions; geographic extent over which effects occur; duration and frequency of effects; reversibility of effects; context or resiliency of the ecosystems affected; probability of effects; and confidence in the cause-effect relationships.

Wetland values were incorporated into the Project environmental assessment because a preliminary effects screening identified a strong likelihood of the Project adversely affecting wetlands, and First Nations and government regulators identified them as important components of a comprehensive assessment. This assessment, the supporting Wetland Baseline Study (Appendix 17-A) and Wetlands Monitoring Plan (Section 29.20) were drafted to meet the objectives of the *Federal Policy on Wetland Conservation*, which is to “promote the conservation of Canada’s wetlands to sustain their ecological and socio-economic functions, now and in the future” (Environment Canada 1991).

17.2 REGULATORY AND POLICY FRAMEWORK

There are a number of federal and provincial policy statements, acts, and best management practices pertaining to wetland aspects such as function, wildlife, and fish habitat including:

- (BC) *Mines Act* (1996a);
- (Canada) Federal Policy on Wetland Conservation (Environment Canada 1991);
- (BC) *Forest and Range Practices Act* (2002b);
- (Canada) *Species at Risk Act* (SARA; 2002c);
- (BC) Conservation Data Centre (BC MOE 2007);
- (Canada) *Fisheries Act* (1985);
- (BC) *Fish Protection Act (1997);*
- (BC) *Weed Control Act* (1996d);
- (BC) *Wildlife Act* (1996e);
- (BC) *Environmental Management Act* (2003); and
- (Canada) *Environmental Protection Act* (1999)

17.2.1 *Mines Act*

Under the *Mines Act* (1996b), the BC Ministry of Energy and Mines (MEM) requires that wetland mapping of a proposed mine site be completed for all mining permit applications according to provincial standards (BC MEM 1998). Wetlands in the proposed Brucejack Mine Site must be mapped to a 1:5,000 scale, and vegetation must be sampled and analyzed to establish baseline metal levels and trace element uptake (BC MEM 1998). In addition, the British Columbia Ministry of Environment (BC MOE) standards for environmental baseline programs identify wetlands as a component of aquatic ecosystems that need to be studied (BC MOE 2009).

17.2.2 Federal Policy of Wetland Conservation

Wetlands in Canada are managed and conserved through the *Federal Policy on Wetland Conservation*, which states that there will be "no net loss of wetland functions on all federal lands and waters" (Environment Canada 1991). The policy also states that the functions and values derived from wetlands will be maintained, and wetlands will be enhanced and rehabilitated in areas of continuing loss and alteration (Milko 1998). While the policy is specific to federally owned lands, Environment Canada has applied this policy where deemed reasonable such as in the case where wetlands of significance could be affected by a project.

17.2.3 *Forest and Range Practices Act*

The *Forest and Range Practices Act* (2002b) governs all forestry activities including logging, road building, reforestation and floodplain area management. The Act requires that all forestry-related development be conducted in accordance with the rules and regulations identified in the Act to ensure the protection of environmental values. The *Forest and Range Practices Act* (2002b) addresses ecosystems such as wildlife habitat through the Identified Wildlife Management Strategy. As unpaved roads have potential to contribute significantly to soil erosion, road construction within forested areas of BC is governed by the *Forest and Range Practices Act*. The Act requires that road construction adheres to codes provided in the Forest Service Road Use Regulation (BC Reg. 70/2004), which focuses extensively on erosion prevention.

17.2.4 *Species at Risk Act*

The purpose of SARA (2002c) is to prevent species at risk from becoming extirpated or extinct and ensure the appropriate management of species to prevent them from becoming at risk. Certain species are also protected under SARA as part of wildlife habitat and in accordance with the Canadian Biodiversity Strategy. The Canadian Biodiversity Strategy provides federal legislation that supports the conservation of particular species and populations to ensure continuance of biological diversity over time (Federal-Provincial-Territorial Biodiversity Working Group 1995).

17.2.5 BC Conservation Data Centre

The BC Conservation Data Centre (CDC; BC MOE 2007), which is part of the Environmental Stewardship Division of the BC MOE, classifies plant species and ecosystems at risk in the province as either red-listed (extirpated, endangered, or threatened) or blue-listed (of special concern), and tracks information regarding their conservation status and individual locations. Best management practices and guidelines for land developments recommend that red- and blue-listed plants and ecosystems be protected (BC MOE 2006).

17.2.6 *Fisheries Act* (Federal)

The federal *Fisheries Act* (1985) provides the legal framework to protect fish habitat from flooding and potential loss of land due to stream erosion and instability. Section 35 establishes rules guiding development within the Fisheries Sensitive Zones and watercourses. Section 36 establishes rules for erosion control related to land development activities, such as clearing land, grading slopes, and road construction and maintenance.

17.2.7 *Fish Protection Act*

The *Fish Protection Act* (1997) and associated amendments to the provincial *Water Act* (1996c) regulate provincial approvals of alterations and work in and around watercourses. The regulations focus on floodplain retention, which may be involved in vegetation removal and introduction of harmful debris (clay, silt, sand, rock, or any material, natural or otherwise) into the waterways.

17.2.8 *Weed Control Act*

The *Weed Control Act* (1996c) regulates the management of noxious plants in BC. The Act requires all land occupiers to avoid establishment and dispersal of noxious weeds as defined by the Act.

17.2.9 *Wildlife Act*

The provincial *Wildlife Act* (1996e) provides for conservation of specific ecosystems and ecosystem components as they provide habitat for species managed by the BC MOE.

17.2.10 *Environmental Management Act*

Pulling together the provisions of the previous Waste Management and Environment Management acts into a single statute, the *Environmental Management Act* (2003) prohibits the introduction of deleterious substances into the environment in any manner or quantity that may cause pollution to the environment as defined in the Act. This includes substances that would degrade or contaminate soil and water, which could in turn have deleterious effects on terrestrial ecosystems. The Contaminated Sites Regulation (BC Reg. 375/96) included in BC's *Environmental Management Act* (2003) lists Soil Criteria for Toxicity to Soil Invertebrates and Plants. These provide numerical standards to define whether a site is contaminated, to determine liability for site remediation, and to assess reclamation success.

17.2.11 *Environmental Protection Act*

The *Environmental Protection Act (1999)* provides governance on pollution prevention to reduce the risk of toxic substances on human health and the environment. It applies the precautionary principle that, where there are threats of serious or irreversible damage, lack of full scientific uncertainty cannot be used as a reason for postponing cost-effective measures to prevent environmental degradation, and promotes and reinforces enforceable pollution prevention approaches (1999).

In addition to these regulations, draft best management practices (BMPs) for the mining industry include the following key management practices for protecting wetlands in BC (Cox and Cullington 2009):

- controlling leaching and sedimentation;
- ensuring dewatering production processes do not affect wetland hydrology;
- limiting the effects of noise;
- re-vegetating using pre-development area species;
- use of low impact re-vegetation techniques;
- re-establishing wetland functions; and
- monitoring of enhancement, restoration, and creation activities to ensure success.

The BMPs also emphasize caution around planning, construction, and use of trails and roads because they can:

- be a major source of sediment;
- cause habitat loss and/or fragmentation through infilling or dewatering;
- enable exotic invasive species (for the purposes of the assessment the term invasive species includes only exotic invasive species) colonization; and
- increase recreational impacts (Cox and Cullington 2009).

17.3 EXISTING ENVIRONMENT

17.3.1 Regional Overview

Wetlands comprise between 2 to 4% of northwestern BC. This is less than the provincial average (5.6%), reflecting the fact that the high mountains, glaciers, and large dynamic river systems that make up this region inhibit the development of wetlands. Wetlands that do develop in this region typically include fens, swamps, and bogs. Marshes and shallow open water wetlands are less common. Wetland vegetation is diverse and is closely connected with wetland class. Some notable exceptions are the sedges *Carex aquatilis*, *C. utriculata*, and *C. sitchensis*, which are common in a number of wetland classes and associations.

Wetlands are valuable providers of specific habitat features for a number of wildlife species, including early season forage for bears, mid-summer forage for moose, and life cycle habitat for amphibians. Wetlands throughout the region are not considered threatened or at risk, although a number of specific associations are listed by the BC CDC as red- or blue- listed, depending on the biogeoclimatic subzone and forest district where they are found.

17.3.2 Historical Activities

Several historic and current human activities are close to the proposed Project area. These include mining exploration and production, hydroelectric power generation, forestry, and related road construction and use.

The Granduc Mine was a copper mine located approximately 25 km south of the Project, which operated from 1970 to 1978 and 1980 to 1984. The mine included underground workings, a mill site near Summit Lake, and an 18.4-km tunnel connecting them. In addition, a 35-km all weather access road was built from the communities of Stewart, BC and Hyder, Alaska to the former mill site near Summit Lake. The area of the former mill site near Summit Lake is currently used as staging for several mineral exploration projects in the region. The end of the Granduc access road is 25 km south of the proposed Brucejack Mine Site and is currently used by mineral exploration traffic and tourists accessing the Salmon Glacier viewpoint.

The Sulphurets Project was an advanced underground exploration project of Newhawk Gold Mines located at the currently proposed Brucejack Mine Site. Underground workings were excavated between 1986 and 1990 as part of an advanced exploration and bulk sampling program. Reclamation efforts following the Newhawk advanced exploration work included deposition of waste rock and ore in Brucejack Lake.

The exploration phase of the proposed Brucejack Gold Mine Project commenced in 2011 and has included a drilling program, bulk sample program, construction of the Brucejack Access Road from Highway 37 to the west end of Bowser Lake, and rehabilitation of an existing access road from the west end of Bowser Lake to Brucejack Mine Site.

In 2010, construction began on the Long Lake Hydroelectric Project, which is located approximately 42 km south of the Project. It includes redevelopment of a 20-m high rockfill dam located at the head of Long Lake and a new 10-km long 138-kV transmission line.

Historical forestry activities occurred in the Project area between Highway 37 and Bowser Lake, south of the Wildfire Creek and Bell-Irving River confluence.

Most of these developments and activities have likely affected wetlands on some level. However, this has not been well documented. Known affected wetlands closest to the Project include wetlands along the Brucejack Access Road. A number of wetlands were affected when this road was constructed, including the loss of 1.8 ha of wetland extent. Wetland loss was minimized by strategically avoiding crossing wetlands where possible. It is also possible that wetlands may continue to be affected, beyond the direct effects of lost extent, through altered site hydrology and other effects on wetland functions.

Within the broader region, most developments have also likely affected wetlands on some level. However, this has not been well documented. Wetlands have not been considered in the federal or provincial environmental assessment processes until recently, and scant information at the provincial scale exists for wetland extent and function. Projects that have affected wetlands at the broader regional level include:

- Sulphurets Advanced Exploration Project;
- Long Lake Hydroelectric; and
- construction of the Northwest Transmission Line (NTL).

This list is not exhaustive but does illustrate decades of project effects on wetlands by publically and privately funded resource development projects. Although effects to wetlands have likely resulted from these projects, the magnitude and significance is largely unknown due to lack of information on wetlands across BC.

17.3.3 Baseline Studies

Wetland baseline studies were undertaken in 2012. The goal of the baseline study was to characterize the wetland type, distribution, extent, and function that could potentially be affected directly or indirectly by the Project, and included wetlands near the proposed Mine Site, the proposed transmission line, the existing Brucejack Access Road, and other mine-related clearing or infrastructure. Specific objectives included:

- describing the functions of identified wetland classes;
- identifying potentially rare or unique wetlands;
- collecting sufficient information to determine potential effects on wetlands to guide management and mitigation plans and to develop a reclamation and closure plan; and
- determining soil and vegetation baseline metal concentrations at select wetlands.

17.3.3.1 Data Sources

A number of data sources were consulted to guide the wetland baseline studies and effects assessment. These sources included the following:

- Biogeoclimatic Ecosystem Classification (BEC) line work and descriptions (2008 and 2012);
- Terrain Resource Information Management (TRIM);
- Ecoregion Classification line work and descriptions;
- BC CDC (for provincially blue- and red-listed plants and ecosystems);
- publically available data associated with relevant adjacent projects;
- stereo aerial photography using ArcGIS and Purview;
- data acquired via data sharing agreements;
- the Cassiar Iskut-Stikine Land and Resource Management Plan (BC ILMB 2000);
- the Nass South Sustainable Resource Management Plan (BC MFLNRO 2012); and
- data made available from First Nations, local stakeholders, and the general public.

17.3.3.2 Methods

This section provides an overview of the study areas and methods used to characterize wetland type, distribution, extent, and function. Baseline studies included field data collection, wetland classification and mapping.

Baseline Study Area

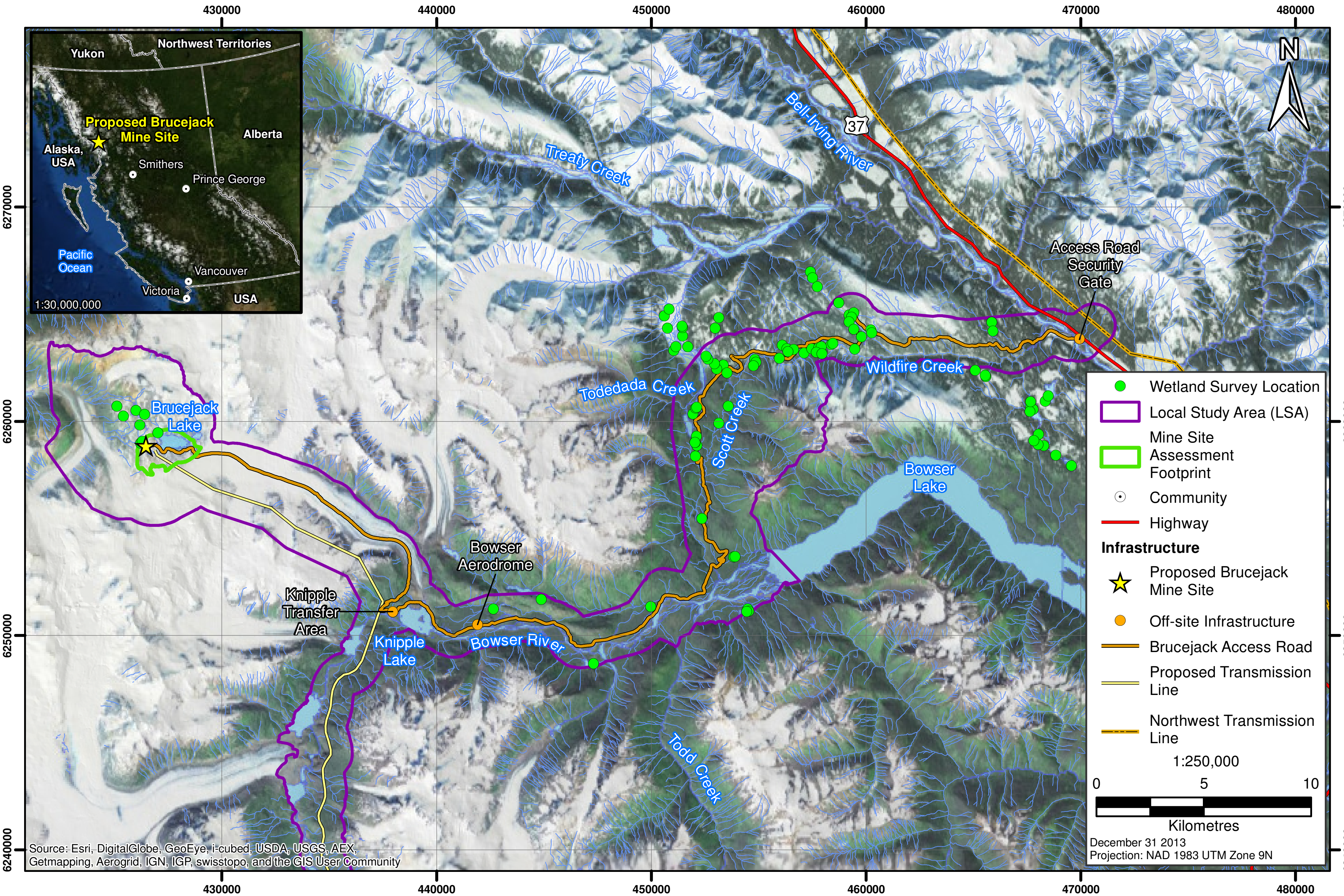
The Project is situated approximately 65 km north-northwest of the Town of Stewart, BC. It is located within the Kitimat-Stikine Regional District, an administration providing local government services to member municipalities within northwestern BC. It is also situated within the Kalum and Skeena-Stikine Forest districts and the Nass and the Cassiar Timber Supply areas, administrative boundaries within which forest resources are presently managed by the BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO). The Project also overlaps portions of the Cassiar Iskut-Stikine Land and Resource Management Plan area (BC ILMB 2000), and the Nass South Sustainable Resource Management Plan area (BC MFLNRO 2012).

Several First Nation and Treaty Nations have traditional territory within the general region of the Project including the Skii km Lax Ha, Nisga'a Nation, and Tahltan Nation.

Wetlands were characterized within a Local Study Area (LSA; Figure 17.3-1). The LSA is 31,848 ha in size and is defined by a buffer extending at least to the height of land or a 1 km buffer around the outer limits of the proposed infrastructure and linear developments.

There are three main types of infrastructure that the LSA was designed to capture: the Brucejack Access Road, the Mine Site, and the proposed Brucejack Transmission Line. The LSA associated with the Brucejack Access Road area is 13,835 ha; it has a transitional climate, from coastal at the western edge to continental at the eastern edge. The Mine Site area is 5,040 ha in size, and is situated above the tree line in alpine and parkland ecosystems. The Transmission Line area comprises 12,972 ha and extends from near the Premier Mine Site to the Project area (Figure 17.3-1). Wetlands were not surveyed in the Transmission Line area during wetlands field work, as preliminary investigation using air photos did not identify any. A small number of wetlands were mapped, however, during terrestrial ecosystem mapping along the Transmission Line route for the *Brucejack Gold Mine Project: 2012 Terrestrial Ecosystem Baseline Studies* and are included (Rescan 2013b) in Appendix 16-A.

Figure 17.3-1
Wetland Local Study Area and 2012 Survey Locations



Wetland Survey, Classification, and Mapping

Wetlands were delineated as part of the terrestrial ecosystem mapping (TEM) carried out for the Project. This classification involved characterizing wetlands using the standard five-class system of bog, fen, marsh, swamp, and shallow open water classes (Warner and Rubec 1997). Wetlands were surveyed in July and September 2012, with 91 wetland survey plots established (Figure 17.3-1). Survey methods followed *Field Description of Wetland and Related Ecosystems in the Field* (MacKenzie and J.R. Shaw 1999) and *Wetlands of British Columbia: A Guide to Identification* (MacKenzie and Moran 2004). Data collected during these field surveys were used to refine wetland mapping and to assign site associations as per MacKenzie and Moran (2004). TRIM wetland polygons were also used where no surveyed data had been gathered; the polygon was selected but then was redrawn to match adjacent TEM boundaries. Wetland classification data were recorded in the wetland database (Wetland Baseline Study, Appendix 17-A).

Information was collected during field surveys to assist in an analysis of wetland function. Wetland functions are the processes that wetlands carry out, such as storage and filtration of water. Four primary functions—hydrological, biochemical, functional diversity, and habitat—are considered during an environmental assessment (Tables 17.3-1 and 17.3-4; Milko 1998). Table 17.3-1 shows which field work components provide field data to describe aspects of the wetland functions.

Table 17.3-1. Wetland Function and Associated Fieldwork Component

Wetland Function	Fieldwork Component
Hydrological Function	• Wetland classification (wetland class) • Ecosystem survey (hydrodynamics) • Ecosystem survey (hydrogeomorphic position)
Biochemical Function	• Wetland Classification (wetland class) • Vegetation tissue samples
Functional Diversity	• Ecosystem survey (wetland size and distribution) • Wetland classification (wetland complexes, rare, or unique wetlands)
Habitat Function	• Ecosystem survey (wildlife observations) • Wetland classification (wetland class)

The principle wetland functions for each wetland class were determined by integrating survey data, individual wetland class and landscape position, and scientific literature (Hanson et al. 2008).

17.3.4 Characterization of Wetland Ecosystem Baseline Condition

Wetlands within the LSA were found to include all five federally defined wetland classes (Plates 17.3-1 through 17.3-5) and eleven provincially described wetland associations. In addition to these, wetland types were also identified through ecosystem mapping and TRIM data. Table 17.3-2 shows the area and occurrence of each wetland association. Wetlands occurred most frequently adjacent to the Brucejack Access Road in the study area with few wetlands observed at the Mine Site (Table 17.3-3).

A total of 517.8 ha of wetlands and 18 distinct wetland communities were mapped in the LSA. Fens and swamps accounted for the largest area of wetlands totalling 300 ha (58%) of all wetlands. This is also true for the number of vegetation communities identified; fens and swamps accounted for 11 of the 18 identified site associations. The Wetland Herb (WH) and Ws06 vegetation communities accounted for the largest area, and TRIM Marsh accounted for the most occurrences (Table 17.3-2).

Plate 17.3-1. Wb05 bog at site W044.

Plate 17.3-2. Wf01 fen at site W030.

Plate 17.3-3. Wm01 marsh at site W020.

Plate 17.3-4. Ws06 swamp at site W014.

Plate 17.3-5. Yellow pond lily wetland (site W058) with pond lily species floating near shore area.

Table 17.3-2. Area and Occurrence of Wetland Associations in the Wetlands Local Study Area

Wetland Associations	Area (ha)	Occurrence	Wetland Associations	Area (ha)	Occurrence
Bog Class Wetlands			*Marsh Class Wetlands (cont'd)*		
Wb05	1.3	1	TRIM Marsh[2]	25.0	30
Wb13	0.5	*1*	*Swamp Class Wetlands*		
Fen Class Wetlands			Ws06	90.9	4
Wf01	12.3	3	WS[1]	29.4	4
Wf03	18.0	6	WT[1]	27.2	3
Wf04	72.2	8	Willow/Horsetail	1.7	1
Wf08	11.7	1	TRIM Swamp[2]	66.4	4
Wf12	34.7	*7*	*Shallow Open Water Class Wetlands*		
WH[1]	83.0	8	Yellow pond lily	0.5	1
Marsh Class Wetlands			Shallow open water	5.5	2
Wm01	8.0	2	**Total**	**517.7**	**87**[3]
Wm04	29.3	1			

[1] WH - Wetland Herb, WS - Wetland Shrub, and WT - Wetland Tree generalized ecosystem types as described in the TEM (Rescan 2013b).
[2] TRIM Marsh and TRIM Swamp wetlands mapped by TRIM and classified as Marsh or Swamp.
[3] Does not include the 11 wetland features identified by TEM along the Brucejack Transmission Line (Table 17.3-3).

Table 17.3-3. Occurrence of Wetland Associations in the Wetlands Local Study Area

Study Area Component	LSA (ha)	Wetland Area (ha)	Wetland Occurrence	% Wetland Coverage
Brucejack Access Road area	13,835.5	515.7	86	3.7
Mine Site area	5,040.3	2.0	1	0.04
Transmission Line area[1]	12,972.1	34.9[2]	11	0.3
Entire LSA	31,847.9	552.6	98	1.7

[1] Wetland area and wetland occurrence identified as WT, WS, and WH wetland ecosystems from TEM.
[2] Area only includes wetlands that are shown as deciles in terrestrial ecosystem polygon.

Within the LSA, wetlands cover a small but important component of the landscape. They are the connection between wetter aquatic habitats and drier upland habitats. They contain processes specific to wetlands such as regulating flood waters, improving water quality, and offering semi-aquatic wildlife habitat. The primary wetland functions were identified for each wetland class (Table 17.3-4).

Table 17.3-4. Overview of General Wetland Functions[1]

Function Category	Value	Probable Services
Hydrology	Flow moderation Groundwater recharge Erosion and shoreline protection Climate regulation	Replenishing groundwater supplies Moderation of stormwater peaks Climate moderation Maintenance of water flow during drought Reduced water velocity and removal of suspended sediments
Biochemical Cycling	Water quality treatment Carbon storage Nutrient and organic export	Atmospheric carbon sequestration Natural water quality improvements Reduction in excess nutrients
Habitat	Biological productivity and diversity	Production of harvestable species Provision of biodiversity Habitat for species at risk
Functional Diversity (ecological function)	Assemblages of different wetland ecosystems that provide synergistic effects	Multiple and diverse combinations of functions in wetland complexes including hydrology, biochemical, and habitat functions

[1] Adapted from Hanson et al. (2008).

17.3.5 Wetland Functions

Wetland functions for this assessment have been grouped into the four classes previously mentioned (Table 17.3-4). Hydrological function refers to how wetlands moderate hydrological cycles through water storage or alteration of overland or groundwater flow. Biochemical function is related to nutrient cycling and organic soil development and is often referred to when the water quality services of wetlands are discussed. The relative rareness and the unique conditions in wetlands provide valuable habitat functions making them hotspots for biodiversity and rare or at risk species.

Functional diversity has been included to account for the more varied combination of functions that are offered by complexes of different classes of wetlands. It is also a reflection of the transitional state of wetlands, as they rarely occur in discrete units and that function, while convenient to associate with wetland class, will vary depending on other characteristics. Some of this variety will be indicated by the spatial co-occurrences of different wetland ecosystems. The concept of functional diversity is also an indication that functions themselves will vary within each wetland class. Hydrological, biochemical, and habitat functions are provided at different levels by different wetlands. When wetlands occur as complexes, they offer a greater array of these functions. For example, bog and forested swamps can form wetland complexes. When this occurs, there is a greater potential for them to provide the biochemical functions of carbon storage associated with bogs and the higher nutrient cycling associated with the swamps. Hydrologic functioning would also be more diverse and the limited flow moderation provided by bogs would be contrasted with the high flow moderation provided by swamps. Habitat function would also be enhanced as structural diversity would be higher. The resulting ecotones provide important habitat for animals such as forage, day bed sites on raised micro topography, escape cover, and perching sites. The open nature of bogs allows animals to thermoregulate during stressful weather conditions. For plant species, the transition from swamp to typical bog vegetation occurs along gradients determined by peat characteristics (input species, depth, pH, and state of decomposition), hydrology, light availability, nutrients, and microclimate. These variable conditions provide more habitat niches than occur in ecosystems where gradients are less varied and provide habitat for rare or listed species.

Wetland class is an indication of which functions will be provided and how well a wetland will perform the various functions. Function by wetland class is shown in Table 17.3-5. Each of the five federal wetland classes and three of the functions are discussed below. Functional diversity (ecological function) is not described further in this section, as it is not specific to one wetland class.

Table 17.3-5. Summary of Functions and Values by Wetland Classes[1]

Wetland Class	Hydrological Function	Biochemical Function	Habitat Function
Bog	**Low** - Water flow moderation **Low/Moderate** - Groundwater recharge **Low** - Erosion protection **Low** - Climate regulation	**Low** - Water quality treatment **High** - Carbon storage **Moderate/High** - Nutrient and organic export	**Moderate/High** - Provides tall tree, shrub, and open area cover types for a variety of species
Fen	**Moderate** - Water flow moderation **Low** - Groundwater recharge **Low** - Erosion protection **Moderate** - Climate regulation	**Moderate/High** - Water quality treatment **Moderate/High** - Carbon storage **Moderate/High** - Nutrient and organic export	**Moderate/High** - Provides open area cover; provides early season palatable vegetation for bears
Marsh	**Low/High** - Water flow moderation, **Low/Moderate** - Groundwater recharge **Moderate/High** - Erosion protection **Moderate/High** - Climate regulation	**Moderate/High** - Water quality treatment **Moderate** - Carbon storage **Moderate/High** - Nutrient and organic export	**High** - Provides migratory bird habitat; the most important wetland class for providing habitat
Swamp	**Moderate to High** - Water flow moderation **Low** - Groundwater recharge **Moderate** - Erosion protection **Moderate** - Climate regulation	**Moderate/High** - Water quality treatment **Moderate/High** - Carbon storage **Low/Moderate** - Nutrient and organic export	**Highly Variable** - Provides cover habitat and moose forage; provides connectivity with freshwater aquatic systems such as rivers
Shallow Open Water	**Moderate/High** - Water flow moderation **Variable** - Groundwater recharge **Low** - Erosion protection **Low/Moderate** - Climate regulation	**Moderate/High** - Water quality treatment **Low** - Carbon storage **Low** - Nutrient and organic export	**Highly Variable** - Provides open water habitat for migratory birds, moose, and amphibians

[1] *Adapted from Hanson et al. (2008).*

17.3.5.1 Bog Wetland Function

<u>Bog Hydrological Functions</u>

The hydrological functions provided by bogs are generally low (Hanson et al. 2008). Water flow moderation, groundwater recharge, and reduction in shoreline erosion functions are often limited due to the lack of surface water flow into bogs. Because of the saturated soils found in bogs, they have limited capacity to slow down volume responses in lower systems during freshet and rainfall events. The exception to this is during dry summer months when water levels are low, allowing for recharge. Bogs generally occur in low energy environments and have little value in reducing erosion (Plate 17.3-1).

<u>Bog Biochemical Functions</u>

Carbon storage is a key biochemical function provided by bogs. Due to low hydrodynamism, anoxic conditions, and low pH, decomposition rates are slow. This results in the accumulation of organic carbon in the forms of fibric, mesic, and humic peat. Disturbance of these sites can result in accelerated decomposition rates and reduction in their carbon storage function.

Bogs can be integral to nutrient and organic export as soluble organic matter can percolate through groundwater flow into adjacent ecosystems. The nutrient quality of this matter can be poor and the tannins and other associated leachates can alter nutrient cycling in adjacent ecosystems. Because of their isolated nature, bogs are less important in improving water quality than other wetland forms (Hanson et al. 2008). The low energy environment of bogs, anoxic conditions, and limited nutrient availability results in slow decomposition processes.

All wetland soils contain some concentration of metals. Metals may exist in wetland soils or vegetation and enter wetlands through surface water, groundwater flow, and aerial deposition. Wetlands can remove metals from surface and groundwater by binding metals to iron and aluminum ions via adsorption to clay surfaces or through carbonates precipitating as inorganic compounds. They can also form complexes with organic soils (Gambrell 1994).

<u>Bog Habitat Functions</u>

The unique environment provided by bogs creates habitat niches that can support a variety of rare or unusual plant species. They provide travel corridors and forage for a variety of species such as bears, ungulates, and wolves, depending on their position in the landscape. Bogs are often associated with shallow open water; invertebrates and amphibians may use these areas for various stages of their life cycles.

17.3.5.2 Fen Wetland Functions

<u>Fen Hydrological Functions</u>

The hydrological functions of fens are low to moderate (Hanson et al. 2008). For example, fens can provide some mitigation of local flooding but the value of this function is largely related to downstream flows and the potential impacts of changes to these flows. However, fens provide some mitigation for stream bed scouring, sediment loading, and temperature mitigation for cold-water species.

Fens provide a groundwater recharge capacity; however, the capacity is highly dependent on basin size, location in the watershed, substrate, and local groundwater gradients (Hanson et al. 2008). Smaller wetlands have a greater perimeter to volume ratio than larger wetlands and have been demonstrated to better support groundwater recharge than larger wetlands (Weller 1994).

Fen Biochemical Functions

The biochemical functions of fens are potentially high (Hanson et al. 2008). This potential is difficult to quantify because biochemical functions are influenced by a myriad site-specific factors such as ambient temperature, local geology, base water chemistry, vegetation species, aspect, slope, drainage, etc. (Almas and Singh 2001; Brunham and Bendell 2010). It is generally accepted that fen ecosystems can improve water quality; actively facilitate nutrient storage, transformation, and transport; and store carbon (Mitsch and Gosselink 2000).

Fens, like other wetland classes, facilitate the nitrification/de-nitrification process (Reilly 1991; Gilliam 1994). Fens can be considered both carbon sinks and carbon sources depending on the wetland condition. This is determined by the stability of the ecosystem and by whether the system is developing (active peat accumulation and vegetation deposition), flooded (such as during extreme precipitation events), drained (through anthropomorphic disturbance), or in decline (drying out through natural successional processes).

Fen Habitat Functions

The habitat function of fens is related to their biological productivity (Hanson et al. 2008). The biological productivity of a fen can be attributed to a number of factors, including surrounding landscape type and use, stand age, complexity of landscape patterns, availability of specific habitat types for specific species of the area, uniqueness of habitat types available at various scales, and adjacency of habitat types. Collectively, fen wetlands are among the most floristically diverse of all wetland classes (Bedford and Godwin 2003). This increases habitat diversity and complexity and contributes to habitat function. In early spring, open sedge areas provide forage opportunities for grizzly bear and black bear. Treeless wetland areas adjacent to mature trees provide forage habitat for bat species throughout the growing season (Plate 17.3-2). In spring and summer, emergent and submergent vegetation in open water areas provide browse for moose. Migratory bird species and signs of use are common, particularly where fens are occur with shallow open water.

17.3.5.3 Marsh Wetland Functions

Marsh Hydrological Functions

The hydrological function of marshes is high when compared to other wetland classes (Hanson et al. 2008). The hydrological function of marshes typically includes water flow moderation, groundwater recharge, and shoreline erosion protection. Marshes adjacent to surface water features, such as lakes, rivers, and creeks, receive a portion of their water during high water events. Marsh wetlands in these positions are extremely valuable for stormwater retention, mitigating channel alterations, stream bed scouring and sedimentation downstream that commonly occur during flood and high rainfall events. They can also be valuable for temperature mitigation for cold-water species using these areas.

Marsh Biochemical Functions

The biochemical function of marsh wetlands is high but varies depending on local physical processes, interaction between root/bacteria assemblages, substrate, and oxidation (Hanson et al. 2008). Biochemical functionality can range among wetland complexes and temporally within a single wetland, depending on season and the processes indicated above. Marshes, like other wetland classes, facilitate the nitrification/de-nitrification process (Reilly 1991; Gilliam 1994) and are thus major contributors to the nitrogen cycle in the environment. Phosphorus absorption is facilitated through the deposition of suspended solids or dissolved phosphorus within wetlands. Floodplain marsh complexes tend to be important sites for phosphorus removal from the water column and improving water quality (Walbridge and Struthers 1993).

Marsh wetlands can reduce sulphate to sulphide, which can be released to the atmosphere as hydrogen, methyl, and dimethyl sulphides or can be bound to wetland sediments as complexes of phosphates and metal ions (Mitsch and Gosselink 2000). These sulphides, when released to the atmosphere, can produce condensation nuclei and affect regional climates, while produced complex metal phosphates remove metals from free water within the water table.

Marshes filter suspended solids in the water column when it comes into contact with wetland vegetation. Live and dead vegetation, leaves and stems, slow down the velocity of the water, allowing suspended solids to settle and thus removing potential pollutants from the water column (Johnston 1991). Marshes can be considered both carbon sinks and carbon sources depending on the wetland condition. This is determined by the stability of the ecosystem, the developmental stage of the ecosystem, and whether it is flooded (such as extended flooding during extreme precipitation events), drained (through anthropomorphic disturbance), or in decline (drying out through natural successional processes).

Marsh Habitat Functions

The habitat function of marsh wetlands is generally high but variable depending on site conditions (Hanson et al. 2008). Marshes are the most heavily used wetland class for most wetland-using wildlife species. They are typically eutrophic and support vigorous growth of vegetation and aquatic invertebrates. They are the favoured wetland class for most waterfowl, amphibians, and semi-aquatic mammals because they provide good cover, open water, and food (MacKenzie and Moran 2004). Marsh and open water complexes provide opportunities for beaver habitation, which was observed within the local LSA (Plate 17.3-3).

17.3.5.4 Swamp Wetland Functions

Swamp Hydrological Functions

The hydrological function of swamp wetlands is dependent on the wetland sub-form; it is low for mid-slope or tidal swamp wetlands, but generally high for riparian swamps (Hanson et al. 2008). Treed and shrubby riparian swamp wetlands slow the velocity of runoff and have the capacity to store water for extended periods (Plate 17.3-4).

Swamp Biochemical Functions

The biochemical functions of swamps can be similar to marsh wetlands; variable, but generally quite high compared to other wetland classes and upland ecosystems with the variability arising from local physical processes, interaction between root/bacteria assemblages, substrate, and oxidation (Hanson et al. 2008). Swamps provide numerous biochemical functions such as nutrient and organic export and carbon storage and sequestration. For example, swamps facilitate the nitrification/de-nitrification process (Reilly 1991; Gilliam 1994), while phosphorus absorption is facilitated through the deposition of suspended solids or dissolved phosphorus within swamp wetlands. This is likely to occur in riparian-associated swamp complexes (Walbridge and Struthers 1993).

Swamps are both carbon sinks and sources depending on the wetland condition, stability, and hydrodynamism. The high accumulation of organic matter and slow decomposition rates of vegetation that can occur in hydrologically stagnate forested swamps enable these swamps to sequester carbon at a relatively higher rate than many other wetland classes.

Riparian swamps have the capability to filter suspended solids in the water column as these solids come into contact with wetland vegetation. Vegetation and detritus slow down the velocity of the water, allowing settling of suspended solids and removal of potential pollutants from the water column (Johnston 1991).

Swamp Habitat Functions

Swamps are capable of producing mature forests and the associated complex vertical structure. This supports more diverse avifaunal assemblages than any other wetland classes (MacKenzie and Moran 2004). Forested swamps can have an open canopy that appears to be favoured by many bird and bat species (MacKenzie and Moran 2004; Lausen 2006). The habitat functions of swamp wetlands are considered moderate to high due to habitat diversity and structure. In winter, spring, and summer months, willow swamp complexes can provide moose with thermoregulation sites as well as browse opportunities (Plate 17.3-4).

17.3.5.5 Shallow Open Water Wetland Functions

Shallow Open Water Hydrological Functions

The primary hydrological function of shallow open water wetlands is water storage within the landscape. Water is held for prolonged periods, extending into the drier summer months and providing a source of freshwater to adjacent ecosystems and wildlife during these periods. Generally, hydrological function of shallow open water wetlands is high (Hanson et al. 2008).

Shallow Open Water Biochemical Functions

Biochemical function is dependent on nutrient/sediment loading rates, flow through rates and volumes, retention time, wetland capacity, volume to surface area ratios, and productivity. As these wetlands are usually relatively small, shallow open water wetlands have a moderate capacity to remove sediments by allowing them to settle out in slower moving waters.

Shallow Open Water Habitat Functions

The habitat function of shallow open water wetlands is highly variable (Hanson et al. 2008) but is always limited to aquatic habitat. Their level of function is dependent on the availability of such habitat within the landscape and the presence of species that may use such habitat. These wetlands provide important open water habitat for migratory birds, mammals, and ungulates such as moose (Plate 17.3-5).

17.4 ESTABLISHING THE SCOPE OF THE ASSESSMENT FOR WETLANDS

Scoping is fundamental to focusing the Application for an Environmental Assessment Certificate / Environmental Impact Statement (Application/EIS) on those issues where there is the greatest potential to cause adverse effects. The scoping process for the assessment of wetlands consisted of the following four steps:

- *Step 1* – undertaking an issues scoping process to select wetland VCs and sub-components based on a consideration of the Project's potential to interact with wetlands;
- *Step 2* – consideration of feedback on the results of the scoping process from technical experts and the EA Working Group[1];
- *Step 3* – defining assessment boundaries for wetland VCs and sub-components; and
- *Step 4* – identification of key potential effects on wetland VCs and/or sub-components.

These steps are described in the following sections.

[1] The EA Working Group is a forum for discussion and resolution of technical issues associated with the proposed Project, as well as providing technical advice to the BC EAO and CEA Agency, which remain ultimately responsible for determining significance. It comprises representatives of provincial, federal, and local government, and Aboriginal groups.

17.4.1 Selecting Receptor Valued Components

Receptor VCs are selected to focus the Application/EIS on the issues of highest concern. Receptor VCs are specific attributes of the biophysical and socio-economic environments that have environmental, social, economic, heritage, or health significance. To be considered for assessment, a component must be of recognized importance to society, the local community, or the environmental system, and there must be a predicted likelihood that the receptor VC will be affected by the proposed Project. Receptor VCs are scoped during consultation with key stakeholders, including Aboriginal communities and the EA Working Group. Consideration of certain receptor VCs may also be a legislated requirement, or known to be a concern because of previous project experience.

As described in Section 6.4.1.1, a scoping exercise was conducted during the development of the draft AIR to explore potential Project interactions with candidate receptor VCs, and to identify the key potential adverse effects associated with that interaction. The results of the scoping exercise were circulated for review and approval by the EA Working Group. Feedback from that process and from additional comments received has been integrated into the EA.

Subject areas are classified as either intermediate components or receptor VCs and are further refined into sub-components and indicators as described in Section 17.4.1.3. Wetlands were identified as a receptor VC as a result of the scoping process, along with the following sub-components:

- wetland extent; and
- wetland function.

As a receptor VC, the assessment of potential effects on wetlands included consideration of the following intermediate component:

- air quality intermediate component (discussed in Chapter 7 - Air Quality Predictive Study).

17.4.1.1 Potential Interactions between the Project and Wetlands

Table 17.4-1 provides an impact scoping matrix of wetlands VCs that have a possible or likely interaction with Project components and activities. A full impact scoping matrix for all intermediate and receptor VCs is provided in Table 6.4-1 in Chapter 6. Interactions between the Project and wetlands were assigned a colour code as follows:

- none expected (white);
- possible (grey); and
- likely (black).

Interactions coded as not expected (white) are considered to have no potential for adverse effects on a receptor VC, and are not considered further. No likely interactions were identified.

17.4.1.2 Consultation Feedback on Receptor Valued Components

No feedback on scoping was received from Aboriginal groups or stakeholders regarding wetlands. The EA Working Group comments during the draft Application Information Requirements (AIR) and Environmental Impact Statement (EIS) Guidelines review phase have been used to guide the development of the effects assessment on wetlands, specifically regarding the inclusion of wetland extent and function as part of the assessment.

Table 17.4-1. Interaction of Project Components and Physical Activities with Wetland Receptor Valued Components

Project Components and Physical Activities by Phase	Wetlands
Construction Phase	
Activities at existing adit	
Air transport of personnel and goods	
Avalanche control	
Chemical and hazardous material storage, management and handling	
Construction of back-up diesel power plant	
Construction of Bowser Aerodrome	
Construction of detonator storage area	
Construction of electrical tie-in to BC Hydro grid	
Construction of electrical substation at mine site	
Construction of equipment laydown areas	
Construction of helicopter pad	
Construction of incinerators	
Construction of Knipple Transfer Area	
Construction of local site roads	
Construction of mill building (electrical induction furnace, backfill paste plant, warehouse, mill/concentrator)	
Construction of mine portal and ventilation shafts	
Construction of Brucejack Operations Camp	
Construction of ore conveyer	
Construction of tailings pipeline	
Construction and decommissioning of Tide Staging Area construction camp	
Construction of truck shop	
Construction and use of sewage treatment plant and discharge	
Construction and use of surface water diversions	
Construction of water treatment plant	
Development of underground portal and facilities	
Employment and labour	
Equipment maintenance/machinery and vehicle refueling/fuel storage and handling	
Explosives storage and handling	
Grading of the mine site area	
Helicopter use	
Installation and use of Project lighting	
Installation of surface and underground crushers	
Installation of transmission line and associated towers	
Machinery and vehicle emissions	
Potable water treatment and use	
Pre-production ore stockpile construction	
Procurement of goods and services	

(continued)

Table 17.4-1. Interaction of Project Components and Physical Activities with Wetland Receptor Valued Components (continued)

Project Components and Physical Activities by Phase	Wetlands
Construction Phase (cont'd)	
Quarry construction	
Solid waste management	
Transportation of workers and materials	
Underground water management	
Upgrade and use of exploration access road	
Use of Granduc access road	
Operation Phase	
Air transport of personnel and goods and use of aerodrome	
Avalanche control	
Backfill paste plant	
Back-up diesel power plant	
Bowser Aerodrome	
Brucejack Access Road use and maintenance	
Brucejack Operations Camp	
Chemical and hazardous material storage, management, and handling	
Concentrate storage and handling	
Contact water management	
Detonator storage	
Discharge from Brucejack Lake	
Electrical induction furnace	
Electrical substation	
Employment and labour	
Equipment laydown areas	
Equipment maintenance/machine and vehicle refueling/fuel storage and handling	
Explosives storage and handling	
Helicopter pad(s)	
Helicopter use	
Knipple Transfer Area	
Machine and vehicle emissions	
Mill building/concentrators	
Non-contact water management	
Ore conveyer	
Potable water treatment and use	
Pre-production ore storage	
Procurement of goods and services	
Project lighting	
Quarry operation	

(continued)

Table 17.4-1. Interaction of Project Components and Physical Activities with Wetland Receptor Valued Components (continued)

Project Components and Physical Activities by Phase	Wetlands
Operation Phase (cont'd)	
Sewage treatment and discharge	
Solid waste management/incinerators	
Subaqueous tailings disposal	
Subaqueous waste rock disposal	
Surface crushers	
Tailings pipeline	
Truck shop	
Transmission line operation and maintenance	
Underground backfill tailing storage	
Underground backfill waste rock storage	
Underground crushers	
Underground: drilling, blasting, excavation	
Underground explosives storage	
Underground mine ventilation	
Underground water management	
Use of mine site haul roads	
Use of portals	
Ventilation shafts	
Warehouse	
Waste rock transfer pad	
Water treatment plant	
Closure Phase	
Air transport of personnel and goods	
Avalanche control	
Chemical and hazardous material storage, management, and handling	
Closure of mine portals	
Closure of quarry	
Closure of subaqueous tailing and waste rock storage (Brucejack Lake)	
Decommissioning of Bowser Aerodrome	
Decommissioning of back-up diesel power plant	
Decommissioning of Brucejack Access Road	
Decommissioning of camps	
Decommissioning of diversion channels	
Decommissioning of equipment laydown	
Decommissioning of fuel storage tanks	
Decommissioning of helicopter pad(s)	
Decommissioning of incinerators	

(continued)

Table 17.4-1. Interaction of Project Components and Physical Activities with Wetland Receptor Valued Components (completed)

Project Components and Physical Activities by Phase	Wetlands
Closure Phase (cont'd)	
Decommissioning of local site roads	
Decommissioning of Mill Building	
Decommissioning of ore conveyer	
Decommissioning of Project lighting	
Decommissioning of sewage treatment plant and discharge	
Decommissioning of surface crushers	
Decommissioning of surface explosives storage	
Decommissioning of tailings pipeline	
Decommissioning of transmission line and ancillary structures	
Decommissioning of underground crushers	
Decommissioning of waste rock transfer pad	
Decommissioning of water treatment plant	
Employment and labour	
Helicopter use	
Machine and vehicle emissions	
Procurement of goods and services	
Removal or treatment of contaminated soils	
Solid waste management	
Transportation of workers and materials (mine site and access roads)	
Post-closure Phase	
Discharge from Brucejack Lake	
Employment and labour	
Environmental monitoring	
Procurement of goods and services	
Subaqueous tailing and waste rock storage	
Underground mine	

Notes:
White = interaction not expected between project components/physical activities and a receptor VC.
Grey = possible interaction between project components/physical activities and a receptor VC.
Black = likely interaction between project components/physical activities and a receptor VC.

17.4.1.3 Summary of Receptor Valued Components Included/Excluded in the Application for Environmental Assessment Certificate / Environmental Impact Statement

Wetlands are regarded as important ecosystems within BC, Canada, and internationally, because they provide critical habitat for fish, birds, and other wildlife (Environment Canada 1991; Milko 1998; Hanson et al. 2008; BC MOE 2010). Many wildlife species in BC use wetland habitat at some point in their life cycle, and many red- and blue-listed species are wetland-dependent (BC MOE 2011).

Due to the value placed on wetlands by local communities and governments, wetlands were selected for specific study within the LSA. Wetland extent and function were selected as receptor VC sub-components because they represent aspects of wetlands that are measurable, valued by society, and respond differently to environmental effects. These sub-components include consideration of spatial distribution, wetland class, total area, and wetland processes. Wetland extent is valued as reduction in wetland area results in an alteration of wetland functions. Wetland function is valued because the processes performed by wetlands have high potential of interactions with values and processes on the landscape such as habitat for critical wildlife species and modification of hydrological regimes.

Wetlands play a key role in the maintenance of hydrologic cycles, wildlife habitat, nutrient cycling, water quality, biodiversity, and carbon sequestration. Wetlands also provide habitat for rare plants as well as plants of cultural and/or economic importance. They are unique assemblages from an ecological perspective, transitional communities between upland terrestrial communities and aquatic communities. The functions and ecological processes that occur in wetlands are vital to ecosystems and organisms at a much greater scale than their localized boundaries and limited extent suggests.

Both wetland extent and function are included as Project related activities may have a measureable change on one of these sub-components without affecting the other. For example, activities that change the vegetation species composition, such as the inadvertent introduction of an invasive wetland species, will result in changes to the habitat and biochemical functions of a particular wetland but will not necessarily affect the extent of that wetland. Additionally, in areas dominated by numerous small isolated fens or bogs, activities that remove some of these wetlands affect wetland extent and function at a site level but may not affect specific functions provided by these wetlands at a local to regional scale.

Receptor VC sub-components were identified by integrating a number of important information sources including the Skii km Lax Ha, Nisga'a Nation, Tahltan Nation, federal policy, scientific literature, and professional expertise. Although no direct feedback from any of the Aboriginal groups was received during consultation (Table 17.4-2), previous information has indicated that wetlands contribute to the economic, social, and cultural well-being of the Skii km Lax Ha and Nisga'a Nation's citizens, because they contain or support culturally significant species such as some migratory waterfowl, fish, and aquatic plants (NLG, Province of BC, and Government of Canada 1998; Rescan 2013a; Appendix 25-B). For example, coho salmon, which are present in the Project area, use wetlands for rearing and overwintering (Appendix 15-A). Under the Nisga'a Final Agreement, Nisga'a Nation citizens have the right to harvest migratory birds, fish, and aquatic plants within the Nass Area (NLG, Province of BC, and Government of Canada 1998).

Table 17.4-2. Wetlands Receptor Valued Components included in the Application for an Environmental Assessment Certificate / Environmental Impact Statement

Sub-component	Identified by*				Rationale for Inclusion
	AG	G	P/S	IM	
Wetland Extent	X	X		X	First Nations value wetlands and wetland-dependent species. Nisga'a Nation values wetlands and wetland-dependent species. There is a growing concern over the escalating rate of wetland losses in BC (BC MOE 2011). Wetland extent often supports wetland function. Wetland extent is easily quantifiable and potential effects can be predicated directly through a footprint analysis.
Wetland Function		X		X	Wetlands support a variety of wildlife, birds, fish, amphibians, and edible plants that are economically and culturally important. Federal policy is of no-net-loss to wetland function.

**AG = Aboriginal Group; G = Government; P/S = Public/Stakeholder; IM = Impact Matrix.*

Aboriginal traditional knowledge and traditional use (TK/TU) can provide valuable information on the historical and current use and cultural importance within or adjacent to a project area. A goal of the Application/EIS was to integrate TK/TU into Project development wherever possible.

TK/TU information was sought from the Aboriginal groups noted in the Section 11 order and includes information from the Skii km Lax Ha and Tahltan Nation. Following efforts to engage First Nations in TK/TU studies, information was also obtained through desk-based research using publicly available sources. The Skii km Lax Ha worked collaboratively to provide primary source information in the form of specific TK/TU sites and areas, and a report has been developed based on those discussions. Information can be found in Appendix 25-B.

Nisga'a Lisims Government (NLG) does not support the concept of a traditional knowledge and use study due to the existence of the Nisga'a Final Agreement. Chapter 27 addresses interests and concerns, including land and resource use activities that pertain to the Nisga'a Final Agreement (NLG, Province of BC, and Government of Canada 1998). The information was obtained from publicly available sources as well as primary data gathering done in the communities with support of the NLG.

The Skii km Lax Ha, Tahltan Nation, and Nisga'a Nation have identified wetlands as culturally important or as ecosystems that support culturally important plants and animals (THREAT 2009; Rescan 2012). The Skii km Lax Ha have further identified wetlands as preferred trapping locations (Chapter 25). Wetlands were selected for study because:

- there is a growing concern over the escalating rate of wetland loss in BC (BC MOE 2010);
- federal wetland policy and environmental assessment guidelines request that wetland functions be included in environmental assessments (Environment Canada 1991; CEA Agency 2013); and
- wetland functions are valued by society.

No wetland-related receptor VC sub-components were excluded from further assessment.

17.4.2 Assessment Boundaries for Wetlands

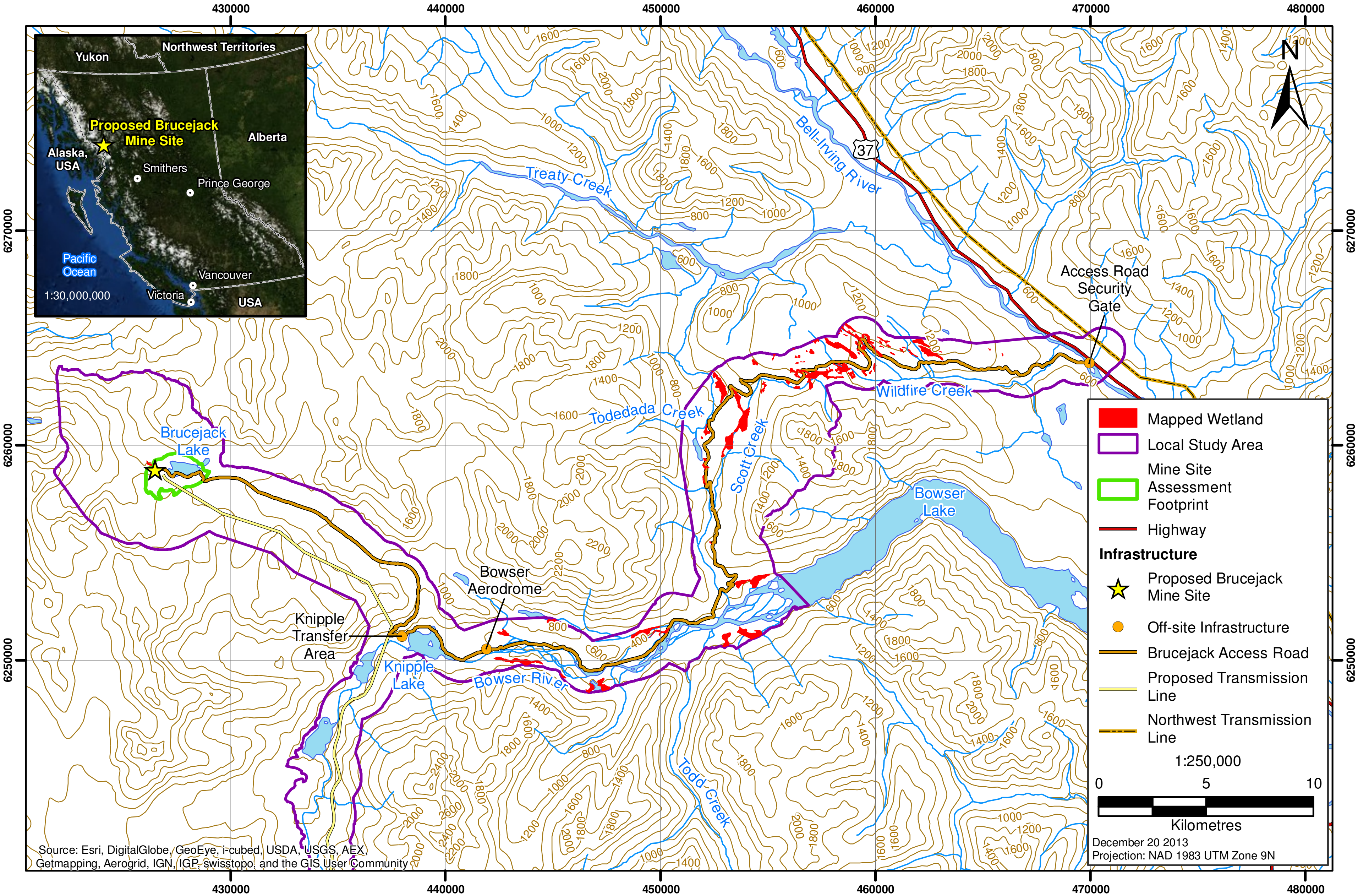
Assessment boundaries define the maximum limit within which the effects assessment is conducted. They encompass the spatial and temporal extent within which the Project is expected to interact with the receptor VCs. They also consider the constraints that may be placed on the assessment of those interactions due to political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The definition of these assessment boundaries is an integral part of the assessment of wetlands and encompasses possible direct, indirect, and induced Project effects on wetlands, inclusive of Project effects on relevant intermediate components.

17.4.2.1 Spatial Boundaries

<u>Local Study Area</u>

The wetland LSA is 31,848 ha in extent and is defined by a buffer extending at least to the height of land or a 1 km buffer around the outer limits of the proposed infrastructure and linear developments (Figure 17.4-1). Watershed height-of-land borders were used as these provide physical barriers to the many Project-related effects.

Figure 17.4-1
Wetland Local Study Area and Mapped Wetlands



The Brucejack Access Road area is 13,835 ha in extent and has a climate that transitions from coastal at the western edge to continental at the eastern edge (Figure 17.4-2). The Mine Site area is 5,040 ha in extent and is situated above the treeline in alpine and parkland ecosystems (Figure 17.4-2). The Brucejack Transmission Line area is 12,972 ha in extent and extends from near the Premier Mine Site to the Project area (Figure 17.4-2). Wetlands were not surveyed in the Transmission Line portion of the LSA, but were mapped as part of TEM.

Wetlands account for 1.7% of the LSA. The Project assessment footprint (the delineation of which is described in detail in Section 17.4.2.3) does not directly overlap any wetlands; therefore no direct loss to wetland extent is expected. External to the Project assessment footprint, effects on wetland habitat, biochemical, hydrological functions, or functional diversity may occur due to changes in hydrological connectivity, fragmentation, edge effects, dustfall, sedimentation/water quality, or introduction of exotic invasive species.

<u>Regional Study Area</u>

The Regional Study Area (RSA) is 374,433 ha and is the same RSA used in the *Brucejack Gold Mine Project: 2012 Terrestrial Ecosystem Baseline Studies* (Rescan 2013b; Figure 17.4-2). Design of the RSA took into account the area that provides habitat for wildlife species that may come into contact with proposed Project infrastructure during the course of a season or a lifetime. Other ecological factors, such as height of land, were also considered when delineating boundaries. Project-specific wetland mapping was not done within the RSA, because the large size of the area and the footprint nature of Project effects, which precludes any effects from occurring great distances from the Project assessment footprint. However, regional wetland extent as identified through Predictive Ecosystem Mapping (PEM) is discussed in the *Brucejack Gold Mine Project: 2012 Terrestrial Ecosystem Baseline Studies* (Rescan 2013b).

17.4.2.2 Temporal Boundaries

The temporal boundaries for the assessment are determined by the proposed Construction, Operation, Closure phases, as well as the expected longevity of effects Post-closure:

- Construction — 2 years;
- Operation — 22-year run-of-mine life;
- Closure — 2 years (includes Project decommissioning, abandonment and reclamation activities); and
- Post-closure — minimum of 3 years (includes ongoing reclamation activities and post-closure monitoring).

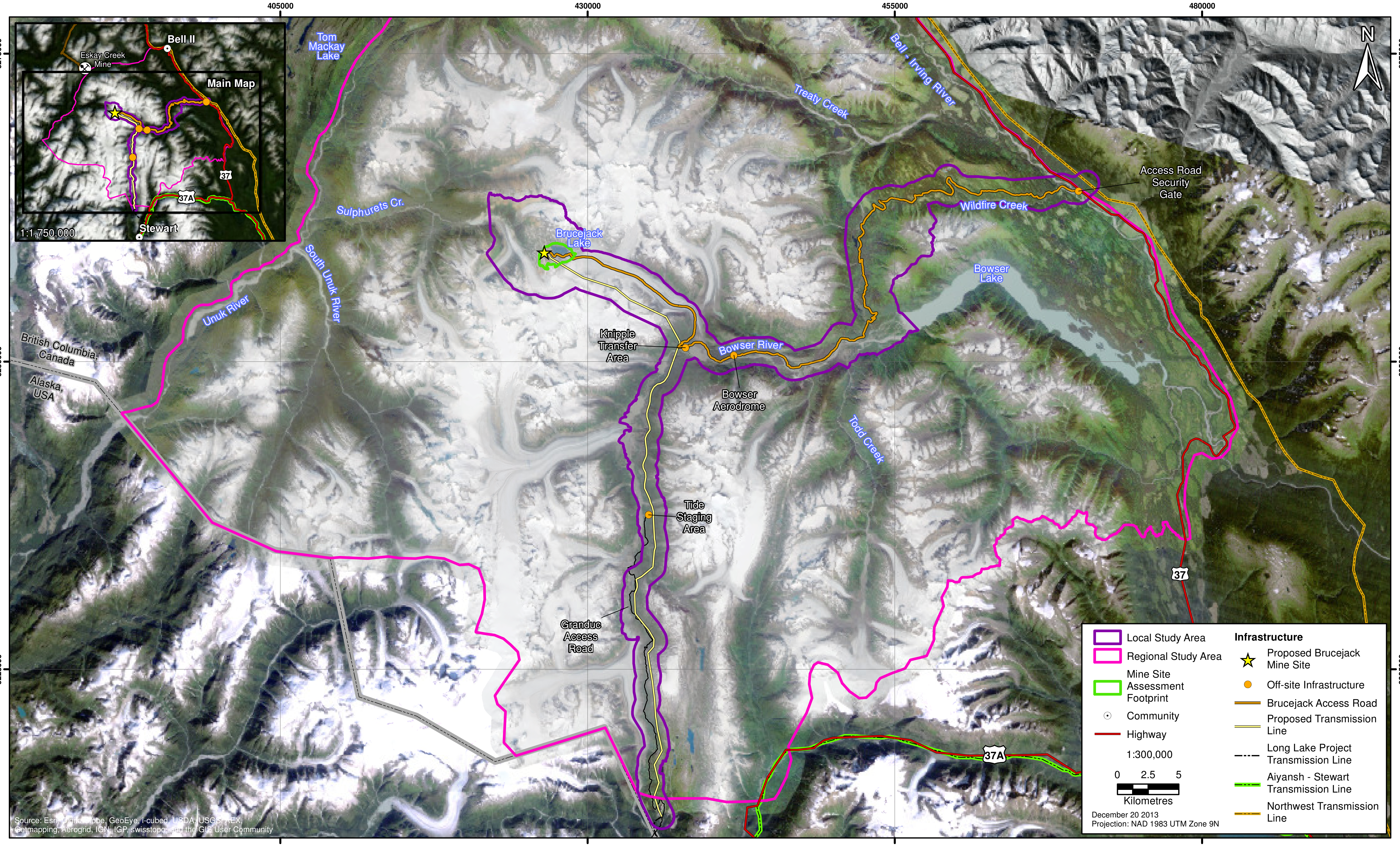
17.4.2.3 Other Boundaries

To assess Project-related impacts on wetland receptor VCs in the LSA, proposed infrastructure was grouped in four generalized classes for assessment of effects on wetland extent or function:

- Brucejack Access Road;
- Mine Site;
- aerodrome and associated buildings and clearing, transfer station at the base of Knipple Glacier, and staging areas; and
- Brucejack Transmission Line.

Figure 17.4-2
Wetland Study Areas

ERM



The construction of the Brucejack Access Road was carried out under a separate permit (Permit MX-1-832); therefore, the effects due to construction are not part of this assessment. The use of the road is part of the assessment. The Brucejack Access Road and cleared right-of-way (ROW) was buffered to characterize ongoing and potential future changes in wetland function related to the road and road use, upgrades, and maintenance.

An assessment footprint (393.1 ha) that encompasses all the structures related to mine development adjacent to Brucejack Lake was used to assess wetland loss of extent around the Mine Site.

The assessment footprint area around the aerodrome and associated structures and staging areas was 49.4 ha. The footprint for the aerodrome was created by buffering existing features by 50 m and hand digitizing some of the smaller features such as the pump house to include these in the aerodrome footprint. To facilitate use of the aerodrome, a portion of a rocky knoll will be removed (3.5 ha). This area was buffered by 50 m to account for possible additional impacts (33.2 ha).

Footprints for staging areas such as the Knipple Transfer Area below Knipple Glacier (8.0 ha) were hand digitized with Purview (stereo viewing software that is used in ESRI ArcGIS) using recent digital stereo images to incorporate current disturbed area outside of the proposed footprint. The Tide Staging Area, north of the old Granduc Mine airstrip, was also buffered by 50 m to account for area lost for this staging area (4.6 ha).

An average clearing width of 30 m along the proposed Brucejack Transmission Line was identified in the *Transmission Feasibility Study and Cost Estimates* (Valard 2013). As some areas cleared for the Transmission Line will exceed 30 m, a 40 m cleared area has been used to identify effects on wetlands related to this feature. The total area is 219.6 ha, with 90.2 ha located above the treeline where tree clearing will not be required. Adjacent to either side of the proposed transmission line cleared width, a 50 m buffer was used to identify potential effects on wetland function related to edge effects such as windthrow. This buffer width was chosen due to the relatively small width of the corridor and lack of potential dust or sedimentation inputs. Edge-related effects on microclimate tend to decrease more quickly as clearing size decreases (Spittlehouse, Adams, and Winkler 2004), and 50 m is a conservative estimate of potential effects on wetlands adjacent to the Transmission Line.

17.4.3 Potential Effects Assessment

Potential effects of the Project on wetlands follow one of two pathways: (1) Project component interaction with wetland extent and function resulting in a loss of extent and function; and (2) Project component interaction with one or more wetland functions resulting in an alteration of one or more wetland functions.

The effects on wetland extent that follow the first pathway are quantified through a footprint analysis of the Project infrastructure using GIS analysis. Project areas that do not affect wetlands are excluded from further effects assessment for the purposes of extent analysis.

A precautionary approach was used to identify effect on function where loss of extent occurs. Given that the area is relatively undisturbed, we can assume that current wetland function is at or near maximum. An effect on wetland extent may therefore result in an effect on wetland function of the same magnitude.

Effects on function that follow the second pathway have the potential to result in an alteration of wetland function. These effects are identified through a second footprint analysis that uses buffers to identify effects on function.

Effects on wetland function can be assessed using wetland functions characterized for each wetland class (Table 17.3-5; Hanson et al. 2008). Other effects of the Project on wetland function can be identified by assessing proposed land uses adjacent to wetland communities and the possible effects on wetland function (wetlands within the buffers used to identify effects). This type of interaction may result in:

- alterations to wetland hydrological function through putting in ditches, culverts, watercourse crossing, or through water flow alteration;
- alterations to wetland biochemical function through sedimentation, dustfall, site runoff, alteration of hydrology or point source discharge;
- alterations to wetland functional diversity through the introduction of invasive plant species or loss of adjacent wetland areas; and
- alterations to wetland habitat function through fragmentation, change of vegetation structure, or change of water quality or quantity.

17.4.3.1 Hydrologic Effects

Initial hydrological effects from the Brucejack Access Road occurred during its construction and are not within the scope of this assessment, continued effects related to ongoing changes in surface and groundwater flow will be assessed, and are possible.

Hydrological effects are difficult to measure, but the effects of excavation and activities such as ditching can have substantial upslope and downslope effects. Depending on soil conditions, ditch spacing of up to 300 m can alter wetland hydrology enough to make it suitable for tree growth (Skaggs et al. 2011).

Structures (buildings, roads, etc.) alter water movement through a variety of methods. The creation of impervious surfaces reduces infiltration rates into groundwater and changes the timing and quantity of water flow in wetlands (Azous and Horner 2010). Compaction of soil and loss of pore space can reduce infiltration rates and obstruct or reduce groundwater flow, depending on soil depth, porosity, and other characteristics that influence groundwater (Schack-Kirchner, Fenner, and Hildebrand 2007). Surface runoff water flow can also be increased by the removal of vegetation or routing of ditches (Ziemer and Lisle 1998). Ditches can also result in dewatering of wetlands by interrupting subsurface and surface water flow, allowing rapid water drainage and redirection. Ditches can also increase surface water flow to wetlands when water is directed in channels into wetlands and exceeds infiltration capacity. Both dewatering and impoundment can result in permanent shifts in vegetation communities and alteration of habitat types.

Changes in the timing and quantity of water entering wetlands may influence the functions that wetland can provide (Mitsch and Gosselink 2000). Alterations to wetland functions may continue to occur as new hydrological regimes in affected wetlands become established. Possible changes to wetland functions may include alteration of habitat due to altered successional pathways, hydrodynamics, and hydrological connectivity; water quality treatment; and nutrient and organic export (Odland and del Moral 2002; Sheldon 2005).

17.4.3.2 Fragmentation Effects

Initial effects of fragmentation from the Brucejack Access Road occurred during construction and are not within the scope of this assessment; the effects related to this disturbance may increase over time. Fragmentation affects upland habitat and wetland habitat through direct and indirect habitat alteration (Trombulak and Frissell 2000). The term *hyperfragmentation* has been used in reference to the effects on wetlands when typical upland fragmentation occurs in association with hydrological fragmentation and biotic effects that encompass many functions and processes (Trombulak and Frissell 2000). Fragmentation has multiple effects on wetland functions. Isolation of species has been found to reduce species richness and abundance for many taxonomic groups (Harris 1988). Organisms with limited dispersal are most affected (Brown, Smith, and Batzer 1997). However, even species with high dispersal abilities may experience small population decreases associated with the disruption of cover from land clearing (Lynch and Whigham 1984). Fragmentation can also impact the hydrological functions of wetlands by changing water flow into and out of wetlands, altering their connectivity and hydrodynamics (Sheldon 2005).

17.4.3.3 Edge Effects

Most measurable physical environmental effects on vegetation associated with linear features such as roads appear not to extend beyond a distance of 100 m. Many of the changes associated with microclimate occur within one tree length of the dominant trees (Spittlehouse, Adams, and Winkler 2004). However, aspect and slope can increase or decrease this distance.

Most likely the depth of the edge effects may be much smaller in open (treeless) habitats. On the other hand, in forested habitats the extent of the real, long-term effect might be higher (and more discernible statistically), because most of the currently available data are based on short-term research.

17.4.3.4 Dust Effects

Dust can have various effects on the health of vegetation depending on the amount and frequency of dusting, the chemical properties of the dust, and the receptor plant species. In addition to blocking photosynthesis, respiration, and transpiration, dust can also cause physical injuries (Farmer 1993).

Cumulative impacts through long-term dust fall and sedimentation can result in a shift in vegetative communities and thus a shift or loss of biochemical and habitat functions. Dust impacts can be substantial in areas such as road sides where the traffic rate is high (Padgett et al. 2008). Wetlands provide natural funnels that facilitate the spread of dust and can be expected to experience greater dust dispersal than treed ecosystems.

The chemical effects of deposited dust often have greater impacts than the quantity of dust (Farmer 1993). Chemical effects can result from direct deposition on foliage or other tissues or through uptake through fine roots from the soil. Plant growth may be affected by dust-induced changes in soil pH, nutrient availability, radiation absorption, and leaf temperature and chemistry (Eller 1977; McCune 1991; Walker and Everett 1991; Farmer 1993; CEPA/FPAC Working Group on Air Quality Objectives and Guidelines 1998; Anthony 2001). Evergreen shrubs may experience greater cumulative dusting than deciduous shrubs as they retain leaves from year to year (Auerbach, Walker, and Walker 1997). Chemically active dusts that are alkaline, acidic, or bio-available will have the largest effects on vegetation, ecosystem, and biochemical pathways (Grantz, Garner, and Johnson 2003). Heavy metal concentrations and the amount of vehicle traffic are related and are observable 200 m or more from a road (Dale and Freedman 1982). Vehicle size and speed can also be an important determinant in dust production from roads.

Soil pH may be altered by dust inputs. The effects of pH changes on wetlands can include loss of listed species, and alterations to functional diversity and habitat functions. The effects of pH change are species dependent. Species tolerant of high or low pH conditions will respond positively within a range of acidity levels, outside of which they will generally decline (Farmer 1990). As acidity increases, there is a general decrease in species diversity in lacustrine wetlands and a presumed loss of functional diversity (Farmer 1990). The effects of pH changes are more pronounced on invertebrates, amphibians, fish, and birds and include a general decrease in habitat quality associated with greater acidity (Sheldon 2005).

Biochemical functions are also susceptible to pH changes. In bog wetlands, pH changes can result in the release of heavy metals or reduced capacity to bind toxic metals; however, some contaminants can be more tightly held at low pH (Sheldon 2005).

17.4.3.5 Sedimentation and Waterborne Pollutant Effects

Sediment deposition to wetlands from roads can effect wetland function (Bilby, Sullivan, and Duncan 1989). Sloughing of road fill directly into wetlands can occur during and following construction activities. Additionally, maintenance activities such as grading and road repair have the potential to expose soils and cause sediment deposition in wetlands. Road use during the life of the mine may also result in sedimentation, and sediment rates are related to traffic volume (Bilby, Sullivan, and Duncan 1989).

Sediment accumulation in wetlands can cause shifts in wetland plant species composition and abundance by changing: nutrient concentrations; physical conditions that alter functional diversity (Tilman et al. 1997); biochemical functions such as nutrient export or carbon storage; or habitat quality for fish, invertebrates, amphibians, and other organisms by changing habitat depth (Sheldon 2005). Invasive plant species are often favoured over native plant species in cases where they tolerate disturbance or exposed soils offer favourable germination conditions (Pyke and Havens 1999). Sedimentation can also reduce the storage capacity of a wetland and reduce the ability of wetlands to ameliorate floods (Sheldon 2005). It is important to reduce sedimentation in wetlands as the effects are long-lasting and cannot be mitigated (Hagans, Weaver, and Madej 1986).

Changes in nutrient inputs can have multiple effects on wetland functions. Enrichment with nitrogen (N) and other nutrients that are essential to plant growth can increase primary production and biomass, which can lead to changes in plant species community composition (Wetzel and Valk 1998). Low nutrient systems, such as bogs, are most sensitive to these additions and can experience floristic shifts that do not favour species adapted to low nutrient conditions (Moore et al. 1989). Increased biomass production may also result in reduction in water storage capacity and flood water reduction (Adamus et al. 1991).

The functions related to water quality may improve in moderately enriched wetlands, but with high levels of enrichment or eutrophication, algal blooms may occur and negatively affect water quality, plant species composition and diversity, and inhibit the ability of a wetland to reduce nitrogen levels through denitrification (Majora, Mayfielda, and Barkerb 1988; Ettema et al. 1998; Adamus, Danielson, and Gonyaw 2001). In nutrient poor systems, the addition of nutrients can change plant community structure, which in turn modifies wetland pH. This can alter adsorption of cations, resulting in the release of heavy metals or reduced capacity to bind toxic metals (Sheldon 2005).

Processing of toxic compounds by microbial communities in wetlands, especially metals and petroleum products has been documented by numerous researchers (Nyman 1999; Sikora et al. 2000). The effects of toxic contaminants on wetland plant species is not well established (Sheldon 2005). However, the negative impacts on other wetland species including invertebrates, birds, and fish have been well established (Sheldon 2005).

17.4.3.6 Invasive Species Effects

Invasive species have the potential to negatively affect native plant and animal communities, especially where native biodiversity has been reduced by other impacts (Dukes 2002). The effects of invasive species on native diversity have been well documented, are growing in magnitude, and are the second greatest threat to listed species after habitat loss (Wilcove et al. 1998; Enserink 1999). Some wetland types, such as marshes, fens, swamps and other wetlands with low canopy cover, are more susceptible to invasive species than forested wetlands (Detenbeck et al. 1999). Depending on the species involved and pre-existing conditions, wetlands can experience dramatic loss of biodiversity from 50 to 100% as a result of colonization by invasive plant species (Sheldon 2005). In BC, there are 163 species of plants identified as nuisance, noxious, or invasive (E-Flora BC 2012). These include species such as purple loosestrife (*Lyhtrum salicaria*), giant knotweed (*Polygonum sachalinense*), and canary reed grass (*Phalaris arundinaceae*), which have moderate to high impacts on wetlands (Voller and McNay 2007).

Anthropogenic disturbances, particularly vegetation removal and site disturbance, are key determinants of colonization by invasive species (Detenbeck et al. 1999). Excessive nutrient input can provide the opportunity for fast growing species to invade wetlands and displace native species (Adamus, Danielson, and Gonyaw 2001). Hydrological disturbances such as ditches and culverts have also been associated with invasive species (Zedler and Kercher 2004), and sedimentation has been shown to increase rates of invasive colonization (Kercher and Zedler 2004). Roads, power lines and other linear features are key causes of increased rates of introduction (Trombulak and Frissell 2000). Roads provide three mechanisms that increase exotic species spread (Trombulak and Frissell 2000), namely by:

- providing habitat by altering conditions (hydrological regimes, soil disturbance, and light regimes);
- reducing competition from native species through removal or stress; and
- acting as corridors for dispersal by human or animal vectors.

Invasive plants are often found along road verges and other recently disturbed areas. Once established, they can decrease vegetation biodiversity, forest and range productivity, and ultimately reduce the overall efficacy of reclamation initiatives (Polster 2005b). Vehicles and machinery can carry plant propagules in their tires, undercarriages, or in mud on the vehicle, inadvertently transporting them to previously unaffected areas. In addition to roadside ditches and verges, forest edges are susceptible to the introduction of invasive species propagules from adjacent clearings (Murphy and Lovett-Doust 2004).

When colonization of wetlands occurs, hydrological, biochemical, habitat, and diversity functions can be affected. Some species have the ability to alter the physical nature of wetlands through infilling (high productivity or lower decomposition rates). It is speculated that this can reduce the topographic diversity of a wetland, reducing water volume and distribution and simplifying habitat complexity and species richness (Zedler and Kercher 2004). This can alter the hydrological functions of wetlands by changing the capacity to buffer flood waters (Zedler and Kercher 2004). Higher evapotranspiration rates can also affect wetland hydrological functions by reducing soil moisture and water levels (Ehrenfeld 2003). Invasive species tend to have higher biomass and net primary production than native species which alters biochemical functions (Ehrenfeld 2003). Invasive N fixing plants can dramatically alter N cycling, enriching sites or where plants are high N users, they may deplete soil N reserves (Ehrenfeld 2003). Changes in pH, which can affect pH sensitive wetlands such as bogs, are associated with invasive species colonization (Ehrenfeld 2003). Biodiversity and habitat loss associated with invasive species colonization has been confirmed by numerous studies, and species richness has been shown to be affected by competition for light resources and changes related to nutrient cycling (Richburg, Patterson, and Lowenstein 2001; Zedler and Kercher 2004). Negative impacts on bird, mammal, fish, and invertebrates have all been documented due to invasive species colonization (Benoit and Askins 1999; Weinstein and Balletto 1999; Fell et al. 2003).

17.4.3.7 Construction

A footprint analysis was used to identify which Project areas and which Project components interact with wetlands. This was done using the assessment footprint to represent the maximum extent of disturbance. Consideration of effects on wetland function included: hydrological connectivity, fragmentation, edge effects, dustfall, sedimentation and water quality, and invasive species. Where Project/wetland interactions were identified during the Construction Phase, they were carried through to Closure. Reclamation will include wetlands; however, this is not expected until the Closure and Reclamation phases, so effects on wetlands are still identified through all Project phases. Although the effects analysis was done using the footprint for the maximum extent of disturbance, Project phases were used to identify when the effects were expected to start.

Loss of Wetland Extent

Brucejack Access Road Construction

As the Brucejack Access Road is already constructed and permitted under Permit MX-1-832, no loss of extent or alteration of wetland function has been assessed related to construction. However, effects upon wetland hydrology associated with the road may continue to alter wetland hydrology and habitat functions for the life of the road.

Mine Site Construction

No loss of wetland extent and function will occur due to Mine Site construction as no wetlands occur in the assessment footprint identified for the Mine Site.

Aerodrome and Staging Areas' Construction

No loss of wetland extent and function will occur due to Bowser Aerodrome, Knipple Transfer Area, and Tide Staging Area construction, as no wetlands occur in the assessment footprint identified for these components.

Transmission Line Construction

No definitive footprint for transmission line towers is available. However, wetlands are generally not suitable sites for the construction of transmission lines towers, as they provide unstable substrate for foundations. As well, wetlands tend to be located in depressions, which can decrease the span length between towers. Raised areas are preferred locations for towers to reduce the number of towers required. Loss of wetland extent and functions is not expected due to clearing for tower footprint construction as no wetlands were found to intersect the proposed transmission line 40 m cleared area. In Section 17.5.2.3, avoidance measures are proposed to guide planning of tower locations and reduce the potential for direct effects on wetlands if small, unmapped wetlands are identified during construction.

Alteration of Wetland Function

Brucejack Access Road Construction

Use of the Brucejack Access Road and upgrades or changes during the Construction Phase of the Mine Site may result in changes to wetland functions. Alteration of water flow, fragmentation effects, edge effects, dust inputs, and sedimentation have the potential to affect wetland function where wetlands are adjacent to the road or where hydrologic connectivity is altered. The introduction of invasive species could also affect wetland function.

Mine Site Construction

Mine Site infrastructure will be constructed within 300 m of wetlands. The construction and use of the Mine Site will create dust which could potentially alter wetland function.

Wetlands are an endpoint receptor for water quality; however, no input of deleterious substances along water gradient pathways from the Mine Site is expected because the only adjacent wetland is above the level of the water flowing out of Brucejack Lake.

Aerodrome and Staging Areas' Construction

Construction of the Bowser Aerodrome, Knipple Transfer Area, and Tide Staging Area will not cause a loss in wetland functions. No wetlands were identified within 300 m of these areas. No construction effects in any phase of the Project are expected.

Transmission Line Construction

Transmission line construction is not expected to impact wetland function as no clearing of the ROW vegetation within 50 m of wetlands will occur. Alterations to functions are not expected. No changes in micro-climate or altered nutrient inputs related to adjacent vegetation are anticipated.

17.4.3.8 Operation

Brucejack Access Road Operation

Wetlands within 300 m of the Brucejack Access Road could continue to be altered due to the presence of the road. Hydrological functions may be altered where the road has changed surface and groundwater flow. Dust inputs and sedimentation from road operation, upgrades, and maintenance may alter biochemical and habitat functions and may result in changes to functional diversity as ecosystem changes occur. Adjacent to the road are extensive windrows of exposed soil; these will continue, until successfully re-vegetated, to erode, and sediment will be delivered to adjacent wetlands, streams, waterbodies, and terrestrial ecosystems.

Mine Site Operations

At the Mine Site, mining operations will contribute dust to a wetland at the Mine Site, which will alter biochemical function and may result in changes to functional diversity.

Aerodrome and Staging Areas' Operations

No expected alteration to wetland function will occur due to operations.

Transmission Line Operations

Since there are no wetlands within 50 m of the proposed transmission line ROW, there is no expected alteration to wetland function.

17.4.3.9 Closure

During Closure, the Project infrastructure will be decommissioned and disturbances reclaimed. As such, effects are no longer considered for major project components as presented above. No additional loss of wetland extent and function will occur during this time.

The Brucejack Access Road will be decommissioned during Closure based upon a deactivation plan that will be prepared and submitted for approval. Some minor effects related to road decommissioning may occur such as an increase in sedimentation. Over time, this should be offset by road reclamation activities.

Removal of the transmission line and related structures will allow re-establishment of successional processes and associated canopy structure. No effects are anticipated on wetlands during closure and reclamation of the proposed transmission line.

17.4.3.10 Post-closure

It is not expected that any new Project components or areas will result in a loss of wetland extent in the Post-closure Phase. Reclamation actions for wetland restoration will be completed during the Closure Phase. It is expected that wetland functions will begin to recover in response to implementation of reclamation planning. Habitat functions associated with wetlands will begin and will continue to develop as wetland vegetation moves along its successional trajectory. However, it may take 15 to 20 years for vegetation to reach an equilibrium state (Wilson and Mitsch 1996). Additionally, it can take decades for organic sediments to develop to the state that they contribute to nutrient cycling (Johnson and Smardon 2011).

17.5 EFFECTS ASSESSMENT AND MITIGATION FOR WETLANDS

17.5.1 Key Effects on Wetland Extent

17.5.1.1 Identifying Key Effects on Wetland Extent

No direct loss of wetland extent related to Construction, Operation, Closure, or Post-closure has been identified. Therefore, residual losses of wetland function due to loss of wetland extent are not expected, as illustrated by the *negligible* to *minor* adverse effects recorded for such loss in Table 17.5-1. As no loss of wetland extent will occur during the life of the Project, no residual effects or mitigation measures are required. Loss of wetland extent will not be considered further in the assessment of potential wetland effects.

Table 17.5-1. Ranking Potential Effects on Wetlands

Project Components/ Physical Activities	Potential Effects on Wetlands	
	Loss of Wetland Extent	Alteration of Wetland Function
Construction		
Brucejack Access Road	● (green)	● (yellow)
Mine Site	● (green)	● (yellow)
Aerodrome and staging areas	○	○
Transmission line	○	○
Operation		
Brucejack Access Road	● (green)	● (yellow)
Mine Site	● (green)	● (yellow)
Aerodrome and staging areas	○	○
Transmission line	○	○
Closure		
Brucejack Access Road	● (green)	● (yellow)
Mine Site	● (green)	● (yellow)
Aerodrome and staging areas	○	○
Transmission line	○	○
Post-closure		
Brucejack Access Road	● (green)	● (yellow)
Mine Site	● (green)	● (yellow)
Aerodrome and staging areas	○	○
Transmission line	○	○

Notes:
○ = *No interaction anticipated.*
● (green) = *Negligible to minor adverse effect expected; implementation of best practices, standard mitigation, and management measures; no monitoring required, no further consideration warranted.*
● (yellow) = *Potential moderate adverse effect requiring unique active management/monitoring/mitigation; warrants further consideration.*
● (red) = *Key interaction resulting in potential significant major adverse effect or significant concern; warrants further consideration.*

17.5.2 Key Effects on Wetland Function

17.5.2.1 Identifying Key Causes of Effects on Wetland Function

Alteration of wetland function has been identified based on the proximity of wetlands to the Mine Site and Brucejack Access Road. Wetland functions adjacent to the mine and the Brucejack Access Road were deemed to be potentially altered; it is quite likely that they will remain unaffected where they are not:

- hydrologically connected to the lost areas;
- fragmented;
- subject to edge effect;
- subject to dust deposition;
- subject to sedimentation;
- subject to waterborne pollutants; or
- subject to the introduction of invasive wetland plant species.

The sources of potential alteration of wetland function by the Project include changes in wetland hydrological functions due to changes in surface and groundwater flow caused by the Brucejack Access Road. Changes to habitat related to fragmentation and edge effects by the Brucejack Access Road are not restricted to the time period in which they occur. They often take decades to manifest as indicated by parameters such as species abundance and diversity, especially where species with low dispersal rates occur. Wetlands are an endpoint receptor for air quality and surface water quality effects. Dust inputs from the Mine Site and Brucejack Access Road could alter biochemical and habitat functions by changing pH and nutrient concentrations. Sedimentation and contaminants from the Brucejack Access Road could affect habitat, biochemical processes, and hydrological functions by changing physical properties related to water storage and treatment. One of the most serious effects on wetland function is the introduction of invasive species, which can alter all wetland functions by changing abiotic and biotic processes.

Where wetlands are subject to any of these effects, the processes they modify and functions they perform will be altered. Wetlands with potentially degraded wetland functions were identified using methods described in Section 17.6.2 using probability and consequence ratings that identified interactions between Project effects and wetland function.

17.5.2.2 Mitigation Measures for Alteration of Wetland Functions

Implementing mitigation strategies will minimize alteration of wetland function. Avoiding wetland areas is the best way to limit potential effects. As the road infrastructure is already in place, the assessment footprint does not include any wetlands, and the transmission line will not affect wetlands, mitigation measures will concentrate on reducing hydrological, fragmentation, edge, dust, sedimentation and water born pollutants, and invasive species effects on wetland functions related to the Brucejack Access Road.

The commitment to mitigation measures and related monitoring objectives are provided in the various management plans and the Wetland Monitoring Plan (Section 29.20). Although monitoring is not a mitigation measure, the information collected during monitoring will inform future development of appropriate adaptive management strategies for wetland management. Tools and practices to minimize Project effects on wetland function, as can be accomplished through the implementation of environmental management plans, are discussed below.

Management plans relevant to mitigating effects on wetland functions include:

- Air Quality Management Plan — Section 29.2;
- Aquatic Effects Monitoring Plan — Section 29.3;
- Ecosystem Management Plan — Section 29.5;
- Hazardous Materials Management Plan — Section 29.7;
- Invasive Plants Management Plan — Section 29.9;
- Rare Plant and Lichens Management Plan — Section 29.12;
- Soils Environmental Management and Monitoring Plan — Section 29.13;
- Spill Prevention and Response Plan — Section 29.14;
- Transportation and Access Management Plan — Section 29.16;
- Wetlands Monitoring Plan — Section 29.20; and
- Wildlife Management and Monitoring Plan — Section 29.21.

Hydrological Effects

To reduce the effects of loss of hydrological connectivity, mitigation measures should follow recommendations in the Soils Environmental Management and Monitoring Plan (Section 29.13) and the Ecosystem Management Plan (Section 29.5).

Fragmentation Effects

Following recommendations in the Transportation and Access Management Plan (Section 29.16) and Wildlife Management and Monitoring Plan (Section 29.21) will also help meet the target of minimizing loss of wetland functions related to fragmentation.

Edge Effects

Wildlife and wildlife habitat areas that are located in or are associated with wetlands are to be protected by strategies identified in the Wildlife Management and Monitoring Plan (Section 29.21). Additional mitigation for edge effects can be found in the Invasive Species Management Plan (Section 29.9), and the Transportation and Access Management Plan (Section 29.13).

If maintenance and operation activities must take place within sensitive periods, appropriate preconstruction and operation surveys are to be conducted to ensure minimal risk to wetland habitat associated with wildlife, birds, and amphibians. Sensitive periods, specific guidelines, and applicable legislation for species of concern are presented in the Wildlife Management and Monitoring Plan (Section 29.21).

Wetland habitat function includes providing aquatic, semi-aquatic, and transition environments that are used by a variety of fish and wildlife. Mitigation measures on reducing edge effects are included in the Wildlife Management and Monitoring Plan (Section 29.21) and the Aquatic Effects Monitoring Plan (Section 29.3).

Dust Effects

Dustfall impacts will be managed through the: Air Quality Management Plan (Section 29.2) and Transportation and Access Management Plan (Section 29.16) along all access corridors and work locations as required.

Sedimentation and Water Borne Pollutants Effects

To manage the effects of Project development on the biochemical and habitat functions of wetlands, the quality of any discharge will be controlled through the various environmental management plans. The two types of discharge are:

- point source (e.g., end of pipe or ditch discharge or seepage from a dam into a seepage collection pond); and
- non-point source (i.e., surface runoff).

Recommendations on mitigating the effects of sedimentation and pollutant on wetlands are included in the Soils Environmental Management and Monitoring Plan (Section 29.13), Ecosystem Management Plan (Section 29.5), Aquatic Effects Monitoring Plan (Section 29.3), Spill Prevention and Response Plan (Section 29.14), Transportation and Access Management Plan (Section 29.16), and Hazardous Materials Management Plan (Section 29.7).

Adverse effects of herbicide use, insecticide use, and road ploughing on wetland functions will be mitigated through the implementation of the Transportation and Access Management Plan (Section 29.16), Ecosystem Management Plan (Section 29.5), and the Invasive Species Management Plan (Section 29.9).

The Spill Prevention and Response Plan (Section 29.14) details measures intended to prevent and mitigate the effects of deleterious substances discharged into the environment. It also provides emergency response procedures should a spill occur.

Invasive Species

Implementation of the Invasive Species Management Plan (Section 29.9) is integral to reducing the probability of introducing invasive species to wetlands. Avoiding introducing invasive species is central to circumventing costly measures required for their eradication to protect wetland functions.

The Invasive Species Management Plan will manage for the Northwest Invasive Plant Council of BC priority species throughout the Project area. A site-specific plan will be developed by the Project's Environmental Manager through discussion (as needed) with the Invasive Plant Council, environmental scientists, and local governing agencies. The plan will draw upon the recent *Pest Management Plan for Invasive Alien Plants on Provincial Crown Lands in Central and Northern British Columbia* (BC MOFR 2010b), and the *Invasive Alien Plant Program: Reference Guide* (BC MOFR 2010a), which outline an Integrated Pest Management approach for invasive alien plants, under the authority of several partnering ministries.

17.5.2.3 Wetland Buffers

To support the maintenance of wetland function, reserve and management area buffers will be established around all wetlands. These buffers will be used to guide clearing activities for the Construction Phase and were selected following the BC Ministry of Forests and BC Ministry of Environment *Forest Practices Code Riparian Management Area Guidebook* (BC MOE and BC MOF 1995). The smallest reserve zone (10 m) proposed in the guidebook will be extended to all wetlands. This will provide protection of the vegetation, soil, and hydrological constituents of wetlands, which will maintain their extent and reduce impacts on function. Wetland management zones will be extended beyond the 10 m reserve zone to the distances detailed in Table 17.5-2. These buffers must be considered during tower placement for construction of the proposed transmission line.

Table 17.5-2. Wetland Buffer Guidelines

Environmental Feature	Reserve Zone	Management Zone	Total Buffer
Small Wetlands (< 5 ha)	10 m	20 m	30 m
Large Wetlands (> 5 ha)	10 m	30 m	40 m
Wetland Complexes	10 m	40 m	50 m

Light activities, such as construction access, sediment and erosion controls, and targeted vegetation clearing will be permitted within the wetland management zone; however, permanent features such as buildings and main roads will be located outside this zone wherever possible.

17.5.2.4 Additional Mitigation Measures

Where road widening is required to increase road safety, specifically if at road chainages 17-560 km to 17-647 km, additional measures will be required to protect wetland function and extent. These measures will apply at any location where road work could impact wetlands:

- avoid expanding road footprints in wetlands by using existing cleared areas of ROW footprint;
- surface roads adjacent to wetlands with clean crush that is compacted to reduce erosion and dust;
- employ silt fences, erosion control matting, and other suitable sediment control measures to reduce sediment delivery to wetlands;
- conduct work in or adjacent to wetlands during dry or frozen periods;
- insert culverts at each end of a wetland, where it is intersected by a road, and at low points in between to ensure hydrological flow is maintained where wetlands are intersected;
- isolate ditches adjacent to wetlands (i.e. create un-ditched breaks to reduce ditch flow along the road edges and associated funnelling of water and sediments into wetlands);
- construct and maintain sediment traps in ditches to reduce sedimentation into wetlands;
- place riprap or a shot-rock pad at the outlet of all cross-drains where ditch water is being diverted from an approach ditch line and discharged onto erodible soils or fills;
- re-vegetate exposed soils outside of wetlands with native species during the first available planting window;
- do not plant or sow non-wetland species in or along the margins of wetlands; and
- schedule regular inspections and maintenance of all structures related to water management and sediment control.

17.6 RESIDUAL EFFECTS ON WETLANDS

The footprint analysis determined that some wetlands may be at high risk of alteration due to proximity to Project infrastructure. The majority of the potential alteration is adjacent to the access road, while effects from dustfall are expected at the Mine Site. Conducting site-wide water quality monitoring, applying adaptive management strategies, and implementing the various relevant management plans, are measures that will help mitigate the potential for residual effects on wetland function.

The loss of wetland function was carried through as a residual effect for the Brucejack Access Road and proposed Brucejack Mine Site because it is expected that mitigation efforts may not return wetland function to baseline level for a long time (Table 17.6-1). Residual effects for loss of wetland extent and effects related to the Transmission Line and aerodrome and staging areas are not considered further.

Table 17.6-1. Summary of Predicted Residual Effects on Wetland Function

Receptor VC Sub-component	Project Phase (timing of effect)	Project Component/ Physical Activity	Description of Cause-Effect	Description of Mitigation Measure(s)	Description of Residual Effect
Wetland Function	Construction	Mine Site	Dust deposition	Air Quality Management Plan, and Transportation and Access Management Plan	Alteration of biochemical, habitat, and hydrologic functions
	Operation	Brucejack Access Road	Hydrologic connectivity	Soil Management Plan, Transportation and Access Management Plan, and Ecosystem Management Plan	Ongoing impacts related to loss of hydrologic, habitat, and functional diversity functions
		Brucejack Access Road	Fragmentation	Transportation and Access Management Plan, Wildlife Management and Monitoring Plan	Alteration of functional diversity, habitat, and hydrologic functions; greater potential for invasive species colonization
		Brucejack Access Road	Edge effect	Wildlife Management and Monitoring Plan, Invasive Species Management Plan, Transportation and Access Management Plan, and Aquatic Effects Monitoring Plan	Alteration of habitat function, functional diversity; greater potential for invasive species colonization
		Brucejack Access Road	Dust deposition	Air Quality Management Plan, and Transportation and Access Management Plan	Alteration of biochemical, habitat, and hydrologic functions and functional diversity
		Brucejack Access Road	Sedimentation	Soil Management Plan, Ecosystem Management Plan, Aquatic Effects Monitoring Plan, Spill Prevention and Response Plan, Transportation and Access Management Plan, Hazardous Materials Management Plan, and Invasive Species Management Plan	Alteration of biochemical, hydrological, habitat functions and functional diversity; greater potential for invasive species colonization
		Brucejack Access Road	Invasive species	Invasive Species Management Plan	Greater potential for invasive species colonization
	Closure	Mine Site	Dust deposition	Air Quality Management Plan, and Transportation and Access Management Plan	Biochemical effects will begin to be ameliorated
		Brucejack Access Road	Fragmentation, edge effect, sedimentation, hydrologic connectivity		Ongoing effects of hydrological, biochemical functions; some ongoing effects related to habitat and functional diversity

17.6.1 Residual Effects on Wetland Functions

A risk-based approach to wetlands management in BC has been recommended to address the loss and damage to wetland functions (MacKenzie and Shaw 2000) and was employed to assess residual effects on wetland function for the Project. It informs management decision-making on risk reduction by providing a framework that allows for the identification of cause and effect. This approach has been employed in various fields from wildfire, flood, and ecological risk management (Blackwell et al. 2004) (Sayers, Hall, and Meadowcroft 2002). Risk is defined as the probability that an adverse event will occur multiplied by the consequences of an adverse event (Sayers, Hall, and Meadowcroft 2002). While the end result of risk assessment is an overall characterization of risk, it is helpful to also present both probability and consequence separately to assist in management decisions to reduce potential impacts. It provides a more transparent process to guide decision making (Figure 17.6-1).

To develop a risk-based approach to wetland assessment, a spatial model was developed in ArcGIS using the probability of Project components and activities affecting wetlands and the associated consequences to wetland functions. The purpose of the model is to identify where function is most likely to be affected (probability) and where wetlands with the highest values at risk occur (consequence). The output of the model is the calculation of risk, derived from probability and consequence ratings. The model consists of four groups: 1) risk; 2) ratings (probability and consequence); 3) components, and 4) sub-components (these components and sub-components refer only to groupings within the model and not VC categories). Risk is calculated as probability multiplied by consequence. Knowledge of where and what project risks exist provides guidance on where active management is required. Probability and consequence are calculated using the components and sub-components. Within sub-components, criteria specific to each sub-component are used to evaluate individual characteristics (Figure 17.6-2).

17.6.2 Probability of Project Effects on Wetland Extent and Function

To calculate the probability rating, six components were assessed: hydrological connectivity, fragmentation, edge effect, dust, sedimentation and water quality, and invasive species (Table 17.6-2; Figure 17.6-2). Each of these six components' contribution to the final probability rating was weighted as a percent (Table 17.6-2). Probability ratings were assigned to each sub-component based upon either quantitative values from baseline data and modelling, where available, or qualitative values, determined through reviews of relevant literature, baseline information, or expert opinion.

Table 17.6-2. Probability Ratings for Wetlands for the Project

Component	Rating Weight	Sub-component Contribution
Loss of Extent		
Loss		100%
Alteration of Function		
Hydrological connectivity	0-10	35%
Fragmented	0-10	20%
Edge	0-10	5%
Dust	0-10	10%
Sedimentation/water quality	0-10	25%
Exotic invasive species	0-10	5%
Total		**100%**

Figure 17.6-1

Probability and Consequence Assessment to Guide Risk Management Planning

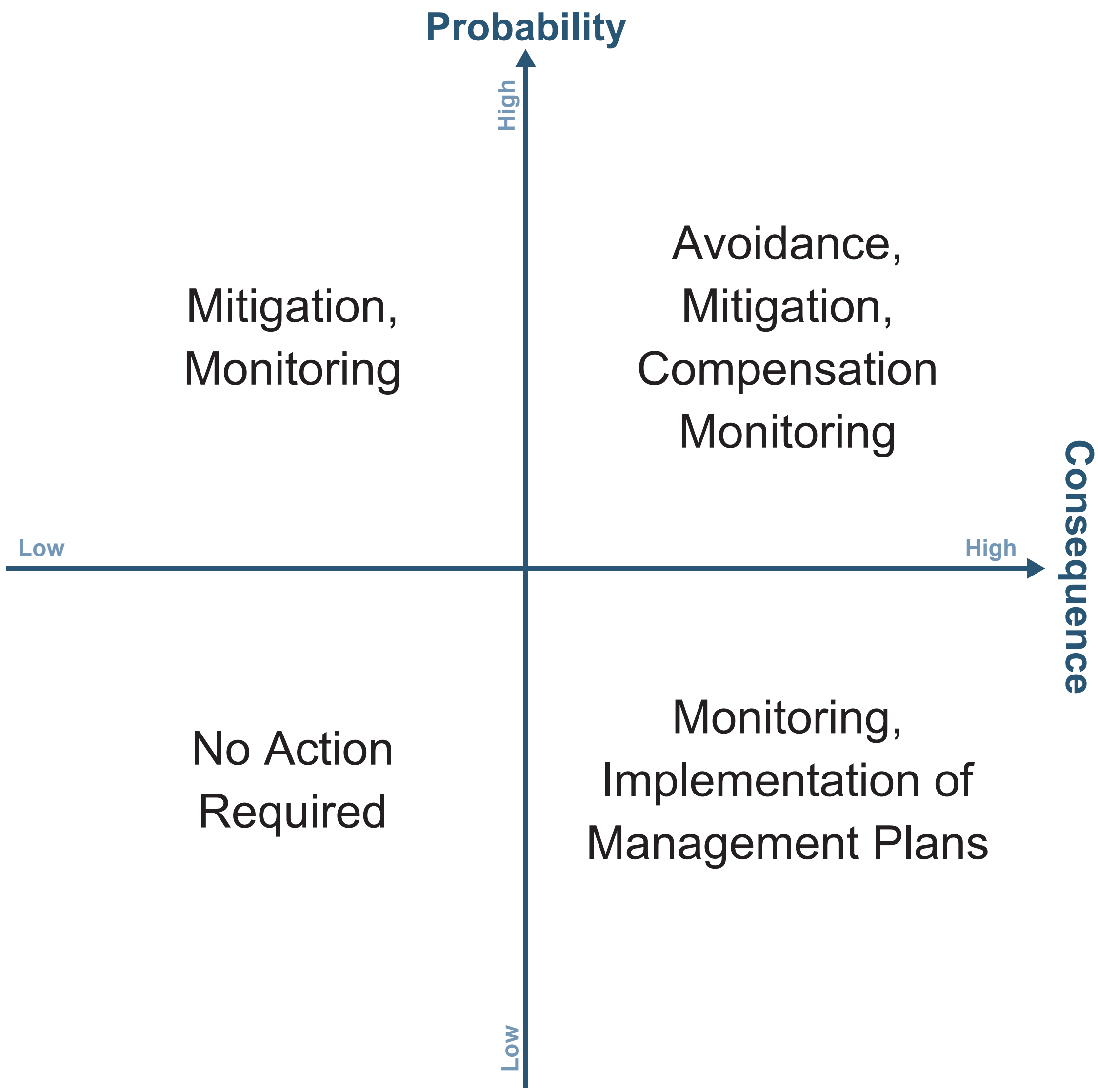
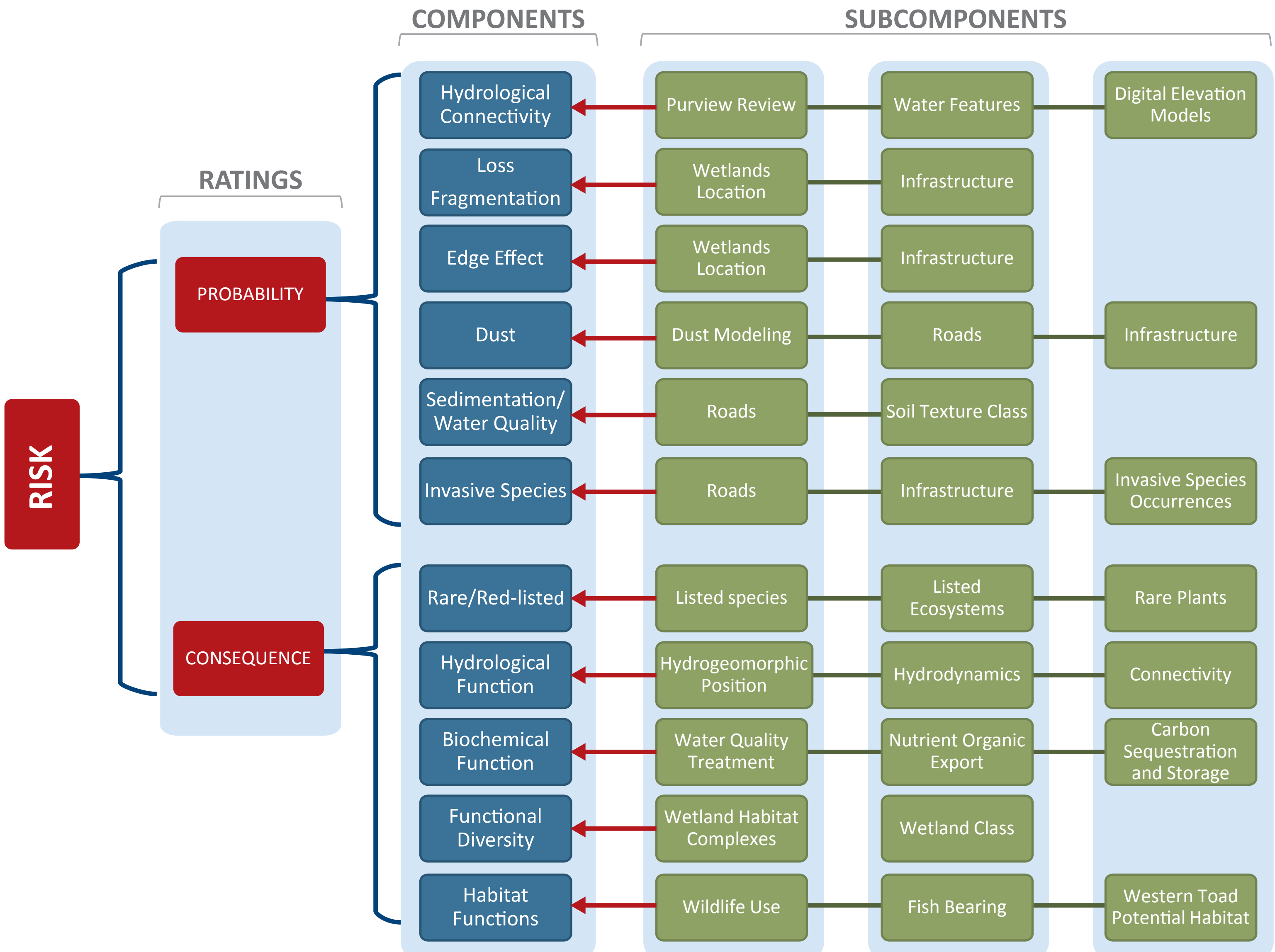


Figure 17.6-2

Probability and Consequence Model used to Evaluate Project Effects on Wetland Function



As an example, Table 17.6-3 shows the rating system used to identify the probability of sedimentation based upon distances from infrastructure and grouping of soil surficial materials into coarse or fine texture classes. Buffers up to 100 m from existing infrastructure were created and adjacent soil types were identified using data from the *Brucejack Gold Mine Project: 2012 Terrestrial Ecosystem Baseline Studies* in Appendix 16-A. The buffer distance from infrastructure and soil texture was grouped in classes based upon the potential for erosion, transportation, and deposition of materials and assigned a rating weight between 0 and 10 (Table 17.6-3). The final sub-component weighting for sedimentation is weighted as 30% of the total probability rating.

Table 17.6-3. Example of Probability Ratings for Project Sedimentation and Water Quality Effects

Assessable Characteristic	Data Source	Rating Scale	Rating Weight	Sub-component Weight
Sedimentation, water quality, soil texture		> 100 m from infrastructure	0	
	Infrastructure footprint soil texture (*Brucejack Gold Mine Project: 2012 Terrestrial Ecosystem Baseline Studies*)	50 - 100 m and soil texture (coarse texture - fluvial, glacial fluvial, and all other types)	5	25%
		50 - 100 m and soil texture (fine textured - lacustrine, morainal, organic, and water)	7	
		30 - 50 m and soil texture (coarse texture - fluvial, glacial fluvial, and all other types)	7	
		30 - 50 m and soil texture (fine textured - lacustrine, morainal, organic, water)	8	
		< 30 m and all soil surficial types	10	

17.6.3 Consequence of Project Effects on Wetland Extent and Function

Consequence was assessed on five components including: rare/listed species or ecosystems, hydrological function, biochemical function, functional diversity (ecological function), and habitat function. All polygons with rare or listed species or ecosystems were given a final consequence rating of 10, the highest value possible (Table 17.6-4). This was to ensure they were set as a high priority and distinguishable from other values at risk.

Table 17.6-4. Consequence Ratings for Wetlands for the Project

Component	Rating Weight	Sub-component Contribution
Rare/Listed Species or Ecosystems		
Rarity	10	100%
Functions		
Hydrological function	0-10	40%
Biochemical function	0-10	20%
Functional diversity	0-10	20%
Habitat function	0-10	20%
Total		**100%**

Each of the four remaining components' contribution to the final consequence rating was weighted as a percent (Table 17.6-4). Consequence ratings were assigned to each sub-component based upon either quantitative values from baseline data or modelling where available or qualitative values that were determined through reviews of relevant literature, baseline information, or expert opinion. Components for consequence were derived from sub-components, which are assessable or measurable parameters (Figure 17.6-2). The sub-component ratings were based upon inputs from baseline reports, literature review, or expert opinion.

For example, Table 17.6-5 shows the three characteristics used to evaluate habitat functions: wetland bird habitat use, based on wildlife baseline identification of bird preference by wetland class; fish presence (anadromous and resident), based on aquatics baseline sampling; and habitat values, based on wetland class as identified by (Hanson et al. 2008). Identification of potential western toad habitat was based on a review of all wetlands with a component of shallow open water (SOW) using Purview. Each of these characteristics was broken down into a rating scale, which was then assigned a rating weight between 0 and 10 (confirmed western toad habitat is automatically assigned a high consequence rating as it is a listed species). The three characteristics were then summed based on a sub-component weight.

Table 17.6-5. Example of Consequence Ratings for Wetland Habitat Function

Assessable characteristic	Data Source	Unit	Rating Scale	Rating Weight	Sub-component Weight
Wetland bird habitat use	Wildlife bird habitat preference (Wildlife Baseline Report)	Wetland Class	Open water	10	25%
			Fen/Marsh/Swamp	7	
			Bog	3	
Fish presence absence	Fish mapping (Aquatics Baseline Report)	Species/Use	Anadromous	10	25%
			Resident	8	
			None	1	
General habitat by wetland class	Wetland mapping (Wetlands Baseline Study - Appendix 17-A)	Wetland Class	Marsh	10	40%
			Swamp	7	
			Fen	5	
			Bog	3	
Western toad (potential habitat)	Review of wetlands in Purview	Potential	None	2	10%
			Possible	10	

The final output is a spatial characterization of risk based on probability and consequence ratings for individual wetlands. In addition to the final risk database and map, maps are generated for each component and sub-component based on their weightings. The map outputs follow the general model as shown in Figure 17.6-2. The individual components for probability and consequence and the model outputs specific to each component for the Project are discussed in greater detail below.

17.6.4 Probability Analysis Components and Project Specific Effects

17.6.4.1 Hydrological Connectivity Component

Hydrological connectivity inputs included TRIM water features, mapped wetlands, a Digital Elevation Model (DEM), and Project infrastructure. These were reviewed in ArcGIS using Purview to identify where Project infrastructure had the potential to affect wetland hydrology by interrupting or diverting subsurface or surface water flow to a wetland. The potential effects were assigned a value based on whether disruption in water flow to a wetland due to the Project infrastructure could occur and the severity of impairment. Wetlands 500 m or more from Project infrastructure were not evaluated. Wetlands upslope and downslope were assessed equally, as alterations of natural flow can result in dewatering or impoundment of wetlands.

Project-specific Effects

Hydrological connectivity was identified as being moderately affected in 18 ha of wetland, primarily fens and swamps (Table 17.6-6). Connectivity effects were high for 42.7 ha of wetland, with fens (29 ha) being the most affected class.

Table 17.6-6. Probability of Hydrological Connectivity Effects by Wetland Class

Hydrological Connectivity	Wetland Class (Area ha)					
Probability Class	**Bog**	**Fen**	**Marsh**	**SOW**	**Swamp**	**Total (ha)**
Low	1.8	187.9	62.5		203.9	456.1
Moderate		7.5		0.5	9.9	18.0
High		29.0	7.3	5.5	1.9	43.7
Total (ha)	**1.8**	**224.4**	**69.8**	**6.0**	**215.7**	**517.7**

17.6.4.2 Loss and Fragmentation Component

To assess probability associated with loss, Project infrastructure, and the footprint areas were assumed as total loss of all extent and function. This maximum extent of disturbance footprint represents the largest spatial extent of disturbance across all temporal boundaries; in essence, it is the "worst case scenario." Areas potentially affected by the Project were identified in terms of the amount of anticipated disturbance. Generalized infrastructure, with the exception of the Brucejack Access Road, which is currently in place, were assigned a designation of "lost" to indicate that any wetlands within these areas will be completely removed and essentially replaced by infrastructure, at least for the duration of the Project. No loss was identified for wetland extent, so only fragmentation is discussed.

Fragmentation was assessed when infrastructure occurred within 500 m of a wetland on one, two, three, or more sides. For fragmented wetlands with Project infrastructure on three or more sides, all loss of function and extent was assumed. For wetlands with less than three sides adjacent to infrastructure or where the isolated wetland fragments were less than 1 ha, alteration was rated as high. Fragments of 1 to 2 ha were rated moderate, and wetland fragments greater than 2 ha rated low for fragmentation.

The assumption in these cases is that wetland habitat, hydrological, functional diversity, and biochemical functions are all altered relative to their initial level of function, but the size of the remaining fragment affects the degree of alteration. The alterations in hydrological connectivity, plant and animal dispersal, biochemical pathways, and maintenance of habitat complexes all contribute to a general reduction in wetland functions.

Project-specific Effects

No mapped wetlands were identified with fragmentation on three or more sides; therefore, no loss of extent was identified. Only 2 ha of wetlands were identified as highly fragmented, as the fragments were less than 1 ha (Table 17.6-7). No wetland fragments measured from 1 to 2 ha. Low ratings were assigned to 516.3 ha of wetlands, as either no fragmentation occurred or fragments measured more than 2 ha.

Table 17.6-7. Probability of Fragmentation Effects by Wetland Class

Fragmentation	Wetland Class (Area ha)					
Probability Class	**Bog**	**Fen**	**Marsh**	**SOW**	**Swamp**	**Total (ha)**
Low	1.8	223.3	69.5	6.0	215.7	516.3
High		1.2	0.2			1.4
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**

17.6.4.3 Edge Effect Component

Edge effects were modelled using concentric 50 and 100 m buffers from newly cleared edges. Edge effects include, but are not limited to, potential changes in microclimate, structural diversity, biotic edge effects, invasive species colonization, increased sedimentation, and windthrow.

Project-specific Effects

Edge effects related to the Brucejack Access Road occur where the road intersects a wetland. There were 24.3 ha of high edge effect identified (Table 17.6-8). As only a single buffer was used to model edge effect, only two classes were used: low and high.

Table 17.6-8. Total Area of Low, Moderate and High Probable Effects Caused by Edge Effect by Wetland Class

Edge Effect	Wetland Class (Area ha)					
Probability Class	**Bog**	**Fen**	**Marsh**	**SOW**	**Swamp**	**Total (ha)**
Low	1.8	207.4	66.1	5.4	212.7	493.4
High		17.1	3.6	0.6	3.0	24.3
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**

17.6.4.4 Dust Component

Dust was modelled based on three buffer widths extending from the assessment footprint and Brucejack Access Road. Areas within 100 m were identified as high potential for dustfall, areas from 100 to 200 m were identified as having moderate potential for dustfall, and areas from 200 to 300 m were identified as having low potential for dustfall.

Project-specific Effects

Particulate matter can demonstrate different deposition patterns depending on size; large dust particles typically settle near the source (e.g., within 100 m), while finer particles travel much greater distances (US EPA 1995). The moist, humid climate within this region of BC, together with tree canopies that intercept dust, will likely restrict the majority of dustfall. However, adjacent to wetlands, dust interception is often reduced and dust can travel greater distances. The wet climate is also expected to regularly wash plant leaves; this will result in deposition and accumulation of the dust in wetland soils.

Dust or sediment from ore material being transported on the access road is not expected to contribute additional dust, as their loads will be covered to prevent loss of concentrate during transport. The potential effects of dust deposition on vegetation with respect to effects on human health are discussed in Chapter 21. Dust has a high probability of effects on 22.5 ha, a moderate probability on 40.2 ha and low probability on 455.0 ha of altering wetland function (Table 17.6-9).

Table 17.6-9. Probability of Dust Effects by Wetland Class

Dust Effects	Wetland Class (Area ha)					
Probability Class	**Bog**	**Fen**	**Marsh**	**SOW**	**Swamp**	**Total (ha)**
Low	1.8	181.8	63.1	3.0	205.3	455.0
Moderate		25.6	3.3	2.8	8.5	40.2
High		17.1	3.3	0.2	1.9	22.5
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**

17.6.4.5 Sedimentation and Water Quality Component

Sedimentation was modelled using soil texture and buffers adjacent to the access road. High ratings were assigned closer to road edges where easily erodible and transportable soils occurred and deposition in a wetland was more probable.

Project-specific Effects

During road construction salvaged soil stockpiles, often 5 to 10 m in width and 5 to 7 m in depth, were located along the road edges. This exposed soil is easily erodible and susceptible to creep and soil flow into ditches and downslope wetlands as was evident in several areas adjacent to the Brucejack Access Road. Subsequently, the stockpiles have been contoured and seeded for stabilization. Sedimentation was identified as high risk in 6.8 ha and moderate risk in 11.7 ha of primarily fen wetlands (Table 17.6-10). Most wetlands (499.2 ha) were identified as having low risk of sedimentation effects.

Table 17.6-10. Probability of Sedimentation Effects by Wetland Class

Sedimentation Effects Probability Class	Wetland Class (Area ha)					
	Bog	Fen	Marsh	SOW	Swamp	Total (ha)
Low	1.8	212.7	66.3	5.4	213.0	499.2
Moderate		6.7	2.2	0.6	2.2	11.7
High		5.1	1.2		0.5	6.8
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**

17.6.4.6 Invasive Species Component

Invasive species were modelled using known invasive species locations and buffers on infrastructure and footprints. Where wetlands overlap the buffers, ratings were assigned from *low*, where no invasive species occur, to *high*, were invasive species are present. Wetlands within 100 m of infrastructure were still assigned a probability rating even in the absence of invasive species due to increased human access, which provides a vector for invasive species. No invasive species were identified during baseline studies.

Project-specific Effects

Although no invasive plant species were found during baseline studies in the LSA, invasive plants could be introduced throughout the Construction, Operation, and Closure phases. In the broader region, an online database from the Invasive Alien Plant Council of BC indicates that some invasive plants are found nearby along Highway 37, including spotted knapweed (*Centaurea maculosa*), common toadflax (*Linaria vulgaris*), Canada thistle (*Cirsium arvense*), perennial sow-thistle (*Sonchus arvensis*), king devil (*Hieracium praealtum*), and oxeye daisy *(Leucanthemum vulgare*). It is important to recognize that this list does not include all the invasive plants that could be introduced into the Project area, but may represent those with higher likelihood of establishing (Table 17.6-11). Due to physical separation from the Brucejack Access Road, most wetlands were at low risk of invasive species occurring. Adjacent to the road, 46.5 ha of wetland were identified as being at low-moderate risk of invasive species colonization. These were assessed as low-moderate, because vectors for invasive species come in frequent contact with these wetlands, but no invasive species have been observed.

Table 17.6-11. Probability of Invasive Species Effects by Wetland Class

Invasive Species Probability Class	Wetland Class (Area ha)					
	Bog	Fen	Marsh	SOW	Swamp	Total (ha)
Low	1.8	185.5	62.2	6.0	215.7	471.2
Low-Moderate		39.0	7.5			46.5
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**

17.6.4.7 Probability of Adverse Effects on Wetlands

The ratings for probability of effects on wetland function are shown in Figure 17.6-3 and Table 17.6-12. The maps are made by combining the individual contributions of each probability component. They are overlaid in GIS to create a resultant final probability map that shows total contribution. The combined probability of effect is greater directly adjacent to the road, as most acute effects related to dust deposition, sedimentation/water quality, and invasive species are concentrated close to the road. Overall, there are 21.1 ha of high, 24.5 ha of moderate, and 472.3 ha of low probability of adverse effects on wetlands.

Table 17.6-12. Probability of Effects on Wetland Function

Total Probability	Wetland Class (Area ha)					
Probability Class	**Bog**	**Fen**	**Marsh**	**SOW**	**Swamp**	**Total (ha)**
Low	1.8	194.2	62.7	0.9	212.7	472.3
Moderate		14.6	3.6	4.8	1.5	24.5
High		15.8	3.4	0.4	1.5	21.1
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**

17.6.5 Consequence Analysis Components and Project-specific Ratings

17.6.5.1 Rare and Listed Species or Ecosystems Component

When rare or listed species occurred in specific wetlands or listed wetland ecosystems were identified in the *Wetlands Baseline* (Appendix 17-A), *Brucejack Gold Mine Project Wildlife Characterization Baseline Report* (Appendix 18-A), or in the rare plant surveys (Appendix 16-A), the wetlands were identified and the consequence weighting was automatically calculated as high. This was done to ensure that they were clearly identified so appropriate management measures could be developed.

Project-specific Consequence Ratings

Rare or sensitive ecosystems and species (including those identified by the BC CDC as red- and blue-listed) were identified in 168.1 ha of wetlands, with the majority of occurrences in fen (85.8 ha) and swamp wetlands (45.7 ha; Table 17.6-13). Almost all SOW had rare, listed species, or listed ecosystems. No listed species or ecosystems were found in the remaining 349.6 ha of mapped wetlands.

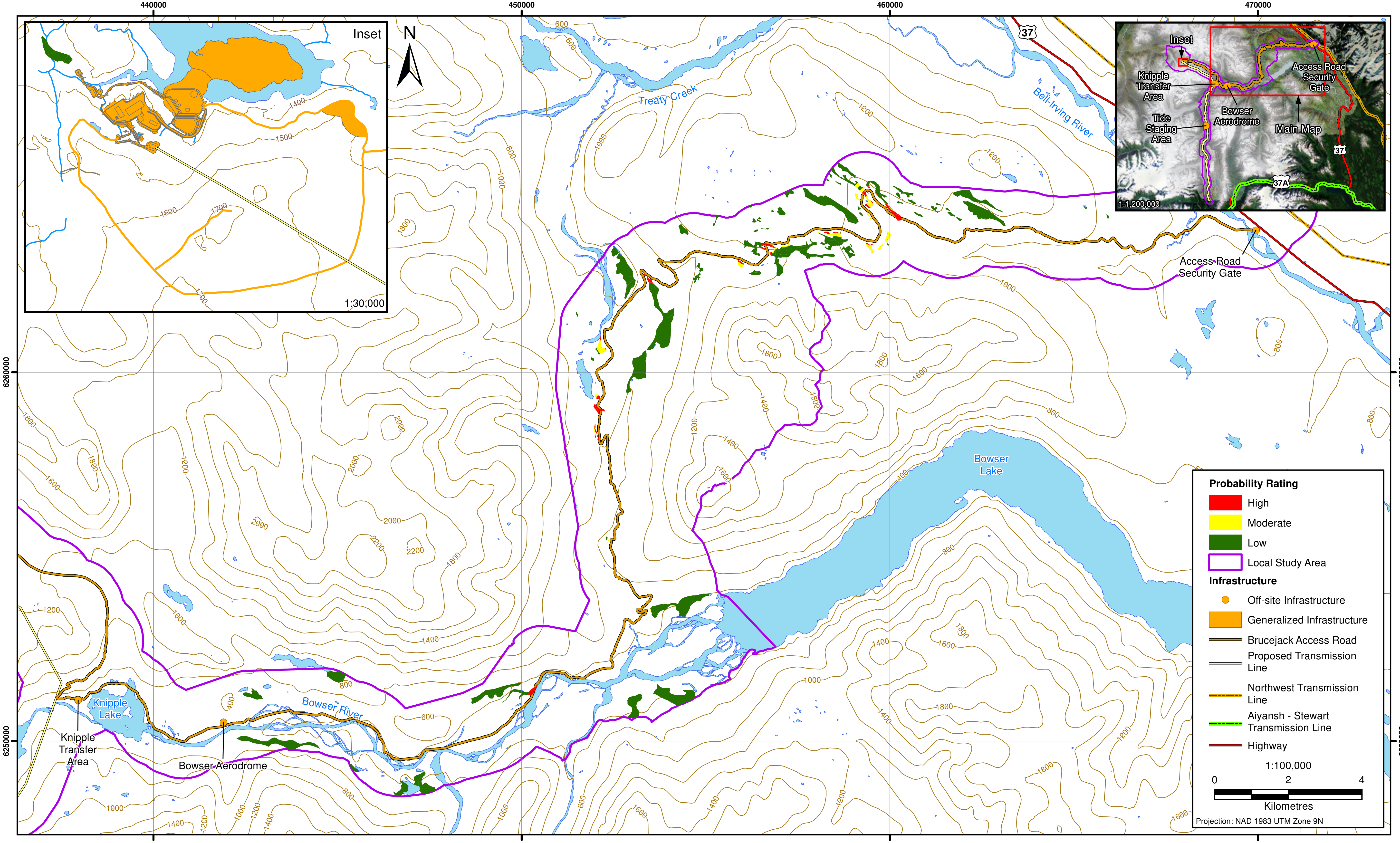
Table 17.6-13. Total Area of Wetlands with Identified Listed Species or Ecosystems by Wetland Class

Listed Species or Ecosystems	Wetland Class (Area ha)					
Consequence Class	**Bog**	**Fen**	**Marsh**	**SOW**	**Swamp**	**Total (ha)**
Absent		138.7	40.4	0.5	170.0	349.6
Present	1.8	85.8	29.3	5.5	45.7	168.1
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**

17.6.5.2 Hydrological Function Component

Hydrological function values were assigned based upon wetland characteristics. Hydrogeomorphic position, hydrodynamics, and connectivity (streams or channels visible in Purview) were used as sub-component inputs to assess hydrological function.

Figure 17.6-3
Probability Component Ratings for Wetlands



Project-specific Consequence Ratings

Hydrological function outputs identified 199.2 ha with low hydrological functioning, which was primarily in fens and swamps (Table 17.6-14). Many of these were wetlands with low connectivity and were basins and hollows or seepage slopes. Most of the 174.0 ha of moderate consequence occurred in fen and swamp wetlands. The 144.5 ha of high connectivity rated wetlands occurred primarily in swamps. However, a significant proportion of marsh wetlands were identified as having high hydrologic functions, and most of these wetlands were associated with creeks with mobile or dynamic hydrodynamics.

Table 17.6-14. Total Area of Low, Moderate, and High Hydrologic Function by Wetland Class

Hydrological Function	**Wetland Class (Area ha)**					
Consequence Class	**Bog**	**Fen**	**Marsh**	**SOW**	**Swamp**	**Total (ha)**
Low	1.8	132.6	13.6	0.5	50.7	199.2
Moderate		81.3	6.8	5.5	80.4	174.0
High		10.6	49.3		84.6	144.5
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**

17.6.5.3 Biochemical Function Component

Biochemical function was calculated based on wetland classes as reported in the literature (Hanson et al. 2008). Water quality treatment, nutrient organic export, and carbon sequestration were included as sub-component for assessment.

Project-specific Consequence Ratings

The majority of mapped wetlands (85%) had high biochemical functions based on the functional assessment of water quality treatment, nutrient and organic export, and carbon sequestration. All fens and swamps were identified as having high biochemical function, while bogs, marshes, and SOW were rated as moderate (Table 17.6-15).

Table 17.6-15. Total Area of Low, Moderate, and High Biochemical Function by Wetland Class

Biochemical Function	**Wetland Class (Area ha)**					
Consequence Class	**Bog**	**Fen**	**Marsh**	**SOW**	**Swamp**	**Total (ha)**
Moderate	1.8		69.7	6.0		77.6
High		224.5			215.7	440.1
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**

17.6.5.4 Functional Diversity Component

Loss of function in diverse ecological assemblages can have greater effect than loss of function in single community ecosystems (Tilman et al. 1997). Where multiple wetland classes were mapped either as deciles in a polygon or as distinct ecosystems with shared boundaries, functional diversity was assumed to increase with increasing number of wetland types. Wetlands with three or more ecological communities were rates as high, those with two communities were rated as moderate, and single wetlands were rated as low.

Project-specific Consequence Ratings

High ratings for functional diversity in mapped wetlands were identified in all wetland classes, with swamps and fens being the most common (238.5 ha; Table 17.6-16). Moderate ratings were attributed primarily to fen, marsh, and swamp wetlands. Only isolated fen wetlands had low ratings (37.2 ha).

Table 17.6-16. Total Area of Low, Moderate, and High Functional Diversity by Wetland Class

Functional Diversity Consequence Class	Wetland Class (Area ha)					
	Bog	Fen	Marsh	SOW	Swamp	Total (ha)
Low		37.2				37.1
Moderate	1.3	107.7	62.1		70.9	242.1
High	0.5	79.6	7.6	6.0	144.8	238.5
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**

17.6.5.5 Habitat Function Component

To assess habitat functions, wetland bird habitat preferences based upon extrapolation from observations identified in the Wildlife Baseline Report (Appendix 18-A) were used. Fish presence or absence based on connectivity to fish-bearing waterbodies or field observations in the Fish and Fish Habitat Baseline Report (Appendix 15-A) was also used. Wetland class was also included as a parameter on which habitat function was assessed (Hanson et al. 2008).

Project-specific Consequence Ratings

Wetlands rated as high for habitat function occurred mainly in marsh and swamp wetlands (111.6 ha) (Table 17.6-17). Swamps were also the most common wetland with moderate habitat ratings, followed by fen, marsh, and SOW. Low ratings were assigned to fens, swamps and bogs.

Table 17.6-17. Total Area of Low, Moderate, and High Habitat Function by Wetland Class

Habitat Function Consequence Class	Wetland Class (Area ha)					
	Bog	Fen	Marsh	SOW	Swamp	Total (ha)
Low	1.8	199.3			50.7	251.8
Moderate		25.2	22.7	6.0	100.4	154.3
High			47.0		64.6	111.6
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**

17.6.5.6 Consequence Ratings for Wetland Functions

The classes used for the consequence ratings, based on the components and sub-components for wetland function are shown in Figure 17.6-4 and Table 17.6-18. The maps are made by combining the individual contributions of each of the components that are used to calculate consequence. They are overlaid in GIS to create a resultant final consequence map that shows the total contribution of each layer. As consequence is a measure of wetland function, not the potential impacts associated with the Project, the value associated with consequence is independent of the distance to Project infrastructure. There are 255 ha of wetlands that have high consequences related to wetland function, and 207.2 ha of wetlands have moderate consequence (Table 17.6-18). Only 55.5 ha of wetland were identified with low consequences related to hydrological connectivity, biochemical functions, functional diversity, habitat functions, and rare or listed species or ecosystems.

Figure 17.6-4
Consequence Component Ratings for Wetlands

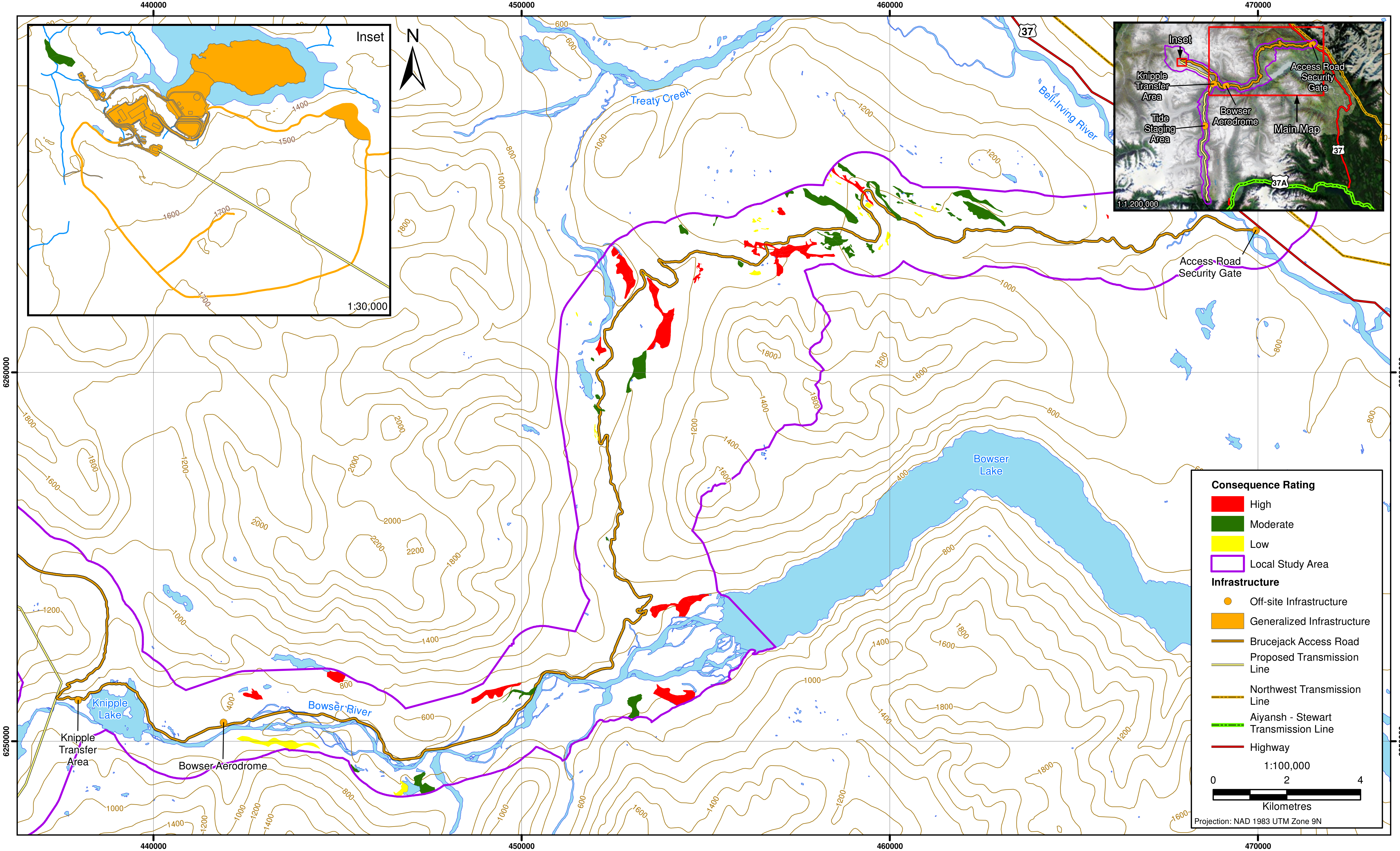


Table 17.6-18. Consequence Rating of Wetland Functions by Wetland Class

Total Consequences	Wetland Class (Area ha)					
Consequence Class	**Bog**	**Fen**	**Marsh**	**SOW**	**Swamp**	**Total (ha)**
Low		1.7	13.6		40.2	55.5
Moderate		123.2	18.8	0.5	64.7	207.2
High	1.8	99.6	37.3	5.5	110.8	255.0
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**

17.6.6 Final Risk Determination

As described in Section 17.6.2, risk is probability of an event occurring multiplied by the consequences of that event occurring. The total effect on wetland functions related to Project infrastructure and activities is shown below in Figure 17.6-5. Probability and consequence maps were included in Figures 17.6-3 and 17.6-4 to clearly indicate the cause of the final risk rating. This is important as it provides guidance as to appropriate levels of management that should be considered. For example, a situation in which probability of altering wetland function is moderate but the consequences of this change are low might warrant monitoring or standard mitigation measures. In contrast, a situation in which probability is the same but consequences are high would warrant either avoidance or the consideration of special mitigation measures.

Overall the residual risk to wetlands as a result of the Project is low (Figure 17.6-5, and Table 17.6-19). Residual risk is low for 422.1 ha (82%), moderate for 62.8 ha (12%), and high for 32.9 ha (6%) of mapped wetlands.

Table 17.6-19. Wetland Risk Ratings Shown by Wetland Class

	Wetland Class (Area ha)						% of Mapped Wetlands
Risk	**Bog**	**Fen**	**Marsh**	**SOW**	**Swamp**	**Total (ha)**	
Low	1.8	160.4	62.5		197.4	422.1	82%
Moderate		43.0	3.8	0.3	15.6	62.8	12%
High		21.1	3.4	5.7	2.7	32.9	6%
Total (ha)	**1.8**	**224.5**	**69.7**	**6.0**	**215.7**	**517.7**	**100%**

17.7 CHARACTERIZING RESIDUAL EFFECTS, SIGNIFICANCE, LIKELIHOOD, AND CONFIDENCE ON WETLANDS

Although demonstrated in the previous section to be low overall, there are predicted residual effects on the alteration of wetland function. Loss of function is predicted to occur along the Brucejack Access Road and to a more limited extent adjacent to the Mine Site at Brucejack Lake due to dust deposition. The definitions in Table 17.7-1 were used to characterize residual effects on wetlands. Magnitude is further characterized in Table 17.7-2.

17.7.1 Residual Effects Characterization for Wetland Functions

The residual effects on wetland function are characterized according to the criteria in Table 17.7-1. In addition to the mitigation measures in Section 17.5.2.2, a Wetland Monitoring Plan has been proposed to verify the residual effects on wetland function associated with the Project. The Wetland Monitoring Plan (Section 29.20) was designed to collect information on possible changes to wetland hydrology using shallow groundwater piezometers and visual inspections for sedimentation at three sites.

Residual effects on wetland functions will occur along the Brucejack Access Road and adjacent to the Mine Site. Alteration of wetland functions associated with Project infrastructure will occur in a relatively narrow effects area along the road and due to dust deposition adjacent to the mine. Magnitude was assessed in terms of the amount of area affected in risk categories. If the area in wetlands in high risk was greater or equal to 20% of the total wetland area or moderate risk plus high was greater than or equal to 30% of the total mapped wetland area, magnitude was assessed as major (Table 17.7-2). If the sum of wetland area in moderate and high risk categories was less than 50% of the total mapped area and less than 20% of this was high, magnitude was assessed as moderate. If the sum of moderate and high risk was less than 30% and high risk was less than 20%, magnitude was assessed as minor. If over 90% of the area occurs in low risk, the magnitude is negligible.

The value of 30% is adapted from scientific research and reviews on ecological thresholds. Research has indicated that as total habitat declines both population size and the number of wildlife species decline (not necessarily in a linear relationship) and that thresholds for wildlife often occur somewhere between 30 and 70% of habitat loss, depending on the ecosystem and wildlife species of interest (Mace et al. 1996; Mace and Waller 1997; Mace 2004; Schwartz et al. 2006; Interagency Conservation Strategy Team 2007; Price, Holt, and Kremsater 2007).

The threshold value of 20% for high magnitude was selected based on the concept of maintaining ecosystem group representation. It has been suggested that poorly represented or rare ecosystems, such as wetlands, be offered greater protection (Bunnell et al. 2003; Wells et al. 2003).

Effects will be minor in magnitude as most wetlands were identified as being low risk. Six percent of all the wetland area in the LSA was identified as being high risk, and 12% of wetland area was identified in the moderate risk class.

The effects will be long-term, as wetland function can take decades to re-develop after disturbance (Trombulak and Frissell 2000). There is the potential for hydrological function to be restored after the access road is decommissioned and surface and groundwater flow are re-established. While these changes will occur relatively rapidly, restoration of biochemical function, habitat functions, and functional diversity to pre-effect conditions could take several decades or longer (Trombulak and Frissell 2000).

The frequency of disturbances such as sedimentation and dustfall due to Mine Site activity, weather events, road maintenance, and road use and the effects on wetland function will be sporadic. The geographic extent of effects on wetland function is local in nature and confined to limited areas where the road intersects wetlands and where dustfall from the Mine Site affects wetland function. The effect on wetland functions are probably reversible over the long-term once hydrologic regimes are re-established and fragmentation, edge, dust, sedimentation, and water quality effects cease after Post-closure. However, there is uncertainty associated with this, as wetlands have low resilience due to their susceptibility to disturbance; physical, chemical, and biotic changes can have long-lasting effects on wetland function.

17.7.1.1 Likelihood for Residual Effects on Wetland Function

To determine the potential for the Project to cause residual effects, the likelihood of a residual effect occurring can be expressed as a measure of probability. The likelihood of a residual effect does not influence the determination of significance, rather it influences the risk of an effect occurring. Likelihood has been considered here in keeping with the most recent guidance issued in September 2013 by the BC Environmental Assessment Office (BC EAO; 2013): *Guidelines for the Selection of Valued Components and Assessment of Potential Effects.*

Figure 17.6-5
Final Risk Ratings for Wetlands

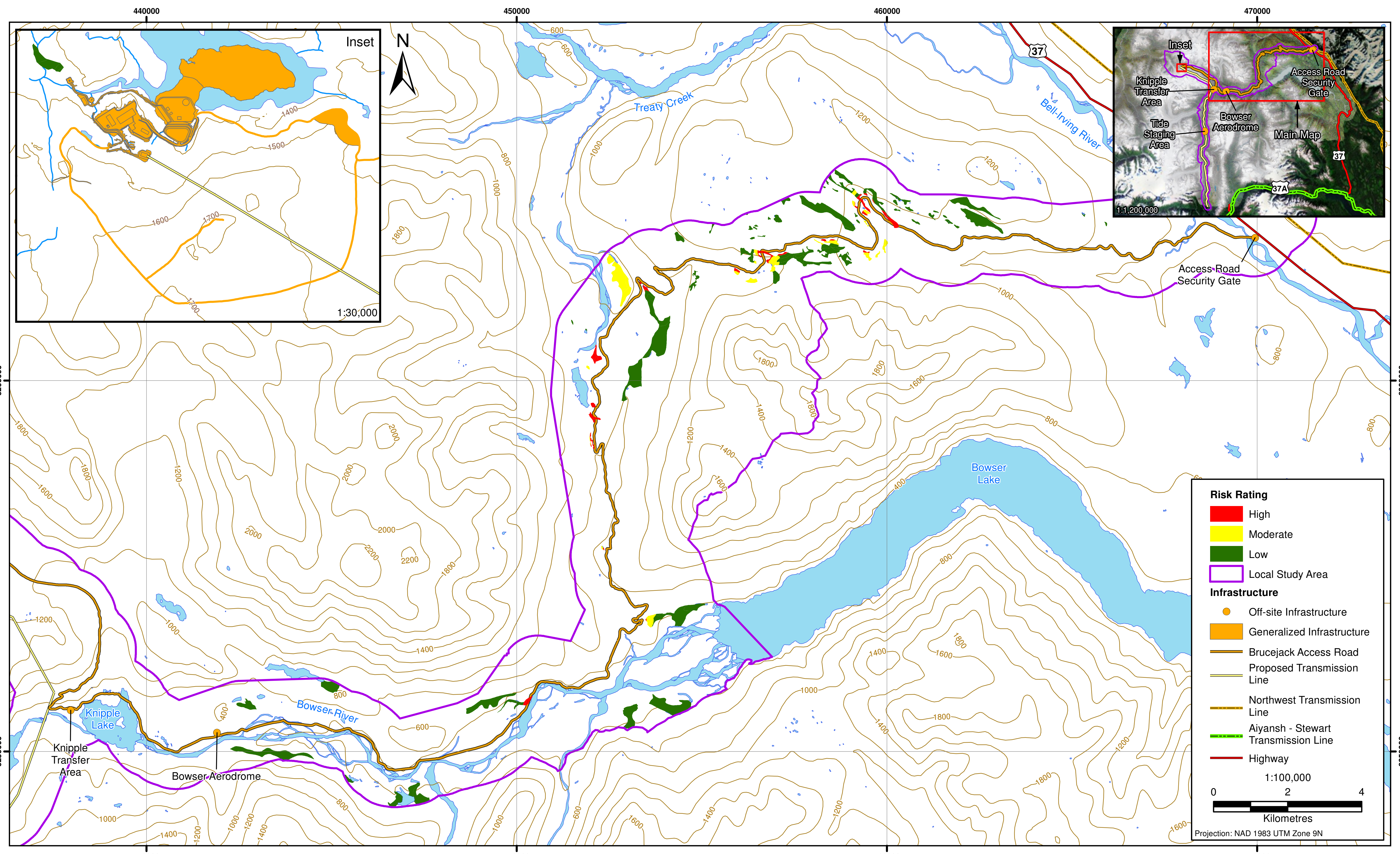


Table 17.7-1. Definitions of Characterization Criteria for Residual Effects on Wetlands

Magnitude	Duration	Frequency	Geographic Extent (Physical/Biophysical)	Reversibility	Resiliency	Ecological Context	Likelihood	Confidence Level
How severe will the effect be?	*How long will the effect last?*	*How often will the effect occur?*	*How far will the effect reach?*	*To what degree is the effect reversible?*	*How resilient is the receiving environment or population? Will it be able to adapt to or absorb the change?*	*What is the current condition of the ecosystem and how commonly is it represented in the LSA?*	*How likely is the effect to occur?*	*How certain is this analysis? Consider potential for error, confidence intervals, unknown variables, etc.*
Negligible: No or very little detectable change from baseline conditions. See Section 17.7-1 and Table 17.7-2 for classes.	Short-term: Effect lasts approximately 10 years or less.	Once: Effect is confined to one discrete period in time during the life of the Project.	Local: Effect extends less than 500 m from infrastructure or activity.	Reversible short-term: Effect can be reversed relatively quickly.	Low: The receiving environment or population has a low resilience to imposed stresses and will not easily adapt to the effect.	Low: The receptor is considered to have little to no unique attributes or provision of functions is severely degraded.	High: It is highly likely that this effect will occur.	High: > 80% confidence. There is a good understanding of the cause-effect relationship and all necessary data are available for the Project area. There is a low degree of uncertainty and variation from the predicted effect is expected to be low.
Low: Differs from the average value for baseline conditions to a small degree. See Section 17.7-1 and Table 17.7-2 for classes.	Medium-term: Effect lasts from 11 to 50 years.	Sporadic: Effect occurs at sporadic or intermittent intervals during any phase of the Project.	Landscape: Effect is limited to the LSA or one watershed.	Reversible long-term: Effect can be reversed within 20 years of Post-closure.	Neutral: The receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect.	Neutral: The receiving environment is considered to have some unique attributes and provides most functions that an undisturbed environment would provide.	Medium: This effect is likely, but may not occur.	Medium: 50 to 80% confidence. The cause-effect relationships are not fully understood, there are a number of unknown external variables, or data for the Project area are incomplete. There is a moderate degree of uncertainty; while results may vary, predictions are relatively confident.
Moderate: Differs substantially from the average value for baseline conditions and approaches the limits of natural variation. See Section 17.7-1 and Table 17.7-2 for classes.	Long-term: Effect lasts between 51 and 100 years.	Regular: Effect occurs on a regular basis during the life span of the Project.	Regional: Effect extends across the broader region (e.g., RSA, multiple watersheds, etc.).	Irreversible: Effect cannot be reversed (i.e., is permanent).	High: The receiving environment or population has a high natural resilience to imposed stresses, and can respond and adapt to the effect.	High: The receiving environment or population is uncommon and occurs in a natural state and provides functions at a maximum capacity	Low: This effect is unlikely but could occur.	Low: < 50% confidence. The cause-effect relationships are poorly understood, there are a number of unknown external variables, and data for the Project area are incomplete. High degree of uncertainty and final results may vary considerably.
High: Differs substantially from baseline conditions, resulting in a detectable change beyond the range of natural variation. See Section 17.7-1 and Table 17.7-2 for classes.	Far Future: Effect lasts more than 101 years.	Continuous: Effect occurs constantly during the life of the Project.	Beyond Regional: Effect extends beyond the regional scale and may extend across or beyond the province.					

Table 17.7-2. Magnitude Threshold for Wetlands Grouped by Risk Category

Area of Mapped Wetlands Grouped by Risk Category		Magnitude of Effect	Actual % of Mapped Wetlands
	> 90% in Low. No detectable change from baseline conditions	Negligible	
	Moderate + High < 30% and High < 20%	Low	82%
	Moderate + High > 30% and < 50% and High < 20%	Moderate	12%
	Moderate + High ≥ 30% and High ≥ 20%	High	6%

Likelihood criteria are provided in Table 17.7-1. Likelihood of residual effects to wetland function is high (Table 17.7-3). This is based on a risk model of the probability of residual effects on wetland function due to the Project. Most wetlands have a low probability of residual effects (472.3 ha); moderate and high probability classes account for 24.5 and 21.1 ha of wetland area respectively.

17.7.1.2 Significance of Residual Effects on Wetland Function

Residual effects are expected on wetland functions adjacent to the Brucejack Access Road and Mine Site. These effects on function, however, are considered to be **not significant**. As indicated in Table 17.6-18, 32.9 ha (6%) of mapped wetlands are at high risk of being affected and 62.8 ha (12%) are at moderate risk; therefore, the magnitude of effect is minor. The residual effects are local in extent, albeit long-term, and will be within the range of natural variation at a landscape level scale (Table 17.7-3).

17.7.1.3 Characterization of Confidence for Residual Effects on Wetland Function

Once a significance determination is made, the confidence in the significance predictions is made. Confidence, which can also be thought of as scientific uncertainty, is a measure of how well residual effects are understood, which includes a consideration of the acceptability of the data inputs and analytical methods used to predict and assess Project effects. The evaluation of confidence and uncertainty for each residual effect is provided in Table 17.7-1.

As indicated in Table 17.7-3, there is a high degree of confidence in the outcomes of this assessment. The outputs from the probability and consequence model and final risk ratings from the model support this characterization of adverse effects on wetland function (Figure 17.6-5; Table 17.6-18). While uncertainty exists in every prediction of future change, the approach used to assess the effects on wetland function was developed to incorporate quantitative data from baseline reports and literature reviews. The goals were to remove as much subjectivity from the assessment as possible and to increase certainty in the predictions of alteration of wetland functions, residual effects, and the determination of significance to ensure a robust, transparent, and defensible approach to the effects assessment of wetlands.

17.8 SUMMARY OF RESIDUAL EFFECTS FOR WETLANDS

Alteration of wetland function is rated low in magnitude as determined by the criteria in Table 17.7-2. As shown in the probability and consequence model, 6% and 12% of wetlands in the LSA are in high and moderate risk respectively. The probability of effects on hydrological functions, biochemical functions, functional diversity, or habitat function will be minimized through adherence to the mitigation and management strategies described within the Management and Monitoring Plans (Chapter 29).

Table 17.7-3. Characterization of Residual Effects, Significance, Confidence, and Likelihood on Wetlands

Residual Effects	**Evaluation Criteria**							**Likelihood** *(low, medium, high)*	**Significance of Adverse Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
	Magnitude *(low, moderate, high)*	**Duration** *(short-term, medium-term, long-term, far future)*	**Frequency** *(once, sporadic, regular, continuous)*	**Geographic Extent** *(local, landscape, regional, beyond regional)*	**Reversibility** *(reversible short-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Ecological Context** *(low, neutral, high)*			
Alteration of Wetland Function	Low	Long-term	Sporadic	Local	Reversible long-term	Low	High	High	Not significant	High

Alteration of wetland function is local in extent, as it occurs directly adjacent to the Brucejack Access Road and Mine Site. The use of weighted buffers to model effects of hydrological connectivity, fragmentation, edge effects, dust, sedimentation/water quality, and exotic invasive species was chosen to model Project effects on function, as effects generally decrease with increasing distance from the causal agent. The weighted buffers also facilitated the contribution of each effect to the final assessment of consequence, ensuring that minor effects (such as invasive species in this case) were not over emphasized and potentially important effects (such as changes to hydrologic connectivity) were allotted appropriate weighting.

The effects of alteration of wetland functions are generally reversible in the long-term (e.g., after Construction, Closure, and Post-closure activities are complete), except where infrastructure such as roads and transmission lines are not reclaimed as continued use may degrade adjacent ecosystems. Wetlands are sensitive to disturbance, have low resiliency compared to most upland ecosystems, and they recover more slowly in many cases. Implementing management measures to help ameliorate impacts during the life of the mine will help ensure successful restoration of wetland functions Post-closure.

It is expected that effects will not occur uniformly throughout the buffers used to model probability of function alteration. Uncertainty exists with respect to where and to what degree alteration of functions may occur. As a result, alteration of function may exceed or fall short of the chosen buffers or have a lesser or greater effect. However, the approach of selecting the buffer sizes and the weights assigned to each effect was precautionary to avoid underestimating the potential Project effects. In summary, the potential residual effects of the proposed Brucejack Gold Mine Project on wetlands are **not significant**.

17.9 CUMULATIVE EFFECTS ASSESSMENT FOR WETLANDS

Cumulative effects are defined in this EA as “effects that are likely to result from the designated project in combination with other projects and activities that have been or will be carried out.” This definition is similar to section 19(1) of the *Canadian Environmental Assessment Act, 2012* (CEAA; 2012) and is consistent with the International Finance Corporation Good Practice Note on Cumulative Impact Assessment, which refers to consideration of other existing, planned, and/or reasonably foreseeable future projects and developments. A cumulative effects assessment is a requirement of the AIR and the EIS Guidelines and is necessary for the proponent to comply with CEAA, 2012 (2012) and the BC *Environmental Assessment Act* (2002a).

The Canadian Environmental Assessment Agency (CEA Agency) issued an Operational Policy Statement in May 2013 entitled *Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act 2012*, which provides a method for undertaking a cumulative effects assessment (CEA Agency 2012). Recently the BC EAO has also released the updated *Guideline for the Selection of Valued Components and the Assessment of Potential Effects* (BC EAO 2013), which includes advice for determining the need for a cumulative effects assessment. The cumulative effects assessment methodology adopted in this Application/EIS, therefore, follows the guidance of the CEA Agency as outlined above, as well as the selection criteria in BC EAO (2013).

The method involves the following key steps, which are further discussed in the proceeding sub-sections:

- scoping;
- analysis;
- identification of mitigation measures;
- identification of residual cumulative effects; and
- determination of significance.

17.9.1 Establishing the Scope of the Cumulative Effects Assessment

The scoping process involves identification of the intermediate components and receptor VCs for which residual effects are predicted, definition of the spatial-temporal boundaries of the assessment, and an examination of the relationship between the residual effects of the Project and those of other projects and activities.

17.9.1.1 Identifying Intermediate Components and Receptor VCs for the Cumulative Effects Assessment

Intermediate components and receptor VCs included in the wetlands cumulative effects assessment were selected using four criteria following BC EAO (2013):

- there must be a residual environmental effect of the project being proposed;
- that environmental effect must be demonstrated to interact cumulatively with the environmental effects from other projects or activities;
- it must be known that the other projects or activities have been or will be carried out and are not hypothetical; and
- the cumulative environmental effect must be likely to occur.

The receptor VCs included in this wetland cumulative effects assessment are:

- wetland extent; and
- wetland function.

Wetland extent and function were selected for the cumulative effects assessment, because they play a key role in the maintenance of hydrologic cycles, wildlife habitat, nutrient cycling, water quality, biodiversity, and carbon sequestration. The functions and ecological processes that occur in wetlands are vital to ecosystems and organisms at a much greater scale than their localized boundaries and limited extent suggests.

The footprint analysis for the Project determined that 32.9 ha of wetlands will be at high risk of function alteration. The majority of the potential alteration is adjacent to the Brucejack Access Road, while effects from dustfall are expected at the Mine Site. The alteration of wetland function was carried through as a residual effect because it is expected that mitigation efforts will not return wetland function to baseline level (Table 17.6-1).

17.9.1.2 Potential Interaction of Projects and Activities with the Project for Wetlands

A review of the interaction between potential effects of the Project and effects of other projects and activities on wetlands was undertaken. The review assessed the projects and activities identified in Section 6.8.2 of the assessment methodology, including:

- regional projects and activities that are likely to affect wetlands, even if they are located outside the Project's direct zone of influence;
- effects of past and present projects and activities that are expected to continue into the future (i.e., beyond the effects reflected in the existing conditions); and
- activities not limited to other reviewable projects, if those activities are likely to affect wetlands cumulatively (e.g., forestry, mineral exploration, and commercial recreational activities).

A matrix identifying the potential cumulative effect interactions for wetlands is provided in Table 17.9-1.

Table 17.9-1. Potential Cumulative Effect Interactions for Wetlands

Projects and Activities	Wetlands
Historic	
Eskay Creek Copper-Gold Mine	
Galore Creek Copper-Gold Project (access road only)	
Goldwedge Mine	
Granduc Copper-Gold Mine	
Johnny Mountain Mine	
Kitsault Molybdenum Mine	
Silbak Premier Mine	
Snip Mine	
Sulphurets Advanced Exploration Project	
Swamp Point Aggregate Mine	
Present	
Brucejack Exploration and Bulk Sample Program	
Forrest Kerr Hydroelectric Power	
Long Lake Hydroelectric	
McLymont Creek Hydroelectric Project	
Northwest Transmission Line (NTL)	
Red Chris Mine	
Reasonably Foreseeable Future	
Arctos Anthracite Coal Mine	
Bear River Gravel	
Bronson Slope Mine	
Coastal GasLink Pipeline Project	
Granduc Copper-Gold Project	
KSM Copper-Gold Project	
Kinskuch Hydroelectric Project	
Kitsault Molybdenum Project	
Kutcho Copper-Gold-Zinc Project	
LNG Canada Export Terminal Project	
Northern Gateway Pipeline Project	
Prince Rupert Gas Transmission Project	
Prince Rupert LNG Project	
Schaft Creek Copper-Gold Project	
Spectra Energy and BG Group Natural Gas Transportation System	
Storie Moly Mine	
Treaty Creek Hydroelectric Project	
Turnagain Mine	
Volcano Hydroelectric Project	

(continued)

Table 17.9-1. Potential Cumulative Effect Interactions for Wetlands (completed)

Projects and Activities	Wetlands
Land Use Activities — All Stages (past, present, future)	
Parks and Protected Areas	
Guide Outfitting	
Aboriginal Harvest (fishing, hunting/trapping, plant gathering)	
Hunting	
Trapping	
Commercial Recreation (including fishing)	
Forestry	(grey)
Transportation	(grey)

Notes:
Black = likely interaction between the Brucejack Gold Mine Project and other project or activity.
Grey = possible interaction between the Brucejack Gold Mine Project and other project or activity.
White = unlikely interaction between the Brucejack Gold Mine Project and other project or activity.

17.9.1.3 Spatial-Temporal Boundaries of the Cumulative Effects Assessment

The cumulative effects assessment boundaries define the maximum limit within which the effects assessment is conducted. They encompass the areas within, and times during which, the Project is expected to interact with the intermediate component and receptor VCs and with other projects and activities, as well as the constraints that may be placed on the assessment of those interactions due to political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The definition of these assessment boundaries is an integral part of the wetlands cumulative effects assessment; it encompasses possible direct, indirect, and induced effects of the Project on wetlands.

Spatial Boundaries

The cumulative effects assessment spatial boundary is intended to encompass an area beyond which effects of the Project would not cumulatively interact with effects of other Projects. The 374,433 ha RSA was selected as a suitable boundary to base the cumulative effects assessment on. It encompasses the regional setting for the Project and implicitly considers ecological factors, such as height of land in boundary delineation. Given the limited size of the Project, the RSA provides a suitable spatial scale on which to evaluate the Project and encompasses other relevant regionally important projects (Figure 17.9-1).

Temporal Boundaries

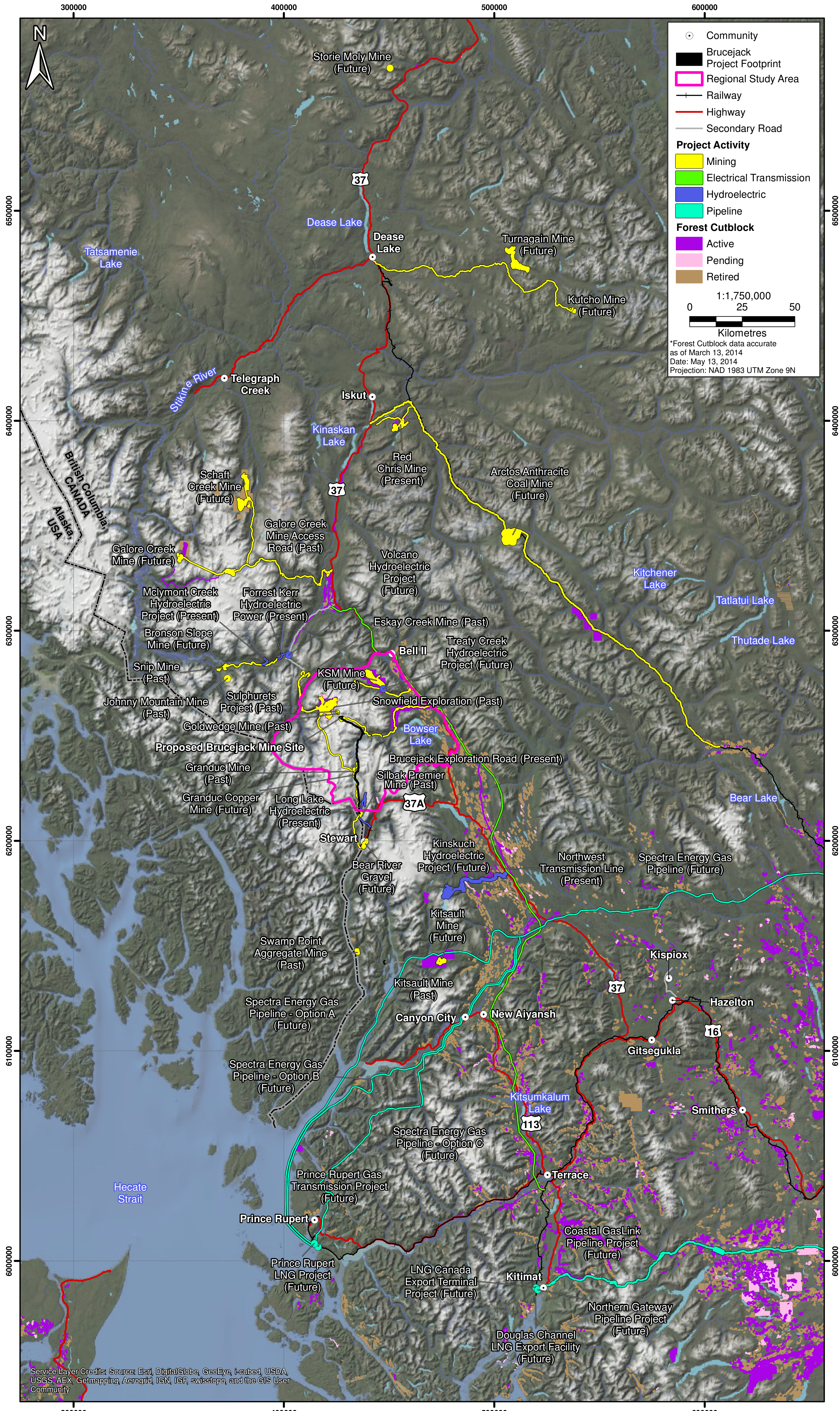
The temporal boundaries selected for the cumulative effects assessment extend for 20 years into Post-closure. This time frame was selected because it is anticipated that the return of wetland function to baseline conditions will take several decades after reclamation activities are completed. Where wetlands do not return to baseline conditions within this period, it is not believed that substantial difference will remain for much longer than the 20 year period. It is anticipated that these areas will be negligible and reflective of levels of natural disturbance and change in the region.

- Past — 1964 to 2011: coinciding with the development of the Granduc Copper-Gold Mine, which influenced the growth of the community of Stewart and other human activities in the area;
- Present — 2011 to 2014: from the start of Brucejack baseline studies to the completion of the environmental effects assessment; and
- Future — twenty years post-closure to recover to baseline conditions.

Figure 17.9-1

Cumulative Effects Scoping: Projects and Activities Interacting with the Project for Wetland Ecosystems

ERM



17.9.1.4 Potential for Cumulative Effects

Carrying forward the residual effects in Table 17.9-1, the projects and activities anticipated to have an interaction with the Project are shown in Table 17.9-2.

Table 17.9-2. Potential Cumulative Effects between the Proposed Brucejack Gold Mine Project Wetlands and Other Projects and Activities

	Brucejack Gold Mine Project	Past Project or Activity	Existing Project or Activity	Reasonably Foreseeable Future Project or Activity	Type of Potential Cumulative Effect *(physical-chemical transport, nibbling loss, spatial crowding, temporal crowding, synergistic, additive, growth inducing)*
Loss of wetland extent or altered function	X	• Sulphurets Project • Silbak Premier Mine • Goldwedge Mine	• Northwest Transmission Line • Long Lake Hydroelectric Project • Brucejack Exploration and Bulk Sample Program	• KSM Mine • Treaty Creek Hydroelectric Project	Additive

17.9.2 Analysis of Cumulative Effects

Potential cumulative effects on wetland function and extent were determined through a review of relevant past, existing, or reasonable foreseeable future projects in relation to the proposed Project residual effects. Table 17.9-2 summarizes the relevant past, present, and future projects and/or land use activities with potential to cumulatively interact with the residual effects estimated for the Project.

No information is available on potential wetland effects from the Silbak Premier or Goldwedge mines. No information was available for the Sulphurets Project. However, as this project was close to the proposed Brucejack Mine Site at high elevation, the potential impacts on wetlands were likely similar to the impacts from the Brucejack Mine Site and minor. No information is available on potential effects on wetlands due to the Long Lake or Treaty Creek Hydroelectric projects. Construction of access roads, transmission lines, and facilities may affect wetland extent and function. However, without additional project information, potential cumulative effects cannot be predicted for these projects.

The Northwest Transmission Line (NTL) occurs along Highway 37 and parallels the eastern RSA boundary. For the clearing of the ROW and construction of the transmission line, 2,309 ha of wetland were surveyed. Of these, 811 ha occurred on the ROW and 55 ha of wetland were identified as having loss of extent or function (Table 17.9-3; Rescan 2010). Much of the affected wetlands occur outside the RSA; however, as the NTL project occurs within 1 km of the proposed Brucejack Gold Mine Project RSA, all effects on wetlands were reviewed.

The KSM Project EA identified a residual cumulative effect on wetland extent and function, but it was not expected to be significant due to the compensation and reclamation plans. The KSM Project is expected to result in the loss of 59 ha and degradation of 52 ha of wetlands (Table 17.9-3). However, proposed reclamation and compensation activities will create 2.5 times as many wetlands at closure than were present at baseline (275 ha of reclamation and 48 ha of compensation; Rescan 2013c). Despite the reclamation and compensation activities, the created wetlands will probably not offer the same quality or variety of functions offered by natural wetlands.

Table 17.9-3. Potential Cumulative Effects on Wetland Function and Extent from Past, Present, and Reasonably Foreseeable Future Projects

Project	Past	Present	Future	Effect	Wetland Area Affected or Lost (ha)	Total Wetland Area (ha)	Affected Wetland
Proposed Brucejack Gold Mine Project			x	Function alteration (High)	33	518	6%
Brucejack Exploration and Bulk Sample Program		x		Wetland loss	2	518	0.4%
Sulphurets Mine	x			Unknown	Unknown	-	-
Northwest Transmission Line		x		Wetland loss	55	811	7%
KSM Mine			x	Wetland loss/ function alteration	111	522	21%
Silbak Premier Mine	x			Information unavailable	Information unavailable		
Goldwedge Mine	x			Information unavailable	Information unavailable		
Long Lake Hydroelectric			x	Information unavailable	Information unavailable	-	-
Treaty Creek Hydroelectric			x	Information unavailable	Information unavailable	-	-
Total					**201**	**1,851**[1]	**11%**

[1] *The 518 ha for Brucejack wetland area was only added once to the total area.*

There was 1.8 ha of wetland area lost due to construction of the Brucejack Access Road for the Brucejack Exploration Project (Table 17.9-3). Ongoing functional alteration is addressed in this assessment. Strategically locating the Brucejack Access Road minimized loss of wetland extent, as the road avoided crossing most wetlands.

The proposed Project overlaps the Cassiar and Nass TSAs. There has been historical forest harvesting activities in the vicinity of the proposed Project, but there has been no recent logging activity in the Bob Quinn area. Two of the three licences overlap the proposed Project infrastructure. Due to increased access provided by other industrial activities on the landscape, reductions in access costs for forest companies associated with road building will perhaps lead to an increase in forest harvesting.

No quantitate data are available for the forest industry effects on wetland extent or function. However, forest activities in relation to wetlands are guided by Land Resource Management Plans and regulated by the *Forest and Range Practices Act* (2002b). The *Cassiar Iskut-Stikine Land and Resource Management Plan* (BC ILMB 2000) provides detailed guidance on the location of roads, harvesting methods, and wetland buffer to forest licensee, which mitigate impacts on wetlands and dictates that best management practices from the Forest Practices Code *Riparian Management Area Guidebook* (BC MOE and BC MOF 1995) be employed. In addition, use of the Brucejack Access Road by forest companies will not be permitted, so increased access and harvesting opportunities are not predicted. Based on these comprehensive measures, effects on wetlands by forestry related activities are anticipated to be negligible.

17.9.2.1 Cumulative Effects on Wetlands

The Project will affect wetland extent and function as will other projects in the region (Table 17.9-2). The cumulative effects on wetland extent will be limited to projects near the Brucejack Gold Mine Project as effects on individual wetlands are local. Projects where an expected cumulative loss of the extent of wetlands is expected are detailed in Table 17.9-3.

A residual cumulative effect on the loss of wetland extent and alteration of function is expected due to additive losses in the region. However, it is not expected that this effect will be significant because of the limited loss of wetlands associated with the Brucejack exploration program and limited alteration of function associated with the Project. Compensation and reclamation activities planned for the KSM Project will also mitigate cumulative effects on regional wetland extent and function.

17.9.3 Mitigation Measures to Address Cumulative Effects

No additional mitigation measures are recommended to address cumulative effects on wetland extent or function due to the Project.

Compensation and reclamation for the KSM Project will, at closure, result in 2.5 times as many wetlands at closure than were present at baseline. Compensation efforts for this project include development of wetland features into three fish habitat compensation projects; creation of a wetland near Smithers, BC will create education, research, and recreation benefits. Although the communities will be different than those present at baseline, the reclaimed wetlands will provide functions such as habitat function for migratory birds and moose, hydrological functions such as water storage, and ecological functions such as complex ecosystems.

17.9.4 Cumulative Residual Effects for Wetlands

Cumulative residual effects are effects that remain after the implementation of all mitigation measures; they are summarized in Table 17.9-4.

Table 17.9-4. Summary of Cumulative Residual Effects on Wetlands

Wetlands	Timing of Cumulative Residual Effect[1]	Description of Cause-Effect[2]	Description of Additional Mitigation (if any)	Description of Cumulative Residual Effect
Wetland Extent	Construction to Post-closure	Construction footprints - Loss extent due to construction	KSM Project reclamation and compensation plans, Brucejack Access Road decommissioning	Loss of extent
Wetland Function	Construction to Post-closure	Construction activities, road use, upgrades, and maintenance — sedimentation, hydrological changes, invasive species, fragmentation, edge effects, and dust	KSM Project reclamation and compensation plans, Brucejack exploration road decommissioning	Altered function of affected wetlands for at least 20 years

[1] Refers to the Project phase or other timeframe during which the effect will be experienced by the receptor VC.
[2] "Cause-effect" refers to the relationship between the Project component or physical activity that is causing the change or effect in the condition of the receptor VC and the action change or effect that results.

17.9.5 Characterizing Cumulative Residual Effects, Significance, Likelihood, and Confidence for Wetlands

The cumulative residual effects for each intermediate receptor or VC were characterized by considering the Project's incremental contribution to the cumulative residual effect under two scenarios:

1. Future case *without* the Project — A consideration of residual effects from all other past, existing, and future projects and activities *without* the Project. This analysis was designed to answer the following question: given the status of current baseline conditions, how will receptor VCs be affected by the residual effects from other reasonably foreseeable projects and activities in the absence of the Project? The results of baseline data used in the Project-related effects assessment were used to facilitate this discussion.
2. Future case *with* the Project — A consideration of all residual effects from past, existing, and future projects and activities on a VC *with* the Project. This scenario was designed to answer the question: when combined with other project and activities, does the Project act as a trigger that pushes the intermediate component or receptor VC beyond significant thresholds?

This approach helps predict the relative influence of the proposed Project on the residual cumulative effect for each intermediate component or VC, while also considering the role of other projects and activities in causing that effect.

17.9.5.1 Cumulative Residual Effects Characterization for Wetlands

In comparing these two scenarios, no changes in magnitude, duration, geographic extent, frequency, reversibility, resiliency, or ecological context are anticipated with the addition of the Project. Duration is primarily reflective of anticipated effects related to the KSM Project, and the regional geographic extent would be appropriate with or without the inclusion of the Brucejack Gold Mine Project.

17.9.5.2 Likelihood of Cumulative Residual Effects on Wetlands

In keeping with the BC EAO (2013) guidelines, likelihood of cumulative effects was considered prior to significance for wetlands. Likelihood of effects was considered high given the detailed analysis and available baseline information.

17.9.5.3 Significance of Cumulative Residual Effects on Wetlands

The evaluation of significance was completed by comparing predicted cumulative effects against thresholds, standards, trends, or objectives relevant to wetlands, as defined below.

- **Not significant**: Residual effects have low or moderate magnitude, local to regional geographic extent, short- or medium-term duration, could occur at any frequency, and are reversible in either the short- or long-term. The effects on the receptor VC (e.g., at a species or local population level) are either indistinguishable from background conditions (i.e., occur within the range of natural variation as influenced by physical, chemical, and biological processes), or distinguishable at the individual level. Land and resource management plan objectives will likely be met, but some management objectives may be impaired. There is a medium to high level of confidence in the analyses. Follow-up monitoring of these effects may be required if the magnitude is medium.
- **Significant**: Residual effects have high magnitude, regional or beyond regional geographic extent, long-term or far future duration, and occur at all frequencies. Residual effects on receptor VCs are consequential (i.e., structural and functional changes in populations, communities, and ecosystems are predicted) and are irreversible. The ability to meet land and resource management plan objectives is impaired. Confidence in the conclusions can be high, medium, or low.

The cumulative effects of the proposed Project and the other projects assessed as part of the cumulative effects assessment are not significant (Table 17.9-5). It was assumed that the effects from previous projects were all in high risk categories. Magnitude was 11% and still less than the 20% threshold in Table 17.7-2. The residual effects are however regional in extent and long-term, but will be within the range of natural variation at a regional scale. The effects are reversible in the long-term if mitigation measures are adhered to and reclamation and compensation plans are implemented. Once a significance determination was made, the confidence in the significance prediction was evaluated to assess scientific certainty in the result.

17.9.5.4 Confidence of Cumulative Residual Effects on Wetlands

Confidence is considered to be medium given the duration of the KSM Project and NTL as well as uncertainty surrounding the success of restoration and compensation planning, interaction with climate change, and other long-term factors that may influence residual effects. There is uncertainty as to precisely where and to what degree alteration of wetland functions may occur, as the effects will not occur uniformly in the areas used to model probability effects on wetland function. As a result, alteration of function may exceed or fall short of the chosen buffers or have a lesser or greater effect.

17.10 EFFECTS ASSESSMENT CONCLUSIONS FOR WETLANDS

Alteration of wetland function is rated low in magnitude. As shown by the probability and consequence model, 6% and 12% of wetlands are in high and moderate risk. The probability of effects on hydrological, biochemical, functional diversity, or habitat function will be minimized through adherence to the mitigation and management strategies described within the relevant management and monitoring plans (Chapter 29).

Alteration of wetland function is local in extent, as it occurs directly adjacent to the Brucejack Access Road and Mine Site (Table 17.10-1). The use of weighted buffers to model effects of hydrological connectivity, fragmentation, edge effects, dust, sedimentation/water quality, and exotic invasive species was chosen to model Project effects on function, as effects generally decrease with increasing distance from the causal agent. The weighted buffers also facilitated the contribution of each effect to the final assessment of probability, ensuring that minor effects (such as invasive species in this case) were not over emphasized and potentially important effects (such as changes to hydrologic connectivity) were allotted appropriate weighting.

The effects of alteration of wetland functions are generally reversible in the long term (e.g., after Construction, Closure, and Post-closure activities are complete), except where infrastructure such as roads and transmission lines are not reclaimed, as continued use may degrade adjacent ecosystems. Wetlands are sensitive to disturbance, have low resiliency compared to most upland ecosystems, and they recover more slowly in many cases. Implementing management plans to help ameliorate impacts during the life of the mine will help in the restoration of wetland functions Post-closure.

It is expected that effects will not occur uniformly throughout the buffers used to model probability of function alteration. Uncertainty exists with respect to where and to what degree alteration of functions may occur. As a result, alteration of function may exceed or fall short of the chosen buffers or have a lesser or greater effect. However, the approach to selecting the buffer sizes and the weights assigned to each effect was precautionary to avoid underestimating the potential Project effects. In summary, the potential residual effects of the proposed Project on wetlands are considered to be **not significant.**

Table 17.9-5. Significance Determination of Cumulative Residual Effects for Wetlands — Future Case with the Project

Cumulative Residual Effects	Cumulative Residual Effects Characterization Criteria									
	Magnitude *(low, moderate, high)*	**Duration** *(short-term, medium-term, long-term, far future)*	**Frequency** *(once, sporadic, regular, continuous)*	**Geographic Extent** *(local, landscape, regional, beyond regional)*	**Reversibility** *(reversible short-term, reversible long-term, irreversible)*	**Resiliency** *(low, neutral, high)*	**Ecological Context** *(low, neutral, high)*	**Likelihood** *(low, medium, high)*	**Significance of Adverse Cumulative Residual Effects** *(not significant, significant)*	**Confidence** *(low, medium, high)*
Wetland function	Low	Far future	Sporadic	Regional	Reversible long-term	Low	Neutral	High	Not significant	Medium

Table 17.10-1. Summary of Project and Cumulative Residual Effects, Mitigation, and Significance for Wetlands

Residual Effects	Project Phase(s)	Mitigation Measures	Significance of Residual Effects	
			Proposed Brucejack Gold Mine Project	Cumulative
Wetland Function	Construction to Post-closure	Invasive species management, vegetation management, soil management measures along roadways, transportation and access management for the exploration road, wetland monitoring, and environmental effects management and monitoring	Not significant	Not significant
Wetland Extent	Construction and Operation	N/A	N/A	Not significant

Cumulative effects for the Project and projects within or directly adjacent to the RSA were assessed. The KSM, NTL, Long Lake Hydroelectric, Treaty Creek Hydroelectric, Brucejack Exploration, and Sulphurets projects were reviewed in the cumulative effects assessment. Data were not available for wetland extent and effects on function for the Sulphurets, Long Lake, and Treaty Creek projects; however, the KSM, Brucejack Exploration, and NTL and projects had information on wetland extent and function effects.

A residual cumulative effect on the loss of wetland extent and alteration of function is expected due to additive losses in the region. However, this effect is not expected to be significant, because of the limited loss of wetlands associated with the Brucejack Exploration Project and limited alteration of function associated with the proposed Brucejack Gold Mine Project. Compensation and reclamation activities planned for the KSM Project will also mitigate cumulative effects on regional wetland extent and function. The NTL environmental assessment identified that less than 7% of wetlands along the ROW would be affected, which is similar to the Brucejack Gold Mine Project (Rescan 2010). In summary, the potential cumulative effects of the proposed Brucejack Gold Mine Project and other projects in the area on wetland extent and function are considered to be **not significant** (Table 17.10-1).

REFERENCES

1985. *Fisheries Act*, RSC. C. F-14.

1996a. *Forest Act*, RSBC. C. 157.

1996b. *Mines Act*, RSBC. C. 293.

1996c. *Water Act*, RSBC. C. 483.

1996d. *Weed Control Act*, RSBC. C. 487.

1996e. *Wildlife Act*, RSBC. C. 488. s. 1.1.

1997. *Fish Protection Act*, SBC. C. 25.

2002a. *Environmental Assessment Act*, SBC. C. 43.

2002b. *Forest and Range Practices Act*, SBC. C. 69. s. 149.1.

2002c. *Species at Risk Act*, SC. C. 29. s. 15.3.

2003. *Environmental Management Act*, SBC. C. 53.

2012. *Canadian Environmental Assessment Act, 2012*, SC. C. 19. s. 52.

Forest Service Road Use Regulation, BC Reg. 70/2004.

Contaminated Sites Regulation, BC Reg. 375/96.

Adamus, P. R., T. J. Danielson, and A. Gonyaw. 2001. *Indicators for monitoring biological integrity of inland, freshwater wetlands: A survey of North American technical literature (1990-2000)*. US Environmental Protection Agency, Office of Water: Washington, DC.

Adamus, P. R., L. T. Stockwell, C. E. J., M. E. Morrow, and L. P. Rozas. 1991. *Wetlands Evaluation Technique (WET). Volume I: Literature Review and Evaluation Rationale*. Technical Report WRP-DE-2. US Army Engineer Waterways Experiment Station: Vicksburg, MS.

Almas, A. R. and B. R. Singh. 2001. Plant Uptake of Cadmium-109 and Zinc-65 at Different Temperature and Organic Matter Levels. *Journal of Environmental Quality*, 30: 869-77.

Anthony, P. 2001. *Dust from walking tracks: Impacts on rainforest leaves and epiphylls*. Australia: Cooperative Research Centre for Tropical Rainforest Ecology and Management. http://www.jcu.edu.au/rainforest/infosheets/dust_walkingtracks.pdf (accessed October 2008).

Auerbach, N. A., M. D. Walker, and D. A. Walker. 1997. Effects of roadside disturbance on substrate and vegetation properties in arctic tundra. *Ecological Applications*, 7 (1): 218-35.

Azous, A. and R. R. Horner, eds. 2010. *Wetlands and urbanization: Implications for the future*. Boba Ration, FL: CRC Press.

BC EAO. 2013. *Guidelines for the Selection of Valued Components and Assessment of Potential Effects*. British Columbia Environmental Assessment Office: Victoria, BC.

BC ILMB. 2000. *Cassiar Iskut-Stikine Land and Resource Management Plan*. British Columbia Integrated Land Management Bureau. http://ilmbwww.gov.bc.ca/slrp/lrmp/smithers/cassiar/index.html (accessed June 2013).

BC MEM. 1998. *Application Requirements for a Permit Approving the Mine Plan and Reclamation Program Pursuant to the Mines Act R.S.B.C. 1996, C. 293*. British Columbia Ministry of Energy and Mines: Victoria, BC.

BC MFLNRO. 2012. *Nass South Sustainable Resource Management Plan*. http://www.ilmb.gov.bc.ca/slrp/srmp/south/nass/index.html (accessed November 2012).

BC MOE. 2006. *Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia*. http://www.env.gov.bc.ca/wld/documents/bmp/devwithcare2006/develop_with_care_intro.html (accessed September 2009).

BC MOE. 2007. *BC Conservation Data Centre Home Page*. http://www.env.gov.bc.ca/cdc/index.html (accessed May 2010).

BC MOE. 2009. *Water and Air Resource Protection Guidelines for Mine Proponents and Operators: Baseline Monitoring. Draft*. British Columbia Ministry of Environment: BC.

BC MOE. 2010. *Sensitive Ecosystem Inventories*. http://www.env.gov.bc.ca/sei/ (accessed June 2011).

BC MOE. 2011. *Wetlands in BC*. http://www.env.gov.bc.ca/wld/wetlands.html (accessed October 2013).

BC MOE and BC MOF. 1995. *Forest Practices Code Riparian Management Area Guidebook*. *Forest Practices Code of British Columbia Act*. Government of British Columbia: n.p.

BC MOFR. 2010a. *Invasive Alien Plant Program: Reference Guide*. BC Ministry of Forests and Range. http://www.for.gov.bc.ca/hra/plants/RefGuide.htm (accessed October 2012).

BC MOFR. 2010b. *Pest Management Plan for Invasive Alien Plants on Provincial Crown Lands in Central and Northern British Columbia*. BC Ministry of Forests and Range. http://www.for.gov.bc.ca/hra/Publications/invasive_plants/PMPs/PMP-402-0657-DRAFT_7_3.pdf (accessed June 2013).

Bedford, B. L. and K. S. Godwin. 2003. Fens of the United States: Distribution, characteristics, and scientific connection versus legal isolation. *Wetlands*, 23 (3): 608-29.

Benoit, L. K. and R. A. Askins. 1999. Impact of the spread of Phragmites on the distribution of birds in Connecticut tidal marshes. *Wetlands*, 19 (1): 194-208.

Bilby, R. E., K. Sullivan, and S. H. Duncan. 1989. The generation and fate of road-surface sediment in forested watersheds in southwestern Washington. *Forest Science*, 35 (2): 453-68.

Blackwell, B. A., G. Shrimpton, F. Steele, D. W. Ohlson, and A. Needoba. 2004. *Development of a Wildfire Risk Management System for BC Transmission Corporation Rights-of-Way*. Prepared for British Columbia Transmission Corporation: n.p.

Brown, S. C., K. Smith, and D. Batzer. 1997. Macroinvertebrate responses to wetland restoration in northern New York. *Environmental Entomology*, 26 (5): 1016-24.

Brunham, W. G. and L. Bendell. 2010. The Effect of Temperature on the Accumulation of Cadmium, Copper, Zinc, and Lead by Scirpus acutus and Typha latifolia: A comparative analysis. *Waterter, Air, and Soil Pollution*, 219 (2011): 417-28.

Bunnell, F., G. Dunsworth, D. Huggard, and L. Kremsater. 2003. Learning to sustain biological diversity on Weyerhaeuser's coastal tenure. *The Forest Project, Weyerhaeuser, Nanaimo, BC*:

CEA Agency. 2012. *Operational Policy Statement Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012*. http://www.ceaa-acee.gc.ca/Content/1/D/A/1DA9E048-4B72-49FA-B585-B340E81DD6AE/CEA_OPS_May_2013-eng.pdf (accessed October 2013).

CEA Agency. 2013. *Environmental Impact Statement Guidelines for the preparation of an Environmental Impact Statement for an environmental assessment conducted pursuant to the Canadian Environmental Assessment Act, 2012, Brucejack Gold Mine Project*. Canadian Environmental Assessment Agency: Ottawa, ON.

CEPA/FPAC Working Group on Air Quality Objectives and Guidelines. 1998. *National Ambient Air Quality Objectives for Particulate Matter. Science Assessment Document. Canadian Environmental Protection Act* and Federal Provincial Working Group on Air Quality Objectives and Guidelines: n.p.

Cox, R. and J. Cullington. 2009. *Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia*. Wetland Stewardship Partnership: n.p.

Dale, J. M. and B. Freedman. 1982. Lead and zinc contamination of roadside soil and vegetation in Halifax, Nova Scotia. *Proceedings of the Nova Scotian Institute of Science*, 32: 327-36.

Detenbeck, N. E., S. M. Galatowitsch, J. Atkinson, and H. Ball. 1999. Evaluating perturbations and developing restoration strategies for inland wetlands in the Great Lakes basin. *Wetlands*, 19 (4): 789-820.

Dukes, J. S. 2002. Species composition and diversity affect grassland susceptibility and response to invasion. *Ecological Applications*, 12 (2): 602-17.

E-Flora BC. 2012. *E-Flora BC Invasive, Noxious and Problem Plants of British Columbia*. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia. http://www.geog.ubc.ca/biodiversity/eflora/Invasive_Species_Checklist_2012.pdf (accessed October 2013).

Ehrenfeld, J. G. 2003. Effects of exotic plant invasions on soil nutrient cycling processes. *Ecosystems*, 6 (6): 503-23.

Eller, B. M. 1977. Road dust induces increase of leaf temperature. *Environmental Pollution*, 13: 99–107.

Enserink, M. 1999. Biological Invaders Sweep In. *Science*, 285 (5435): 1834-36.

Environment Canada. 1991. *The federal policy on wetland conservation*. Canadian Wildlife Service: Ottawa, ON.

Ettema, H., D. C. Coleman, G. Vellidis, R. Lowrance, and S. L. Rathbun. 1998. Spatiotemporal distributions of bacterivorous nematodes and soil resources in a restored riparian wetland. *Ecology*, 79 (8): 2721-34.

Farmer, A. M. 1990. The effects of lake acidification on aquatic macrophytes—A review. *Environmental Pollution*, 65 (3): 219-40.

Farmer, A. M. 1993. The Effects of Dust on Vegetation: A Review. *Environmental Pollution*, 79: 63–75.

Federal-Provincial-Territorial Biodiversity Working Group. 1995. *Canadian Biodiversity Strategy: Canada's Response to the Convention on Biological Diversity, 1995*. Biodiversity Convention Office, Environment Canada: Hull, QC. http://www.biodivcanada.ca/default.asp?lang=En&n=560ED58E-1&offset=1&toc=show (accessed November 2011).

Fell, P. E., S. R. Warren, J. K. Light, R. L. Rawson, and S. M. Fairley. 2003. Comparison of fish and macroinvertebrate use of typha angustifolia, phragmites australis, and treated phragmites marshes along the lower Connecticut River. *Estuaries*, 26 (2): 534-51.

Gambrell, P. R. 1994. Trace and Toxic Metals in Wetlands: A Review. *Journal of Environmental Quality*, 23: 883-91.

Gilliam, J. W. 1994. Riparian wetlands and water quality. *Journal of Environmental Quality*, 23: 896-900.

Grantz, D. A., J. H. B. Garner, and D. W. Johnson. 2003. Ecological effects of particulate matter. *Environment International*, 29 (2–3): 213-39.

Hagans, D. K., W. E. Weaver, and M. A. Madej. 1986. *Long-term on-site and off-site effects of logging and erosion in the Redwood Creek Basin, northern California*. American Geophysical Union meeting on cumulative effects Technical bulletin.

Hanson, A. R., L. Swanson, D. Ewing, G. Grabas, S. Meyer, L. Ross, M. Watmough, and J. Kirkby. 2008. *Wetland ecological functions assessment: An overview of approaches*. Technical Report Series Number 497. Canadian Wildlife Service, Atlantic Regiopn: n.p.

Harris, L. D. 1988. The nature of cumulative impacts on biotic diversity of wetland vertebrates. *Environmental Management*, 12 (5): 675-93.

Interagency Conservation Strategy Team. 2007. *Final Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Area*. Interagency Conservation Strategy Team: Missoula, MT.

Johnson, L. L. and R. C. Smardon. 2011. Case study of a restored wetland best management practice. *Wetlands*, 31 (5): 921-31.

Johnston, C. A. 1991. Sediment and nutrient retention by freshwater wetlands: Effects on surface water quality. *Critical Reviews in Environtal Control*, 21: 491–565.

Kercher, S. M. and J. B. Zedler. 2004. Multiple disturbances accelerate invasion of reed canary grass (phalaris arundinacea L.) in a mesocosm study. *Oecologia*, 138 (3): 455-64.

Lausen, C. 2006. *Bat Survey of Nahanni National Park Reserve and Surrounding Areas, Northwest Territories*. Prepared for Parks Canada and Canadian Parks and Wilderness Society: n.p.

Lynch, J. F. and D. F. Whigham. 1984. Effects of forest fragmentation on breeding bird communities in Maryland, USA. *Biological Conservation*, 28 (4): 287-324.

Mace, R. D. 2004. Integrating science and road access management: lessons from the Northern Continental Divide Ecosystem. *Ursus*, 15: 129-36.

Mace, R. D. and J. S. Waller. 1997. *Final Report: Grizzly Bear ecology in the Swan Mountains*. Montana Department of Fish, Wildlife, and Parks: Helena, MT.

Mace, R. D., J. S. Waller, T. L. Manley, L. J. Lyon, and H. Zuring. 1996. Relationships among grizzly bears, roads, and habitat use in the Swan Mountains, Montana. *Journal of Applied Ecology*, 33: 1395-404.

MacKenzie, W. H. and J. R. Shaw. 1999. *Field Description of Wetlands and Related Ecosystems in British Columbia*.

MacKenzie, W. H. and J. R. Moran. 2004. *Wetlands of British Columbia: A Guide to Identification*. Land Management Handbook 52. BC Ministry of Forests Research Branch: Victoria, BC.

MacKenzie, W. H. and J. R. Shaw. 2000. *Wetland classification and habitats at risk in British Columbia*. Proceedings of a conference on the biology and management of species and habitats at risk.

Majora, D. W., C. I. Mayfielda, and J. F. Barkerb. 1988. Biotransformation of benzene by denitrification in aquifer sand. *Ground Water*, 26 (1): 8-14.

McCune, D. C. 1991. Effects of airborne saline particles on vegetation in relation to other variables of exposure and other factors. *Environmental Pollution*, 74: 176–203.

Milko, R. 1998. *Wetlands environmental assessment guideline*. Minister of Public Works and Government Services Canada: n.p.

Mitsch, W. J. and J. G. Gosselink. 2000. *Wetlands*. Third ed. New York, NY: John Wiley and Sons, Inc.

Moore, D. R. J., P. A. Keddy, C. L. Gaudet, and I. C. Wisheu. 1989. Conservation of wetlands: Do infertile wetlands deserve a higher priority? *Biological Conservation*, 47 (3): 203-17.

Murphy, H. T. and J. Lovett-Doust. 2004. Context and connectivity in plant metapopulations and landscape mosaics: Does the matrix matter? *Oikos*, 105: 3-14.

NLG, Province of BC, and Government of Canada. 1998. *Nisga'a Final Agreement*. Nisga'a Lisims Government, Province of British Columbia, and Government of Canada: New Aiyansh, BC.

Nyman, J. A. 1999. Effect of crude oil and chemical additives on metabolic activity of mixed microbial populations in fresh marsh soils. *Microbial Ecology*, 37 (2): 152-62.

Odland, A. and R. del Moral. 2002. Thirteen years of wetland vegetation succession following a permanent drawdown, Myrkdalen Lake, Norway. *Plant Ecology*, 162 (2): 185-98.

Padgett, P. E., D. Meadows, E. Eubanks, and W. E. Ryan. 2008. Monitoring fugitive dust emissions from off-highway vehicles traveling on unpaved roads and trails using passive samplers. *Environmental Monitoring and Assessment*, 144 (1-3): 93-103.

Price, K., R. Holt, and L. Kremsater. 2007. *Representative Forest Targets: Informing Threshold Refinement with Science*. Review paper for Raincoast Solutions Project and Coast Forest Conservation Initiative. http://www.forrex.org/program/con_bio/PDF/Workshops/Forest_Workshop/representation_paper.pdf (accessed December 2010).

Pyke, C. R. and K. J. Havens. 1999. Distribution of the invasive reed phragmites australis relative to sediment depth in a created wetland. *Wetlands*, 19 (1): 283-87.

Reilly, W. K. 1991. A New Way with Wetlands. *Journal of Soil and Water Conservation*, 43 (3): 1992-94.

Rescan. 2010. *Northwest Transmission Line Project: Application for an Environmental Assessment Certificate*. Prepared for the British Columbia Transmission Corporation by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2012. *KSM Project: Traditional Use and Traditional Knowledge Report*. Prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2013a. *Brucejack Gold Mine Project Skii km Lax Ha Traditional Knowledge and Traditional Use Report*. Prepared for Pretium Resources Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2013b. *Brucejack Gold Mine Project: 2012 Terrestrial Ecosystem Baseline Studies*. Prepared for Pretium Resources Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2013c. *KSM Project: Application for an Environmental Assessment Certificate / Environmental Impact Statement*. Prepared for Seabridge Gold Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Richburg, J. A., W. A. Patterson, and F. Lowenstein. 2001. Effects of road salt and phragmites australis invasion on the vegetation of a western Massachusetts calcareous lake-basin fen. *Wetlands*, 21 (2): 247-55.

Sayers, P. B., J. W. Hall, and I. C. Meadowcroft. 2002. Towards risk-based flood hazard management in the UK. *Proceedings of the Institution of Civil Engineers: Civil Engineering*, 150: 36-42.

Schack-Kirchner, H., P. T. Fenner, and E. E. Hildebrand. 2007. Different responses in bulk density and saturated hydraulic conductivity to soil deformation by logging machinery on a Ferralsol under native forest. *Soil Use and Management*, 23 (3): 286-93.

Schwartz, C. C., M. A. Haroldson, G. C. White, R. B. Harris, S. Cherry, K. A. Keating, D. Moody, and C. Servheen. 2006. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the greater yellowstone ecosystem. *Wildlife Monographs*, 161: 1-68.

Sheldon, D. 2005. *Wetlands in Washington State: Volume 1: A Synthesis of the Science*. n.p.: Washington State Department of Ecology.

Sikora, F. J., L. L. Behrends, G. A. Brodie, and H. N. Taylor. 2000. Design criteria and required chemistry for removing manganese in acid mine drainage using subsurface flow wetlands. *Water Environment Research*, 72 (5): 536-44.

Skaggs, R. W., B. D. Phillips, G. M. Chescheir, and C. C. Trettin. 2011. Effect of minor drainage on hydrology of forested wetlands. *Transactions of the ASABE*, 54 (6): 2139-49.

Spittlehouse, D. L., R. S. Adams, and R. D. Winkler. 2004. *Forest, Edge, and Opening Microclimate at Sicamous Creek*. Research Report 24. British Columbia Ministry of Forests, Forest Science Program: Victoria, BC.

THREAT. 2009. *Tahltan Traditional Use Study of the Proposed Northwest Transmission Line Project – Interim Report*. Tahltan Transmission Line Project Team, Tahltan Heritage Resources Environmental Assessment Team: n.p.

Tilman, D., J. Knops, D. Wedin, P. Reich, P. Ritchie, and E. Siemann. 1997. The influence of functional diversity and composition on ecosystem processes. *Science*, 277 (5330): 1300-02.

Trombulak, S. C. and C. A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology*, 14 (1): 18–30.

US EPA. 1995. Compilation of Air Pollutant Emission Factors. In *Stationary Point and Area Sources*. Fifth Ed. n.p.: US EPA.

Valard. 2013. *Transmission Feasibility Study and Cost Estimates*. Prepared for Pretium Resources by Valard Construction Ltd.: Vancouver, BC.

Voller, J. and R. S. McNay. 2007. *Problem analysis: effects of invasive species on species at risk in British Columbia*. n.p.: FORREX.

Walbridge, M. R. and J. P. Struthers. 1993. Phosphorus retention in non-tidal palustrine forested wetlands of the mid-Atlantic region. *Wetlands*, 13: 84-94.

Walker, D. A. and K. R. Everett. 1991. Loess ecosystems of northern alaska: regional gradient and toposequence at Prudhoe Bay. *Ecological Monographs*, 61 (4): 437–64.

Warner, B. G. and C. D. A. Rubec. 1997. *The Canadian Wetland Classification System*. 2nd ed. n.p.: National Wetlands Working Group, Wetlands Research Centre, University of Waterloo.

Weinstein, M. P. and J. H. Balletto. 1999. Does the common reed, phragmites australis, affect essential fish habitat? *Estuaries*, 22 (3): 793-802.

Weller, M. 1994. *Freshwater Marshes: Ecology and Wildlife Management*. Third ed. Minneapolis, MN: The University of Minnesota.

Wells, R. W., F. L. Bunnell, D. Haag, and G. Sutherland. 2003. Evaluating ecological representation within differing planning objectives for the central coast of British Columbia. *Canadian Journal of Forest Research*, 33 (11): 2141-50.

Wetzel, P. R. and A. Valk. 1998. Effects of nutrient and soil moisture on competition between carex stricta, phalaris arundinacea, and typha latifolia. *Plant Ecology*, 138 (2): 179-90.

Wilcove, D. S., D. Rothstein, D. Jason, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. *BioScience*, 48 (8): 607-15.

Wilson, R. F. and W. J. Mitsch. 1996. Functional assessment of five wetlands constructed to mitigate wetland loss in Ohio, USA. *Wetlands*, 16 (4): 436-51.

Zedler, J. B. and S. Kercher. 2004. Causes and consequences of invasive plants in wetlands: opportunities, opportunists, and outcomes. *Critical Reviews in Plant Sciences*, 23 (5): 431-52.

Ziemer, R. R. and T. E. Lisle. 1998. *River Ecology and Management: Coast Eco-region Lesson from the Pacific*. New York, NY: Springer.