7. Environmental and Socio-economic Setting

7.1 Introduction

This chapter sets out the environmental and socio-economic setting for Pacific Booker Minerals Inc.'s (PBM) Morrison Copper/Gold Project (the Project). As per Section 5.0 of the *Terms of Reference* (BC EAO 2009), the existing biophysical, socio-economic, and human health settings are described herein. The purpose of this chapter is to provide sufficient background information for identifying, assessing, and determining potential effects from the Project on the surrounding environment. Disciplines providing baseline information for environmental effects assessments are:

- Climate and Meteorology
- Aquatic Resources
- Terrain Hazards
- Socio-economic
- Air Quality
- Fish and Fish Habitat
- Ecosystems and Vegetation
- Visual Resources and Aesthetics
- Hydrology
- Navigable Waters
- Wildlife and Wildlife Habitat
- Noise
- Hydrogeology
- Wetlands
- Archaeology and Heritage Resources
- Human Health
- Sediment Quality
- Terrain, Surficial Materials, Overburden, and Soils
- Land and Resource Use

7.1.1 Project Setting Overview

The Project is 65 km northeast of Smithers and 35 km north of Granisle in north-central British Columbia (BC; Figure 7.1-1). The Project is on the east side of Morrison Lake on Crown land and falls within the traditional territory of the Lake Babine Nation. Access to the Project site is by road with barge access across Babine Lake, which is approximately 50 km south of the site. The Project is approximately 35 km north of the former Bell and Granisle copper/gold mines.

The Morrison mine will be a 30,000 tpd open pit operation with ore processed in a conventional milling plant and the copper/gold concentrate transported to the Port of Stewart for shipment to offshore smelters. Molybdenum concentrate will be trucked from the mine to a refinery location to be confirmed. The mine will produce approximately 224 Mt of tailings and 170 Mt of waste rock.

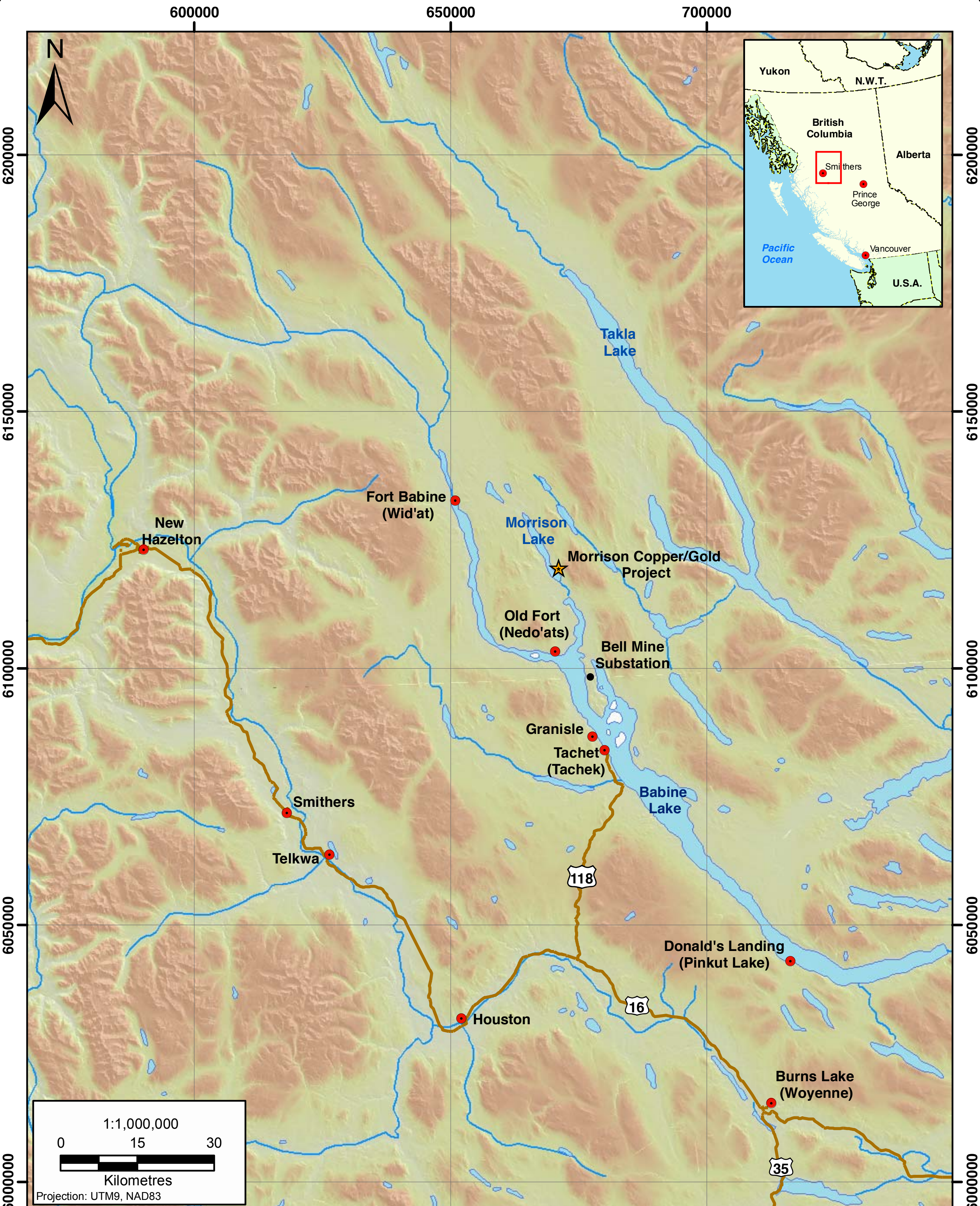


FIGURE 7.1-1

Morrison Copper/Gold Project Location Map

7.2 Climate and Meteorology

This chapter describes the existing meteorological conditions in the Project area and the surrounding region.

The Project area is on the Nechako Plateau, an elevated inland plateau characterized by forested, rolling, and low-relief terrain, complex drainage, and large and plentiful lakes. The climate is characterized by a rain-shadow effect due to the Coast and Babine Mountain ranges directly to the west. Moist air masses moving inland from the Pacific Ocean are lifted over the Coast Mountains, which have peaks of over 3,000 m in elevation. Annual precipitation in the Coast Mountains often exceeds 3,000 mm, while temperatures are mild because of the proximity of the Pacific Ocean. Conversely, the climate of the Nechako Plateau is more continental, with annual precipitation averaging close to 500 mm, and short but warm summers and cool winters.

The study of meteorological conditions is an important part of the environmental and socio-economic impact assessment for the Morrison Project and will be used for a number of purposes including:

- describing the current meteorological conditions at the site and how they might influence the Project:
    - wind speed and direction data are required to select sites for permanent infrastructure and support facilities to accommodate predominant wind patterns and mitigate the effects of fugitive dust;
    - precipitation and evaporation data will be incorporated into the design of water management structures and are also important for identifying potential avalanche threats;
- modelling the potential air quality effect of the mine operations on the environment.

7.2.1 Data Sources

Meteorological data were measured at three regional stations and one site-specific station near the Project site (Table 7.2-1). Data collection in the Project area began in mid-June, 2006, with the installation and commissioning of an automated meteorological station near the proposed Morrison open pit (Figure 7.2-1). The Morrison meteorological station has sensors for:

- wind speed and direction
- air temperature
- relative humidity
- snow depth
- precipitation (rain and snow-water-equivalent)

Table 7.2-1
Meteorological Station Locations

Station Name	Easting	Northing	Elevation (m)	Data Record	Distance from Rescan Morrison Stn (km)
Rescan Morrison	670075	6121295	800	June 2006 – March 2008	n/a
Topley Landing	682503	6077346	722	1971 – 2000 Climate Normals	46
Smithers Airport	616937	6076280	522	1971 – 2000 Climate Normals	70
Babine Lake Pinnut Creek	340508	6035902	713	1971 – 2000 Climate Normals	100

Meteorological data were also measured at three Meteorological Service of Canada (MSC) stations (Environment Canada). Data from these stations were used for comparison with the Rescan Morrison data and to augment the historical record of meteorological conditions in the area. Topley Landing, Smithers Airport, and Babine Lake-Pinnut Creek stations were used for this analysis.

7.2.2 Baseline Conditions

The baseline data collected at the Morrison automated meteorological station from June, 2006, to March, 2008, and the data from the three MSC stations (1971 to 2000) are summarized in Table 7.2-2 and described in more detail below. The available period of record at the Morrison station is 22 months (16 complete).

7.2.2.1 Air Temperature

Monthly average air temperatures at the Rescan Morrison meteorological station ranged from -10.9°C in January, 2008, to 13.9°C measured in July, 2006. The average monthly air temperatures at the Morrison meteorological monitoring station were notably cooler than those at the three MSC stations, likely caused in part by the higher elevation of the Morrison station. The Morrison monitoring station is 280 m above Smithers in elevation, and almost 100 m above Babine Lake-Pinnut Creek and Topley Landing.

The extreme maximum hourly air temperature recorded at the Morrison station was 33.3°C in July, 2007, and the minimum recorded was -36.6°C in January, 2008. The annual average temperature at the Morrison station was 1.5°C. This is cooler than the annual average temperatures at the lower elevation MSC stations, which were recorded at 3.9°C for Smithers Airport, 3.3°C for Babine Lake-Pinnut Creek, and 3.0°C for Topley Landing (1971 to 2000).

7.2.2.2 Precipitation

The low precipitation at the Morrison station is consistent with general established trends throughout the Interior and Nechako plateaus, where rain-shadow effects exist from the adjacent Babine and Coast Mountain ranges. Precipitation from March 1, 2007, to March 1, 2008, totalled 628 mm. This is a higher annual total than expected for the Nechako Plateau region, as evidenced in the average monthly data from the three regional MSC stations (Figure 7.2-2).

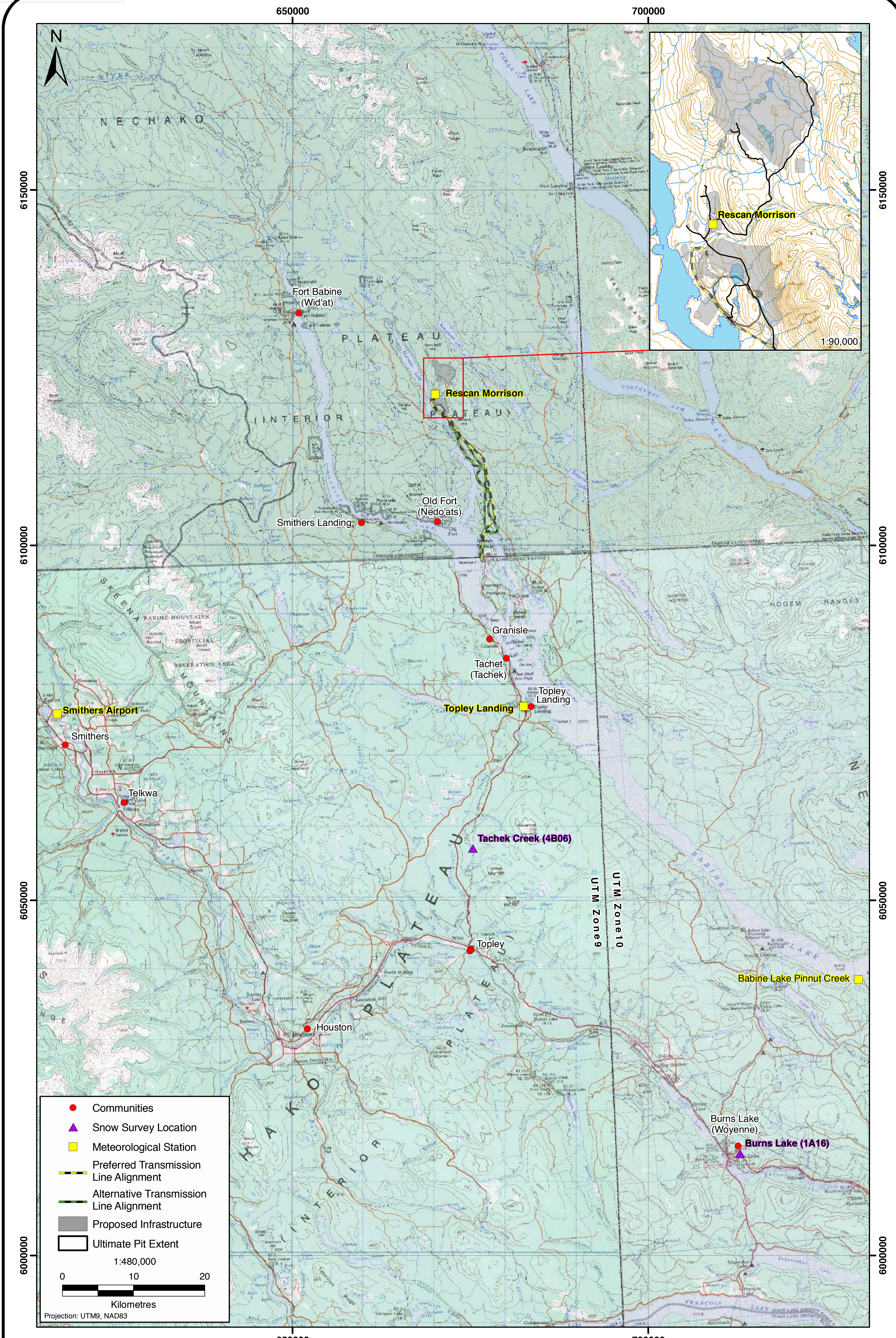


FIGURE 7.2-1

Morrison Copper / Gold Project
Meteorological Stations and Snow Survey Locations

Table 7.2-2
Summary of Monthly Average Meteorological Data

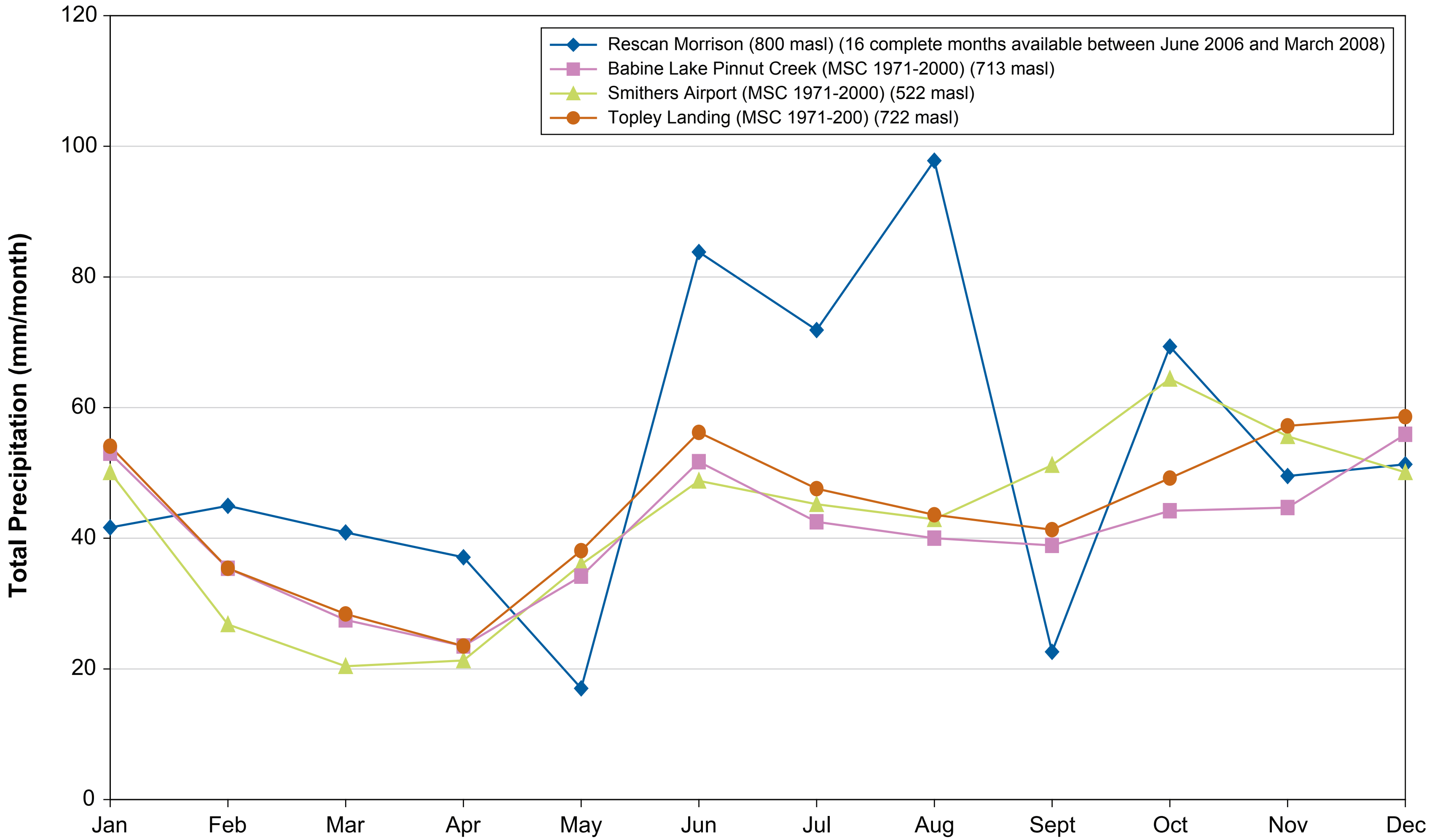
Month	Average Air Temperature (°C)	Extreme Max Air Temperature (°C)	Extreme Min Air Temperature (°C)	Mean Max Air Temperature (°C)	Mean Min Air Temperature (°C)	Snow Depth (Last Day) (cm)	Total Precipitation (mm)	Average Wind Speed (m/s)	Max Instantaneous Wind Speed (m/s)
Rescan Morrison 2006 to 2008 – Monthly									
January	-10.9	6.2	-36.6	-5.2	-16.0	75	41.7	0.5	12.3
February	-6.8	8.0	-30.3	-0.8	-12.0	98	45.0	0.6	8.9
March	-1.5	10.9	-18.7	3.8	-8.3	85	40.9	1.1	10.0
April	0.7	13.7	-23.5	7.2	-5.5	27	37.1	1.0	9.6
May	6.1	21.4	-6.2	13.6	-2.3	0	17.0	1.1	11.7
June	10.7	31.3	-1.3	18.3	3.0	0	83.8	1.1	7.3
July	13.7	33.3	-0.5	20.7	6.0	0	71.9	1.1	8.1
August	11.4	27.9	-1.4	18.9	3.5	0	97.8	1.0	8.5
September	7.4	24.9	-4.0	13.6	1.4	0	22.6	0.9	10.6
October	2.3	17.3	-17.3	7.9	-2.6	26	69.4	1.0	12.4
November	-6.5	8.1	-33.1	-2.6	-10.7	36	49.5	0.7	11.5
December	-8.4	3.4	-32.1	-4.1	-12.8	59	51.3	0.3	10.1
Annual Average	**1.5**	**n/a**	**n/a**	**7.6**	**-4.7**	**n/a**	**627.9**	**0.9**	**n/a**
Topley Landing (MSC) – 1971 to 2000 Climate Normals									
January	-10.3	10.0	-41.7	-6.5	-14.1	48	54.1	n/a	n/a
February	-6.7	12.8	-36.5	-2.2	-11.2	47	35.4	n/a	n/a
March	-1.8	16.0	-35.0	3.6	-7.1	24	28.4	n/a	n/a
April	3.4	23.9	-20.6	9.3	-2.5	1	23.5	n/a	n/a
May	8.1	33.0	-10.0	14.8	1.9	0	38.1	n/a	n/a
June	12.0	32.8	-1.7	18.0	6.0	0	56.2	n/a	n/a
July	14.5	34.4	0	20.7	8.2	0	47.6	n/a	n/a
August	14.0	33.5	-1.0	20.3	7.7	0	43.6	n/a	n/a
September	9.6	31.0	-4.5	15.2	4.0	0	41.3	n/a	n/a
October	4.0	24.5	-20.5	8.1	-0.2	1	49.2	n/a	n/a
November	-2.7	17.8	-34.0	0.2	-5.5	17	57.2	n/a	n/a
December	-7.8	10.5	-41.0	-4.5	-11.0	34	58.6	n/a	n/a
Annual Average	**3.0**	**n/a**	**n/a**	**8.1**	**-2.0**	**n/a**	**44.4**	**n/a**	**n/a**

(continued)

Table 7.2-2
Summary of Monthly Average Meteorological Data (completed)

Month	Average Air Temperature (°C)	Extreme Max Air Temperature (°C)	Extreme Min Air Temperature (°C)	Mean Max Air Temperature (°C)	Mean Min Air Temperature (°C)	Snow Depth (Last Day) (cm)	Total Precipitation (mm)	Average Wind Speed (m/s)	Max Instantaneous Wind Speed (m/s)
Smithers Airport (MSC) – 1971 to 2000 Climate Normals									
January	-8.9	15.6	-43.9	-4.9	-12.7	38	50.1	2.0	33.3
February	-4.9	11.9	-35.6	-0.4	-9.4	31	26.8	2.1	33.3
March	0	17.3	-33.3	5.1	-5.1	9	20.4	1.9	29.7
April	4.8	24.3	-18.3	10.8	-1.3	0	21.3	2.1	25.8
May	9.3	35.8	-7.2	15.7	2.8	0	36	2.1	27.8
June	12.6	33.9	-4.1	18.9	6.3	0	48.8	1.9	20.6
July	15	34.6	-1.1	21.6	8.4	0	45.2	1.6	21.7
August	14.6	35.2	-2.2	21.2	7.9	0	42.9	1.5	20.6
September	9.9	31.1	-6.7	15.8	4	0	51.2	1.4	22.5
October	4.5	24.4	-22	8.8	0.1	1	64.4	1.7	24.7
November	-2.3	15.6	-32.4	0.8	-5.4	12	55.6	1.9	29.4
December	-7.5	11.5	-39	-3.8	-11.1	26	50.1	1.9	30.8
Annual Average	**3.9**	**n/a**	**n/a**	**9.1**	**-1.3**	**n/a**	**42.7**	**1.8**	**n/a**
Babine Lake-Pinnut Creek (MSC) – 1971 to 2000 Climate Normals									
January	-9.3	10	-44.4	-5.9	-12.7	n/a	53	n/a	13.3
February	-6.8	12	-38.3	-2.7	-10.9	n/a	35.4	2.2	13.9
March	-1.9	15.5	-33.3	3	-6.8	n/a	27.5	n/a	13.1
April	3.2	20	-22	8.4	-2	n/a	23.5	n/a	14.2
May	8	30	-5.6	13.7	2.3	n/a	34.2	n/a	11.1
June	11.8	33.3	-2.2	17.1	6.5	n/a	51.7	n/a	9.7
July	14.7	33.9	0	20.2	9.2	n/a	42.5	2.5	11.7
August	14.3	32	-1.7	19.9	8.7	n/a	40	2.4	11.1
September	10	30	-5	15	4.9	n/a	38.9	2.2	12.5
October	4.5	21.5	-20	8.3	0.7	n/a	44.2	2.2	11.1
November	-2.1	14.5	-31.5	0.7	-4.9	n/a	44.7	2.6	13.9
December	-6.5	12	-36.7	-3.4	-9.5	n/a	55.9	n/a	14.7
Annual Average	**3.3**	**n/a**	**n/a**	**7.9**	**-1.2**	**n/a**	**41.0**	**2.3**	**n/a**

n/a = not available



Note: masl = metres above sea level

Morrison Copper/Gold Project
Average Monthly Precipitation at Rescan Morrison Station and Regional MSC Stations

FIGURE 7.2-2

Precipitation was highest at Morrison during the summer of 2007. Northern BC experienced uncharacteristic precipitation through the summer of 2007 that was 22.3% higher than the normal (Environment Canada 2007). Accounting for this, a reduction of 22.3% from the measured precipitation at Morrison in the summer of 2007 would yield an annual average precipitation more in line with those recorded at nearby MSC stations (566 mm).

7.2.2.3 Snow

Snowfall during the 2006 and 2007 winters was recorded at the Morrison meteorological station. However, a battery malfunction in December, 2006, led to a one-and-a-half-month gap in data collection. The station was reactivated in February, 2007, allowing the capture of what was likely the peak snow depth at the beginning of March. The peak snow depth measured by the automated meteorological station over the course of the study period was 104 cm at the beginning of March, 2007.

Northern BC experienced an anomalous snow year in 2007, with record snow depths measured (BC MOE 2008c). This trend was apparent at the Morrison station, where the average end-of-month snow depth was roughly twice that recorded at the nearby Topley Landing station from 1971 to 2000 (Figure 7.2-3). By applying a 50% reduced snowfall correction to the peak 2007 Morrison snow data, an average peak snow depth of 52 cm can be estimated.

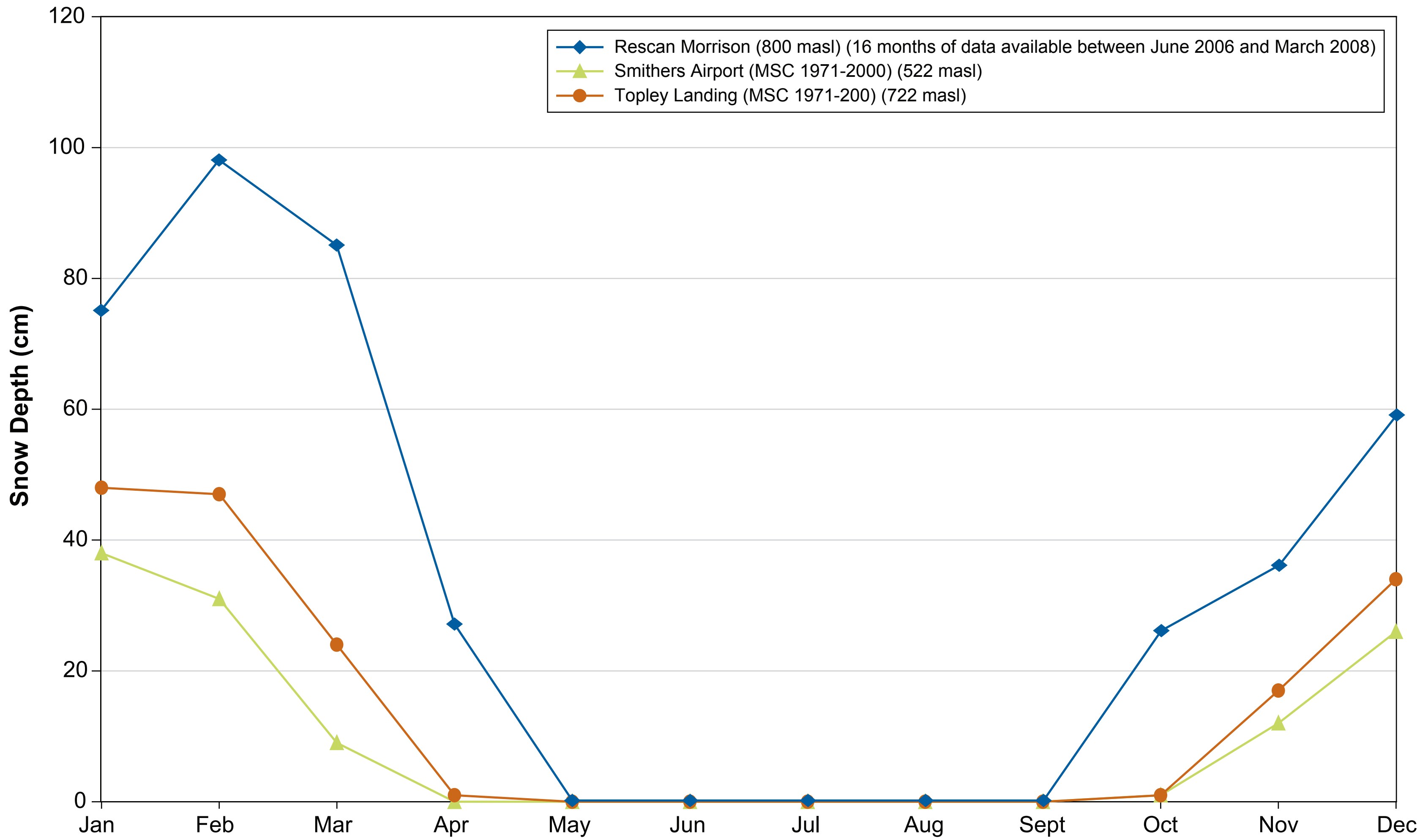
Data gathered to date in 2008 at the Morrison station indicate that snow depth accumulations are anomalously high, and appear similar to 2007 levels. Regional snow surveys at Burns Lake and Tachet Creek for 2008 also indicate above normal amounts; however, the anomaly is not as extreme as in 2007. Snow measurements will be ongoing, and results will assist in gaining higher confidence of the average and maximum snow conditions at the Project area.

7.2.2.4 Wind Speed and Direction

The wind speeds at the Morrison station are categorized as generally light and variable. The average wind speed recorded at the Rescan Morrison station was 0.9 m/s. Monthly average wind speeds were as high as 1.1 m/s in June and July, and as low as 0.3 m/s in December. The station recorded calm conditions (hourly average wind speed <1 m/s) 66% of the time. The dominant wind direction was from the east-southeast with wind blowing from this direction 8% of the time. Winds from the southeast, east, and west formed the secondary wind pattern with each direction occurring approximately 3% to 5% of the time. Winds from the north and south were also common, but more variable.

7.2.2.5 Lake Evaporation

The nearby MSC station at Topley Landing is the closest location where lake evaporation data have been recorded. The conditions at the Topley Landing station are expected to be very similar to those at the Project because these sites share a similar geography and elevation (both sites lie within 100 m elevation of each other). Annual evaporation based on 30 years of record (1971 to 2000) at Topley Landing is 389 mm/yr.



Note: masl = metres above sea level
snow depth not available at Babine Lake Pinnut Creek

Morrison Copper/Gold Project
Average Snow Depth at the End of the Month
at Rescan Morrison and Regional MSC Stations

FIGURE 7.2-3

Measureable lake evaporation was recorded between May and September from 1971 to 2000 (climate normal) at Topley Landing (Table 7.2-3). Because of its marginally higher elevation and smaller size, Morrison Lake is expected to have open water for slightly less time during the warm season than Topley Landing. Therefore, there may be less evaporation in Morrison Lake than Topley Landing, but not significantly.

Table 7.2-3
Average Daily Lake Evaporation – Topley Landing (MSC), 1971 to 2000 Climate Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lake Evaporation (mm/day)	n/r	n/r	n/r	n/r	2.7	3.0	3.1	2.5	1.4	n/r	n/r	n/r

n/r: not recorded.

7.3 Air Quality

This chapter describes the existing air quality conditions in the Project area and the surrounding potential areas of influence.

Air quality is an important environmental factor in ensuring the conservation of local vegetation, wildlife, and the human population. Poor air quality has the potential to negatively affect the growth of vegetation and may pose a risk to the general health of wildlife and local human populations. High sulphate and nitrate concentrations in particulate matter (PM) may indicate the potential for acid deposition or acid rain. High metal content in PM can lead to concentrations of metals in plant and wildlife tissues that exceed safe levels.

Within the Project area, potential background sources of fugitive dust emissions include:

- windblown/fugitive dust from exposed surface soils
- forest fires
- local traffic on unpaved roads

Desk-based research and field observations highlighted a number of local communities near the proposed Morrison mine site that may be potentially sensitive receptors and/or contributors to background air quality emissions in the Project area including:

- Old Fort (seasonal dwellings)
- Granisle
- Fort Babine
- Tachet

Three other human receptors (individual residences only) operating as hunting and wilderness camps near the Project site were observed. Occupancy at these sites is seasonal.

7.3.3 Data Sources

The primary air quality concern for open pit copper and gold mining is fugitive dust that may be generated by mining activities including:

- increased traffic along unpaved roads
- blasting in open pits
- construction and operational equipment

PM refers to the dust and other solid materials that are suspended in the air. Over time PM falls back to earth in a process called dustfall. A baseline dustfall monitoring program for the Project commenced in the fall of 2006.

The type, frequency, and methods of measurement of dustfall were based on the American Society for Testing and Materials guidelines (ASTM 2004). The Project area's air quality characteristics were based on data gathered by six dustfall stations installed in strategic locations around the proposed mine site (Figure 7.3-1). Each site consisted of two sample containers: one analyzed for total particulate dustfall, soluble particulate dustfall, and insoluble particulate dustfall, and the other analyzed for metals, sulphate, and nitrate. These monitoring locations were selected because they are representative of the Project area (i.e., mine site and access corridor) including stations at:

- DF1: Tailings
- DF2: North Pit
- DF3: Conveyor
- DF4: South Pit
- DF5: Tailings
- DF6: Haul Road entry to site

To capture the dustfall, approximately 200 mL of deionized water and a small amount of algicide were added to each sample container. At each site, canisters were exchanged monthly and sent to the laboratory for analysis.

7.3.4 Baseline Conditions

Dustfall baseline data were collected over six periods during the summer and fall months of 2006 and 2007. Baseline concentrations of dustfall are commonly highest during the low-precipitation summer months when the dry ground surface creates the necessary conditions for fugitive dust production. The summer months also coincide with the highest level of human activity near the Morrison site. Therefore, the data collected are assumed to represent the worst case annual ambient conditions for dustfall in the Project area.

Results of the total dustfall monitoring at the six stations are summarized in Table 7.3-1. A maximum total value of 2.18 $mg/dm^2/day$ was measured at DF3 in July, 2007. This sampling interval (July, 2007) also had the highest average value of 1.25 $mg/dm^2/day$ among the six stations. According to Environment Canada's regional climate data, the South BC Mountains region (where the Morrison project is located) was 5.9% drier and 0.8% warmer in 2007 than normal (Environment Canada 2007). The high dustfall measured in July, 2007, is likely attributable to these weather conditions. October, 2006, has the lowest observed total dustfall with all stations reporting dustfall below detection limits (< 0.12 mg/dm^2/day). BC pollution control objectives list the maximum acceptable dustfall rates for mining activity at 2.9 mg/dm^2/day (BC MOE 1979). All of the Morrison baseline dustfall samples registered below this value.

Table 7.3-1
Total Dustfall (mg/dm^2/day)

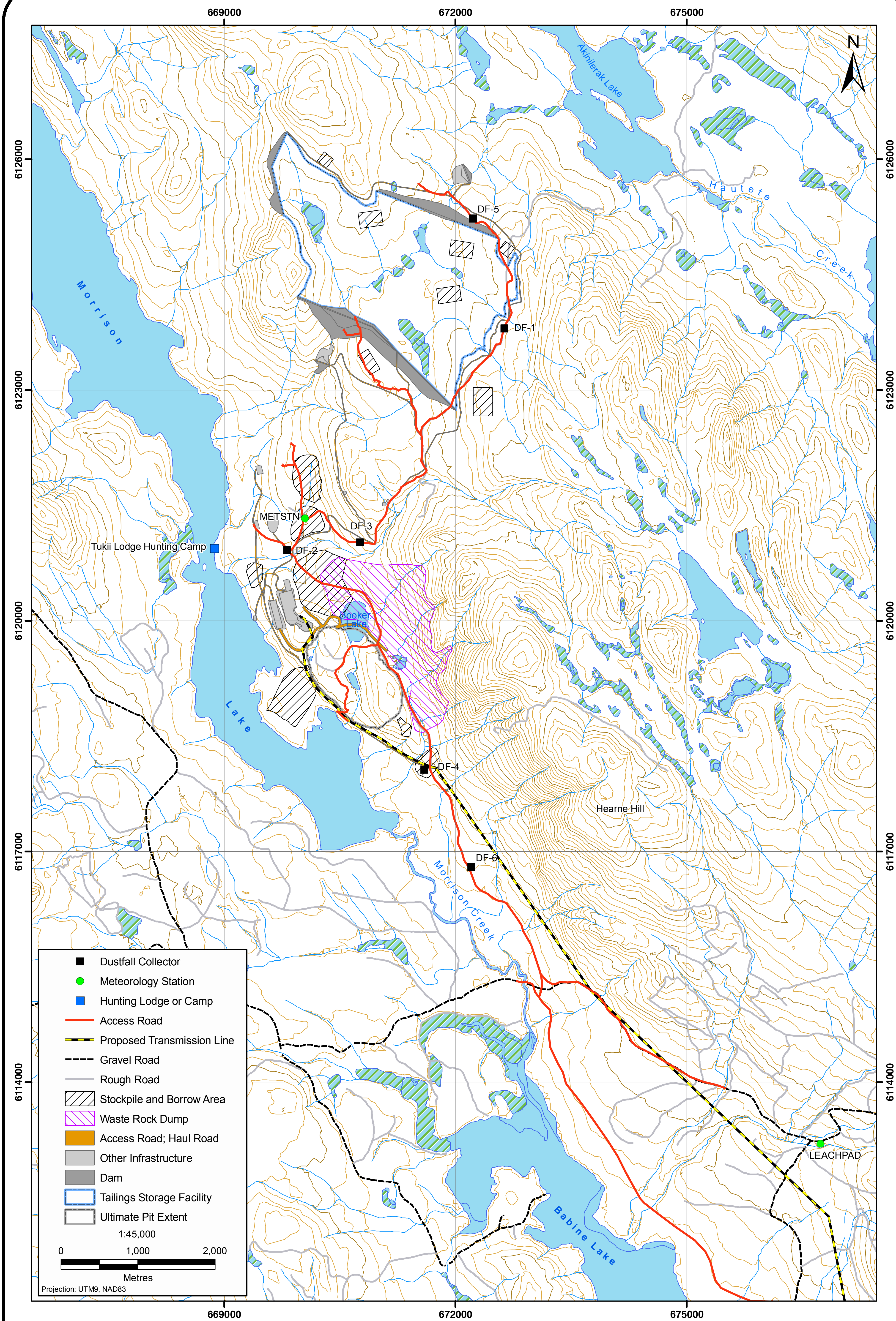
Monitoring Station	Sep 06	Oct 06	Jul 07	Aug 07	Sep 07	Oct 07
DF1	<0.10	<0.12	1.48	0.25	0.73	0.47
DF2	<0.10	<0.12	1.22	0.11	0.31	0.13
DF3	<0.10	<0.12	2.18	0.16	0.18	0.10
DF4	0.12	<0.12	<0.10	0.17	0.28	0.15
DF5	0.13	<0.12	1.13	<0.10	n/a*	0.52
DF6	<0.10	<0.12	0.26	<0.10	n/a*	0.16
Average	0.13	<0.12	1.25	0.17	0.38	0.26

***n/a: not available.**
Less than 0.12 mg/dm2/day is the detection limit of the measurement.

Sulphate and nitrate deposition were only measured in 2007 (Table 7.3-2). The highest sulphate deposition was in July, 2007, with a peak of 2.8×10^{-2} mg/dm^2/day at DF1 and an average of 2.35×10^{-2} mg/dm^2/day across all six dustfall collectors. Peak nitrate deposition was in September, 2007, with a peak deposition of 1.34×10^{-3} mg/dm^2/day at DF1 and an average of 1.17×10^{-3} mg/dm^2/day across DF1 through DF4 (DF5 and DF6 were not measured in September, 2007).

Sulphate and nitrate deposition can be converted into Potential Acid Input (PAI), a measurement used to identify the risk of wet acid deposition (acid rain). PAI is calculated from the sum of all acidic components in dustfall, such as sulphur and nitrogen (excluding neutralizing compounds such as sodium, magnesium, potassium, and calcium). Peak sulphate deposition of 2.80×10^{-2} mg/dm^2/day and peak nitrate deposition of 1.34×10^{-3} mg/dm^2/day yield a maximum PAI of 0.26 keq/ha/yr (kilomoles of hydrogen equivalent per hectare per year). This acid loading is far below the critical loads for BC, which have been estimated at 1.22 keq/ha/yr (Environment Canada 2004). These low levels of acidic components reflect the pristine environment found at the Morrison Project site.

Dustfall samples were also analyzed for deposition of 33 different metals. The only metals with measurable deposition at all the stations were aluminum, barium, calcium, copper, lead, manganese, molybdenum, strontium and zinc (Table 7.3-3). A significant number of the other metals tested were not detectable at any of the dustfall locations.



Morrison Copper / Gold Project
Dustfall Collector Locations

FIGURE 7.3-1

Table 7.3-2
Sulphate and Nitrate Deposition ($mg/dm^2/day$)

Monitoring Station	Jul 07	Aug 07	Sep 07	Oct 07
Sulphate				
DF1	0.028	<0.46	<0.0109	<0.02
DF2	0.019	<0.46	0.012	<0.02
DF3	0.024	<0.46	<0.0109	<0.02
DF4	<0.002	<0.46	<0.0109	<0.02
DF5	0.023	<0.46	n/a	<0.02
DF6	<0.002	<0.46	n/a	<0.02
Average	0.0235	<0.46	0.012	<0.02
Nitrate				
DF1	<0.0002	<0.00098	0.00134	<0.0017
DF2	0.00008	<0.00098	0.00115	<0.0017
DF3	0.00024	<0.00098	0.00096	<0.0017
DF4	0.00008	<0.00098	0.00124	<0.0017
DF5	0.00009	<0.00098	n/a	<0.0017
DF6	0.00003	<0.00098	n/a	<0.0017
Average	0.000104	<0.00098	0.00117	<0.0017

***n/a: not available.**
Detection limits variable.

Table 7.3-3
Maximum Metal Deposition ($mg/dm^2/day$)

Metal	Detection Limit	DF1	DF2	DF3	DF4	DF5	DF6
Aluminum (Al) Total	0.00002	0.00117	0.000433	0.00121	0.000608	0.000139	0.000951
Barium (Ba) Total	0.0000009	0.0000625	0.0000506	0.000154	0.0000833	0.0000392	0.000182
Calcium (Ca) Total	0.0009	0.0079	0.00854	0.0203	0.00546	0.0038	0.0186
Copper (Cu) Total	0.000002	0.01	0.000197	0.00018	0.000158	0.000109	0.000136
Lead (Pb) Total	0.0000009	0.0000025	4.48×10^{-6}	2.78×10^{-6}	4.48×10^{-6}	0.0000031	5.71×10^{-6}
Manganese (Mn)	0.0000009	0.000257	0.000265	0.000324	0.000204	0.000126	0.00155
Molybdenum (Mo) Total	0.0000009	0.0000046	3.05×10^{-6}	9.3×10^{-7}	3.04×10^{-6}	3.3×10^{-7}	4.88×10^{-6}
Strontium (Sr) Total	0.000002	0.0000444	0.0000197	0.0000613	0.0000431	0.0000146	0.0000692
Zinc (Zn) Total	0.00002	0.00025	0.000129	0.000123	0.000183	0.0000171	0.000233

Baseline measurements have shown that the ambient air quality at the Project site is reflective of its remote location and the absence of significant anthropogenic sources at the time of monitoring.

7.4 Water Quality Environmental Setting

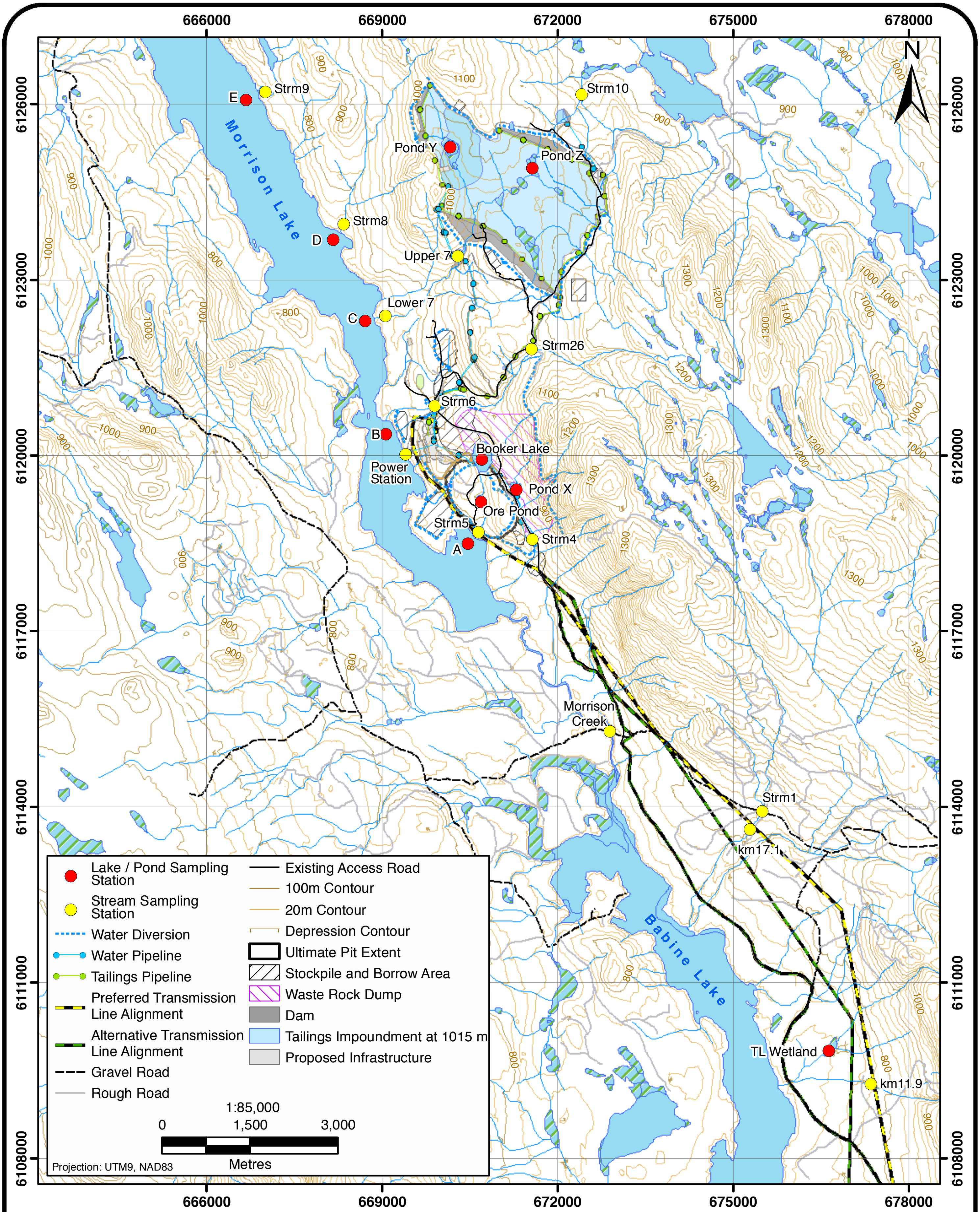
7.4.1 Overview

The provincial and federal governments have guidelines for the protection of aquatic life requiring specific monitoring of surface water quality and associated resources (CCME 2003a; BC MOE 2006b). Surface water quality within the Project area was assessed on a monthly basis for streams and annually for lakes/ponds. A total of 15 streams and 10 lakes/ponds were monitored during the baseline studies (Figure 7.4-1). Streams were sampled between 2004 and 2008 and lakes/ponds were sampled between 2006 and 2008. Detailed water quality baseline data were collected to determine environmental conditions before Project activities (Appendices 26 and 27).

These sites represent all areas potentially affected by the Project including the receiving environment, proposed mine pit and infrastructure, tailings facility, proposed transmission line, and reference sites. These sites are similar to, or a sub-set of, the sites selected for other baseline studies and effects assessments including aquatic resources (Section 7.9), sediment (Section 7.8), and fish and fish habitat (Section 7.10). This environmental setting characterizes the most recent water quality conditions in the Project area as a baseline for future surface water quality monitoring.

The Project area generally receives low amounts of precipitation, which is consistent with general established trends where the presence of rain shadow effects exists from the adjacent Babine and Coast Mountain ranges (Section 7.2). Precipitation from March, 2007 to March, 2008 (628 mm) was higher than expected for the area with the greatest amount of precipitation occurring in the summer of 2007 (Section 7.2). This was generally the case over most of northern BC as precipitation through the summer of 2007 was 22.3% higher than the normal (Environment Canada 2007). This water travels through the Project area by seeping into the ground through the numerous glacial till deposits, then flowing along siltstone, sandstone, and volcanic bedrock until it is collected in depressions forming lakes and ponds, or emerging at lower elevations as streams.

High quality freshwater in the Project area is considered very important by the local Lake Babine Nation, guide outfitting operators, a wilderness lodge owner, and other residents in the local communities (Chapter 6). High quality freshwater provides good quality habitat for fish and wildlife and maintaining potable water sources as safe and secure from contamination. Traditional Use and Ecological Knowledge (TU/TEK) information was collected for the area in and around the Morrison Project from 2007 to 2008 in collaboration with Lake Babine Nation leadership and community members. Lake Babine Nation review of and approval for the release of the TU/TEK information gathered and reported is still pending. As such, TU/TEK consideration and inclusion in this section is unviable before submission of the EA application. TU/TEK may be considered at a later date in the post-application process. Chapter 5 provides additional detail about the TU/TEK methodology and study status.



Morrison Copper/Gold Project
Sampling Sites

FIGURE 7.4-1

Rescan

Surface water is a critical component of the biological and physical environment. It is an indicator of the overall health of the environment and is linked to aquatic and terrestrial ecosystem components including vegetation, fish, birds, and all animals that require clean water to survive. The chemical composition of freshwater environments are known to directly influence resident aquatic communities (Longmuir, Shurin, and Clasen 2007). Concentrations of available nutrients are correlated with the productivity of these ecosystems and either elevated or insufficient levels can affect ecological functions such as organism growth and reproduction. For these reasons surface water quality needs to be accurately characterized and closely monitored in relation to Project activities.

7.4.2 Stream Water Quality Data

From 2004 to 2008, 15 streams in the Project area were sampled. The frequency of sampling at each site is presented in Table 7.4-1. Water samples were analyzed for several variables including hardness, total dissolved solids (TDS), pH, turbidity, conductivity, sulphate, total phosphate, total nitrogen, ammonia, total cyanide, total organic carbon (TOC), and metal concentrations.

Table 7.4-1
Frequency of Water Quality Sampling, 2004 to 2008

Site	Number of Samples
Strm1	28
Morrison Creek	30
Strm4	25
Strm5	30
Strm6	30
Strm26	12
Lower7	27
Upper7	6
Strm8	11
Strm9	5
Strm10	6
Strm17.1	1
Strm11.9	1
TL Wetland	1
Power Station	1

7.4.2.1 Physical Variables and Cyanide

Table 7.4-2 shows the minimum, maximum, and median value for selected variables from all available baseline data (2004 to 2008). Ion concentrations were lowest during the spring when freshet flows have a diluting effect and highest in late summer when stream flow are at their lowest. Turbidity was highest during freshet when flows are highest. Turbidity values generally were low, ranging from 0.19 to 4.94 NTU, with the exception of Strm4 in March, 2005, which had a value of 134 NTU.

Table 7.4-2
Water Quality Summary, 2004-2008

	Strm1			Morrison Cr			Strm4			Strm5			Strm6		
Variable	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**
Turbidity (NTU)	0.23	3.14	0.97	0.41	3.86	1.0725	0.18	134	0.68	0.3	7.37	1.23	0.22	11.45	0.72
TOC	3.2	12.3	7.5	7.0	21.3	10.4	1.9	12.8	4.0	7.6	13.4	9.8	3.0	17.4	5.0
pH	7.1	8.0	7.8	6.9	8.3	7.7	7.4	8.2	8.0	7.9	8.3	8.1	7.7	8.1	7.9
Cyanide	0.0005	0.0169	0.0061	0.0005	0.0192	0.0062	0.0005	0.0086	0.0025	0.0025	0.0098	0.0062	0.0005	0.011	0.0025
Total Aluminum	0.007	0.248	0.048	0.017	0.207	0.039	0.003	3.910	0.016	0.006	0.195	0.032	0.005	0.671	0.031
Dissolved Aluminum	0.0031	0.15	0.03985	0.0088	0.0513	0.0261	0.0005	0.166	0.0063	0.0016	0.0688	0.00345	0.0025	0.188	0.0107
Total Arsenic	0.0001	0.0003	0.00014	0.00029	0.00065	0.000345	0.0001	0.00504	0.00023	0.00133	0.00348	0.002145	0.0001	0.00059	0.00016
Dissolved Arsenic	0.0001	0.00025	0.000135	0.00025	0.00061	0.0003	0.0001	0.00042	0.0002	0.00112	0.00331	0.00193	0.0001	0.00034	0.00014
Total Cadmium	0.0000085	0.00419	0.0000085	0.0000085	0.000022	0.0000085	0.0000085	0.000081	0.00001	0.0000085	0.000134	0.00001	0.0000085	0.00052	0.00000925
Dissolved Cadmium	0.0000085	0.00024	0.0000085	0.0000085	0.00001	0.0000085	0.0000085	0.00003	0.0000085	0.0000085	0.000112	0.0000093	0.0000085	0.00001	0.0000085
Total Copper	0.0004	0.0033	0.001	0.0005	0.0023	0.0009	0.0004	0.0117	0.0014	0.0049	0.0182	0.0093	0.0003	0.0016	0.0005
Dissolved Copper	0.0005	0.0016	0.0009	0.0004	0.00117	0.00081	0.0005	0.00348	0.0014	0.0044	0.013	0.0071	0.0003	0.0012	0.0005
Total Iron	0.02	0.24	0.05	0.14	0.51	0.20	0.02	5.33	0.02	0.02	0.18	0.08	0.02	0.78	0.04
Dissolved Iron	0.015	0.117	0.027	0.0855	0.404	0.134	0.015	0.148	0.015	0.015	0.067	0.015	0.015	0.087	0.015
Total Lead	0.000025	0.000500	0.000025	0.000025	0.0005	0.000053	0.000025	0.0021	0.000025	0.000025	0.0005	0.000048	0.000025	0.0005	0.000061
Dissolved Lead	0.000025	0.0005	0.000025	0.000025	0.0005	0.000025	0.000025	0.0005	0.000025	0.000025	0.0005	0.000025	0.000025	0.0005	0.000025
Total Molybdenum	0.000025	0.001	0.00006	0.000089	0.0005	0.000146	0.00015	0.00050	0.00029	0.00039	0.001150	0.000500	0.000025	0.000500	0.000099
Dissolved Molybdenum	0.000025	0.0005	0.000055	0.0001	0.0005	0.0002	0.000212	0.0005	0.0003	0.0004	0.0012	0.0005	0.000025	0.0005	0.0000885
Total Selenium	0.00005	0.00077	0.00049	0.00005	0.00147	0.00025	0.00005	0.00116	0.00033	0.00005	0.00109	0.00046	0.00005	0.00088	0.00025
Dissolved Selenium	0.00005	0.0006	0.00025	0.00005	0.00076	0.00025	0.00005	0.0009	0.00049	0.00005	0.00073	0.00025	0.00005	0.0005	0.00025
Total Zinc	0.0005	0.0047	0.00165	0.0005	0.0038	0.0015	0.0005	0.021	0.0011	0.0005	0.0061	0.002	0.0005	0.0046	0.0015
Dissolved Zinc	0.0005	0.0025	0.0005	0.0005	0.0026	0.0011	0.0005	0.0025	0.00075	0.0005	0.0025	0.0011	0.0005	0.0025	0.0005

Note: values in mg/l unless otherwise indicated.

(continued)

Table 7.4-2
Water Quality Summary, 2004-2008 (continued)

	Strm26			Lower7			Upper7			Strm8			Strm9		
Variable	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**
Turbidity (NTU)	0.19	3.41	0.7	0.2	11.4	0.86	0.27	1.28	0.765	0.24	2.26	0.57	0.71	1.48	1.05
TOC	3.3	9.9	4.9	5.7	17.2	11.8	7.0	12.8	9.3	5.4	14.4	9.6	7.9	11.3	8.8
pH	7.6	8.1	7.9	3.4	8.2	8.0	7.9	8.1	8.0	7.8	8.1	8.0	8.0	8.1	8.0
Cyanide	0.0005	0.0062	0.0034	0.0005	0.1200	0.0077	0.0037	0.0098	0.0051	0.0018	0.0091	0.0064	0.0021	0.0079	0.0063
Total Aluminum	0.005	0.202	0.024	0.008	0.428	0.063	0.019	0.088	0.029	0.011	0.144	0.035	0.003	0.043	0.028
Dissolved Aluminum	0.0041	0.0703	0.0109	0.0073	0.324	0.0483	0.00955	0.0693	0.016	0.0047	0.0657	0.0125	0.0028	0.0146	0.00655
Total Arsenic	0.0001	0.00024	0.00016	0.00022	0.0006	0.0003	0.00022	0.00047	0.00026	0.00035	0.00063	0.00043	0.00065	0.00089	0.00081
Dissolved Arsenic	0.0001	0.00016	0.00014	0.00021	0.00048	0.00028	0.00021	0.0004	0.00025	0.00033	0.00051	0.00035	0.00067	0.00077	0.000745
Total Cadmium	0.0000085	0.00001	0.00001	0.0000085	0.000036	0.0000085	0.0000085	0.00001	0.0000093	0.0000085	0.00001	0.00001	0.0000085	0.0000085	0.0000085
Dissolved Cadmium	0.0000085	0.000031	0.00001	0.0000085	0.00001	0.0000085	0.0000085	0.00001	0.0000093	0.0000085	0.00001	0.00001	0.0000085	0.0000085	0.0000085
Total Copper	0.0003	0.001	0.0004	0.0005	0.0017	0.001	0.0005	0.0009	0.0007	0.0008	0.0015	0.0011	0.0008	0.0014	0.0012
Dissolved Copper	0.0002	0.00077	0.00037	0.00045	0.00124	0.00095	0.00045	0.0012	0.00069	0.00045	0.00131	0.00097	0.0004	0.00067	0.00052
Total Iron	0.02	0.25	0.04	0.02	0.20	0.07	0.02	0.10	0.03	0.04	0.22	0.07	0.1	0.17	0.13
Dissolved Iron	0.015	0.062	0.015	0.015	0.197	0.06	0.015	0.067	0.015	0.015	0.054	0.015	0.036	0.077	0.0495
Total Lead	0.000025	0.0005	0.000025	0.000025	0.0005	0.000025	0.000025	0.000025	0.000025	0.000025	0.000097	0.000025	0.000025	0.000025	0.000025
Dissolved Lead	0.000025	0.0005	0.000025	0.000025	0.0005	0.000025	0.000025	0.0001625	0.000025	0.000025	0.00015	0.000025	0.000025	0.000025	0.000025
Total Molybdenum	0.000025	0.0005	0.000064	0.000025	0.0005	0.000091	0.000025	0.000082	0.000063	0.000091	0.00020	0.00015	0.00011	0.00014	0.00013
Dissolved Molybdenum	0.000025	0.0005	0.000074	0.000025	0.0005	0.0000915	0.000025	0.000081	0.000066	0.000092	0.00018	0.00015	0.000105	0.00012	0.000109
Total Selenium	0.00005	0.0005	0.00025	0.00005	0.00087	0.00050	0.00005	0.00061	0.00025	0.00005	0.00038	0.00025	0.00005	0.00027	0.00016
Dissolved Selenium	0.00005	0.00062	0.00025	0.00005	0.0005	0.00025	0.00005	0.00057	0.00025	0.00005	0.00067	0.00025	0.00005	0.00041	0.00005
Total Zinc	0.0005	0.0025	0.0005	0.0005	0.0025	0.0015	0.0005	0.0016	0.0005	0.0005	0.002	0.0005	0.0005	0.0016	0.001
Dissolved Zinc	0.0005	0.0025	0.0005	0.0005	0.0026	0.0015	0.0005	0.0005	0.0005	0.0005	0.0013	0.0005	0.0005	0.0017	0.0005

Note: values in mg/l unless otherwise indicated.

(continued)

Table 7.4-2
Water Quality Summary, 2004-2008 (completed)

	Strm10			Strm11.9			Strm17.1			Powerstation			TL Wetland		
Variable	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**
Turbidity (NTU)	0.87	4.28	1.77	1.07	1.07	1.07	0.3	0.3	0.3	3.34	3.34	3.34	1.71	1.71	1.71
TOC	5.7	15.5	11.8	7.8	7.8	7.8	5.1	5.1	5.1	14.9	14.9	14.9	11.8	11.8	11.8
pH	6.9	7.8	7.6	7.9	7.9	7.9	7.7	7.7	7.7	7.7	7.7	7.7	7.3	7.3	7.3
Cyanide	0.0051	0.0093	0.0088	0.0066	0.0066	0.0066	0.0042	0.0042	0.0042	0.0122	0.0122	0.0122	0.0106	0.0106	0.0106
Total Aluminum	0.036	0.288	0.160	0.017	0.017	0.017	0.020	0.020	0.020	0.016	0.016	0.016	0.009	0.009	0.009
Dissolved Aluminum	0.0136	0.265	0.14	0.008	0.008	0.008	0.014	0.014	0.014	0.0033	0.0033	0.0033	0.005	0.005	0.005
Total Arsenic	0.00015	0.0012	0.0002	0.00033	0.00033	0.00033	0.00013	0.00013	0.00013	0.00059	0.00059	0.00059	0.00063	0.00063	0.00063
Dissolved Arsenic	0.00014	0.00076	0.0002	0.00029	0.00029	0.00029	0.00012	0.00012	0.00012	0.00047	0.00047	0.00047	0.00051	0.00051	0.00051
Total Cadmium	0.0000085	0.000023	0.00001	0.0000085	0.0000085	0.0000085	0.0000085	0.0000085	0.0000085	0.000018	0.000018	0.000018	0.0000085	0.0000085	0.0000085
Dissolved Cadmium	0.0000085	0.00001	0.00001	0.0000085	0.0000085	0.0000085	0.0000085	0.0000085	0.0000085	0.0000085	0.0000085	0.0000085	0.0000085	0.0000085	0.0000085
Total Copper	0.0008	0.0011	0.001	0.0007	0.0007	0.0007	0.0008	0.0008	0.0008	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004
Dissolved Copper	0.00043	0.00125	0.0006	0.00079	0.00079	0.00079	0.00073	0.00073	0.00073	0.00042	0.00042	0.00042	0.00031	0.00031	0.00031
Total Iron	0.04	1.94	0.15	0.31	0.31	0.31	0.02	0.02	0.02	0.27	0.27	0.27	1.3	1.3	1.3
Dissolved Iron	0.015	0.868	0.144	0.202	0.202	0.202	0.015	0.015	0.015	0.066	0.066	0.066	0.64	0.64	0.64
Total Lead	0.000025	0.000089	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000053	0.000053	0.000053	0.000025	0.000025	0.000025
Dissolved Lead	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000102	0.000102	0.000102	0.000025	0.000025	0.000025
Total Molybdenum	0.000025	0.00008	0.000025	0.00008	0.00008	0.00008	0.000025	0.000025	0.000025	0.0001	0.0001	0.0001	0.000059	0.000059	0.000059
Dissolved Molybdenum	0.000025	0.000053	0.000025	0.000072	0.000072	0.000072	0.000025	0.000025	0.000025	0.00009	0.00009	0.00009	0.000025	0.000025	0.000025
Total Selenium	0.00016	0.00062	0.00025	0.00021	0.00021	0.00021	0.00025	0.00025	0.00025	0.00005	0.00005	0.00005	0.00033	0.00033	0.00033
Dissolved Selenium	0.00025	0.00061	0.00027	0.00012	0.00012	0.00012	0.00021	0.00021	0.00021	0.00005	0.00005	0.00005	0.00031	0.00031	0.00031
Total Zinc	0.0005	0.0015	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0057	0.0057	0.0057	0.0015	0.0015	0.0015
Dissolved Zinc	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0011	0.0011	0.0011	0.0015	0.0015	0.0015

Note: values in mg/l unless otherwise indicated.

At all sites, pH was similar and slightly basic, ranging from 6.92 to 8.31 among years. Values were within the Canadian Council of Ministers of the Environment (CCME) minimum and maximum guidelines for pH with the exception of Lower7 in January 2008, which was acidic (3.37). Stream conductivity showed a distinct spatial pattern with sites closer to the mine deposit (Strm4 and Strm5) having higher conductivity ranging around 250 to 350 µS/cm. TOC concentrations had high seasonal variability, with the highest values during freshet months. Concentrations ranged from 2.14 to 21.3 mg/L.

Cyanide concentrations were variable, ranging from below detection limits to 0.12 mg/L at Lower7 in 2004. Lower7 consistently had the highest concentrations among years. The CCME and BC 30-day mean guideline of 0.005 mg/L was exceeded at all sites, except Strm17.1, at least once over the five sample years.

7.4.2.2 Total and Dissolved Metals

Several total and dissolved metals concentrations are subject to both CCME and BC guidelines. These metals include: aluminum, arsenic, barium, copper, iron, lead, manganese, molybdenum, selenium, and zinc. Streams sites were assessed for both total and dissolved metal concentrations. Concentrations were often highest at Morrison Creek, Strm4, Strm5, and Strm6, likely because of their proximity to the mine deposit location. Table 7.4-3 summarizes the frequency that the various guidelines were exceeded. Mercury concentrations were generally below detection limits, but the BC guidelines were exceeded once at Strm5. Concentrations of manganese, cadmium, and selenium were generally low, often below detection limits.

Aluminum concentrations showed seasonal variation, with higher values during spring months. The CCME guideline for total aluminum was exceeded at all sites. Dissolved aluminum concentrations exceeded the BC 30-day mean guideline at all sites, while the BC maximum was only exceeded at four sites (Strm1, Strm6, Lower7, and Strm10).

Total and dissolved arsenic concentrations were generally low, except at site Strm5. Only one other sample (Strm4) showed high total arsenic concentrations, likely due to the presence of high total suspended solids (TSS) since the corresponding dissolved sample had a low arsenic concentration. This sample at Strm4 was the only sample among years to exceed the CCME and BC maximum guidelines.

Similar to arsenic, both total and dissolved copper concentrations were low at all sites except Strm5. Total copper guidelines were exceeded at Strm1, Morrison Creek, Strm4, and Strm5, while dissolved copper guidelines were exceeded at Strm4 and Strm5.

7.4.3 Lake and Pond Sites

From 2006 to 2008 water quality was collected at 10 lake and pond sites. Five sites are along Morrison Lake, which were sampled in 2006 and 2008. The remaining five sites, consisting of one small lake and four ponds within the pit and tailings facility areas, were sampled in 2006 and 2007. Water samples were analyzed for several variables including hardness, TDS, pH, turbidity, conductivity, sulphate, total phosphate, total nitrogen, ammonia, total cyanide, TOC, and metal concentrations.

Table 7.4-3

Summary of Sites Exceeding Provincial and Federal Metals Guidelines

Site	Year	Aluminum			Arsenic		Copper						Cadmium	Iron				Mercury		Selenium
		Dissolved		Total	Total		Dissolved			Total			Total	Dissolved		Total		Total		Total
		BC 30d mean	BC Max	CCME	BC Max	CCME	CCME	BC 30d mean	BC Max	CCME	BC 30d mean	BC Max	CCME	BC 30d mean	CCME	BC Max	CCME	BC 30d mean	BC Max	CCME
Strm1	2004	X	X	X						X	X	X								
	2005	X		X						X	X									
	2006																			
	2007	X	X	X						X	X									
	2008	X		X									X							
Morrison Cr	2004																			
	2005	X		X																
	2006													X	X		X			
	2007									X	X									X
	2008												X			X	X			
Strm4	2004						X			X										
	2005	X	X	X	X	X	X			X	X		X			X	X			
	2006																			
	2007	X		X			X	X		X	X									X
	2008												X							
Strm5	2004						X	X		X	X	X								
	2005	X		X			X	X	X	X	X	X								
	2006						X	X		X	X		X							
	2007						X	X		X	X							X	X	X
	2008							X		X			X							
Strm6	2004			X																
	2005	X	X	X									X							
	2006																			
	2007	X	X	X													X			
	2008			X									X							
Strm26	2004																			
	2006																			
	2007	X		X																
	2008			X																
Lower7	2004	X	X	X																
	2005	X	X	X																
	2006																			
	2007	X	X	X																
	2008	X	X	X									X							
Upper7	2006																			
	2008	X																		
Strm8	2007	X		X																
	2008			X																
Strm9	2008																			
Strm10	2006			X										X	X	X	X			
	2007	X	X	X																
	2008	X	X	X									X							
Strm11.9	2008															X	X			
Strm17.1	2008																			
Powerstation	2008																			
TL Wetland	2008													X	X	X	X			

7.4.3.1 Physical Parameters, Nutrients, and Cyanide

Water hardness, measured as the concentration of $CaCO_3$, influences the uptake of metals by aquatic organisms (Markich and Jeffree 1994). Hardness was low at all Morrison Lake sites and remained consistent between years at approximately 30 mg/L. Hardness at the smaller lake/pond sites was generally higher, although ponds Y and Z showed concentrations similar to Morrison Lake. TDS followed the same pattern with low values at the Morrison Lake sites, ponds Y and Z, and elevated values at the remaining lake/pond sites. Turbidity was low at all sites indicating relatively clear water. Water pH was consistent among sites and years ranging from 7.23 to 8.16, which is within the CCME guideline range of pH 6.5 to 9.0.

Conductivity was low at the Morrison Lake sites, Pond Y and Pond Z, ranging between 60 and 90 µS/cm, and higher at the remaining sites with values close to 200 µS/cm. Nitrogen concentrations were generally below 0.50 mg/L. Ammonia was found in low concentrations at Morrison Lake and the small ponds, and slightly higher at Ore Pond and Booker Lake.

Cyanide concentrations exceeded the CCME and BC 30-day mean guidelines during at least one sampling event at all sites except Booker Lake. No sites exceeded the BC Maximum guideline (0.01 mg/L). TOC concentrations ranged from 10 to 19 mg/L with the highest concentrations found at Pond X.

7.4.3.2 Total and Dissolved Metals

Guidelines for aluminum concentrations were exceeded at two sites. In 2007, Pond Y exceeded the total aluminum CCME guideline of 0.1 g/L, while ponds Y and Z exceeded the BC 30-day mean guideline for dissolved aluminum. The guidelines were only exceeded at the surface, with mid-water samples well below guidelines.

Metals concentrations were consistent among the Morrison Lake sites and variable across the smaller lake and pond sites. The Morrison Lake sites generally had metals concentrations lower than at the smaller sites for arsenic, barium, copper, lead, manganese, molybdenum, selenium and zinc. Ore Pond consistently showed the highest concentrations for any site in the study area. These concentrations represent the natural conditions in these aquatic ecosystems and will be used in conjunction with ongoing monitoring throughout the proposed mine construction and operation stages.

7.5 Surface Water Quantity

7.5.1 Introduction

The following is a brief overview of hydrological conditions in north-central BC, with a focus on watersheds potentially affected by the proposed Project. Complete details of the baseline hydrology monitoring program and a regional analysis of the study area are provided in Appendix 22.

The Project area is on the eastern side of the Babine Range. The regional hydroclimate is dominated by weather systems generated over the Pacific Ocean, and is also strongly influenced by orographic effects caused by mountain ranges. Incoming weather systems and local topography combine to produce a high degree of spatial variability in precipitation. Topography also influences temperature, which determines the snow line elevation and the rate and timing of snowmelt. All of these influences result in competing runoff generating processes (i.e., snowmelt runoff versus rainfall runoff), which makes the hydrological regime of the region very dynamic and difficult to predict.

The manner in which precipitation becomes runoff first depends on whether it falls in the form of snow or rain. Snow falling in winter will accumulate on the surface of the watershed and remain (with losses to sublimation) until melted. Mid-winter melt events may occur, especially at lower elevations, but most snowfall persists until the spring melt. At this time, soils quickly become saturated, and much of the snow becomes runoff. Low evapotranspiration rates during the spring also contribute to runoff generation

In contrast to snowfall, rainfall occurs when temperatures are warmer, increasing the potential for losses to evapotranspiration (reducing runoff generation). Rain falling on exposed ground surfaces may be trapped in surface depressions and on vegetation. The remainder flows downslope, where it may infiltrate into the ground or reach a channel.

Considering these runoff processes, a typical hydrological year for watersheds in north-central BC may be divided into four main flow periods:

- Winter: Characterized by ice-covered streams with low to negligible stream flow, depending on the elevation of the stream and watershed area;
- Spring/freshet: Characterized by high flows caused by snowmelt; this period generally contains the annual peak flow;
- Summer: Characterized by steadily decreasing high to moderate flows that are augmented by rainfall and meltwater from residual snow patches;
- Fall: Characterized by moderate to low flows, but interrupted by rainstorm events, which can generate relatively high peak flows, although generally lower than freshet peak flows.

The presence of many lakes and wetlands in the Project area also influence hydrologic response. These features interact with groundwater and help to regulate stream flows. During storm events, for example, runoff is retained within lakes and wetlands, decreasing peak flows downstream. However, flow from the wetland areas and lakes will tend to augment stream flow during low-flow periods and between rainstorm events.

7.5.2 Study Area and Watershed Data

Figure 7.1-1 shows the general Project location. The Project area is on the eastern side of Morrison Lake in the Babine Lake watershed. Morrison Creek flows south from Morrison Lake and discharges into the Morrison Arm (northeast arm) of Babine Lake. Babine Lake is drained by Babine River, a tributary of the Skeena River. The Skeena River flows west towards Prince Rupert, where it discharges into the Pacific Ocean (Figure 7.5-1).

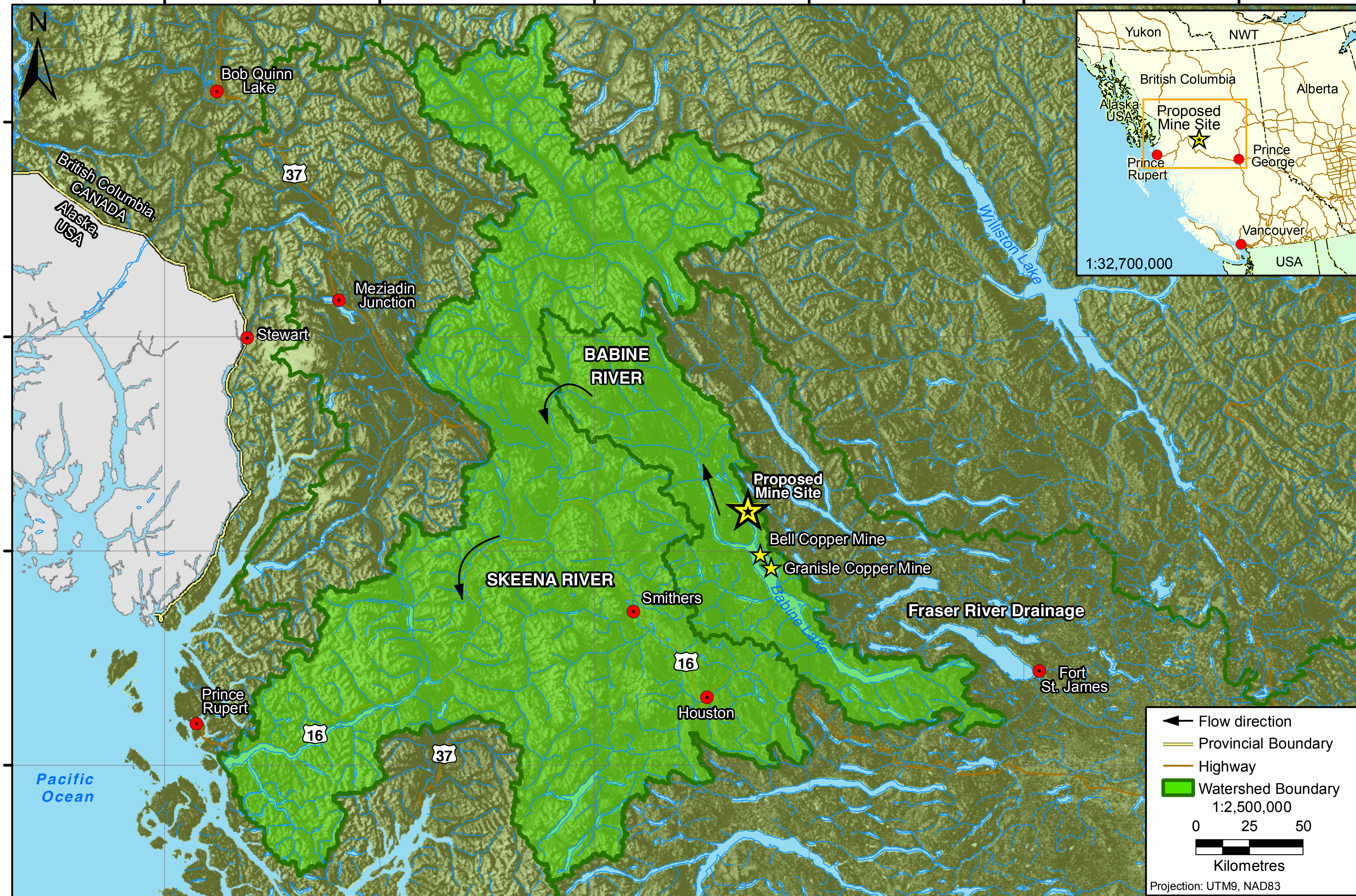


FIGURE 7.5-1

Regional Watersheds of the Morrison Copper/Gold Project

Hydrometric stations were established at eight different locations in the Project area, and are referred to as the on-site stations (Figure 7.5-2). The watersheds associated with each station are described below.

- Morrison Creek drains water from Morrison Lake and its tributaries into Babine Lake;
- MCS-1 flows directly into Babine Lake. The headwaters are a lake and wetland complex, with no clear divide between the watersheds of MCS-1 and MCS-6;
- MCS-4 has a very small watershed area and drains the ridge to the east of Morrison Lake;
- MCS-5 collects runoff from most of the Morrison deposit. The headwaters drain to Booker Lake, which drains into Morrison Lake. The outlet immediately upstream of Morrison Lake has a large waterfall and cascades between 4 and 6 m high;
- MCS-6 flows directly into Morrison Lake at Morrison Narrows. The headwaters are a lake and wetland complex, with no clear divide between the watersheds of MCS-1 and MCS-6;
- MCS-7 drains a low-gradient area northwest of the Morrison deposit, which includes the proposed tailings storage facility (TSF);
- MCS-8 drains a relatively low-gradient area northwest of the proposed TSF into Morrison Lake;
- MCS-10 drains a very small watershed which lies to the east of the Babine Lake drainage divide, on the eastern side of the proposed TSF.

Based on analysis of data from over 400 Water Survey of Canada (WSC) hydrology stations in BC, Obedkoff (2000) divided the province into hydrologic zones, or areas expected to have similar hydrological characteristics. The Project area lies within hydrologic sub-zone "m" as defined by Obedkoff. A regional analysis was conducted using hydrometric data from 25 (20 active) WSC stations in sub-zone "m." These stations are referred to as the regional stations.

Based on the results from the baseline monitoring program and the regional analysis, a set of key hydrological parameters were defined for the Project area. These are described in the following sections.

7.5.3 Annual Runoff

Annual runoff is a measure of the total volume of water flowing through a site of interest. It provides an indication of the water available for human use as well as for aquatic and terrestrial life in a given area. Runoff is expressed as a depth of water, and is generally calculated by dividing the total flow volume (m^3) observed at a monitoring station by the drainage area (m^2) flowing into the site. Two methods were used to estimate annual runoff for the Project area.

The first method involved analyzing regional station data. A relationship between median watershed elevation and annual runoff was established. This relationship was then applied to the on-site station median elevations. Resulting annual runoff values ranged from 152 to 484 mm (Table 7.5-1). In the geotechnical feasibility study (Appendix 9), Klohn Krippen Berger estimated an annual runoff of 275 mm. In general this is consistent with the estimates based on median elevation.

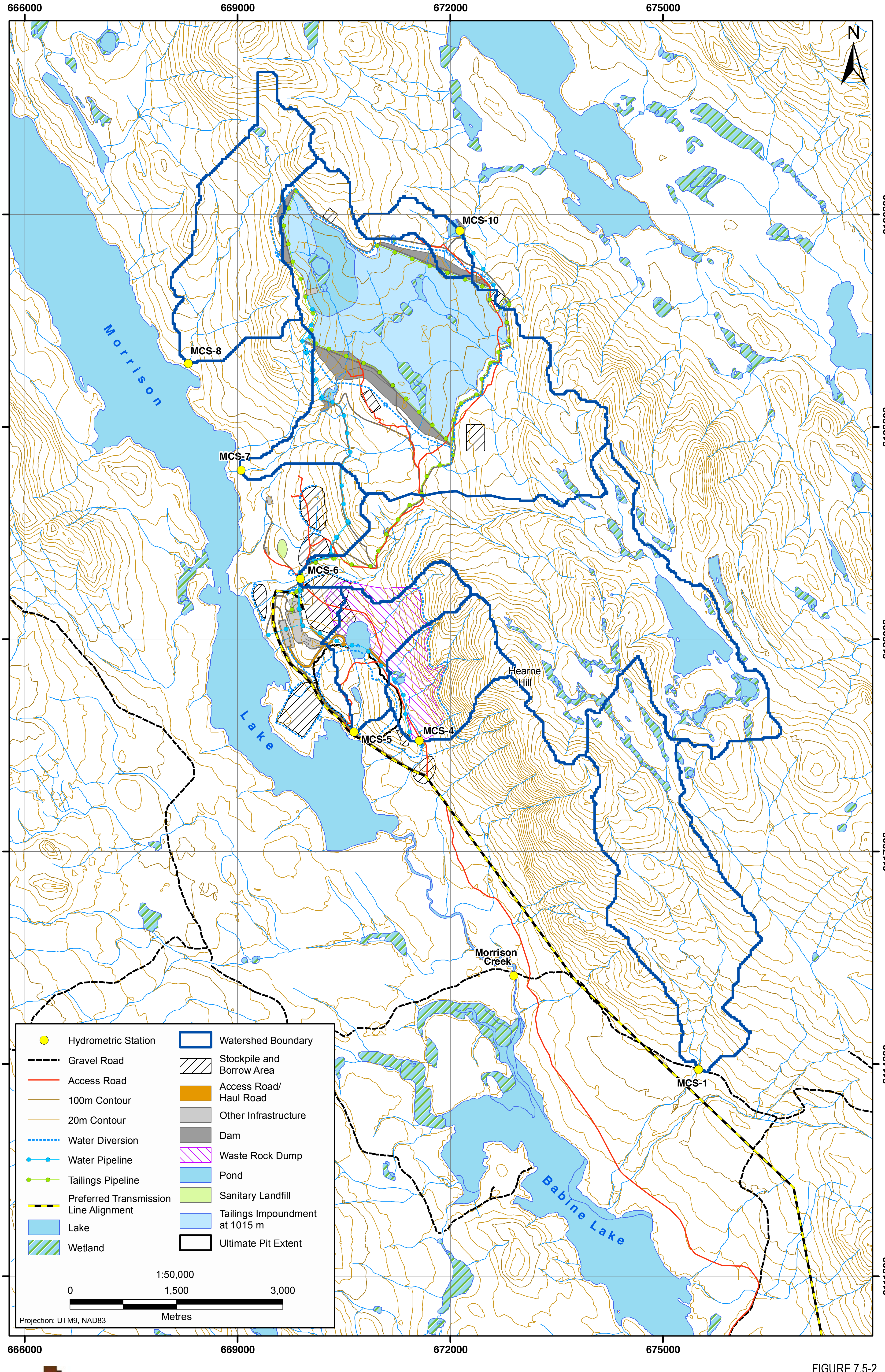


FIGURE 7.5-2

Morrison Copper/Gold Project
Hydrometric Stations and Watersheds

Table 7.5-1
Estimated Average Annual Runoff at On-site Stations Based on Regional Median Elevation Relationship

Station	Area (km^2)	Median Elevation (m)	Estimated Average Annual Runoff (mm)
Morrison Creek	490	916	216
MCS-1	6.8	1,129	415
MCS-4	2.3	1,094	382
MCS-5	2.2	847	152
MCS-6	12.9	1,204	484
MCS-7	12.7	992	287
MCS-8	4.6	907	208
MCS-10	0.8	961	258

7.5.4 Monthly Runoff Distribution

Table 7.5-2 summarizes the estimated monthly runoff distribution from each on-site station. For the winter months, where continuous monitoring data were not available, flow was estimated based on winter flow measurements and comparisons with regional data. While analyzing the data, two distinct runoff regimes were apparent from on-site data. Runoff Regime 1 is characterized by lower annual runoff and earlier peak flow during the spring freshet. This regime incorporates monitored basins MCS-4, MCS-5, MCS-7, and MCS-8. Runoff Regime 2 is characterized by a delayed spring freshet that is of greater magnitude than Regime 1. This regime incorporates the monitored basins of Morrison Creek, MCS-1, MCS-6, and MCS-10. The Runoff Regime 2 distribution is very similar to the estimates made by Klohn Crippen Berger in Appendix 9, which were based on data from regional stations.

7.5.5 High Flows

An understanding of flood potential is important to consider at the Project site, as it could affect the design characteristics of infrastructure such as roads, ditches, dams, and dikes. Floods in north-central BC are typically produced through three main mechanisms:

1. **Rapid snowmelt** during freshet conditions in June or July.
2. **Rain falling on melting snow** during freshet conditions in June or July, or during early winter in October and November.
3. **Heavy rainfall** during September or October.

Based on analysis of the regional WSC stations, high-flow events are regularly generated by all three mechanisms; however, the annual peak flow is generally produced by mechanism 1.

Table 7.5-2
Estimated Monthly Runoff Distributions at On-site Stations (%)

	Watershed	Associated Runoff Regime	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A. Hydrometric Stations														
2007	Morrison Creek	2	0.5	0.4	0.4	1.0	48.5	27.2	7.5	3.2	2.3	3.2	4.8	1.1
	MCS-4	-	-	-	-	-	-	-	-	-	-	-	-	-
	MCS-5	1	1.3	1.2	1.6	7.7	58.0	7.5	4.3	4.3	3.9	3.8	3.5	2.9
	MCS-6	2	0.5	0.4	0.4	1.0	27.5	38.8	11.3	5.4	2.6	6.3	4.8	1.1
	MCS-7	1	1.3	1.2	1.6	7.7	58.0	11.8	3.3	2.4	1.3	5.1	3.5	2.9
	MCS-8	1	1.3	1.2	1.6	7.7	58.0	8.1	5.8	3.1	1.6	5.3	3.5	2.9
	MCS-10	-	-	-	-	-	-	-	-	-	-	-	-	-
2008	Morrison Creek	2	0.5	0.4	0.4	1.5	64.9	13.6	3.3	2.2	2.5	4.8	4.8	1.1
	MCS-1	2	0.5	0.4	0.4	2.9	69.3	8.3	0.7	4.6	2.1	4.8	4.8	1.1
	MCS-4	1	1.3	1.2	1.6	10.8	57.5	7.4	3.9	3.6	2.5	3.8	3.5	2.9
	MCS-5	1	1.3	1.2	1.6	6.0	54.5	13.1	6.0	4.0	2.0	3.8	3.5	2.9
	MCS-6	2	0.5	0.4	0.4	1.0	45.1	17.7	6.4	9.1	8.6	4.8	4.8	1.1
	MCS-7	1	1.3	1.2	1.6	5.3	55.2	2.5	0.3	8.6	13.9	3.8	3.5	2.9
	MCS-8	1	1.3	1.2	1.6	18.9	63.3	3.3	0.0	0.2	0.0	3.8	3.5	2.9
	MCS-10	2	0.5	0.4	0.4	3.7	76.4	7.2	0.0	0.7	0.0	4.8	4.8	1.1
B. Runoff Regimes														
	Regime 1		1.3	1.2	1.6	7.7	58.0	10.0	3.9	2.3	3.8	3.8	3.5	2.9
	Regime 2		0.5	0.4	0.4	1	44.4	27.7	7.6	4	3.3	4.8	4.8	1.1

High flows are characterized using a flood frequency analysis to obtain return period flows. The return period refers to the probability of occurrence of the flood event. For example, a 1-in-50-year return period (Q_{50}) event is a flow magnitude that has a 2% chance of being exceeded in any given year. To complete the analysis, a long-term data record (i.e., >10 years) is required; therefore, data from the 25 regional WSC stations were used. For each return period, regression equations were developed relating discharge and basin area. The equations were then applied to the monitored watersheds surrounding the Project, using the basin area to obtain return period flow estimates (Table 7.5-3). Notably, most of the stations incorporated in the regional analysis are on rivers with large drainage areas (>100 km^2). Extrapolation to smaller streams increases the uncertainty associated with the estimates; however, for the purposes of this assessment, these values are considered reasonable.

Table 7.5-3
Estimated Return Period Flows for Select On-site Stations

Watershed	Watershed Area (km^2)	Q_2 (m^3/s)	Q_{25} (m^3/s)	Q_{50} (m^3/s)	Q_{100} (m^3/s)
Morrison Creek	490.0	36	79	90	110
MCS-1	6.8	1.0	2.7	3.2	3.9
MCS-4	2.3	0.4	1.1	1.4	1.7
MCS-5	2.2	0.4	1.1	1.3	1.6
MCS-6	12.9	1.7	4.5	5.3	6.5
MCS-7	12.7	1.7	4.4	5.2	6.4
MCS-8	4.6	0.7	2.0	2.4	2.9

7.5.6 Low Flows

Low flows are an important consideration for this Project because they could affect aquatic communities. While the annual low flow will occur during the winter months, flow volumes during the summer season (i.e., from June to September) are also important as they can strongly influence species presence. Low flows are characterized using different indices, with the most common measure being the 7-day low flow over a given time period. For example, the average annual 7-day low flow ($7Q_2$) provides an estimate of the average base flow conditions of a stream. Another measure, the $7Q_{10}$, is the 7-day average minimum flow that is expected to occur once every 10 years. The $7Q_2$ and $7Q_{10}$ were calculated for each of the 25 regional WSC stations. Then, as with high flows, regression equations were developed relating discharge and basin area. The resulting equations were used to estimate low flows for the monitored watersheds surrounding the Project area (Table 7.5-4).

Table 7.5-4
Low Flow Estimates for Select On-site Stations

	$7Q_2$		$7Q_{10}$	
Watershed	**Annual (L/s)**	**Jun–Sep (L/s)**	**Annual (L/s)**	**Jun–Sep (L/s)**
Morrison Creek	576.0	1,505.6	223.5	746.7
MCS-1	4.4	19.6	1.1	7.8
MCS-4	1.3	6.5	0.3	2.4
MCS-5	1.2	6.2	0.3	2.3
MCS-6	9.2	37.7	2.4	15.4
MCS-7	9.0	36.8	2.4	15.0
MCS-8	2.9	13.2	0.7	5.1

7.6 Groundwater Quality

7.6.1 Introduction

This section presents the groundwater quality setting for the Project. In 2007 and 2008, Rescan conducted hydrogeological baseline studies in the Project area (Appendix 24); the data presented here are primarily drawn from these studies.

7.6.2 Methodology

In 2007 and 2008, Rescan drilled and installed a total of 22 monitoring wells within the Project footprint. Groundwater samples were collected on a quarterly basis for groundwater quality characterization.

7.6.2.1 Geological Setting

Glacial till composed mainly of silt and clays is the dominant unit in the overburden surficial geology of the Morrison property. Lacustrine and glaciolacustrine materials are also present, but to a limited extent (Appendix 32; Knight Piésold 2006). Other overburden surficial materials in the Morrison property include morainal, fluvial/glaciofluvial, organic, and undifferentiated colluvium/weathered bedrock (Appendix 6).

The Morrison ore deposit is a zoned annular porphyry copper/gold deposit within a multi-phased Eocene "Babine type" biotite feldspar porphyry. The proposed pit area is contained within the middle to upper Jurassic Ashman formation, which consists of argillaceous siltstone and greywacke on the surface gradually becoming marine pebble conglomerate interbedded with greenish grey sandstone and siltstone at depth. The area surrounding the Morrison ore deposit is characterized by subvolcanic intrusions and hydrothermal alteration. Intrusive rocks of the Eocene Babine igneous suite comprise quartz, hornblende, biotite, and plagioclase phyric intrusions.

The main portion of copper/gold mineralization corresponds with the potassic alteration in the central part of the biotite feldspar porphyry intrusive. The major sulphide minerals are chalcopyrite and pyrite; these are occasionally associated with minor minerals such as: bornite, marcasite, pyrrhotite, galena, molybdenite, and sphalerite. The ratio of copper to iron sulphide minerals declines toward the peripheral portion of the plug such that a pyritic halo surrounds the central part. Sulfide mineralization generally occurs in the form of fracture filling and/or disseminated textures in the rock matrix (Appendix 15; MacIntyre, Webster, and Desjardins 1997; D. Maclntyre 2001).

The proposed TSF at the northern end of the Morrison property is underlain by Lower to Upper Jurassic bedrock formations of the Hazelton group including the Telkwa, Nilkitkwa, Saddle Hill, and Smithers. The main lithologic units are interpreted as continental shelf facies sandstone, siltstone, conglomerate, and limestone (Figure 7.6-1).

The intrusions are associated with hydrothermal alteration of country rocks. Structural features are also present because of the influence of tectonic activities during and after mineralization. In combination with the diversity of the geologic units underlying the Project footprint, these features are the result of the highly complex bedrock geology of the area. Depending on the location and depth, the lithologies encountered in the different drill holes included the following: glauconitic or andesitic tuff, greywacke, volcanic breccia, fossiliferous limestone, feldspar biotite porphyry, siltstone and sandstone, and mafic dike. Occasional alteration was noted including chloritization, silicification, calcification, and argillization. Intense clay carbonate alteration is associated with fault zones (Appendix 6).

7.6.2.2 Well Installation

In 2007, Rescan drilled and installed 14 groundwater monitoring wells at seven different sites on the Morrison property (Figure 7.6-2). Four are near the tailings impoundment area (MW07-01A and B and MW07-02 A and B); four groundwater monitoring wells are between the TSF and the open pit (MW07-03 A and B and MW07-04 A and B); and six are in the open pit area (MW07-05 A and B, MW07-06 A and B and MW07-07 A and B).

Eight additional wells were installed at four different locations in 2008. Four were installed to monitor groundwater upstream of the pit and downstream of the waste rock dump (WRD) pile (MW08-01 A and B and MW08-02 A and B); two were on the border of the low grade ore pile to monitor groundwater discharging from it and possibly entering the fish-bearing stream downstream and to the north (MW08-03 A and B); and two monitoring wells (MW08-04 A and B) were installed between the open pit and Morrison Lake. The groundwater monitoring well completion details are compiled in Table 7.6-1.

7.6.2.3 Groundwater Sampling Program

Five groundwater sampling events (November 2007 and January, April, July, and October 2008) were completed over a one-year period from November, 2007, to October, 2008. A total of 71 groundwater samples were collected at all the Rescan monitoring wells and sent to ALS Laboratory Group of Vancouver, BC, for analysis. Samples were also taken from three Knight Piésold monitoring wells (DH06-7, DH-06-11, and DH06-12) in July, 2006, and included in the data set presented. Table 7.6-2 summarizes the locations and collection dates as well as the water type of the groundwater samples collected. The requested analyses were: general

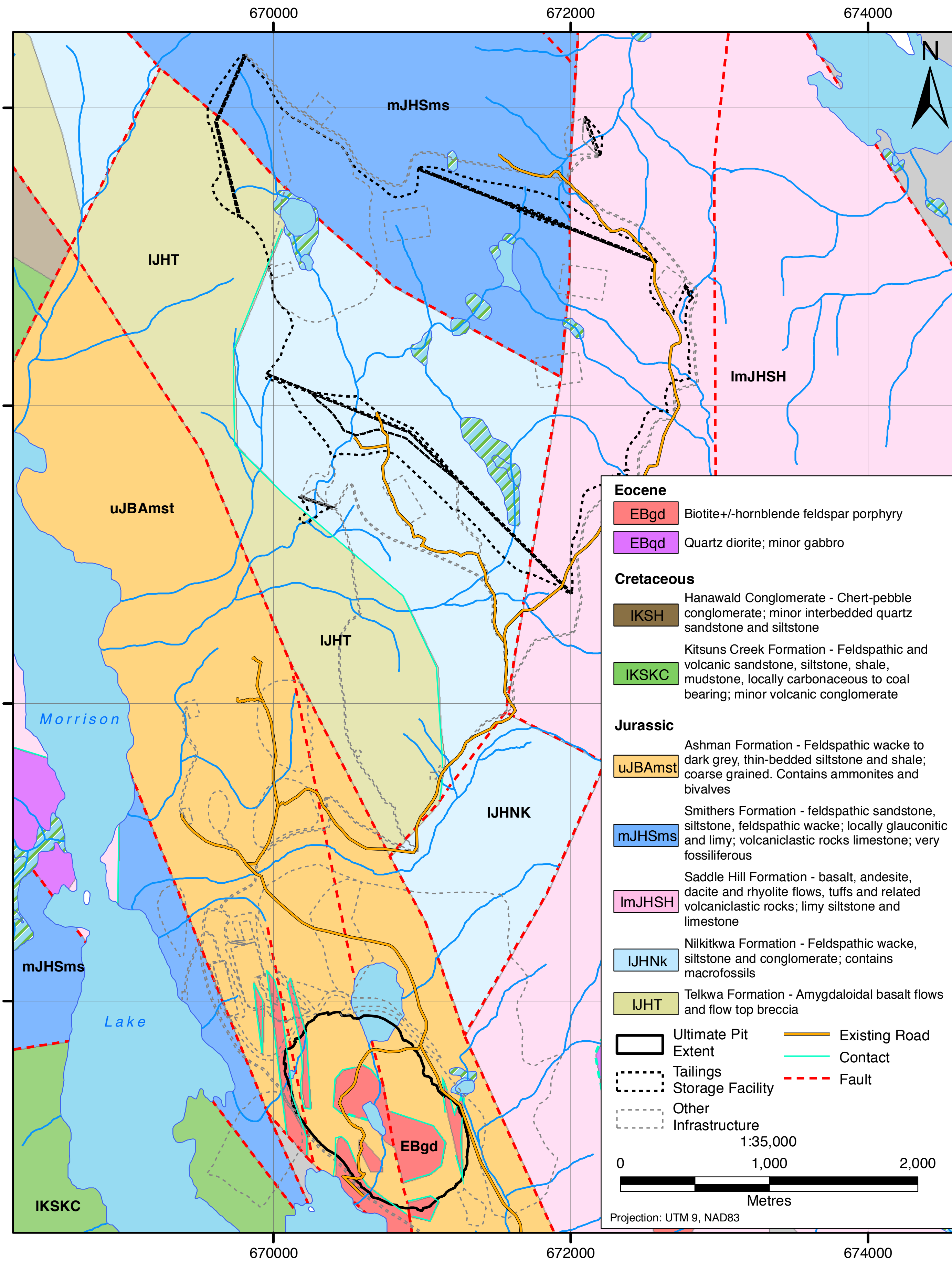


FIGURE 7.6-1

Morrison Copper/Gold Project: Local Geology and Mine Infrastructure

pbm Rescan

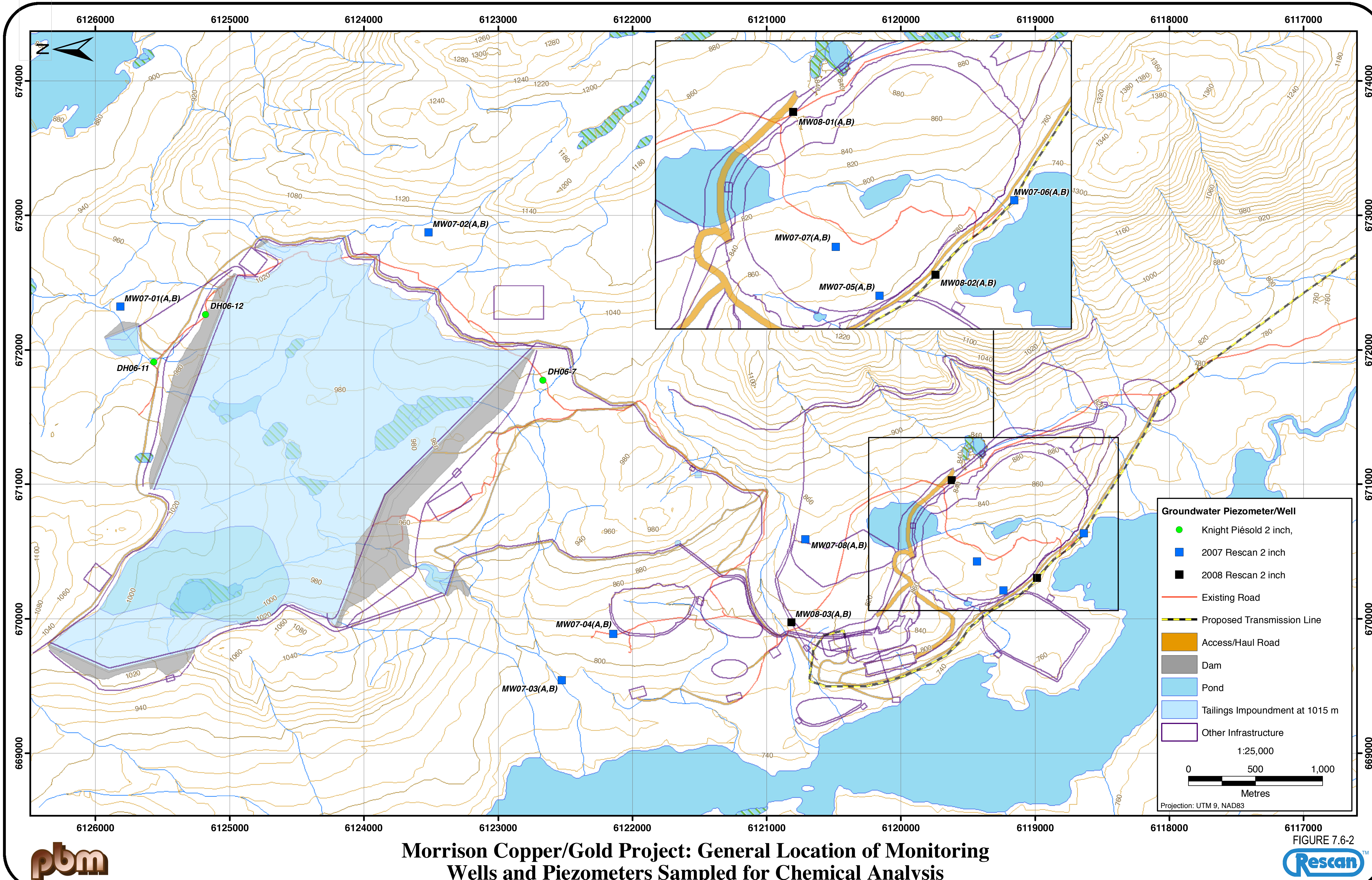


FIGURE 7.6-2

Morrison Copper/Gold Project: General Location of Monitoring Wells and Piezometers Sampled for Chemical Analysis

Table 7.6-1
Morrison Copper/Gold Project: Monitoring Well Completion Table

Well I.D.	Installation Date mm/dd/yy	UTM Location Northing	UTM Location Easting	Elevation (masl)[1]	Depth (m)	Inclination (degrees)	Stick up (mags)[2]	Drilling Method[3]	Screened Interval (mbgs)[4] Top	Screened Interval (mbgs)[4] Bottom	Screened Horizon	Lithology
MW07-01A	10/11/2007	6125820	672325	970	28.04	90	0.93	ODEX and HQ3	21.94	28.04	Bedrock	Glauconitic Volcanoclastic unit
MW07-01B	10/11/2007	6125820	672325	970	12.19	90	0.94	ODEX	8.99	12.04	Overburden	Glacial Till
MW07-02A	07/11/2007	6123522	672874	1091	40.23	90	0.87	ODEX and HQ3	35.81	38.7	Bedrock	Volcanic breccia
MW07-02B	08/11/2007	6123522	672874	1091	9.14	90	0.85	ODEX	6.1	9.14	Bedrock	Fossiliferous Limestone
MW07-03A	24/10/2007	6122530	669544	782	33.53	90	0.83	ODEX	30.32	33.37	Overburden	Glacial Till
MW07-03B	26/10/2007	6122530	669544	782	5.94	90	0.93	ODEX	2.89	5.94	Overburden	Glacial Till
MW07-04A	22/10/2007	6122147	669890	822	40.84	90	0.87	ODEX	37.79	40.84	Overburden	Glacial Till
MW07-04B	24/10/2007	6122147	669890	822	6.1	90	0.87	ODEX	3.05	6.09	Overburden	Glacial Till
MW07-05A	17/10/2007	6119240	670211	807	40.23	90	0.95	ODEX	37.18	40.23	Bedrock	Altered Feldspar Biotite Porphyry
MW07-05B	18/10/2007	6119240	670211	807	21.34	90	0.91	ODEX	18.29	21.33	Overburden	Glacial Till
MW07-06A	19/10/2007	6118638	670637	746	16.31	90	0.93	ODEX and HQ3	11.58	14.63	Bedrock	Volcanic tuff
MW07-06B	20/10/2007	6118638	670637	746	5.18	90	0.91	ODEX	2.13	5.18	Overburden	Glacial Till
MW07-07A	06/10/2007	6119436	670428	837	149.66	90	0.98	ODEX and HQ3	131.97	147.22	Bedrock	Altered Feldspar Biotite Porphyry
MW07-07B	16/10/2007	6119436	670428	837	39.47	90	1.00	ODEX	36.42	39.47	Bedrock	Altered Feldspar Biotite Porphyry
MW07-08A	20/10/2007	6120715	670593	840	40.23	90	0.93	ODEX	37.18	40.23	Bedrock	Siltstone
MW07-08B	22/10/2007	6120715	670593	840	10.36	90	0.84	ODEX	7.31	10.36	Overburden	Glacial Till
MW08-01A	20/09/2008	6119626	671032	832	85.8	90	0.92	ODEX and HQ3	72.09	78.18	Bedrock	Siltstone and Tuff
MW08-01B	21/09/2008	6119626	671032	832	30.18	90	0.88	ODEX	23.78	29.87	Overburden	Gravelly Clay with Sand
MW08-02A	04/10/2008	6118990	670305	752	149.81	90	0.91	ODEX and HQ3	137.62	149.81	Bedrock	Siltstone and Feldspar Biotite
MW08-02B	04/10/2008	6118990	670305	752	75.59	90	1.00	ODEX	66.45	75.59	Overburden	Biotite Feldspar Porphyry
MW08-03A	23/09/2008	6120820	669975	800	35.51	90	0.92	ODEX and HQ3	30.48	35.05	Bedrock	Sandstone
MW08-03B	23/09/2008	6120820	669975	800	13.89	90	0.90	ODEX	8.99	13.72	Overburden	Gravelly Clay with Sand

Notes:

[1] masl = metres above sea level.

[2] mags = metres above ground surface.

[3] ODEX diameter = 11.43 cm and HQ3 diameter = 9.6 cm.

[4] mbgs = metres below ground surface.

Table 7.6-2

Morrison Copper/Gold Project: Summary of Morrison Groundwater Sampling

Well ID	Screened Unit	Total Number	Dates Sampled						Water Type	
			Jul-06	Nov-07	Jan-08	Apr-08	Jul-08	Oct-08		
DH06-7	Volcanic unit/ fine grained siltstone/sandstone	1	July 2006	-	-	-	-	-	sodium calcium-bicarbonate	Na-Ca HCO_3
DH06-11	Silt/Clay matrix with some gravel	1	July 2006	-	-	-	-	-	sodium-bicarbonate	Na HCO_3
DH06-12	Sandstone/Siltstone	1	July 2006	-	-	-	-	-	calcium-bicarbonate	Ca HCO_3
MW07-01A	Glauconitic Volcaniclastic unit	5	-	16-Nov-07*	23-Jan-08	7-Apr-08	18-Jul-08	8-Oct-08	sodium-bicarbonate	Na HCO_3
MW07-01B	Glacial Till	2	-	A	B	B	18-Jul-08	8-Oct-08	sodium calcium-bicarbonate	Na-Ca HCO_3
MW07-02A	Volcanic Breccia	5	-	16-Nov-07	23-Jan-08	7-Apr-08	18-Jul-08	8-Oct-08	sodium-bicarbonate	Na HCO_3
MW07-02B	Fossiliferous Limestone	5	-	16-Nov-07	23-Jan-08	7-Apr-08	18-Jul-08	8-Oct-08	calcium-bicarbonate	Ca HCO_3
MW07-03A	Glacial Till	3	-	14-nov-07*	D	D	16-Jul-08	5-Oct-08	sodium-bicarbonate	Na HCO_3
MW07-03B	Glacial Till	5	-	14-Nov-07	24-Jan-08	8-Apr-08	16-Jul-08	5-Oct-08	calcium-bicarbonate	Ca HCO_3
MW07-04A	Glacial Till	5	-	14-Nov-07	24-Jan-08	8-Apr-08	16-Jul-08	5-Oct-08	mixed cations(2) to calcium sodium(3)-sulfate	Na-Mg-Ca SO_4
MW07-04B	Glacial Till	1		A	C	C	E	5-Oct-08	mixed cations-bicarbonate	Na-Mg-Ca HCO_3
MW07-05A	Feldspar Biotite Porphyry	5	-	12-Nov-07	25-Jan-08*	10-Apr-08*	19-Jul-08*	8-Oct-08*	calcium magnesium-bicarbonate	Ca-Mg HCO_3
MW07-05B	Glacial Till	2	-	C	C	C	19-Jul-08	7-Oct-08	sodium-bicarbonate sulfate	Na HCO_3-SO_4
MW07-06A	Volcanic Tuff	5	-	7-Nov-07	25-Jan-08	11-Apr-08	19-Jul-08	7-Oct-08	sodium-bicarbonate	Na HCO_3
MW07-06B	Glacial Till	4	-	-	25-Jan-08	10-Apr-08	19-Jul-08	5-Oct-08	calcium-bicarbonate	Ca HCO_3
MW07-07A	Feldspar Biotite Porphyry	4	-	-	26-Jan-08	12-Apr-08	17-Jul-08	9-Oct-08	sodium-bicarbonate	Na HCO_3
MW07-07B	Feldspar Biotite Porphyry	5	-	7-Nov-07	25-Jan-08	11-Apr-08	17-Jul-08	9-Oct-08	mixed cations(2) to calcium magnesium(2)-bicarbonate	Na-Mg-Ca HCO_3
MW07-08A	Siltstone	4	-	7-Nov-07	24-Jan-08	9-Apr-08	18-Jul-08	-	mixed cations-bicarbonate(2) to bicarbonate sulfate(2)	Na-Mg-Ca HCO_3-SO_4
MW07-08B	Glacial Till	4	-	C	24-Jan-08	11-Apr-08	18-Jul-08	7-Oct-08	sodium (2) to sodium calcium(1) to mixed cations(1)-bicarbonate	Na-Mg-Ca HCO_3
MW08-01A	Tuff and siltstone	1	-	-	-	-	-	10-Oct-08	mixed cations-bicarbonate	Na-Mg-Ca HCO_3
MW08-01B	Gravelly Clay with Sand	0	-	-	-	-	-	-	-	Na-Ca HCO_3
MW08-02A	Siltstone and Feldspar Biotite Porphyry	1	-	-	-	-	-	9-Oct-08	calcium magnesium-bicarbonate	Mg-Ca HCO_3
MW08-02B	Feldspar Biotite Porphyry	1	-	-	-	-	-	9-Oct-08	calcium magnesium-bicarbonate	Mg-Ca HCO_3
MW08-03A	Sandstone	1	-	-	-	-	-	10-Oct-08	sodium-bicarbonate	Na HCO_3
MW08-03B	Gravelly Clay with Sand	0	-	-	-	-	-	-	-	Na-Ca HCO_3

A = dry well - could not be sampled.
B = frozen water - could not be sampled.
C = shallow water level - insufficient water to sample.
D = frozen artesian.
E = only sampled for general chemistry.
*** = duplicate sample was taken.**

chemistry, TOC, and total and dissolved metals. The concentrations obtained were compared to three guidelines: the British Columbia Approved and Working Water Quality Guidelines (BCWQG) for drinking water, the BCWQG for freshwater aquatic life, and the CCME Canadian Water Quality Guidelines (WQG) for the protection of freshwater aquatic life.

7.6.3 Results and Discussion

7.6.3.1 Physical Parameters, Nutrients and Total Carbon in Groundwater

The analytical results of groundwater samples collected from 16 monitoring wells at 8 different locations on the Morrison property provide a preliminary indication of groundwater quality for the area.

Physical Parameters

The groundwater at the Morrison property had pH values varying from 7.38 (MW07-07B) to 12.1 (at MW07-07A). Four samples collected at one monitoring well location (MW07-07A) exceeded the CCME WQG for freshwater aquatic life. This monitoring well is in the proposed open pit area and is the only location that exceeded the CCME WQG for pH. Eight samples taken from five different locations (MW07-01A, MW07-02A, MW07-03A, MW07-07A, and MW08-03A) exceeded the BCWQG for drinking water pH throughout the sampling program. Electric conductivity varied from 307 (MW07-03B) to 4330 µS/cm (MW07-08B). Thirty-five samples collected at 12 sites (MW07-01A and B, MW07-02B, MW07-04A and B, MW07-05A and B, MW07-06A, MW07-07A, MW07-08A and B, and MW08-03A) exceeded the BCWQG of 700 µS/cm for drinking water for electrical conductivity. Alkalinity varied between 136 (MW07-02A) and 1,660 mg/L (MW07-08B) on the Morrison property. The statistics for general chemistry of the site-wide groundwater are presented in Table 7.6-3 and figures 7.6-3 to 7.6-6.

Nutrients

Nutrient concentrations showed many exceedances. Ammonia ranged between less than 0.005 mg/L (in several monitoring wells) and 0.619 mg/L. (in MW07-06A). There were no exceedances of the ammonia BCWQG for freshwater aquatic life, but ammonia levels in 33 samples collected from 13 different well locations exceeded the CCME WQG values for the protection of freshwater aquatic life for ammonia (assumed all un-ionized). Nitrite varied from less than 0.001 mg/L (in several monitoring wells) to 0.13 mg/L (in MW07-08B). One sample in MW-07-08B exceeded the CCME WQG and BCWQG for freshwater aquatic life (figures 7.6-7 to 7.6-9).

Total Organic Carbon

TOC varied between less than 0.5 mg/L (in MW07-01A) and 130mg/L (in DH06-12). The TOC concentration in most monitoring wells exceeded the BCWQG for drinking water.

Table 7.6-3
Morrison Copper/Gold Project:Physical Parameters, Concentrations of Major Ions, Nutrients, and Total Organic Carbon in Groundwater at the Morrison Property

Parameter	Units	Minimum	Average[1]	Maximum	BCWQG (DW)[2]	BCWQG (FAL)[3]	CCME (FAL)[4]
Physical Parameters							
Anion Sum	me/L	3.6	6.50	9.7	ng	ng	ng
Cation Sum	me/L	3.3	6.32	9.7	ng	ng	ng
Cation - Anion Balance	%	-8	-1.08	3.1	ng	ng	ng
Hardness (as $CaCO_3$)	mg/L	12.8	**212.40**	**1040**	200	ng	ng
Colour, True	CU	<5	8.86	**58.4**	<15 TCU	A	narrative
Conductivity	µS/cm	307	**974.65**	**4,330**	700	ng	ng
pH	pH	7.38	8.21	***12.1***	6.5-8.5	ng	6.5 - 9.0
Total Dissolved Solids	mg/L	150	**571.28**	**3360**	500	ng	ng
Total Suspended Solids	mg/L	<3.0	627.84	11,100	ng	B	B
Turbidity	NTU	0.69	**294.11**	**>4000**	5 NTU	B	ng
Anions and Nutrients							
Ammonia as N	mg/L	<0.005	*0.09*	*0.619*	ng	C	0.019 (un-ionized)
Acidity (as $CaCO_3$)	mg/L	<1.0	7.53	78.7	ng	ng	ng
Alkalinity, Bicarbonate (as $CaCO_3$)	mg/L	<1.0	309.17	1,660	ng	ng	ng
Alkalinity, Carbonate (as $CaCO_3$)	mg/L	<1.0	16.79	278	ng	ng	ng
Alkalinity, Hydroxide (as $CaCO_3$)	mg/L	<1.0	44.08	850	ng	ng	ng
Alkalinity, Total (as $CaCO_3$)	mg/L	136	361.32	1,660	ng	ng	ng
Bromide (Br)	mg/L	<0.05	<0.3	<5.0	ng	ng	ng
Chloride (Cl)	mg/L	<0.5	4.75	30	250	600	ng
Fluoride (F)	mg/L	0.08	0.49	**1.87**	1.5	D	ng
Sulfate (SO4)	mg/L	2.56	127.17	**1060**	500	100E	ng
Nitrate (as N)	mg/L	<0.005	<0.04	<0.5	10	200	2.9
Nitrite (as N)	mg/L	<0.001	0.004	*0.13*	1	F	0.06
Total Kjeldahl Nitrogen	mg/L	<0.05	0.64	3.77	ng	ng	ng
Total Nitrogen	mg/L	<0.05	0.65	3.8	ng	ng	ng
Total Phosphate as P	mg/L	<0.002	0.70	15.1	n/a[5]	n/a[6]	ng
Total Organic Carbon	mg/L	<0.5	**23.08**	**213**	4	G	ng

Note:

Bold = exceeds the BC Water Quality Guidelines for Drinking Water (BCWQG - DW).

Underline = exceeds the BC Water Quality Guidelines for Freshwater Aquatic Life (BCWQG - FAL).

***italic* = exceeds the CCME guidelines for Freshwater Aquatic Life (CCME - FAL).**

1. Average is calculated using half of the detection limit when the result was below it.

2. BCWQG - DW = British Columbia Water Quality Guidelines for Drinking Water (source:http://www.env.gov.bc.ca/wat/wq/BCguidelines/approv_wq_guide/approved.html).

3. BCWQG - FAL = Approved and Working BC Water Quality Guidelines for Freshwater Aquatic Life (source: http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html).

4. CCME - FAL = CCME Water Quality Water Quality Guidelines for Freshwater Aquatic Life (source: http://www.ccme.ca/publications/ceqg_rcqe.html?category_id=124).

5. There is no guideline for Total Phosphate in rivers and streams (0.01 mg/L in lakes).

6. There is no guideline for Total Phosphate, only in salmon predominant lakes (0.005 to 0.015 mg/L).

A = 30-day average transmission of white light >80% of background.

B = depends on background values.

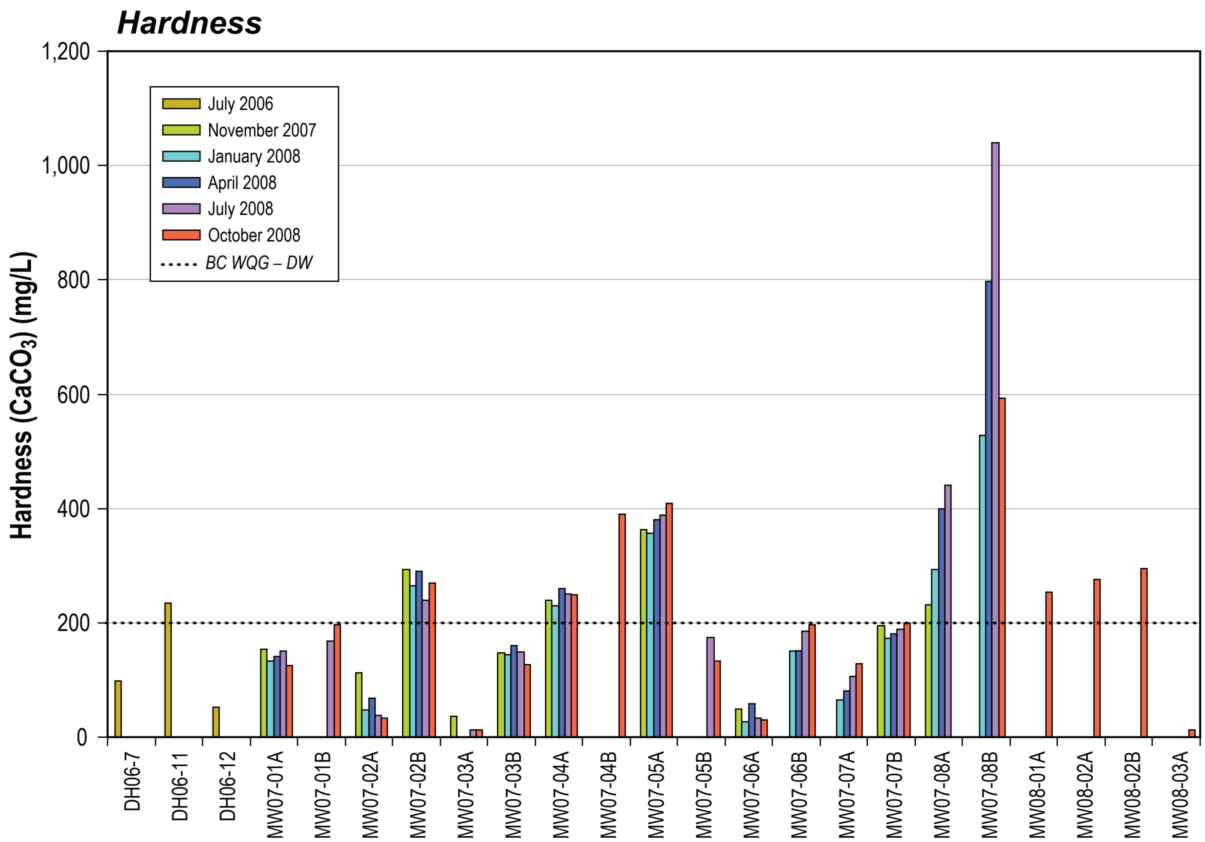
C = depends on field Temperature and pH.

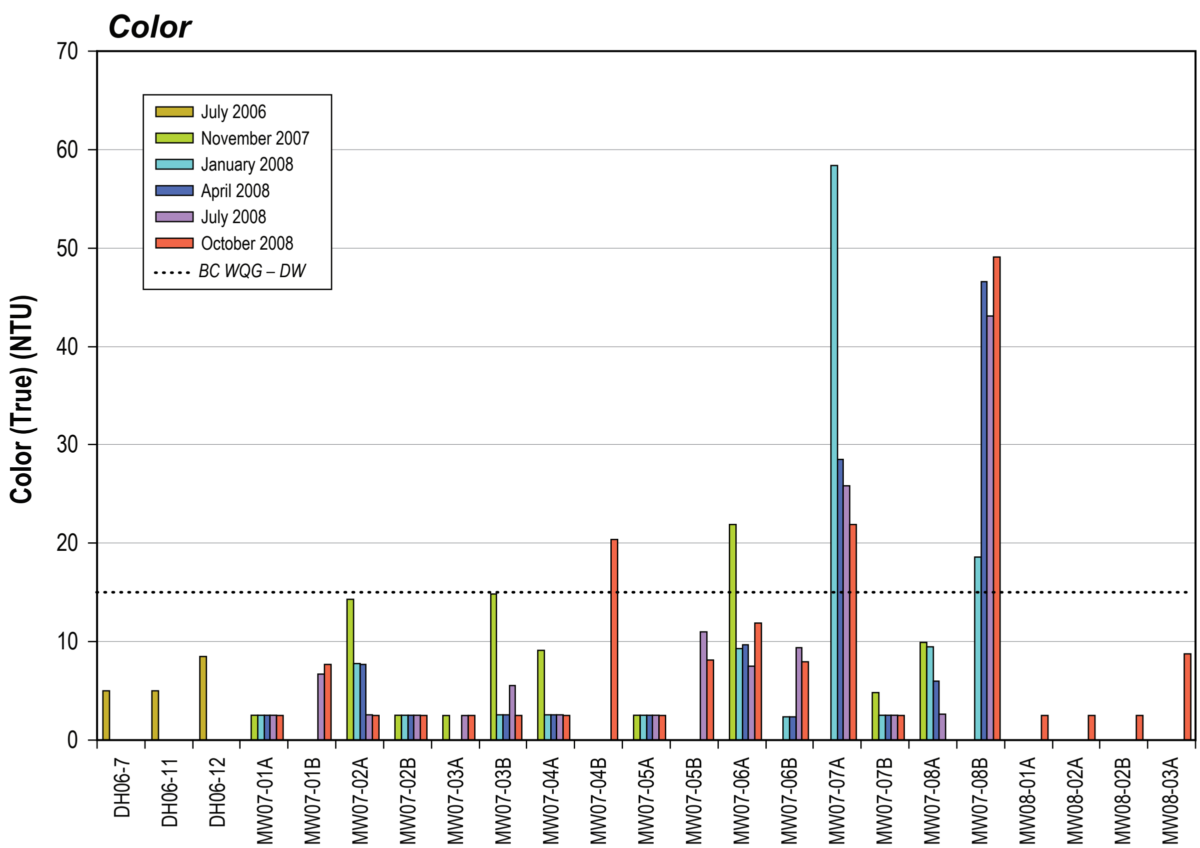
D = Fluoride BC Max 0.2mg/L when at <50mg/L [$CaCO_3$], 0.3mg/L at ≥50mg/L [$CaCO_3$] .

E = Sulphate BC Max alert to monitor aquatic moss at 50mg/L.

F = Nitrite BC Max 0.06mg/L and 30d mean 0.02 mg/L for Cl<2mg/L. BC Max nitrite 0.12 mg/L and 30d mean 0.04 mg/L for Cl 2-4 mg/L.

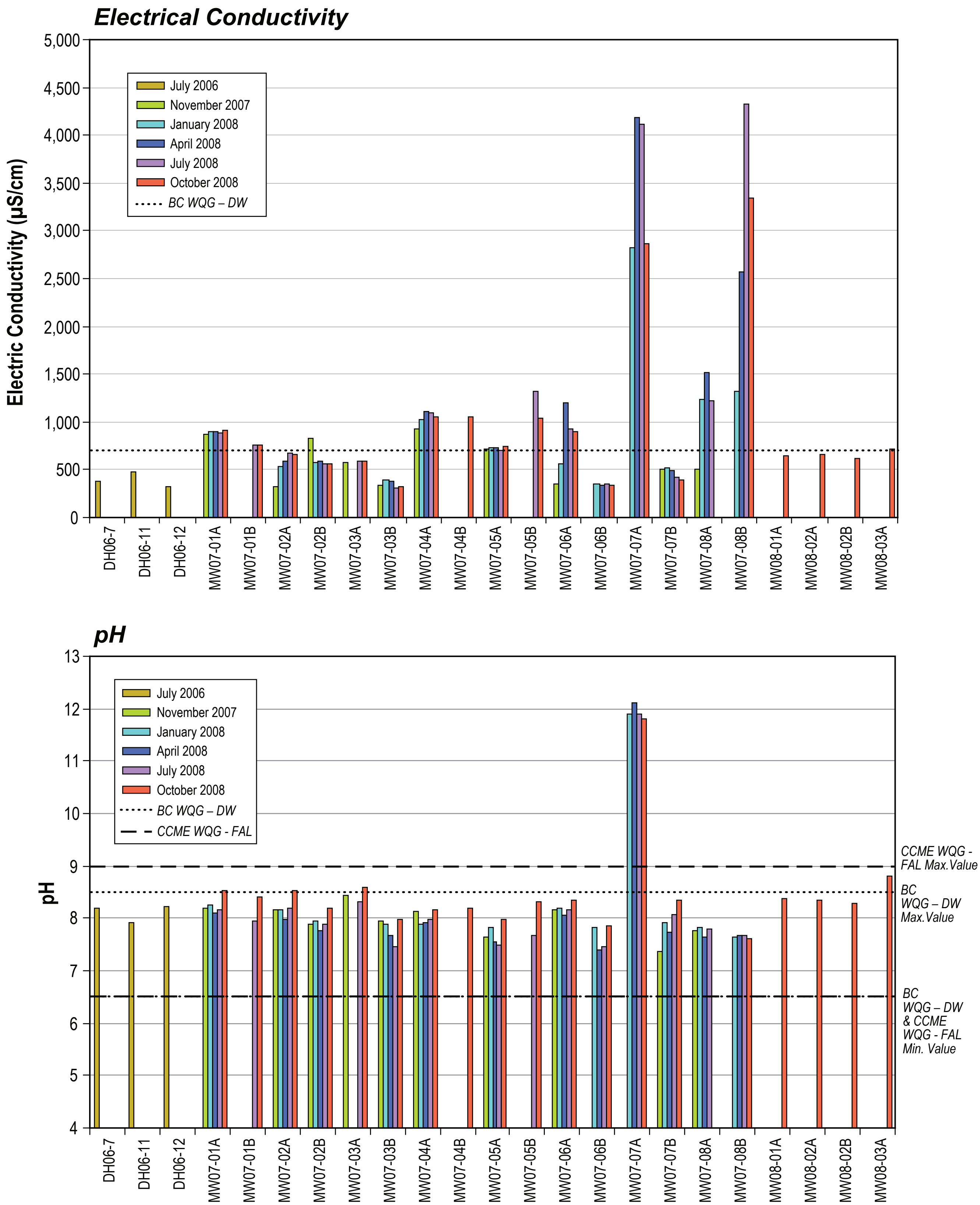
G = 30 day median + 20% of median background concentration.





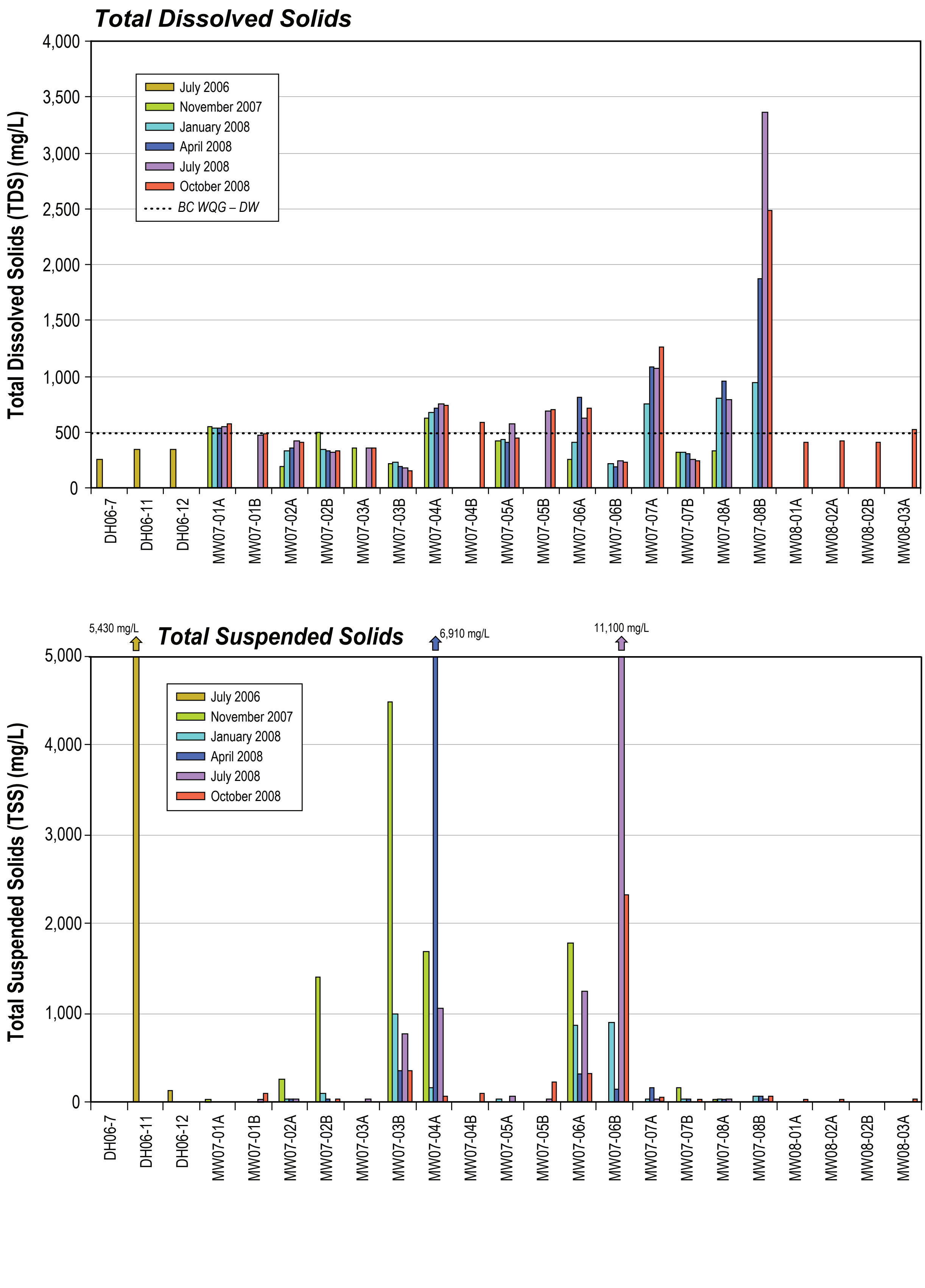
Morrison Copper/Gold Project: Hardness and Colour

FIGURE 7.6-3



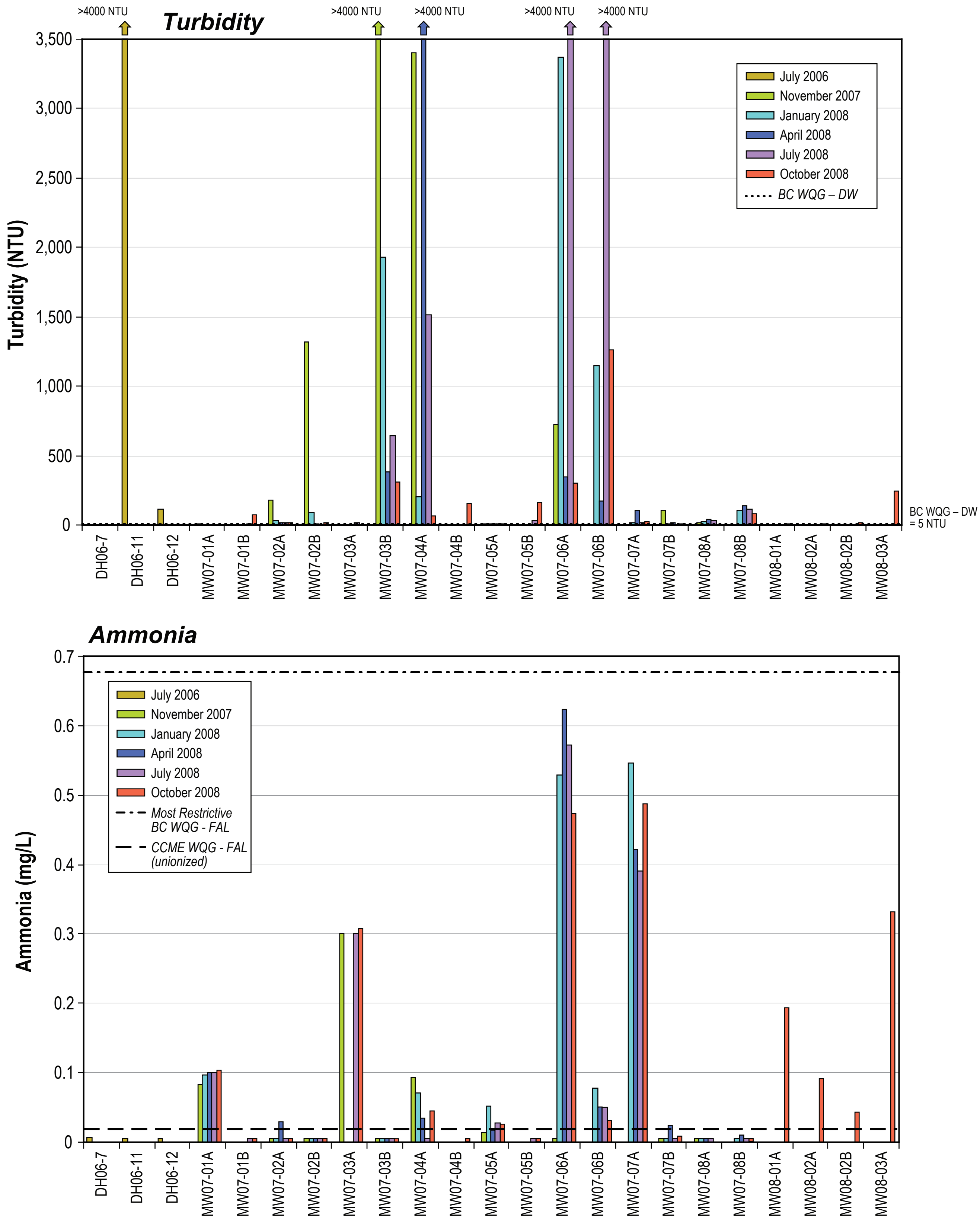
Morrison Copper/Gold Project: Electrical Conductivity and pH

FIGURE 7.6-4



Morrison Copper/Gold Project: Total Dissolved Solids and Total Suspended Solids

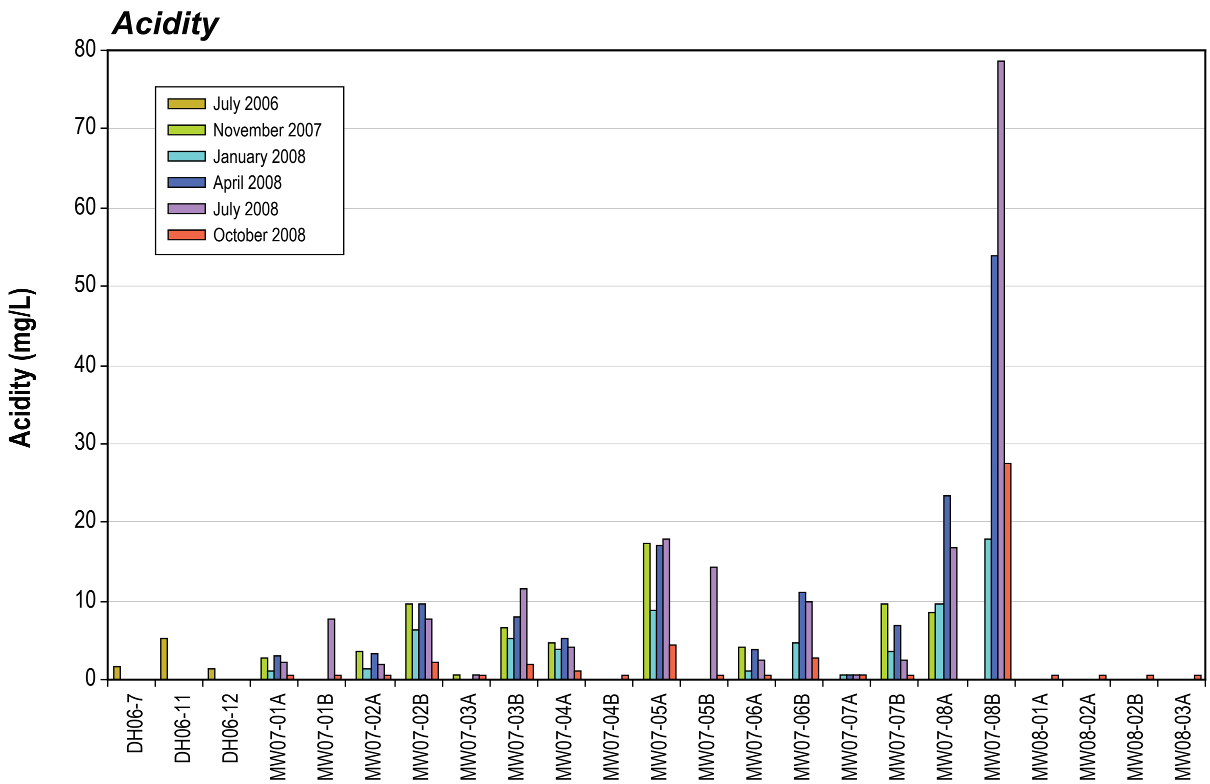
FIGURE 7.6-5



Note: All ammonia was assumed un-ionized (guideline 0.019 mg/L)

FIGURE 7.6-6

Morrison Copper/Gold Project: Turbidity and Ammonia



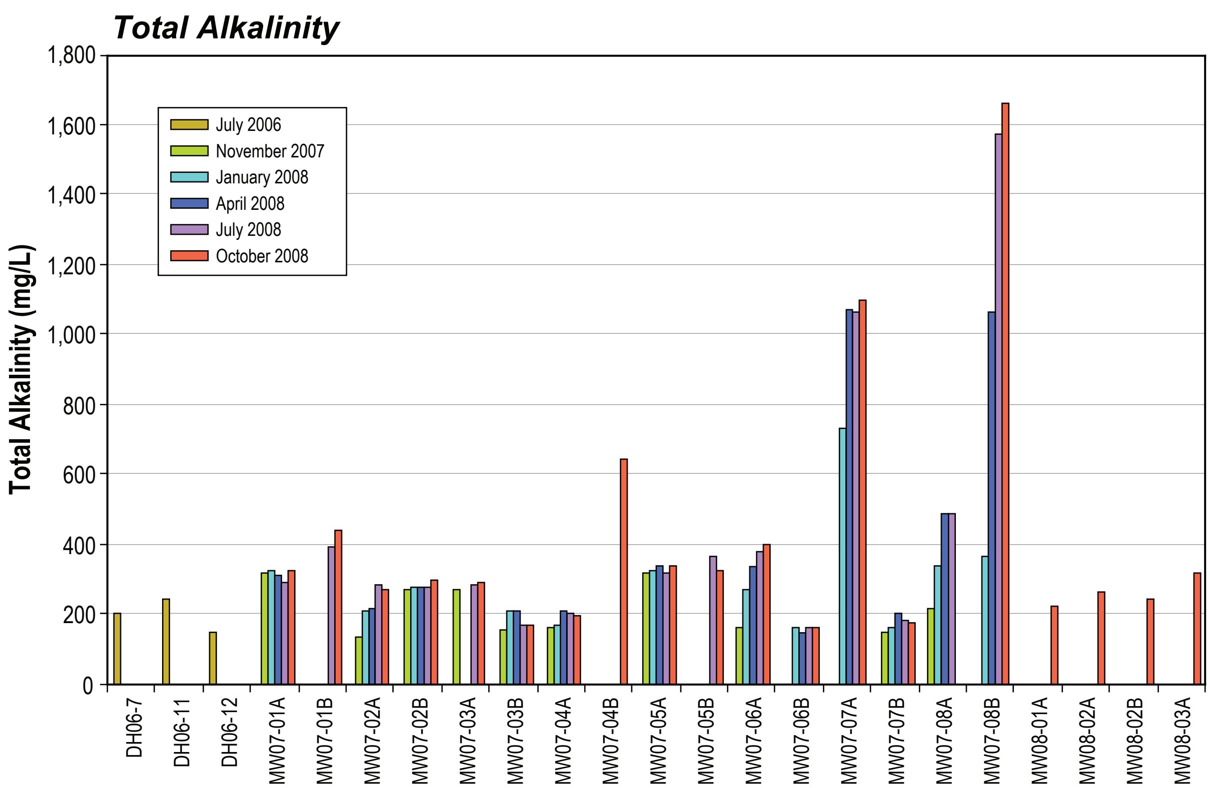
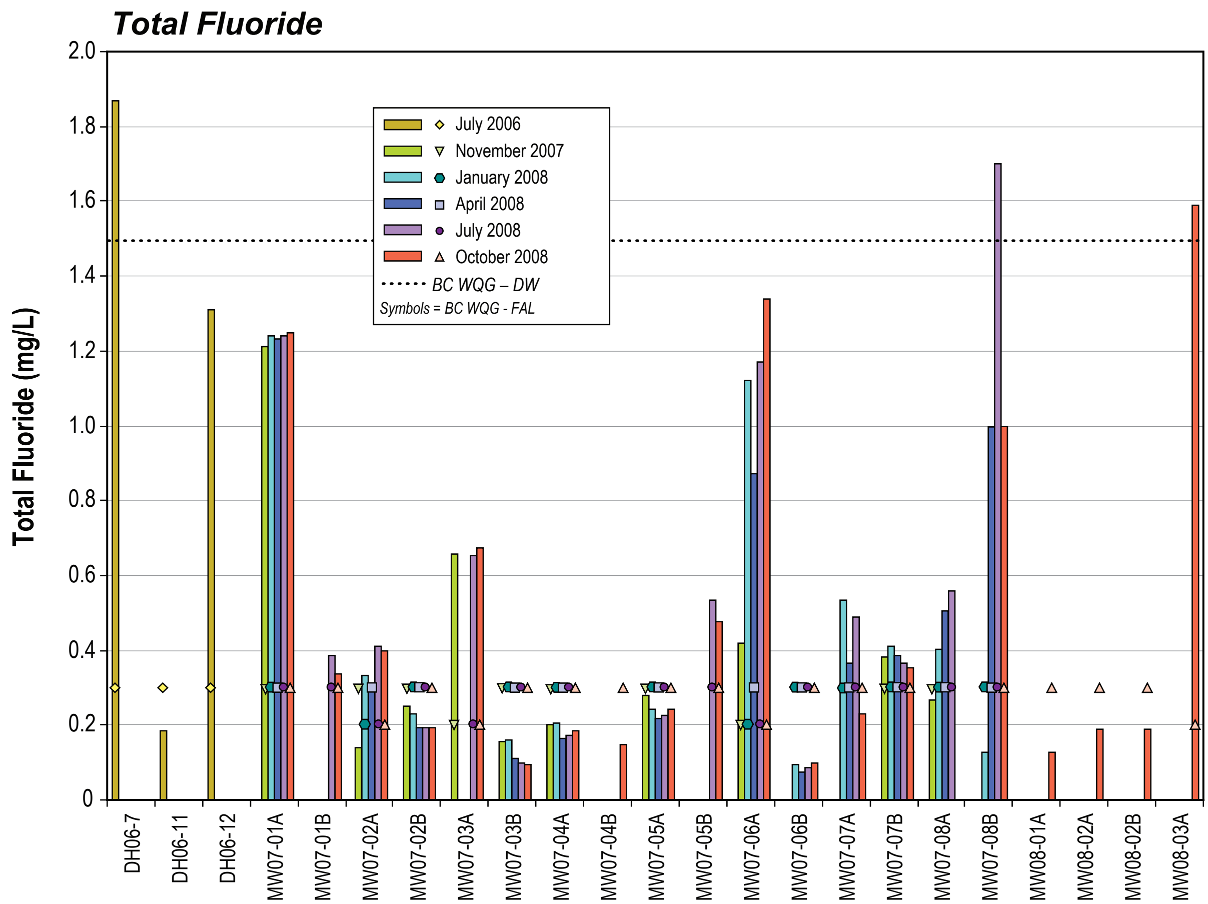


FIGURE 7.6-7

Morrison Copper/Gold Project: Total Acidity and Total Alkalinity



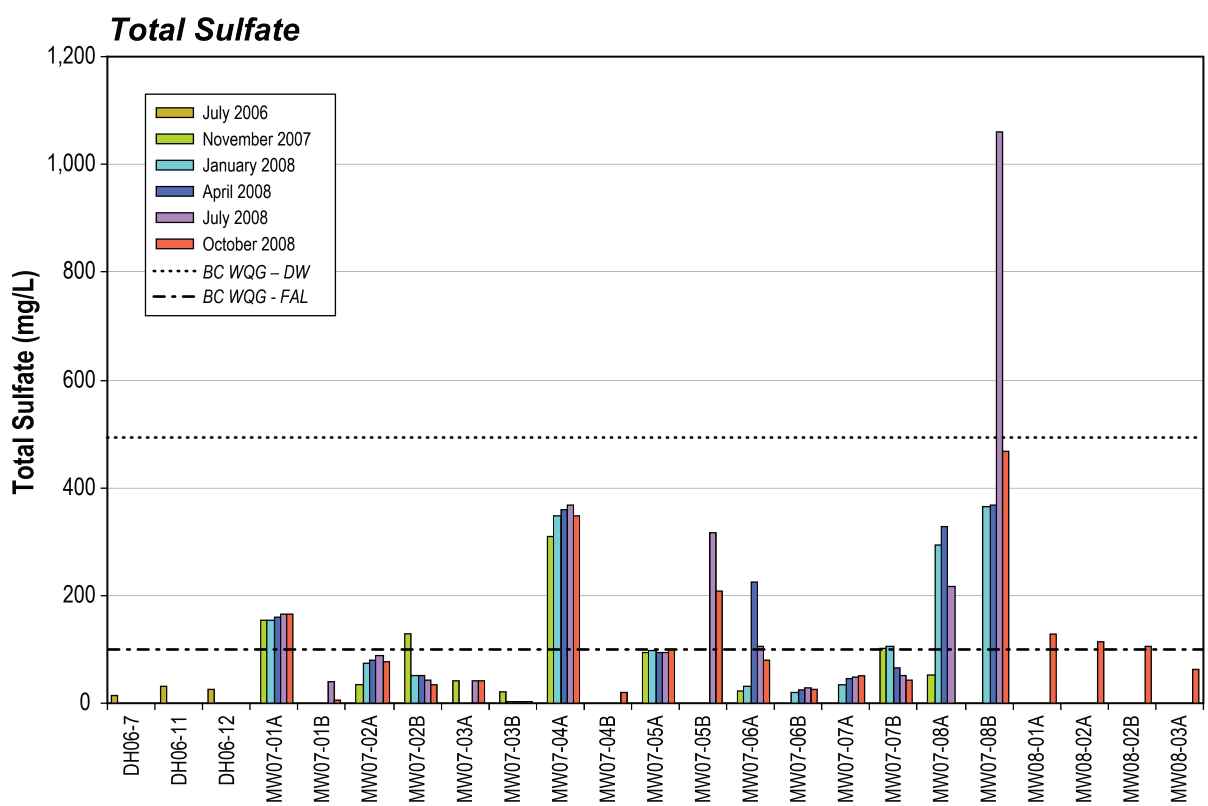
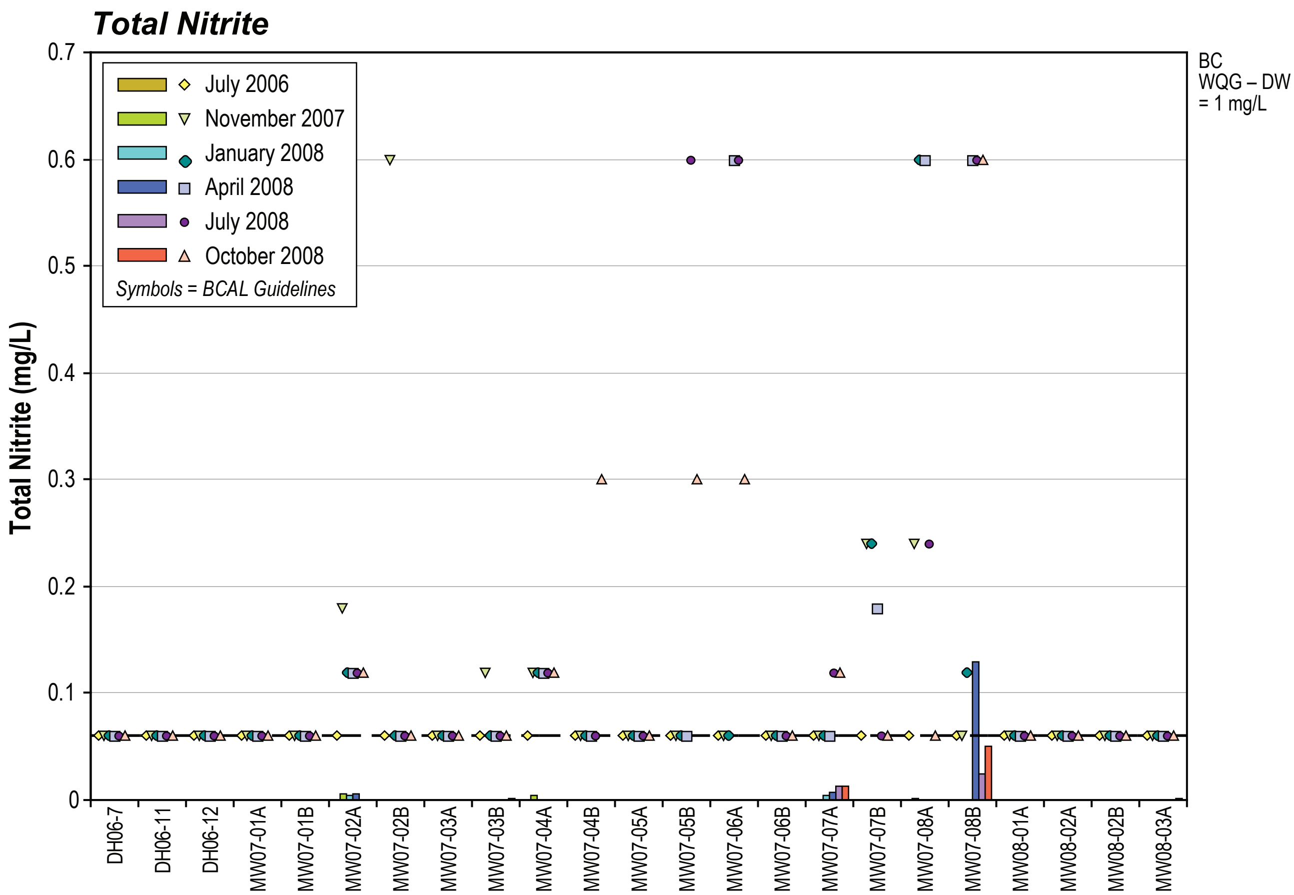


FIGURE 7.6-8

Morrison Copper/Gold Project: Total Fluoride and Total Sulfate



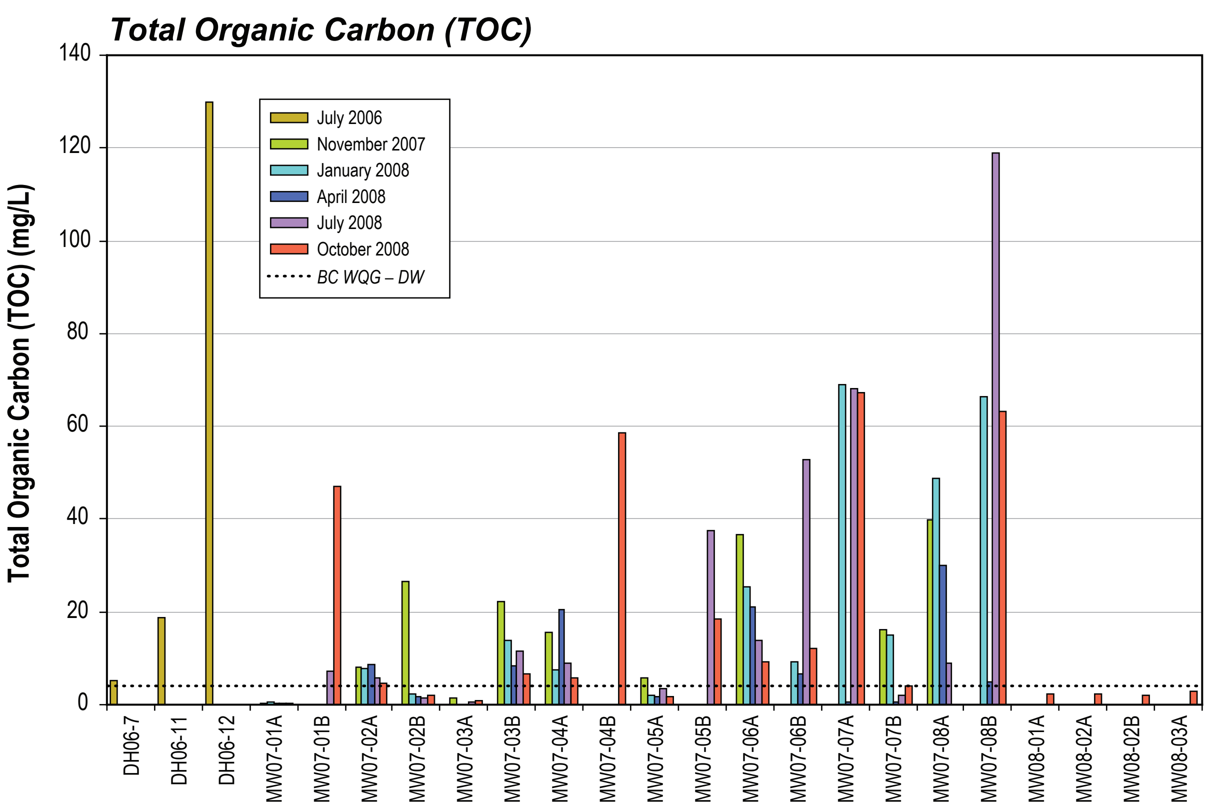


FIGURE 7.6-9

Morrison Copper/Gold Project: Total Nitrite and Total Organic Carbon (TOC)

7.6.3.2 Total and Dissolved Metals in Groundwater

The metals for which there were exceedances of one or more of the three guidelines throughout the sampling program are: aluminum (total and dissolved), antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron (total and dissolved), lead, manganese, mercury, nickel, selenium, silver, sodium, thallium, titanium, uranium, and zinc. The total and dissolved metals statistics for the Morrison property are presented in Table 7.6-4, and the metals concentrations for which one or more of the three guidelines were exceeded are illustrated in figures 7.6-10 to 7.6-22.

Aluminum

Total aluminum concentrations in the Morrison property groundwater samples varied from less than 0.001 (MW07-01A) to 98 mg/L (MW07-06B). Total aluminum exceeded the CCME WQG for the protection of freshwater aquatic life for 54 groundwater samples collected from 18 groundwater wells. Dissolved aluminum concentrations ranged from below the detection limits (in multiple wells) to 2.98 mg/L (MW07-07A). Dissolved aluminum concentrations exceeded the BCWQG for drinking water in 13 samples collected from 5 different wells. Dissolved aluminum concentrations exceeded the BCWQG of 0.1 mg/L for the protection of freshwater aquatic life in 18 groundwater samples from 7 monitoring wells. The results indicate that clay particles may have a great influence on the high content of total aluminum in most of the wells, specifically those with screened intervals located in the glacial till sediments. Figure 7.6-10 shows the total and dissolved aluminum concentrations in groundwater at the Morrison property.

Antimony

Total antimony concentrations varied between less than 0.0001 (in multiple wells) and 0.0205 mg/L (MW07-07B). The total antimony concentrations exceeded the BCWQG for drinking water of 0.006 mg/L in three samples taken from two monitoring wells. The total antimony concentrations exceeded the BCWQG for freshwater aquatic life of 0.02 mg/L in only one groundwater sample from MW07-07B.

Arsenic

Total arsenic concentrations in groundwater samples varied from less than 0.0002 (in multiple wells) to 0.318 mg/L (MW07-06B). Total arsenic concentrations exceeded the BCWQG of 0.025 mg/L for drinking water in 20 samples collected from 8 monitoring wells. The BCWQG (0.005 mg/L) and the CCME WQG (0.005 mg/L) for the protection of freshwater aquatic life for total arsenic were exceeded in 54 samples taken from 19 monitoring wells. Figure 7.6-11 shows the concentrations of total antimony and arsenic in groundwater from monitoring wells at the Morrison property.

Barium

Total barium concentration measured in groundwater from monitoring wells varied from 0.0122 (MW07-01A) and 2.58 mg/L (DH06-11). The BCWQG of 1 mg/L for drinking water was exceeded for total barium in three groundwater samples obtained from three different monitoring wells. No groundwater samples exceeded the BCWQG for the protection of freshwater aquatic life. There is no CCME WQG for the protection of freshwater aquatic life for total barium.

Table 7.6-4
Morrison Copper/Gold Project: Total and Dissolved Metals Concentrations in Groundwater at the Morrison Property

	Units	Count	Total Metals Minimum	Total Metals Average[1]	Total Metals Maximum	BCWQG (DW)[2] Total (maximum)	# Exceedances	BCWQG (FAL)[3] Total (Maximum)	# Exceedances	CCME (FAL)[4] Total (Maximum)	# Exceedances	Count	Dissolved Metals Minimum	Dissolved Metals Average[1]	Dissolved Metals Maximum	BCWQG (DW)[2] Dissolved (maximum)	# Exceedances	BCWQG (FAL)[3] Dissolved (Maximum)	# Exceedances	CCME (FAL)[4] Dissolved (Maximum)	# Exceedances
Aluminum	mg/L	71	<0.001	*10.87*	*98*	ng	-	ng	-	0.005-0.100 H	54	71	<0.001	**0.232**	**2.98**	0.2	13	0.1U	18	ng	-
Antimony	mg/L	71	<0.0001	0.0017	**0.0205**	0.006	3	0.02	1	ng	-	71	<0.0001	0.001	0.0234	ng	-	ng	-	ng	-
Arsenic	mg/L	71	<0.0002	***0.028127***	***0.318***	0.025	20	0.005	54	0.005	54	71	<0.0002	0.011	0.119	ng	-	ng	-	ng	-
Barium	mg/L	71	0.0122	0.272	**2.58**	1	3	5	0	ng	-	71	0.0123	0.10	0.498	ng	-	ng	-	ng	-
Beryllium	mg/L	71	<0.0005	0.000747	<0.005	ng	-	0.0053	0	ng	-	71	<0.0005	0.001	<0.005	ng	-	ng	-	ng	-
Bismuth	mg/L	71	<0.0005	BDL	<0.005	ng	-	ng	-	ng	-	71	<0.0005	BDL	<0.005	ng	-	ng	-	ng	-
Boron	mg/L	71	<0.01	0.096	0.423	5	0	1.2	0	ng	-	71	<0.01	0.091	0.406	ng	-	ng	-	ng	-
Cadmium	mg/L	71	<0.000017	*0.000823*	***0.0158***	0.005	2	N	54	N	54	71	<0.000017	0.00010	0.00076	ng	-	ng	-	ng	-
Calcium	mg/L	71	3.09	64.75	318	ng	-	ng	-	ng	-	71	2.38	54.33	268	ng	-	ng	-	ng	-
Chromium	mg/L	71	<0.0005	*0.020*	***0.213***	0.05	7	0.001	47	I	47	71	<0.0005	0.001	0.0128	ng	-	ng	-	ng	-
Cobalt	mg/L	71	<0.0001	0.0145	0.15	ng	-	0.11	2	ng	-	71	<0.0001	0.002	0.0296	ng	-	ng	-	ng	-
Copper	mg/L	71	0.00013	*0.1060*	***3.06***	0.5	2	O	31	J	42	71	<0.0001	0.002	0.021	ng	-	ng	-	ng	-
Iron	mg/L	71	0.044	***19.6892***	***201***	0.3	58	1	40	0.3	58	71	<0.03	0.623	11.1	ng	-	0.35	23	ng	-
Lead	mg/L	71	<0.00005	***0.010524***	***0.194***	0.01	13	P	2	K	27	71	<0.00005	0.00015	0.00119	ng	-	ng	-	ng	-
Lithium	mg/L	71	<0.005	0.037475	0.233	ng	-	5	0	ng	-	71	<0.005	0.032	0.242	ng	-	ng	-	ng	-
Magnesium	mg/L	71	1.06	22.76	85.5	ng	-	ng	-	ng	-	71	<0.025	18.63	90.5	500	0	ng	-	ng	-
Manganese	mg/L	71	0.00456	**1.73**	**12.6**	0.05	60	Q	12	ng	-	71	0.0019	1.22	12	ng	-	ng	-	ng	-
Mercury	mg/L	71	<0.00001	*0.000159*	***0.0054***	0.001	3	0.0001	7	L	14	71	<0.00001	0.00001	0.0001	ng	-	ng	-	ng	-
Molybdenum	mg/L	71	0.000783	0.0116	0.0475	0.25	0	2	0	0.073	0	71	0.000502	0.011	0.0468	ng	-	ng	-	ng	-
Nickel	mg/L	71	<0.0005	0.028	*0.372*	ng	-	M	7	M	7	71	<0.0005	0.004	0.0302	ng	-	ng	-	ng	-
Phosphorus	mg/L	71	<0.3	0.576	7.43	ng	-	ng	-	ng	-	71	<0.3	0.16	0.61	ng	-	ng	-	ng	-
Potassium	mg/L	71	0.175	4.03	14.1	ng	-	ng	-	ng	-	71	0.17	2.79	13.3	ng	-	ng	-	ng	-
Selenium	mg/L	71	<0.0001	0.00083	*0.0069*	0.01	0	0.002 R	6	0.001	18	71	<0.0001	0.00047	0.00377	ng	-	ng	-	ng	-
Silicon	mg/L	71	3.67	18.77	170	ng	-	ng	-	ng	-	71	2.4	5.23	10.4	ng	-	ng	-	ng	-
Silver	mg/L	71	<0.00001	0.0011	*0.0545*	ng	-	S	10	0.0001	24	71	<0.00001	0.00002	0.00016	ng	-	ng	-	ng	-
Sodium	mg/L	71	3.8	123.08	**849**	200	11	ng	-	ng	-	71	3.6	123.70	870	ng	-	ng	-	ng	-
Strontium	mg/L	71	0.0586	0.6215	3.45	ng	-	ng	-	ng	-	71	0.0398	0.56	3.16	ng	-	ng	-	ng	-
Thallium	mg/L	71	<0.0001	0.00036	*0.0064*	ng	-	0.0003	13	0.0008	5	71	<0.0001	0.00014	<0.0001	ng	-	ng	-	ng	-
Tin	mg/L	71	<0.0001	0.00113	0.0108	ng	-	ng	-	ng	-	71	<0.0001	0.00040	0.0046	ng	-	ng	-	ng	-
Titanium	mg/L	71	<0.01	0.16	2.67	ng	-	0.1	22	ng	-	71	<0.01	0.007	0.028	ng	-	ng	-	ng	-
Uranium	mg/L	71	0.000024	0.0034	**0.0454**	0.02	2	0.3	0	ng	-	71	0.000023	0.002	0.0293	ng	-	ng	-	ng	-
Vanadium	mg/L	71	<0.001	0.041	0.451	ng	-	ng	-	ng	-	71	<0.001	0.003	0.0316	ng	-	ng	-	ng	-
Zinc	mg/L	71	<0.001	*0.110*	*1.67*	5	0	T	18	0.03	29	71	<0.001	0.007	0.074	ng	-	ng	-	ng	-

Note:

All measurements are in unit mg/L.

Bold = exceeds the BC Water Quality Guidelines for Drinking Water (BCWQG - DW).

Underline = exceeds the BC Water Quality Guidelines for Freshwater Aquatic Life (BCWQG - FAL).

***italic* = exceeds the CCME guidelines for Freshwater Aquatic Life (CCME - FAL).**

1. Average is calculated using half of the detection limit when the result was below it.

2. BCWQG - DW = British Columbia Water Quality Guidelines for Drinking Water (source:http://www.env.gov.bc.ca/wat/wq/BCguidelines/approv_wq_guide/approved.html).

3. BCWQG - FAL = Approved and Working BC Water Quality Guidelines for Freshwater Aquatic Life (source: http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html).

4. CCME - FAL = CCME Water Quality Water Quality Guidelines for Freshwater Aquatic Life (source: http://www.ccme.ca/publications/ceqg_rcqe.html?category_id=124).

5. BDL = Below Detection Limit.

H = CCME aluminum guideline=0.005 mg/L at pH<6.5; [Ca2+] <4 mg/L; DOC<2 mg/L, 0.1 mg/L at pH ≥ 6.5; [Ca2+] ≥ 4 mg/L; DOC ≥ 2 mg/L.

I = CCME chromium guideline = 0.001 mg/L (Cr VI), or 0.0089 (Cr III) which is interim.

J = CCME guideline for copper = 0.002 mg/L at 0-120 mg/L [$CaCO_3$], 0.003mg/L at 120 - 180 mg/L [$CaCO_3$], 0.004 mg/L at > 180 mg/L [$CaCO_3$].

K = CCME guideline for lead = 0.001 mg/L for [$CaCO_3$]=0-60 mg/L, 0.002 mg/L for [$CaCO_3$]=60-120 mg/L, 0.004 mg/L for [$CaCO_3$]=120-180 mg/L, 0.007 mg/L for [$CaCO_3$] >180 mg/L.

L = CCME guideline for mercury 0.000026 mg/L inorganic Hg, 0.000004 mg/L MeHg.

M = CCME and BC aquatic life guideline for nickel = 0.025 mg/L at 0-60 mg/L [$CaCO_3$], 0.065mg/L at 60 - 120 mg/L [$CaCO_3$], 0.110 mg/L at 120 - 180 mg/L [$CaCO_3$], 0.150 mg/L at > 180 mg/L [$CaCO_3$].

N = Cadmium BC max and CCME guideline = 0.001 * $10^{\{0.86[\log(hardness)] - 3.2\}}$ mg/L.

O = Copper BC Max guideline of (0.094(hardness)+2) µg/L. The 30-d mean Cu guideline is ≤ 2 µg/L for hardness ≤ 50 mg/L, and guideline is ≤ 0.04*(mean hardness) µg/L for hardness > 50mg/L.

P = Lead BC Max guideline of $e^{(1.273 \ln (hardness) - 1.460)}$ µg/L if hardness > 8mg/L; 0.003 mg/L if hardness ≤ 8mg/L. 30-day mean Pb guideline of ≤3.31 + $e^{(1.273 \ln (mean\ hardness) - 4.704)}$ µg/L for hardness > 8mg/L only. otherwise no 30-d mean guideline.

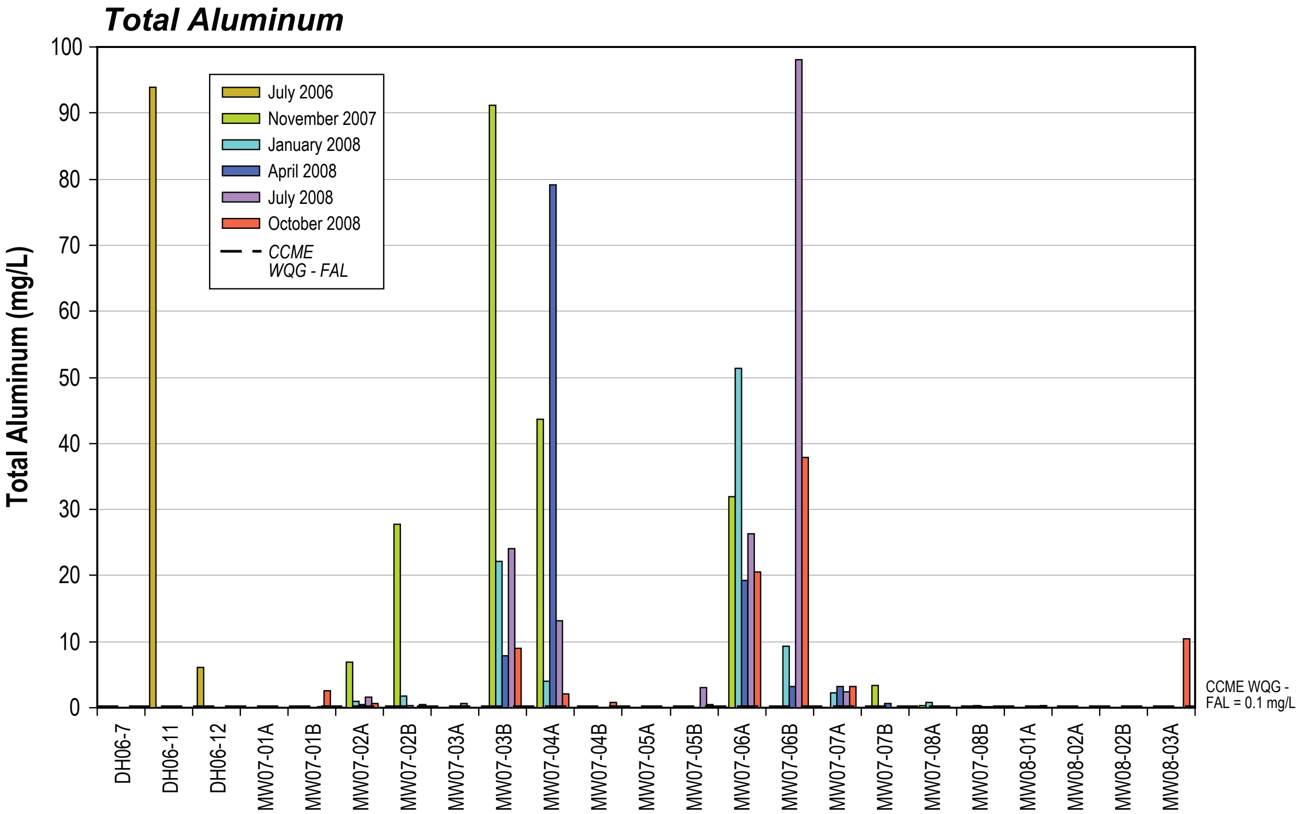
Q = Manganese BC Max guideline 0.01102(hardness)+0.54 mg/L; 30-day mean Mn guideline 0.0044(mean hardness)+0.605 mg/L.

R = selenium BC 30 day mean.

S = Max Ag guideline of 0.003 mg/L if hardness > 100mg/L, max of 0.0001mg/L if hardness ≤ 100mg/L 30-d mean Ag guideline of 0.0015 mg/L if hardness > 100mg/L, 30-d mean of 0.00005 mg/L if hardness ≤ 100mg/L.

T = Max Zn guideline = [33 + 0.75*(hardness - 90)] µg/L, minimum of 33 µg/L. 30-day mean Zn guideline = [7.5 + 0.75*(hardness - 90)] µg/L, min of 7.5 µg/L.

U = for pH ≥ 6.5, for pH < 2 dissolved Al = $e^{(1.209 - 2.426 (pH) + 0.286 K)}$ where K = (pH)2.



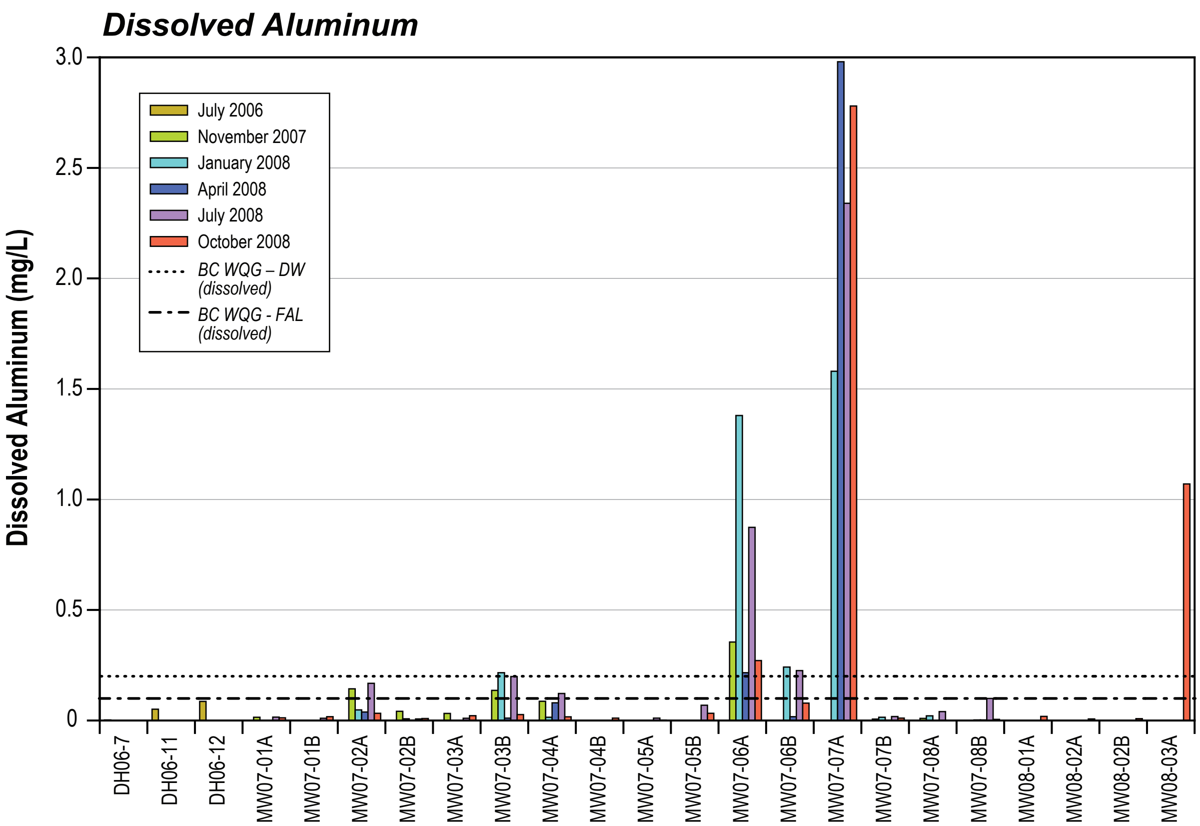
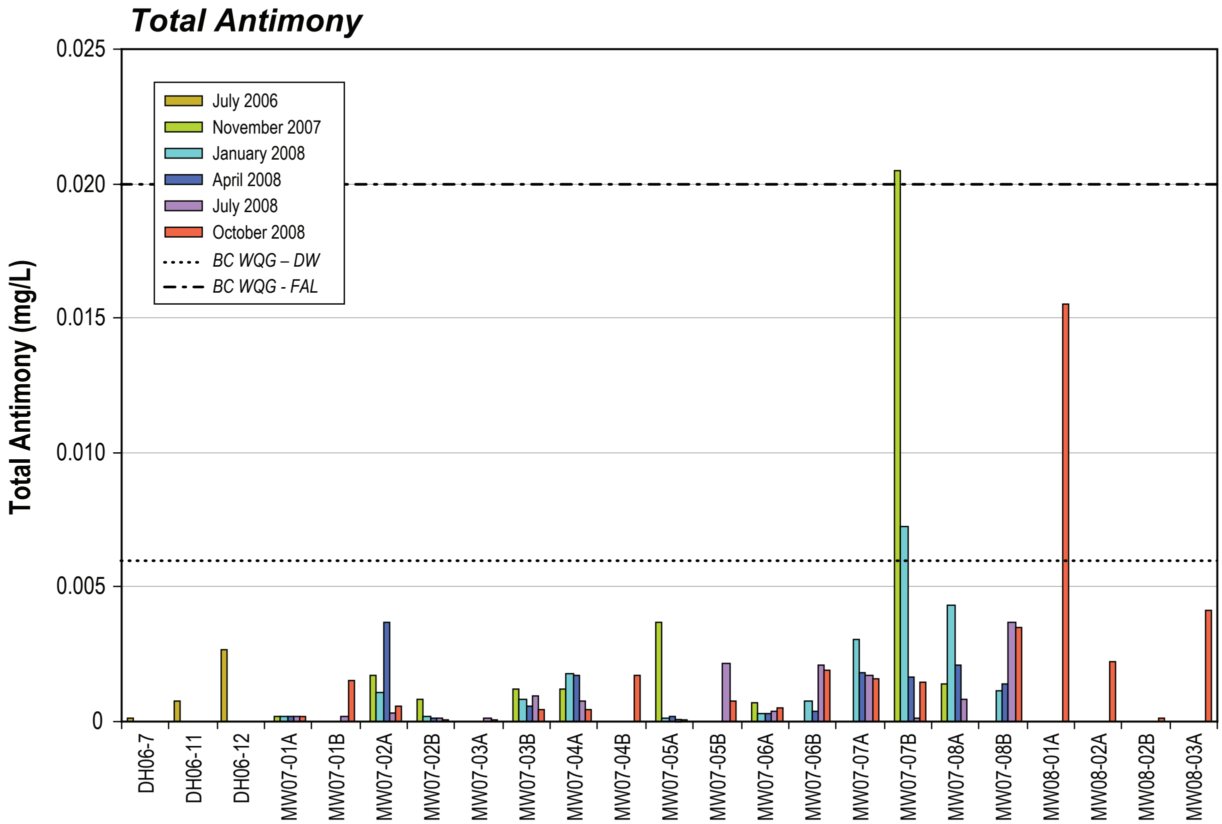
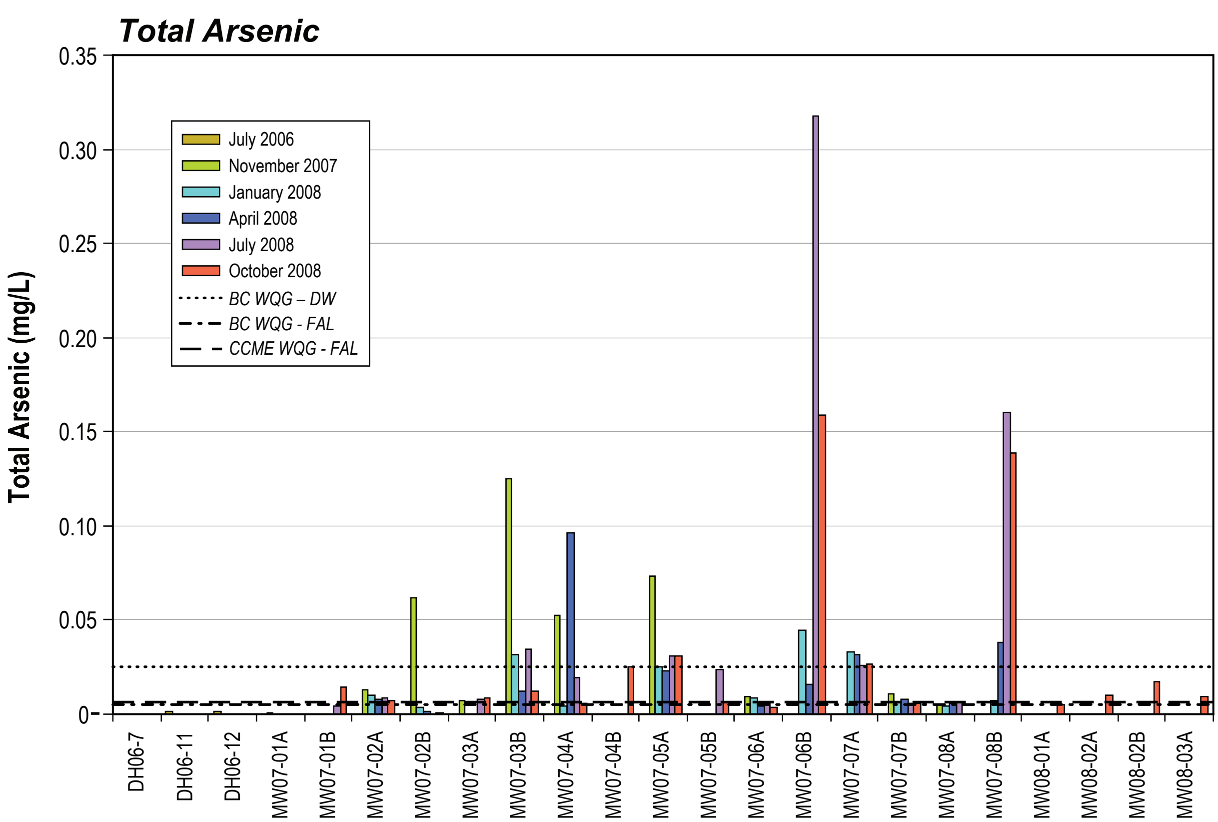


FIGURE 7.6-10

Morrison Copper/Gold Project:
Total and Dissolved Aluminum





pbm

Morrison Copper/Gold Project: Total Antimony and Total Arsenic

FIGURE 7.6-11

Rescan™

Cadmium

Total cadmium concentrations in groundwater varied from less than 0.000017 (in multiple wells) to 0.0158 mg/L (MW07-06B). Two samples exceeded the BCWQG of 0.005 mg/L for drinking water for total cadmium. These were both taken from MW07-06B. The BCWQG and CCME WQG for the protection of freshwater aquatic life are hardness dependent and were exceeded in 54 groundwater samples taken from 19 monitoring wells. The total barium and total cadmium concentrations are shown in Figure 7.6-12.

Chromium

Total chromium concentrations measured in groundwater samples taken from the Project area varied from less than 0.0005 (in multiple wells) to 0.213 mg/L (MW07-06B). Seven samples collected from five monitoring wells exceeded the BCWQG of 0.05 mg/L for drinking water for total chromium. The total chromium concentrations exceeded the BCWQG (0.001 mg/L) and CCME WQG (0.001 mg/L) for the protection of freshwater aquatic life in 47 groundwater samples collected from 18 different monitoring wells.

Cobalt

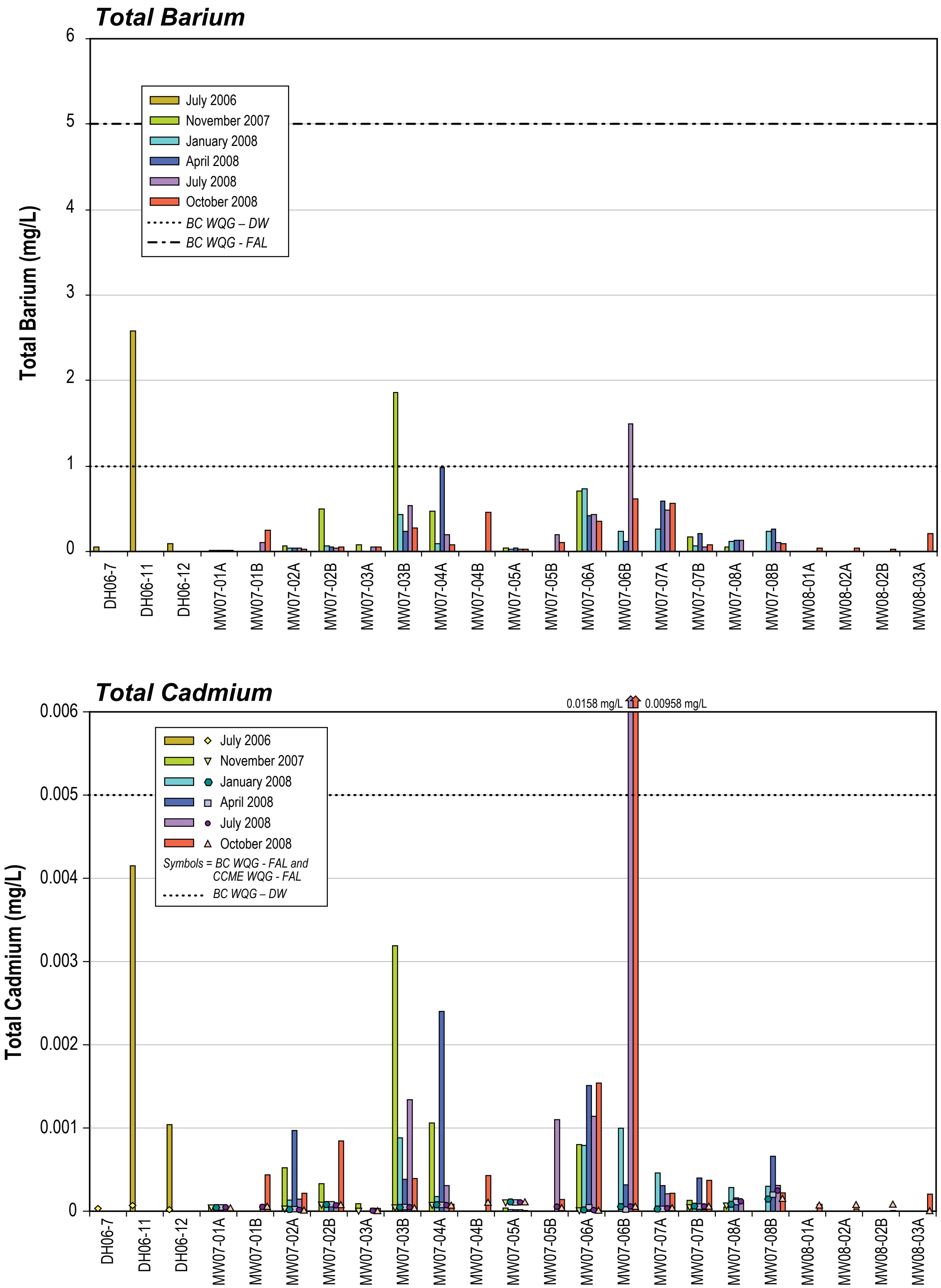
Total cobalt concentrations in monitoring well groundwater varied from less than 0.0001 (in multiple wells) to 0.15 mg/L (MW07-06B). The BCWQG of 0.11 mg/L for freshwater aquatic life for total cobalt were exceeded in only two samples taken during the baseline program. These were groundwater samples from monitoring wells DH06-11 and MW07-06B. Figure 7.6-13 shows the total chromium and total cobalt concentrations measured during the baseline program at the Morrison property.

Copper

Total copper concentrations in groundwater from the Morrison property varied from less than 0.0001 (MW07-01A) to 3.06 mg/L (MW07-06B). The BCWQG of 0.5 mg/L for drinking water was exceeded for two groundwater samples taken from monitoring wells MW07-06B. The BCWQG for freshwater aquatic life, which is hardness dependent, was exceeded for 31 samples collected from 12 monitoring wells. The CCME WQG for the protection of freshwater aquatic life, which is hardness dependent, was exceeded for 42 samples obtained from 17 monitoring wells. The total copper concentrations are shown in Figure 7.6-14.

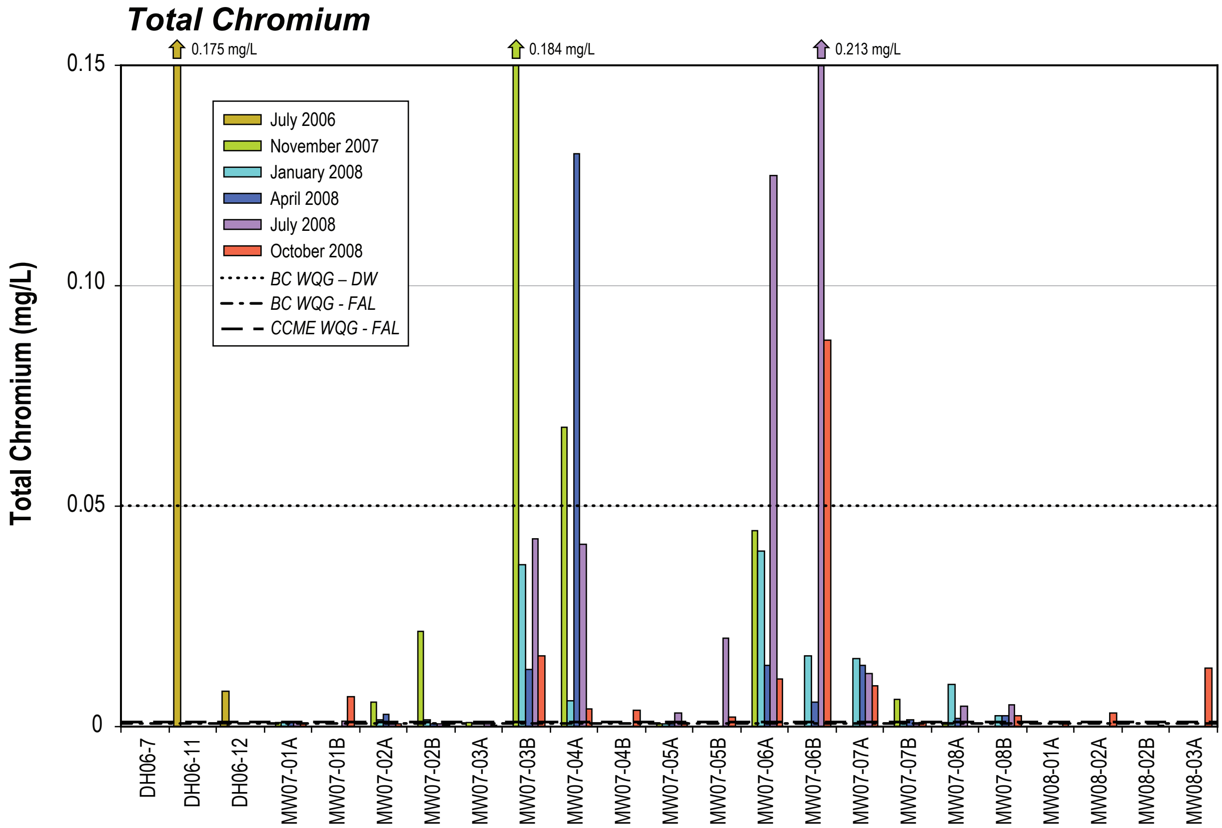
Iron

Total iron concentrations in groundwater samples collected during the baseline study varied from 0.044 (MW07-03A) to 201 mg/L (MW07-06B). The BCWQG of 0.3 mg/L for drinking water and the CCME WQG of 0.3 mg/L for the protection of freshwater aquatic life for total iron were exceeded in 58 samples collected from 21 different monitoring wells. The BCWQG of 1 mg/L for freshwater aquatic life was exceeded for total iron in 40 samples collected from 16 monitoring wells.



Morrison Copper/Gold Project: Total Barium and Total Cadmium

FIGURE 7.6-12



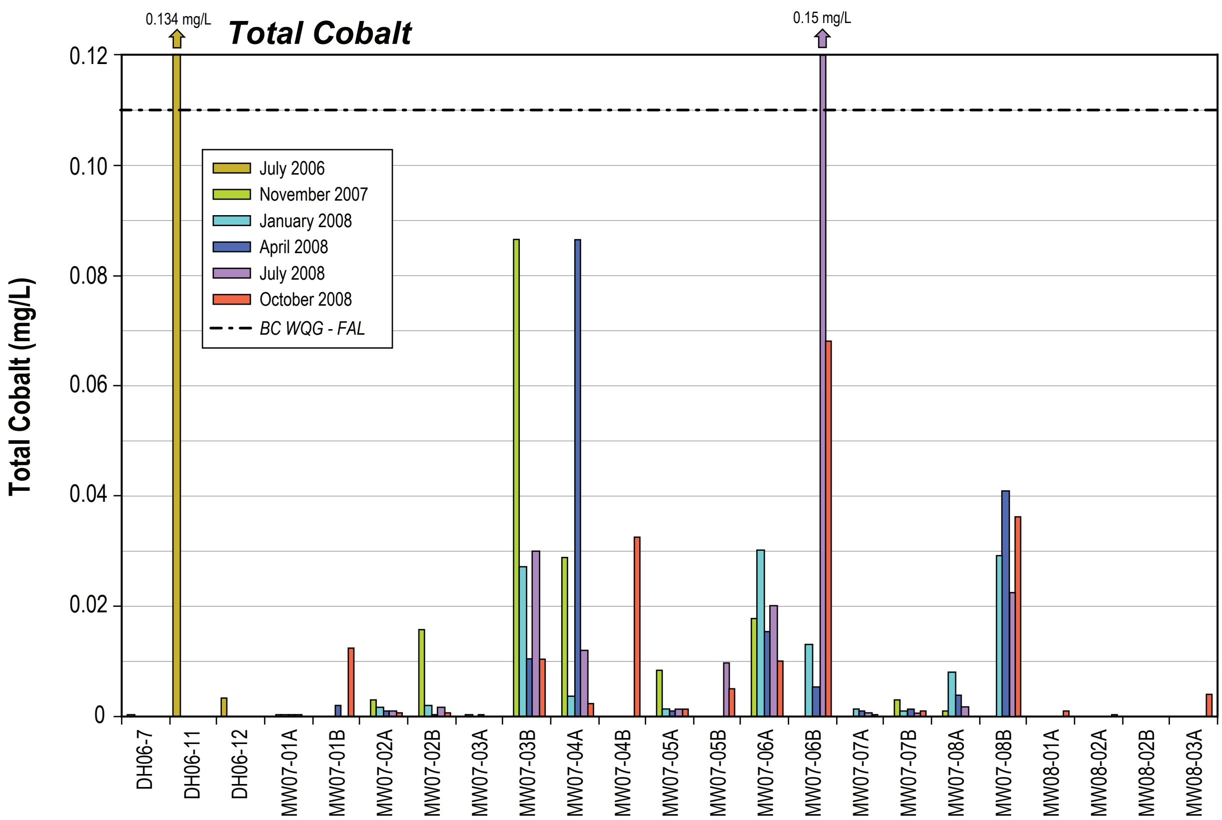
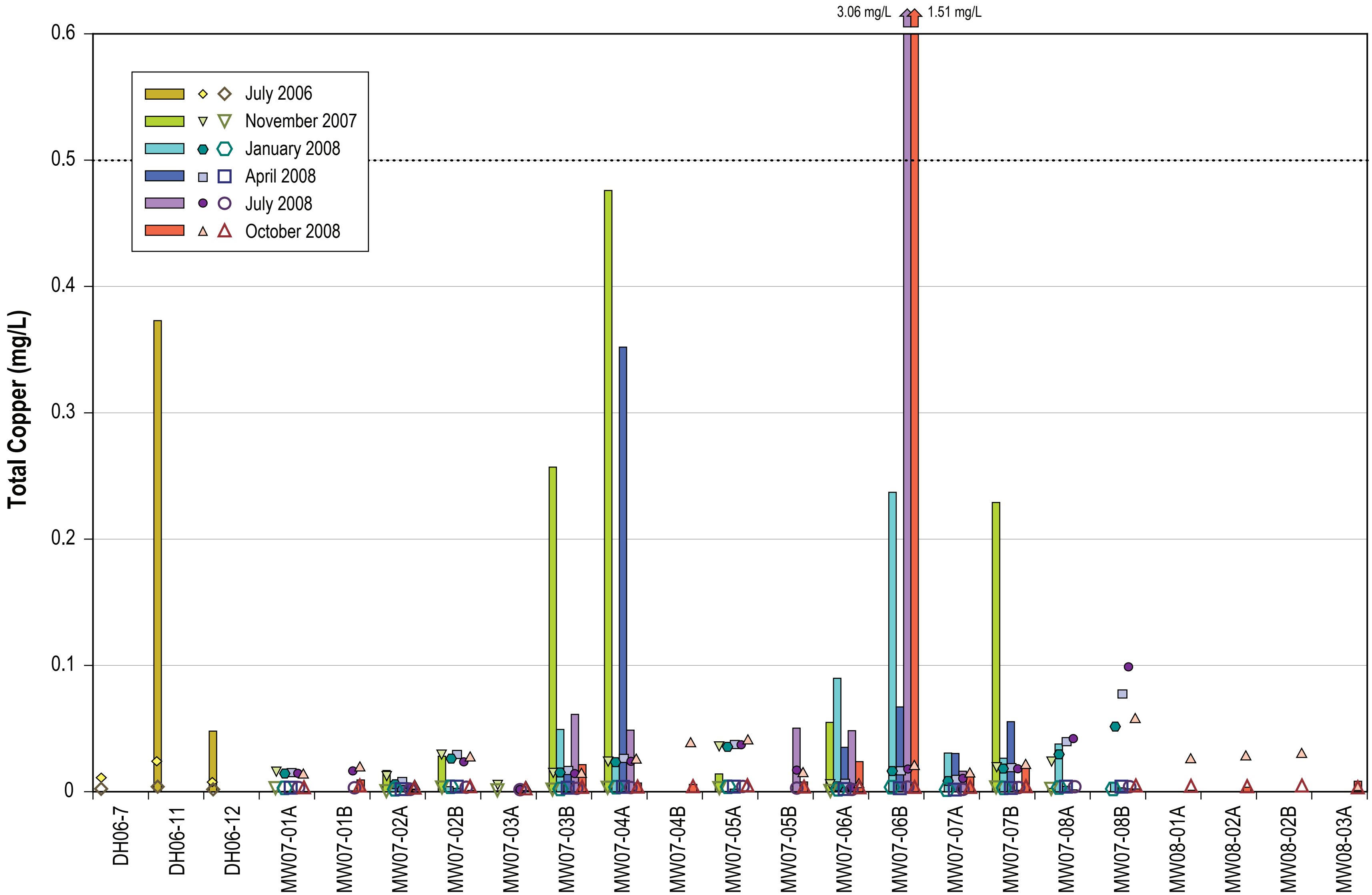


FIGURE 7.6-13

Morrison Copper/Gold Project:
Total Chromium and Total Cobalt



Notes: Dotted line represents the BC WQG – DW.
Solid symbols represent BC WQG - FAL.
Blank symbols represnt CCME WQG - FAL.

FIGURE 7.6-14

Morrison Copper/Gold Project: Total Copper

Dissolved iron concentrations in groundwater samples collected in the Project area as part of the baseline study varied from less than 0.03 (in multiple wells) to 11.1 mg/L (MW07-04B). Dissolved iron concentrations in 23 samples collected from 13 different monitoring wells exceeded the BCWQG of 0.35 mg/L for freshwater aquatic life. Figure 7.6-15 shows the groundwater sampling results for total and dissolved iron.

Lead

Total lead concentrations in groundwater samples varied from less than 0.00005 (in multiple wells) to 0.194 mg/L (MW07-06B). The BCWQG of 0.1 mg/L for drinking water was exceeded in 13 samples collected from 7 monitoring wells. The BCWQG for freshwater aquatic life, which is hardness dependent, was exceeded in two samples collected from monitoring wells MW07-06A and B. The CCME WQG for the protection of freshwater aquatic life, which is hardness dependent, was exceeded in 27 samples collected from 12 different monitoring wells. The total lead concentrations are presented in Figure 7.6-16.

Manganese

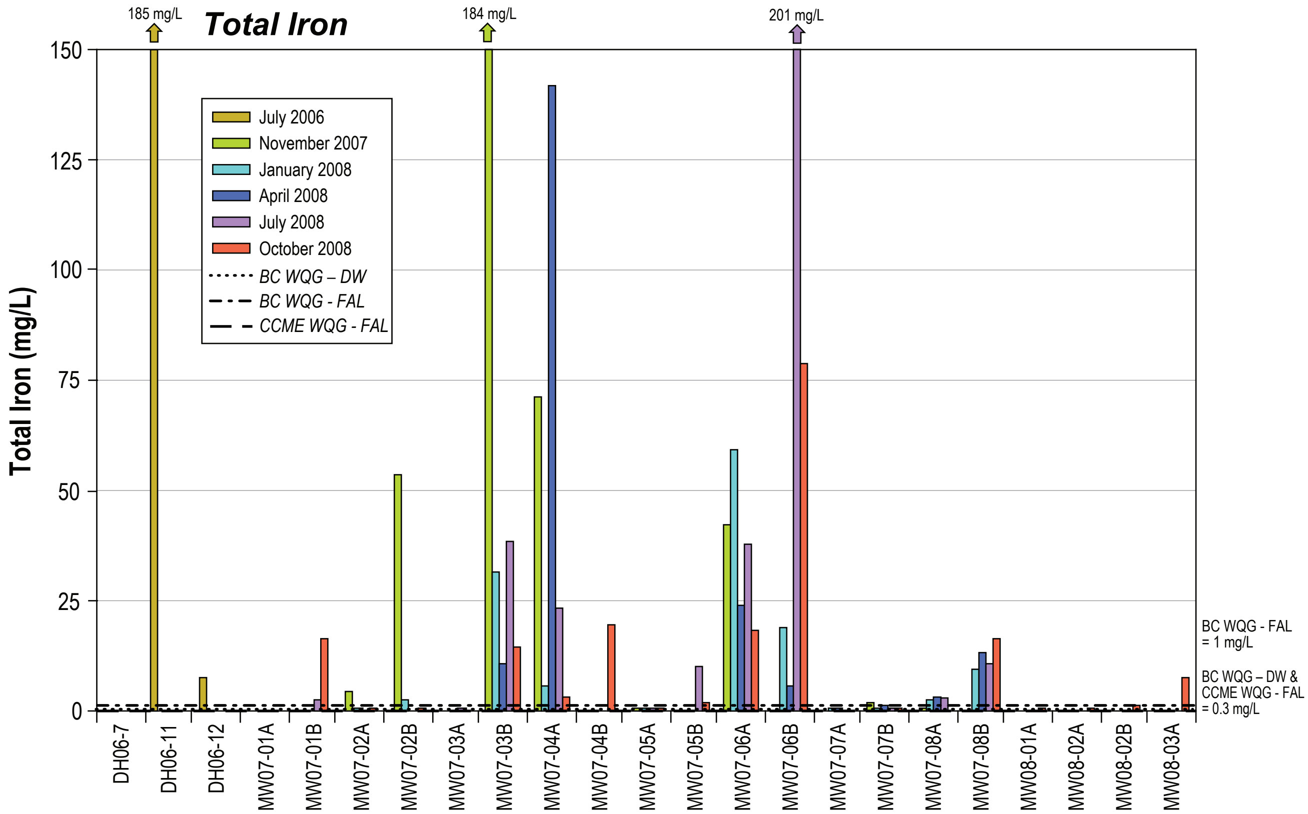
Total manganese concentrations in groundwater samples varied from 0.00456 (MW07-01A) to 12.6 mg/L (MW07-08B). The total manganese concentrations in 60 groundwater samples exceeded the BCWQG of 0.05 mg/L for drinking water in 20 monitoring wells; all wells sampled showed exceedances with the exception of MW07-01A and MW07-03A. Twelve samples from seven monitoring wells also exceeded the BCWQG for freshwater aquatic life, which is hardness dependent. Figure 7.6-17 shows the total manganese concentrations in the groundwater samples. There is no CCME WQG for the protection of freshwater aquatic life for total manganese.

Mercury

Total mercury concentrations in groundwater samples collected from monitoring wells varied from less than 0.00001 (in multiple wells) to 0.0054 mg/L (MW07-04A). The BCWQG of 0.001 mg/L for drinking water was exceeded in three samples collected from three monitoring wells. The BCWQG of 0.0001 mg/L for freshwater aquatic life was exceeded in seven samples collected from four monitoring wells. The CCME WQG for the protection of freshwater aquatic life was exceeded in 14 samples collected from six monitoring wells. Notably, one-half the detection limit exceeded the CCME WQG of 0.000026 mg/L for the protection of freshwater aquatic life. Therefore, three of the samples that were below the total mercury detection limit may have exceeded the CCME guideline: MW07-02B (November 2007) and MW07-06A (November 2007 and January 2008).

Nickel

Total nickel concentrations varied from less than 0.0005 (in multiple wells) to 0.372 mg/L (MW07-06B). The BCWQG and the CCME WQG for the protection of freshwater aquatic life, which are hardness dependent, were exceeded for total nickel in seven samples collected from four monitoring wells. Figure 7.6-18 shows the total mercury and nickel concentrations in groundwater samples collected from monitoring wells in the Morrison property during the baseline study.



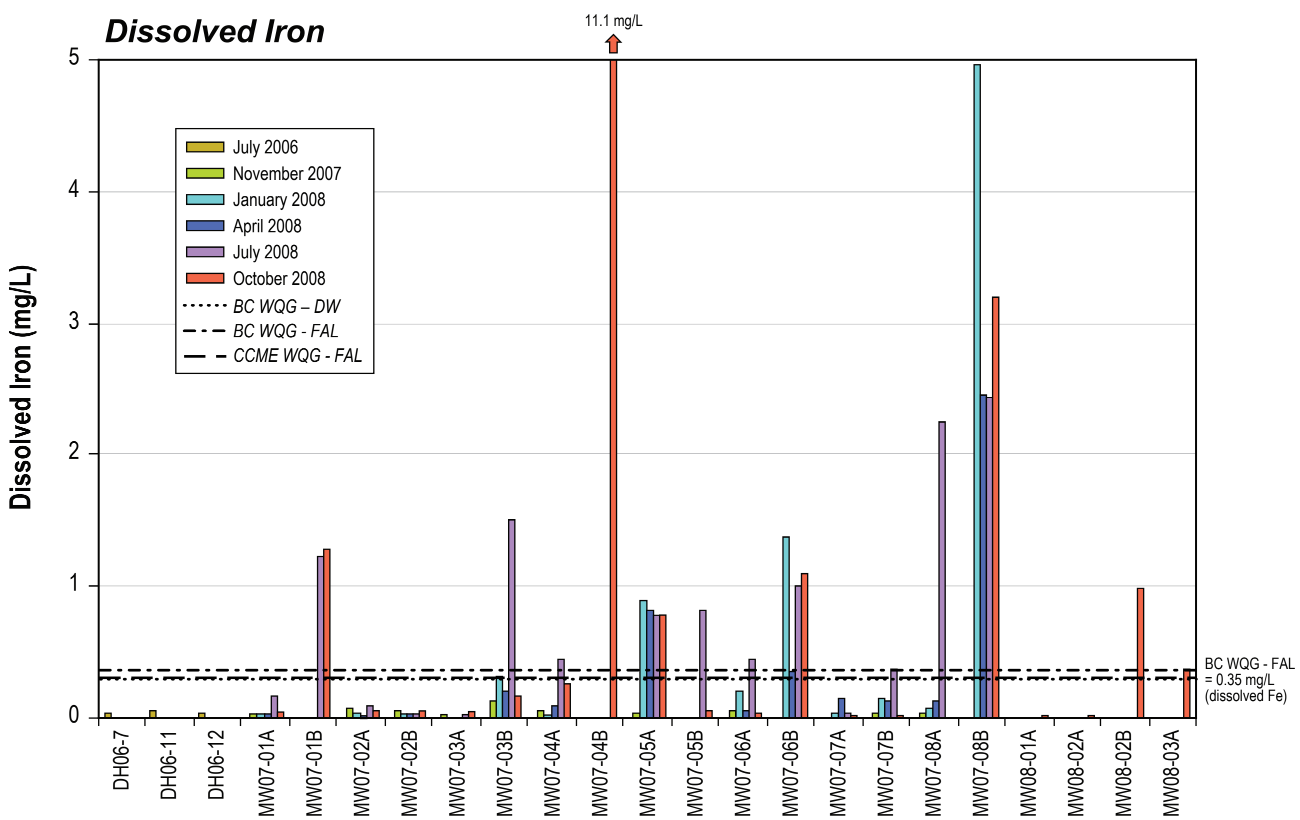
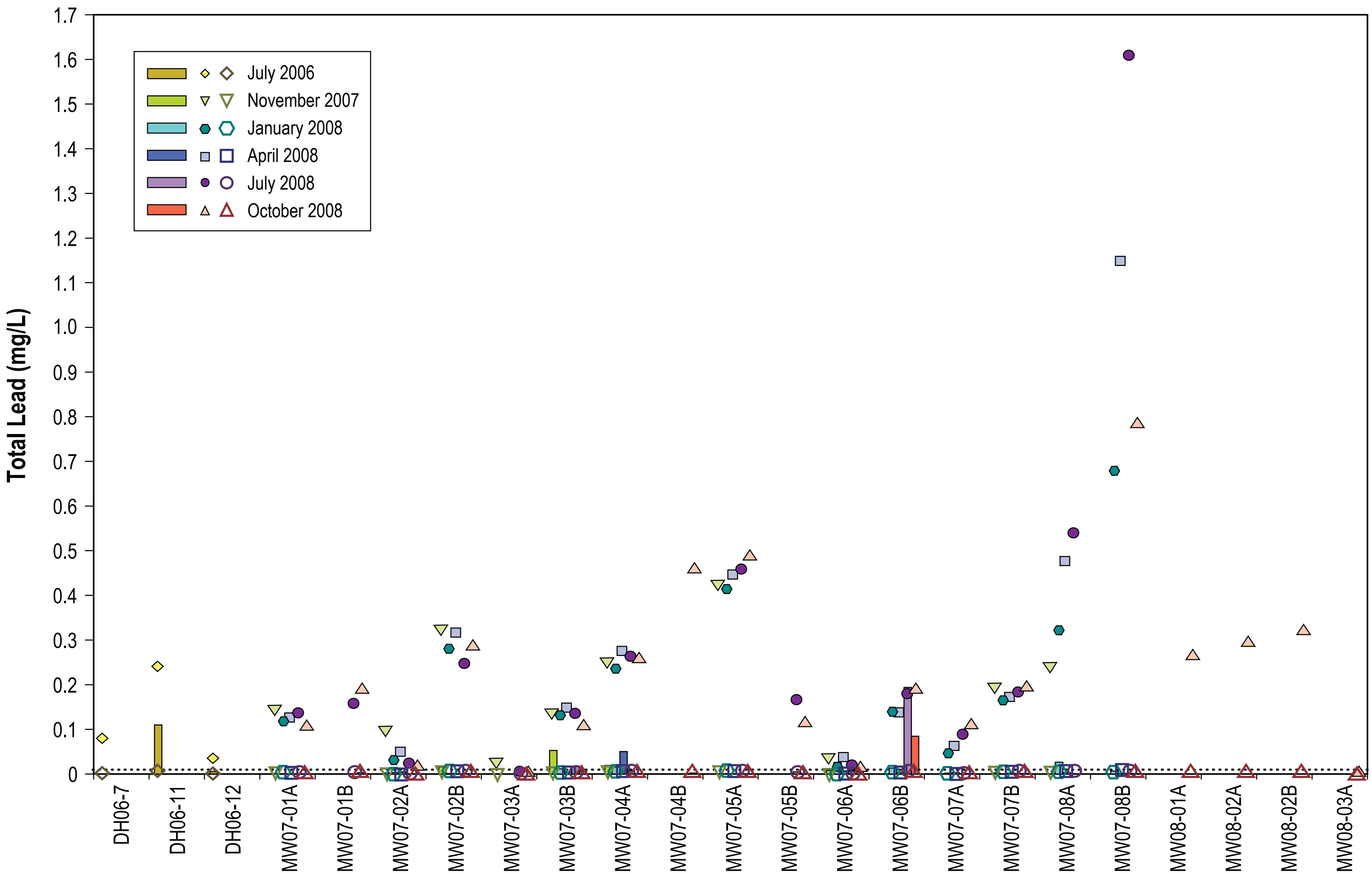


FIGURE 7.6-15

Morrison Copper/Gold Project: Total and Dissolved Iron



Notes: Dotted line represents the BC WQG – DW.
Solid symbols represent BC WQG - FAL.
Blank symbols represnt CCME WQG - FAL.

FIGURE 7.6-16

Morrison Copper/Gold Project: Total Lead

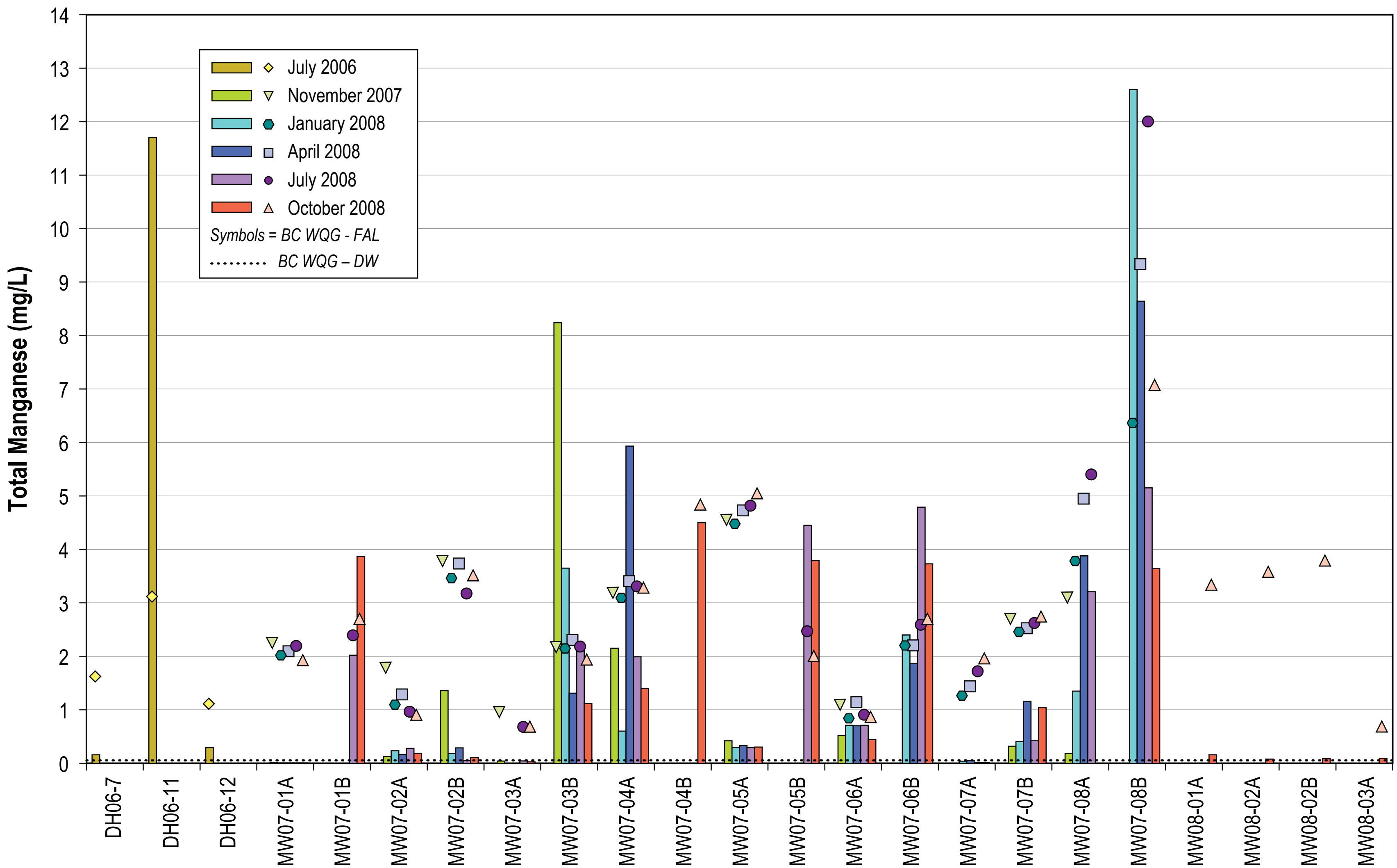
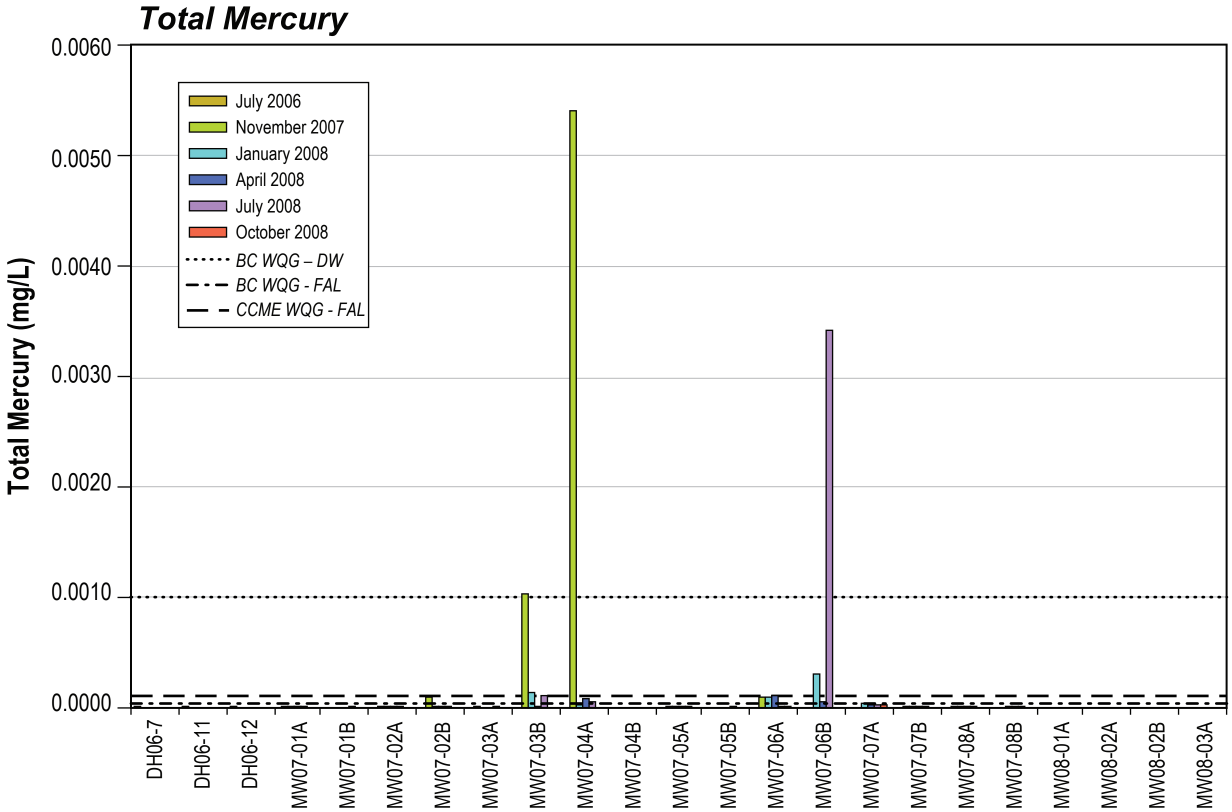
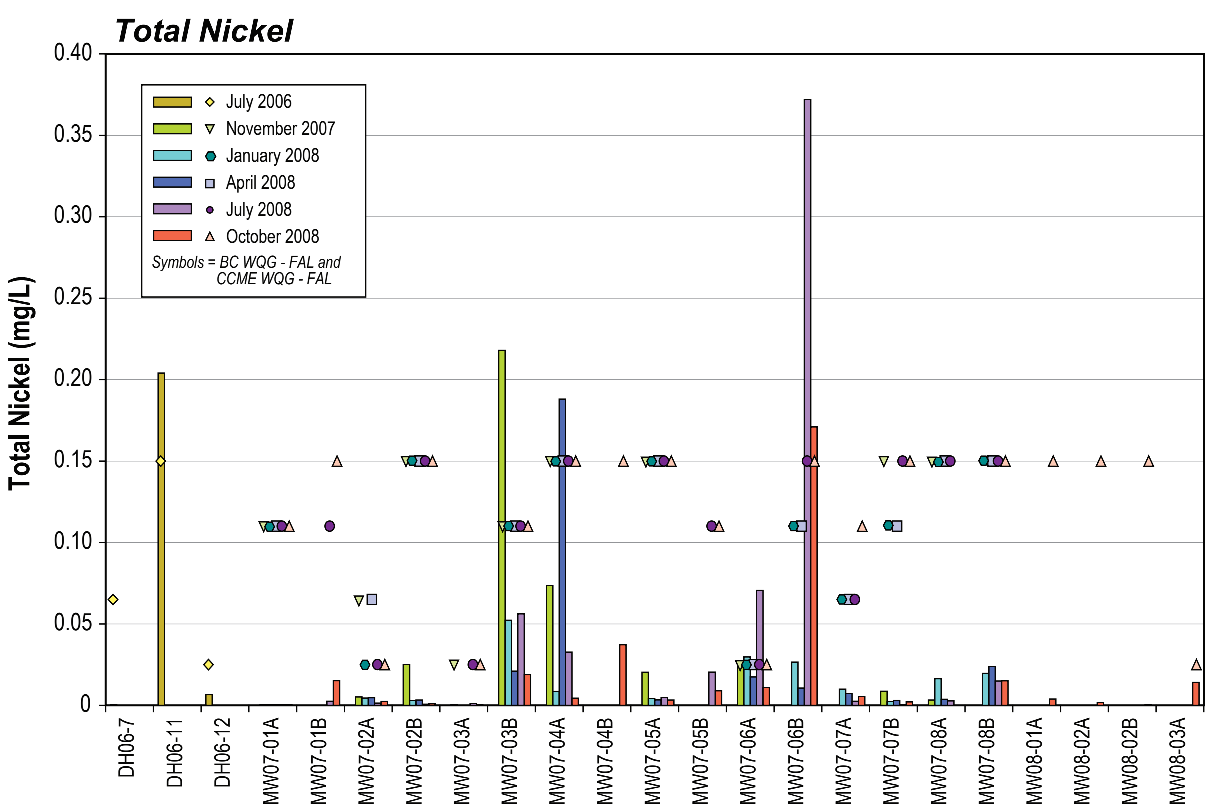


FIGURE 7.6-17

Morrison Copper/Gold Project: Total Manganese





Morrison Copper/Gold Project:
Total Mercury and Total Nickel

FIGURE 7.6-18

Selenium

Total selenium concentrations in the Morrison property varied from less than 0.0001 (in multiple wells) to 0.0069 mg/L (MW07-06B). No samples were collected that exceeded the BCWQG of 0.01 mg/L for drinking water. The selenium concentrations in six groundwater samples collected from four monitoring wells exceeded the BCWQG of 0.002 mg/L for freshwater aquatic life. Eighteen groundwater samples collected from 10 monitoring wells contained selenium concentration that exceeded the CCME WQG of 0.001 mg/L for the protection of freshwater aquatic life.

Silver

Total silver concentrations measured in groundwater samples varied from less than 0.00001 (in multiple wells) to 0.0545 mg/L (DH06-11). Ten samples from seven monitoring wells exceeded the BCWQG for freshwater aquatic life, which is hardness dependent. The CCME WQG of 0.0001 mg/L for the protection of freshwater aquatic life was exceeded in 24 groundwater samples collected from 11 monitoring wells. Figure 7.6-19 shows the total selenium and silver concentrations measured in groundwater samples collected during the groundwater baseline study.

Sodium

Total sodium concentrations measured in groundwater samples collected from monitoring wells in the Project area varied from 3.8 (MW07-06B) to 849 mg/L (MW07-08B). Eleven samples collected from four monitoring wells exceeded the BCWQG of 200 mg/L for drinking water for total sodium.

Thallium

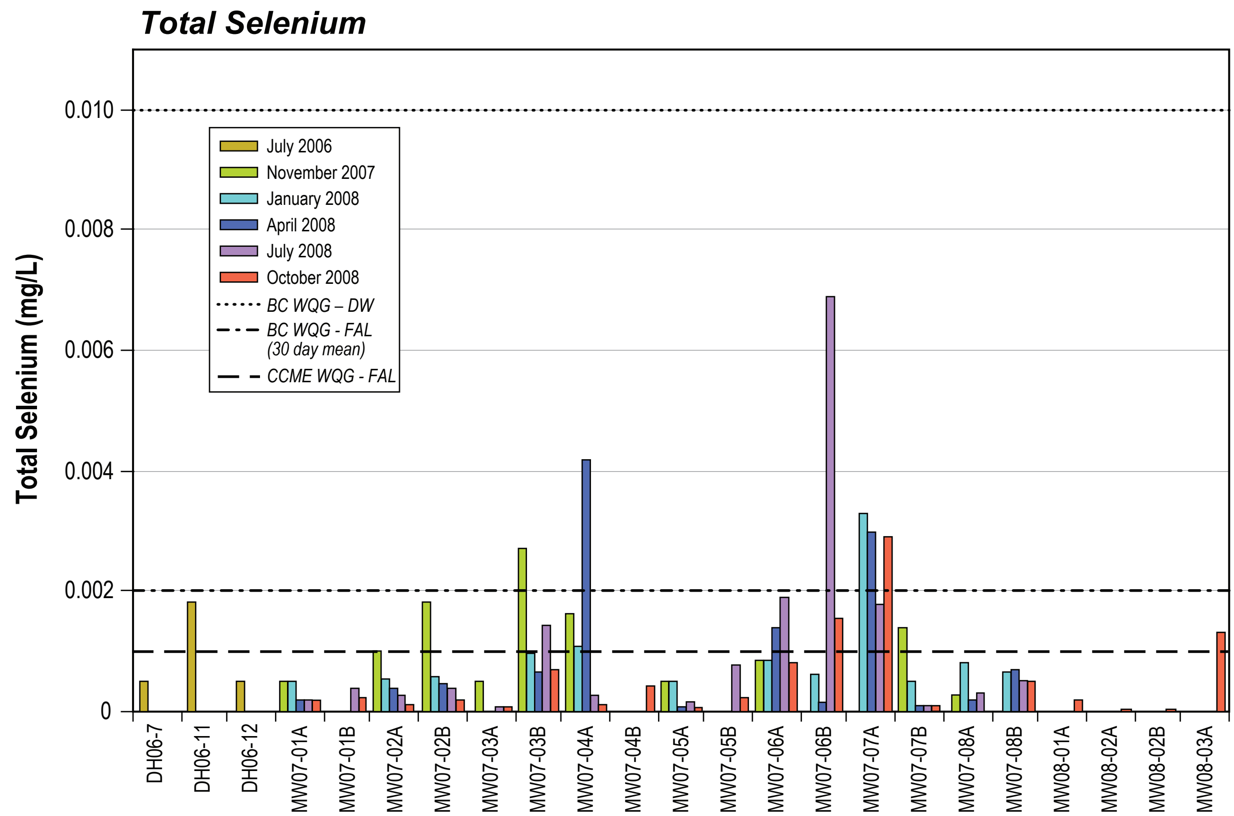
Total thallium concentrations in groundwater samples collected from the monitoring wells in the Morrison property varied from less than 0.0001 (in multiple wells) to 0.0064 mg/L (MW07-06B). The total thallium concentrations in 13 groundwater samples taken from 8 monitoring wells were in excess of the BCWQG of 0.003 mg/L for freshwater aquatic life. Five samples collected from four monitoring wells had total thallium concentrations that were in excess of the CCME WQG of 0.0008 mg/L for the protection of freshwater aquatic life. Figure 7.6-20 illustrates the variations in total sodium and total thallium concentrations in the baseline groundwater samples collected.

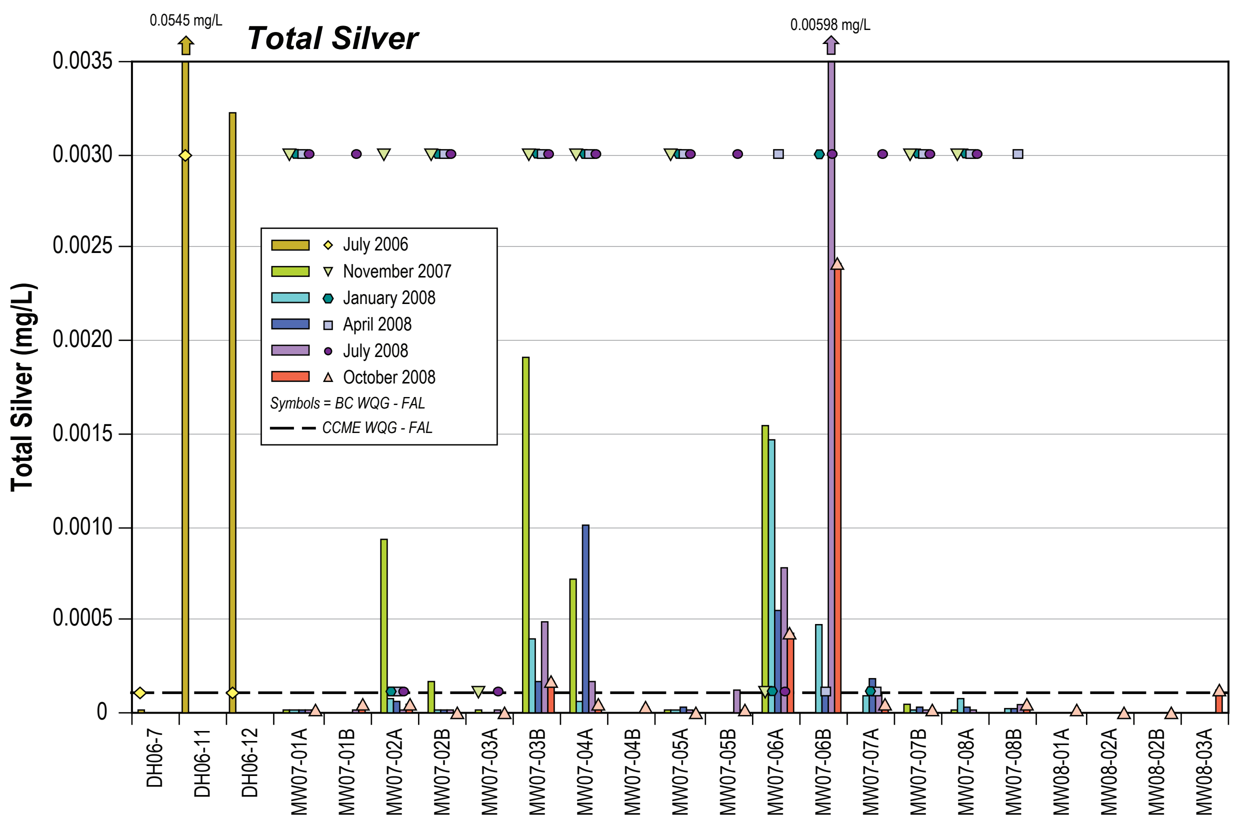
Titanium

Total titanium concentrations in the groundwater samples collected varied from less than 0.01 (in multiple wells) to 2.67 mg/L (MW07-04A). Groundwater samples collected from eight monitoring wells contained a total of 22 samples that exceeded the BCWQG of 0.1 mg/L for the protection of freshwater aquatic life.

Uranium

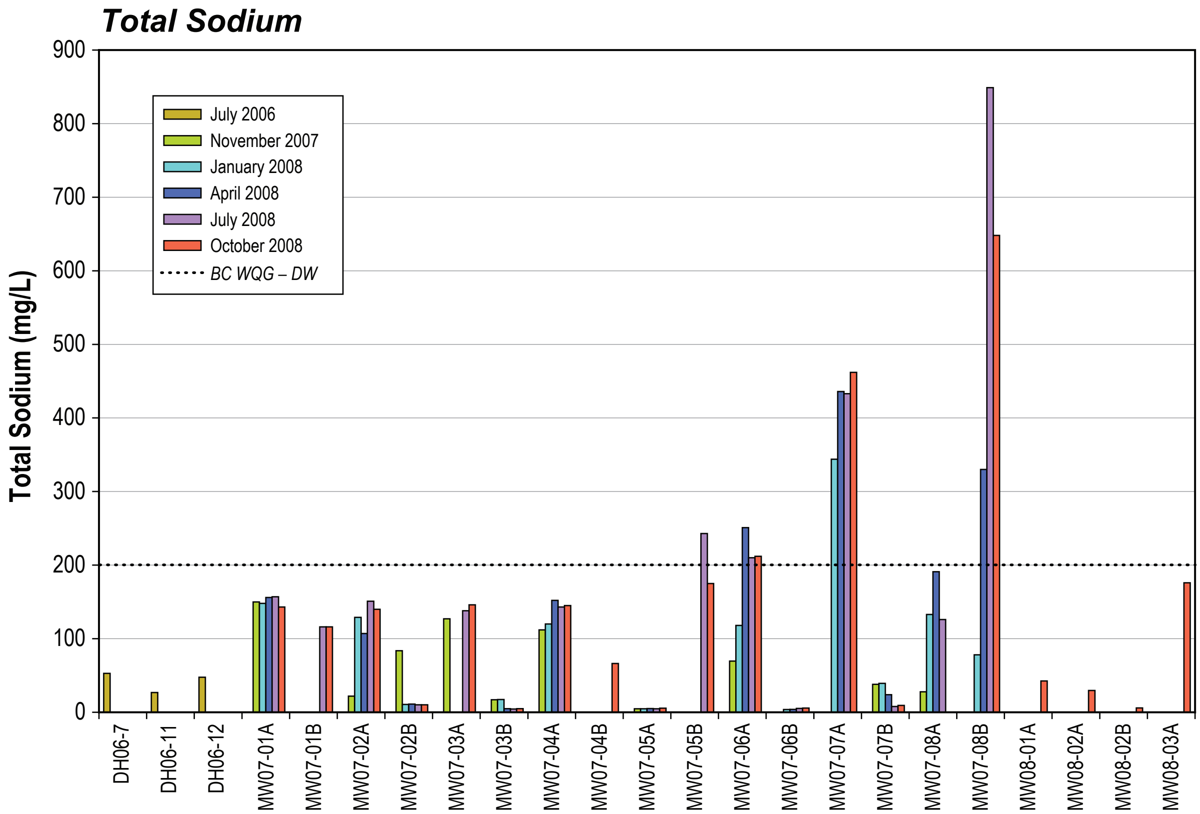
Total uranium concentrations in the groundwater samples collected varied from 0.000024 (MW07-01A) to 0.0454 mg/L (MW07-08B). Two groundwater samples exceeded the BCWQG





Morrison Copper/Gold Project: Total Selenium and Total Silver

FIGURE 7.6-19



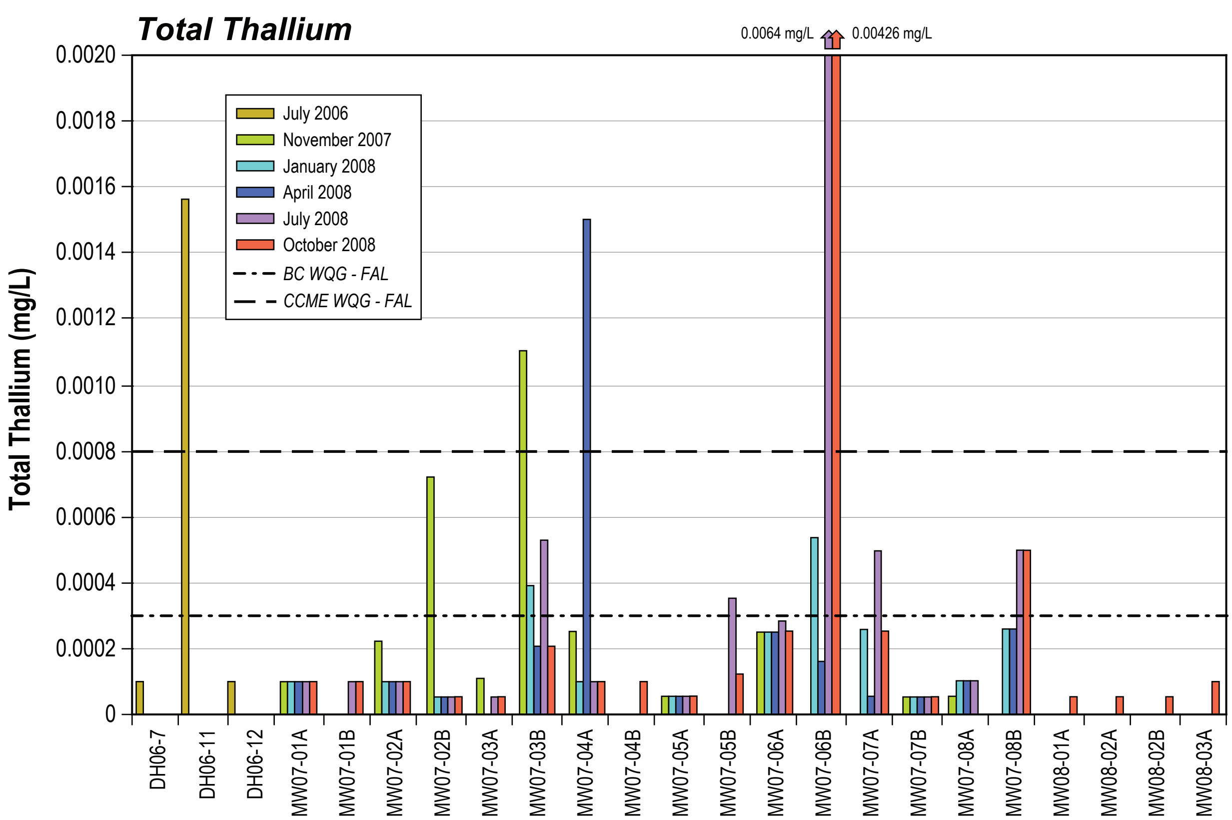


FIGURE 7.6-20

Morrison Copper/Gold Project: Total Sodium and Total Thallium

of 0.02 mg/L for drinking water for uranium. Both of these samples were from MW07-08B. No sample exceeded the BCWQG of 0.3 mg/L for freshwater aquatic life. Figure 7.6-21 shows graphically the total titanium and total uranium concentrations in the groundwater samples.

Zinc

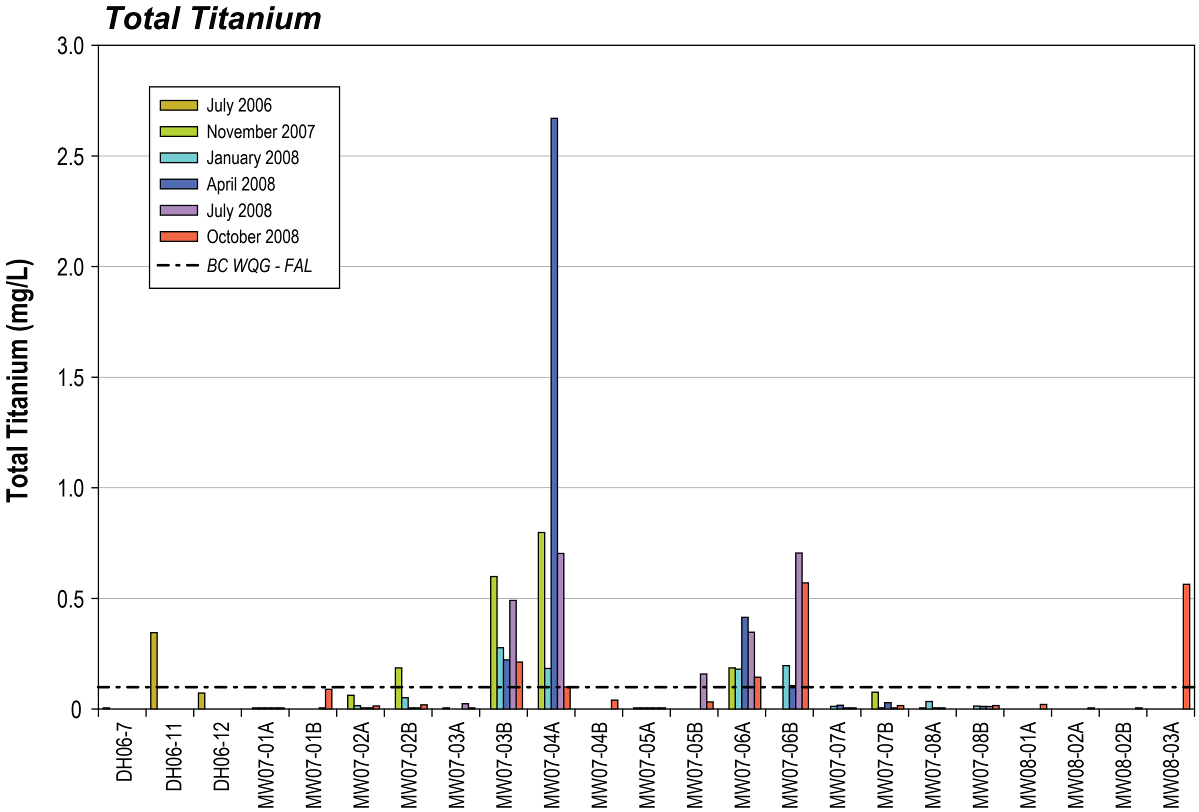
Total zinc concentrations measured in groundwater samples collected from monitoring wells varied from less than 0.001 (in multiple wells) to 1.67 mg/L (MW07-06B). Eighteen groundwater samples taken from eight monitoring wells exceeded the BCWQG for freshwater aquatic life, which is hardness dependent. Twenty-nine groundwater samples from 13 monitoring wells exceeded the CCME WQG of 0.03 mg/L for the protection of freshwater aquatic life. No samples exceeded the BCWQG for drinking water. Figure 7.6-22 shows the total zinc concentrations of the groundwater samples collected.

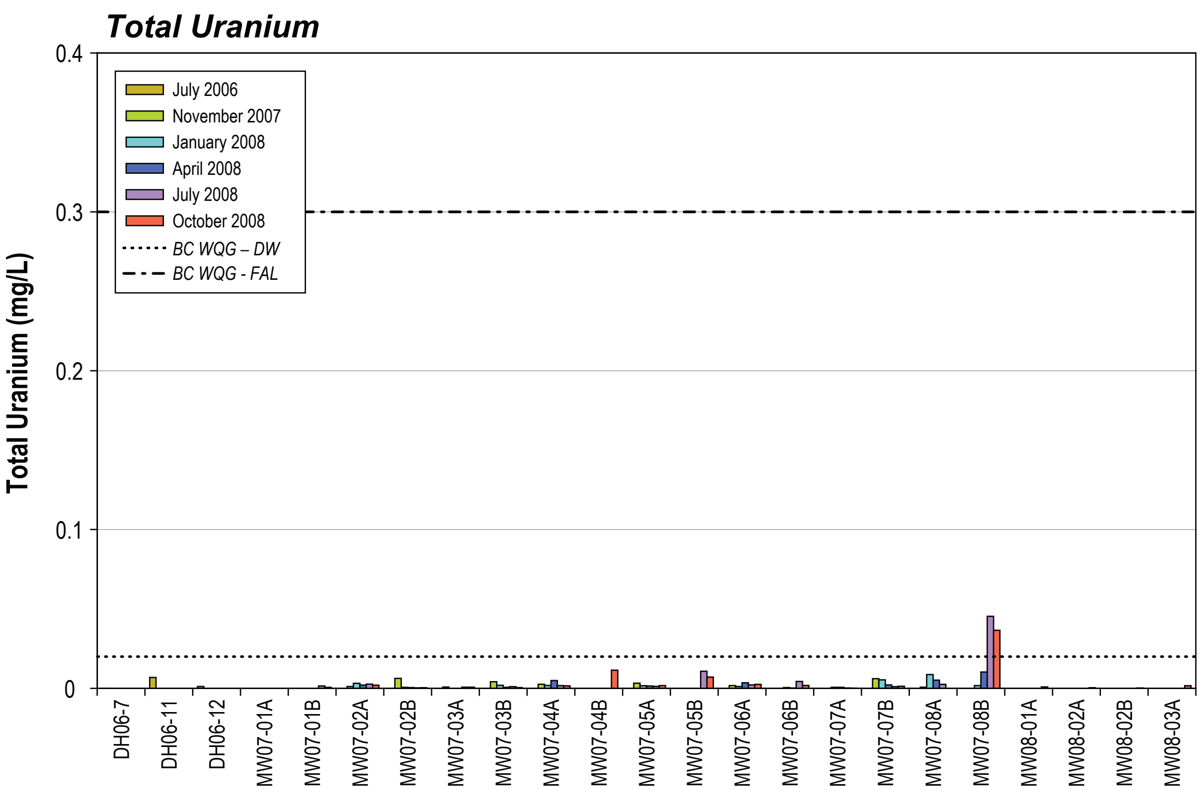
7.6.3.3 Piper diagram

Groundwater chemistry is usually representative of the host rock in which it flows. Hornblende, biotite, plagioclase, quartz, and K-feldspar are the most common rock-forming minerals encountered in the unaltered biotite feldspar porphyry. The Piper diagram shown in Figure 7.6-23 indicates that the groundwater at the Morrison property contains predominantly calcium to sodium-potassium cations and low concentrations of magnesium. The anions are mainly carbonates, with some samples containing higher concentrations of sulphate.

The majority of the groundwater samples collected from monitoring wells on the Morrison property display a calcium-bicarbonate (Ca-HCO_3) water type. This type of water generally characterizes shallow, unconfined aquifers influenced by recharge from surface water, precipitation, and snowmelt. On average, the deep wells are screened at a depth of 30 to 40 m below ground surface (mbgs). Groundwater samples taken from the two deepest monitoring wells (MW07-07A and MW08-02A) screened at approximately 150 mbgs do not show a significant variation from the observed trend. The chemistry of all four groundwater samples taken from MW07-07A was of sodium-bicarbonate (Na-HCO_3) water type. This well is in the proposed open pit area. The one groundwater sample collected from monitoring well MW08-02A west of the proposed open pit area and down-gradient from the ore deposit was of calcium-magnesium bicarbonate water type (Ca-Mg HCO_3).

Groundwater originating from fresh recharge waters that have undergone more intensive water-rock interactions or that have been in longer contact with soils and aquifer sediments will show greater effect of magnesium and sulphate in its composition. For sulphate at the Morrison property, this may reflect the oxidation of sulphide minerals and the release of sulphate, acidity, and metals into groundwater. For example, this is likely the case for groundwater samples taken from MW07-04A that show a higher concentration of sulphate. This monitoring well is northwest of the proposed open pit and south of the second dam (Ashman formation). The metals concentrations in groundwater samples collected from this monitoring well were relatively high for the following metals: aluminum, chromium, cobalt, copper, iron, mercury, nickel, selenium, thallium, titanium, and zinc.





Note: Measurements were below detection limits for total titanium.

FIGURE 7.6-21

Morrison Copper/Gold Project: Total Titanium and Total Uranium

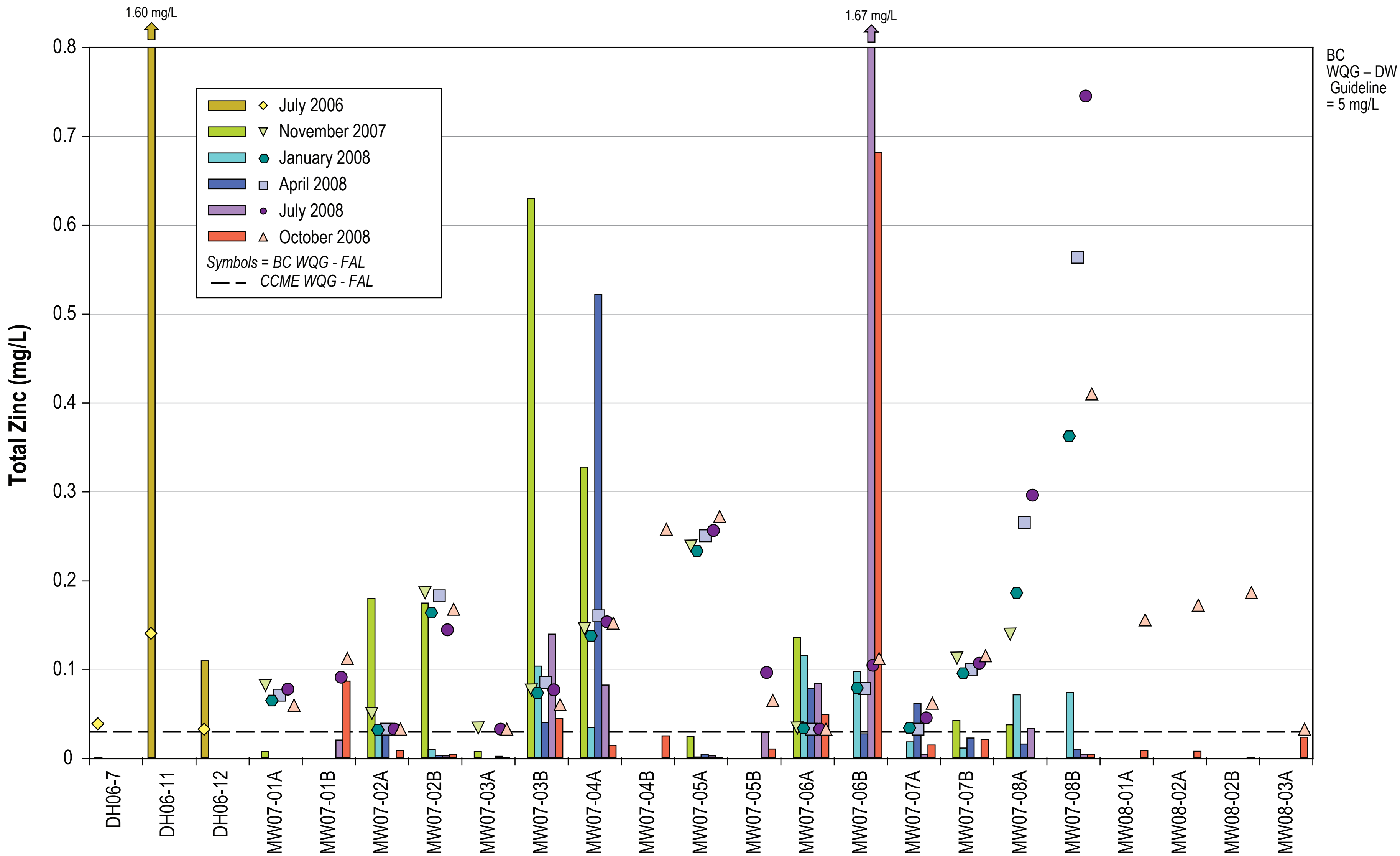
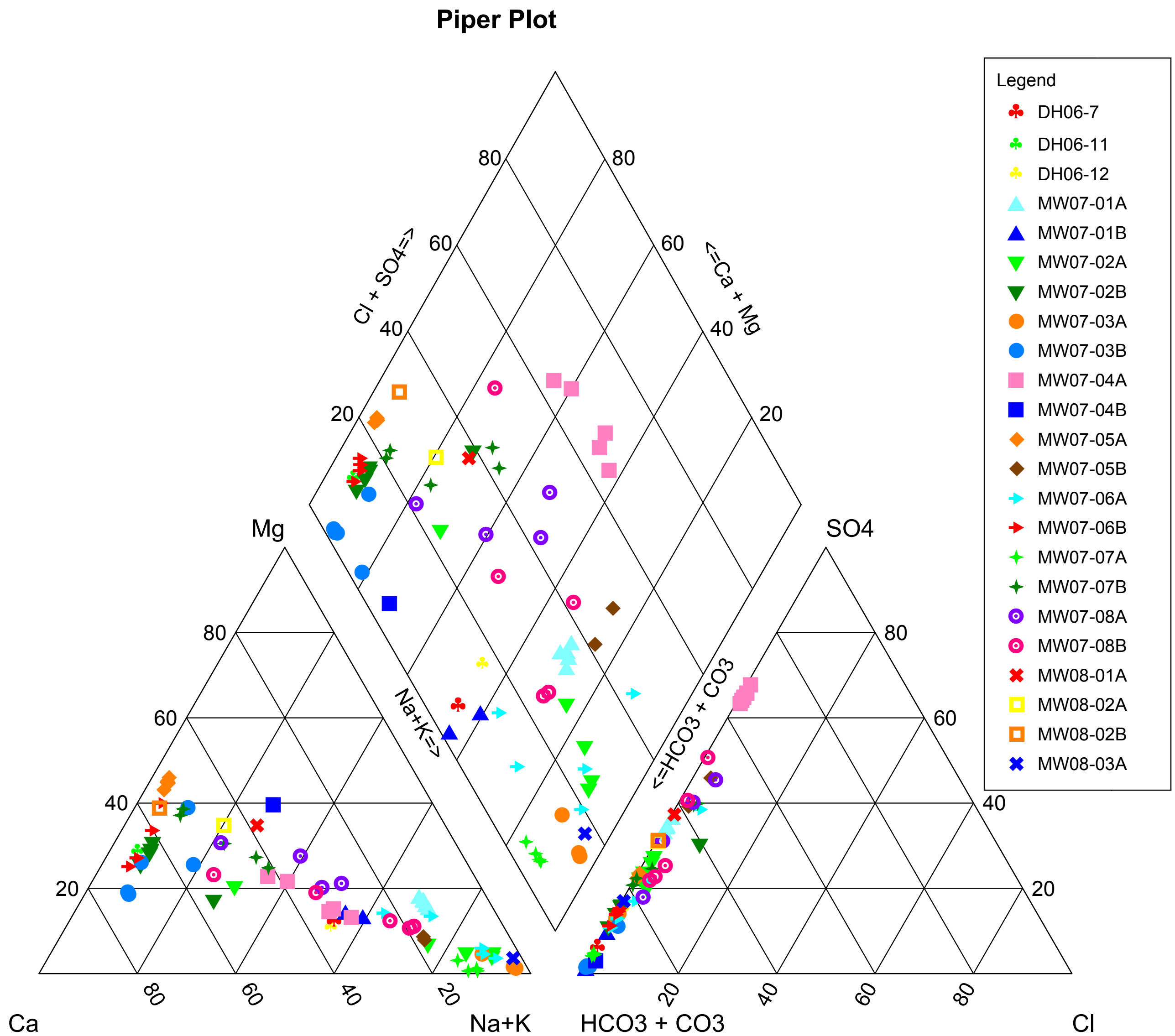


FIGURE 7.6-22

Morrison Copper/Gold Project: Total Zinc



Morrison Copper/Gold Project: Morrison Groundwater Chemical Analysis - Piper Plot

FIGURE 7.6-23

7.6.3.4 Summary of Site-wide Groundwater Chemistry

The presence of high concentrations of total and dissolved metals may be explained by dissolution and leaching of metals originating from mineralization hosted within the bedrock. High concentrations of metals in the groundwater may also be encountered in overburden containing mineralized rock fragments derived from local bedrock.

Groundwater samples collected from MW07-06B in July, 2008, contained metals concentrations that were generally above the average calculated for the Morrison property. This is likely because of the location of this shallow monitoring well, downstream and near the southern end of the proposed pit and the Morrison deposit. The other monitoring wells installed in the glacial till geologic unit (MW07-03, MW07-04, MW07-05B, MW07-06B, and MW07-08B) also generally had high metal concentrations in groundwater throughout the sampling program.

High pH values observed consistently in MW07-07A may indicate that there is interference from the grout seal of the monitoring well. High pH values were only detected at this one location. The high pH values in this one well may affect the validity of other parameters, such as metals, obtained from this well. High concentration of TSS and turbidity values in some wells may indicate that further monitoring of well development is required. Additionally, these values may have affected some other parameters (i.e., elevated metals levels may be the result of elevated TSS).

On the other hand, MW07-01A showed relatively low metals concentrations. This may be because this deep and flowing artesian well is north of the north dam, in an area remote from the deposit. Furthermore, the sodium calcium-bicarbonate water type suggests that the groundwater in this well undergoes strong interactions with surface freshwater.

7.6.4 Conclusion

Anions and metals concentrations in many of the groundwater sampling sites in the Morrison property exceed maximum allowable concentrations listed in the CCME WQG and BCWQG for the protection of freshwater aquatic life and the BCWQG for drinking water. Groundwater quality characterized by various exceedances of these guidelines should be taken into consideration when managing and displacing groundwater on the property during mine development, operation, and closure, especially near Morrison Lake or other groundwater-discharge areas that might be sensitive to a change in water chemistry such as fish-bearing streams.

7.7 Groundwater Quantity

7.7.1 Introduction

This section presents the groundwater quantity hydrogeological setting for the Project. Hydrogeological baseline studies were conducted in 2007 and 2008 (Appendix 24). The hydrogeologic data presented here are primarily drawn from these studies.

7.7.2 Methodology

7.7.2.1 Geological setting

The primary component of overburden on the Morrison property is glacial till, which generally ranges from clay- to gravel-sized particles, but is dominated by silt- and clay-sized particles. In general, a thin veneer of glacial till or colluvium overlies bedrock in areas where slopes are steeper; flat areas between northwesterly trending ridges have a thicker cover of glacial till. Given the low permeability of glacial till, flat areas where till has filled depressions in the bedrock are characterized by wet, swampy conditions due to poor drainage.

The bedrock geology of the Morrison property is characterized by Lower Jurassic to Lower Cretaceous volcanic, clastic, and epiclastic rocks (see Figure 7.7-1). These fine-grained sedimentary and volcanic rocks have been block-faulted by a series of northwesterly trending post-Eocene faults, creating a linear sequence of grabens and horsts.

There are three major faults in the Morrison property. The Morrison fault is a major northwesterly trending dextral fault transecting the ore deposit. The Morrison ore deposit is in a major graben believed to originate from the movement of two additional dextral faults: one is 800 m east of the ore deposit while the other follows the path of Morrison Lake to the west (MacIntyre, Webster, and Desjardins 1997; D. G. Maclntyre 2001).

The area's bedrock geology is complex because of the diversity of the geologic units underlying the Morrison property. The lithologies encountered in the Project footprint included tuff, greywacke, breccia, limestone, porphyry, siltstone, and sandstone.

7.7.2.2 Well installation

Rescan drilled and installed 22 groundwater monitoring wells, in pairs, at 11 sites on the Morrison property in 2007 and 2008. Each monitoring well pair comprises a deep well (A) and a shallow well (B). In general, but not in all cases, the deep well is screened in bedrock and the shallow well is screened in the overburden. This allows characterization of the vertical gradient at each well site. Table 7.7-1 lists the completion details of the Rescan monitoring wells in the proposed Project footprint.

Slug and Packer tests performed in drill holes and previously installed piezometers and groundwater monitoring wells from Knight Piésold (2006) and Klohn Crippen Berger (Appendix 6) were compiled along with hydraulic conductivity tests performed in the Rescan groundwater monitoring wells. Table 7.7-2 is a compilation of the completion details for wells and piezometers from which hydraulic conductivity results were collected.

The location of the Rescan groundwater monitoring wells in the Project footprint is presented in Figure 7.7-2.

gis no. MOR-09-021 Job No. 0793-001-13 February 13, 2009

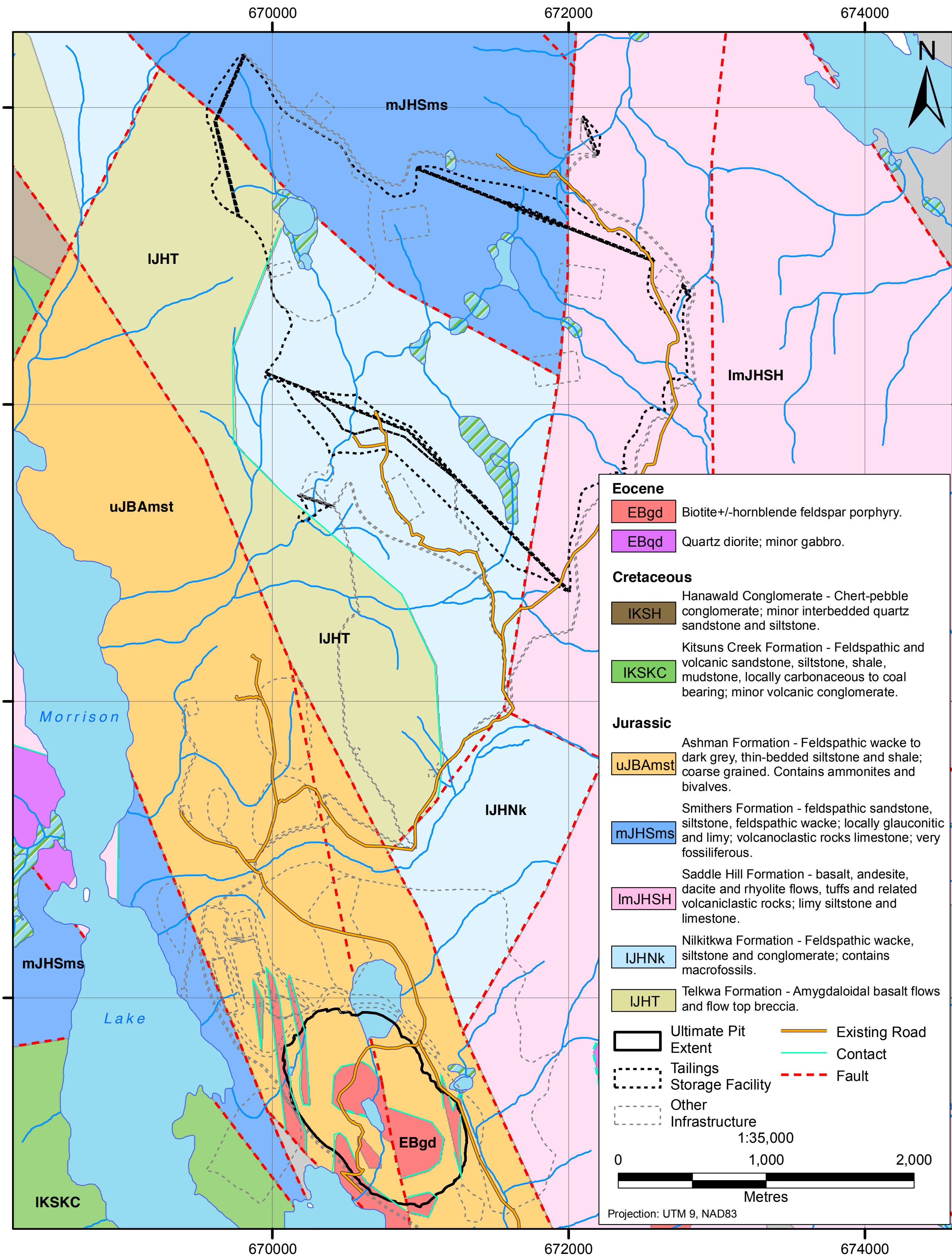


FIGURE 7.7-1

Morrison Copper/Gold Project: Local Geology and Mine Infrastructure

Table 7.7-1
Morrison Copper/Gold Project: Monitoring Well Completion Table

Well I.D.	Installation Date mm/dd/yy	UTM Location Northing	UTM Location Easting	Elevation (masl)[1]	Depth (m)	Inclination (degrees)	Stick up (mags)[2]	Drilling Method[3]	Screened Interval (mbgs)[4] Top	Screened Interval (mbgs)[4] Bottom	Screened Horizon	Lithology
MW07-01A	10/11/2007	6125820	672325	970	28.04	90	0.93	ODEX and HQ3	21.94	28.04	Bedrock	Glauconitic Volcanoclastic unit
MW07-01B	10/11/2007	6125820	672325	970	12.19	90	0.94	ODEX	8.99	12.04	Overburden	Glacial Till
MW07-02A	07/11/2007	6123522	672874	1,091	40.23	90	0.87	ODEX and HQ3	35.81	38.7	Bedrock	Volcanic breccia
MW07-02B	08/11/2007	6123522	672874	1,091	9.14	90	0.85	ODEX	6.1	9.14	Bedrock	Fossiliferous Limestone
MW07-03A	24/10/2007	6122530	669544	782	33.53	90	0.83	ODEX	30.32	33.37	Overburden	Glacial Till
MW07-03B	26/10/2007	6122530	669544	782	5.94	90	0.93	ODEX	2.89	5.94	Overburden	Glacial Till
MW07-04A	22/10/2007	6122147	669890	822	40.84	90	0.87	ODEX	37.79	40.84	Overburden	Glacial Till
MW07-04B	24/10/2007	6122147	669890	822	6.1	90	0.87	ODEX	3.05	6.09	Overburden	Glacial Till
MW07-05A	17/10/2007	6119240	670211	807	40.23	90	0.95	ODEX	37.18	40.23	Bedrock	Altered Feldspar Biotite Porphyry
MW07-05B	18/10/2007	6119240	670211	807	21.34	90	0.91	ODEX	18.29	21.33	Overburden	Glacial Till
MW07-06A	19/10/2007	6118638	670637	746	16.31	90	0.93	ODEX and HQ3	11.58	14.63	Bedrock	Volcanic tuff
MW07-06B	20/10/2007	6118638	670637	746	5.18	90	0.91	ODEX	2.13	5.18	Overburden	Glacial Till
MW07-07A	06/10/2007	6119436	670428	837	149.66	90	0.98	ODEX and HQ3	131.97	147.22	Bedrock	Altered Feldspar Biotite Porphyry
MW07-07B	16/10/2007	6119436	670428	837	39.47	90	1.00	ODEX	36.42	39.47	Bedrock	Altered Feldspar Biotite Porphyry
MW07-08A	20/10/2007	6120715	670593	840	40.23	90	0.93	ODEX	37.18	40.23	Bedrock	Siltstone
MW07-08B	22/10/2007	6120715	670593	840	10.36	90	0.84	ODEX	7.31	10.36	Overburden	Glacial Till
MW08-01A	20/09/2008	6119626	671032	832	85.8	90	0.92	ODEX and HQ3	72.09	78.18	Bedrock	Siltstone and Tuff
MW08-01B	21/09/2008	6119626	671032	832	30.18	90	0.88	ODEX	23.78	29.87	Overburden	Gravelly Clay with Sand
MW08-02A	04/10/2008	6118990	670305	752	149.81	90	0.91	ODEX and HQ3	137.62	149.81	Bedrock	Siltstone and Feldspar Biotite
MW08-02B	04/10/2008	6118990	670305	752	75.59	90	1.00	ODEX	66.45	75.59	Overburden	Biotite Feldspar Porphyry
MW08-03A	23/09/2008	6120820	669975	800	35.51	90	0.92	ODEX and HQ3	30.48	35.05	Bedrock	Sandstone
MW08-03B	23/09/2008	6120820	669975	800	13.89	90	0.90	ODEX	8.99	13.72	Overburden	Gravelly Clay with Sand

[1] masl = metres above sea level
[2] mags = metres above ground surface
[3] ODEX diameter = 11.43 cm and HQ3 diameter = 9.6 cm
[4] mbgs = metres below ground surface

Table 7.7-2
Morrison Copper/Gold Project: Completion Details of Knight Piésold and Klohn Crippen Berger Monitoring Wells and Piezometers

Identification	Installation Year	Contractor[1]	Description	UTM Location Northing	UTM Location Easting	Elevation (masl)*	Depth (m)	Strike (degrees from North)	Inclination (degrees)	Stick-up (mags)**	PVC Pipe Diam.[2] (mm)	Screened Interval (mbgs)***	Screened Lithology
DH07-1A	2007	KCB	Piezometer	6125281	671989	973	49.4	0	90	0.9	26	43.1 - 49.2	Sandstone and siltstone
DH07-1B	2007	KCB	Piezometer	6125279	671996	973	17.4	0	90	0.83	26	14.2 - 17.2	Gravelly clay/silt (TILL)
DH07-2A	2007	KCB	Piezometer	6125496	671403	990	35.1	0	90	0.97	26	31.7 - 34.7	Siltstone
DH07-2B	2007	KCB	Piezometer	6125493	671396	990	11	0	90	0.93	26	7.6 - 10.7	Gravelly clay (TILL)
DH07-3A	2007	KCB	Piezometer	6123345	671446	974	41.6	0	90	0.92	26	38.4 - 41.5	Siltstone
DH07-3B	2007	KCB	Piezometer	6123335	671450	974	15.4	0	90	0.86	26	12 - 15.1	Gravelly clay (TILL)
DH07-4A (S1)	2007	KCB	Piezometer	6123637	671060	960	46.2	0	90	0.82	26	43 - 46	Siltstone
DH07-4A (S2)	2007	KCB	Piezometer	6123637	671060	960	46.2	0	90	0.84	26	33.4 - 36.4	Sandy siltstone
DH07-4B (S1)	2007	KCB	Piezometer	6123634	671070	960	11.4	0	90	0.9	26	9.8 - 11.3	Gravelly clay (TILL)
DH07-4B (S2)	2007	KCB	Piezometer	6123634	671070	960	11.4	0	90	0.92	26	3 - 4.6	Gravelly clay (TILL)
DH07-5A (S1)	2007	KCB	Piezometer	6123951	670477	935	21.5	0	90	0.85	26	19.2 - 21.3	Metasedimentary
DH07-5A (S2)	2007	KCB	Piezometer	6123951	670477	935	21.5	0	90	0.87	26	13.7 - 15.2	Gravel and clay (TILL)
DH07-5B	2007	KCB	Piezometer	6123965	670477	935	58.2	0	90	0.88	26	55 - 58.1	Sandstone
DH07-6	2007	KCB	Piezometer	6120025	671245	863	23.2	0	90	0.86	26	21 - 22.6	Silty clay (TILL)
DH07-7	2007	KCB	Monitoring Well	6120115	671105	851	22.9	0	90	0.91	50	21 - 22.6	Clay, some gravel (TILL)
DH07-9	2007	KCB	Piezometer	6120197	671101	841	25.3	0	90	0.91	26	18.3 - 19.8	Silty clay (TILL)
DH08-01A	2008	KCB	Monitoring Well	6120064	670403	819	20.1	0	90	0.95	50	16.15 - 19.2	Wacke
DH08-01B	2008	KCB	Monitoring Well	6120064	670403	819	12.8	0	90	0.92	50	8.53 - 12.8	Trace Cobbles and Boulders (TILL)
DH08-02	2008	KCB	Monitoring Well	6120472	669743	796	12.4	0	90	0.91	50	8.81 - 12.4	Shale
DH08-03	2008	KCB	Piezometer	6120229	669837	833	55.17	n/a	55	0.93	26	54.17 - 55.17	Biotite Feldspar Porphyry
DH06-2	2006	KP	Monitoring Well	6123723	670576	950	39.5	0	90	1	50	30.5 to 33.5	Volcanic unit
DH06-3	2006	KP	Monitoring Well	6123781	670541	950	37	0	90	1	50	4 to 5.5	Silt/Clay matrix with some gravel
DH06-4	2006	KP	Monitoring Well	6123060	670997	983	41.5	0	90	1	50	24.4 to 27.4	Limestone
DH06-6	2006	KP	Monitoring Well	6122655	671486	960	36.7	0	90	1	50	15.2 to 18.3	Volcanic unit
DH06-7	2006	KP	Monitoring Well	6122667	671775	993	43	0	90	1	50	30.5 to 33.5	Volcanic unit/ fine grained siltstone/sandstone
DH06-8	2006	KP	Monitoring Well	6119649	671249	838	39.9	0	90	1	50	36.6 to 39.6	Clay with some sand
DH06-9	2006	KP	Monitoring Well	6119478	671152	835	33.2	0	90	1	50	27.4 to 30.5	Silt/Clay matrix with traces of gravel and trace sand
DH06-10	2006	KP	Monitoring Well	6125683	671523	1,001	53.6	0	90	1	50	29 to 32	Sandstone/Fine grained siltstone
DH06-11	2006	KP	Monitoring Well	6125568	671912	965	37	0	90	1	50	1.5 to 3	Silt/Clay matrix with some gravel
DH06-12	2006	KP	Monitoring Well	6125182	672265	996	58	0	90	1	50	27.4 to 30.5	Sandstone/Siltstone
DH06-13	2006	KP	Monitoring Well	6119111	670800	808	20.3	0	90	1	50	17.1 to 20.1	Feldspar Biotite Porphyry
DH06-14	2006	KP	Monitoring Well	6119159	671396	840	29	0	90	1	50	17.1 to 20.1	Silt/Clay matrix with some gravel
DH06-15a	2006	KP	Monitoring Well	6120320	670693	817	33.1	0	90	1	50	29.9 to 32.9	Silt/Clay matrix with some gravel
DH06-15b	2006	KP	Monitoring Well	6120319	670690	817	5.6	0	90	1	50	2.4 to 5.5	Sandy silt to silty sand
DH06-16	2006	KP	Monitoring Well	6120880	669420	762	3.8	0	90	1	25	2.1 to 3.7	Silt/Clay matrix with some sand and gravel
DH06-17	2006	KP	Monitoring Well	6122420	669500	763	1.5	0	90	1	25	0.9 to 1.5	Silt/Clay matrix with some sand and gravel
GW1	2006	KP	Monitoring Well	6118724	670847	795	4.3	0	90	1	50	1.5 to 3.2	Silt/clay matrix with some gravel and highly decomposed bedrock
9000-1	2006	KP	Standpipe Piezometer	6119060	670844	818.1	177.1	232.6	55	unknown	19.05	26 to 32	Feldspar Biotite Porphyry
9240-1	2006	KP	Standpipe Piezometer	6119240	670920	848.9	277.7	296.5	45	unknown	19.05	59 to 65.4	Feldspar Biotite Porphyry
9240-3	2006	KP	Standpipe Piezometer	6119240	670760	805	232.6	11.4	55	unknown	19.05	33 to 39.3	Feldspar Biotite Porphyry
MET-1	2006	KP	Vibrating Wire	6119421	670530						**Information unavailable**		
MET-2	2006	KP	Vibrating Wire	6119244	670549						**Information unavailable**		
MET-3	2006	KP	Vibrating Wire	6119543	670569						**Information unavailable**		

Notes:
***masl = metres above sea level**
****mags = metres above ground surface**
*****mbgs = metres below ground surface**
1. Contractors: KCP = Klohn Crippen Berger; KP = Knight Piesold Contracting Ltd.
2. PVC pipe diameters: 26 mm = nominal 1"; 50 mm = nominal 2", 19.05 mm = nominal 3/4"

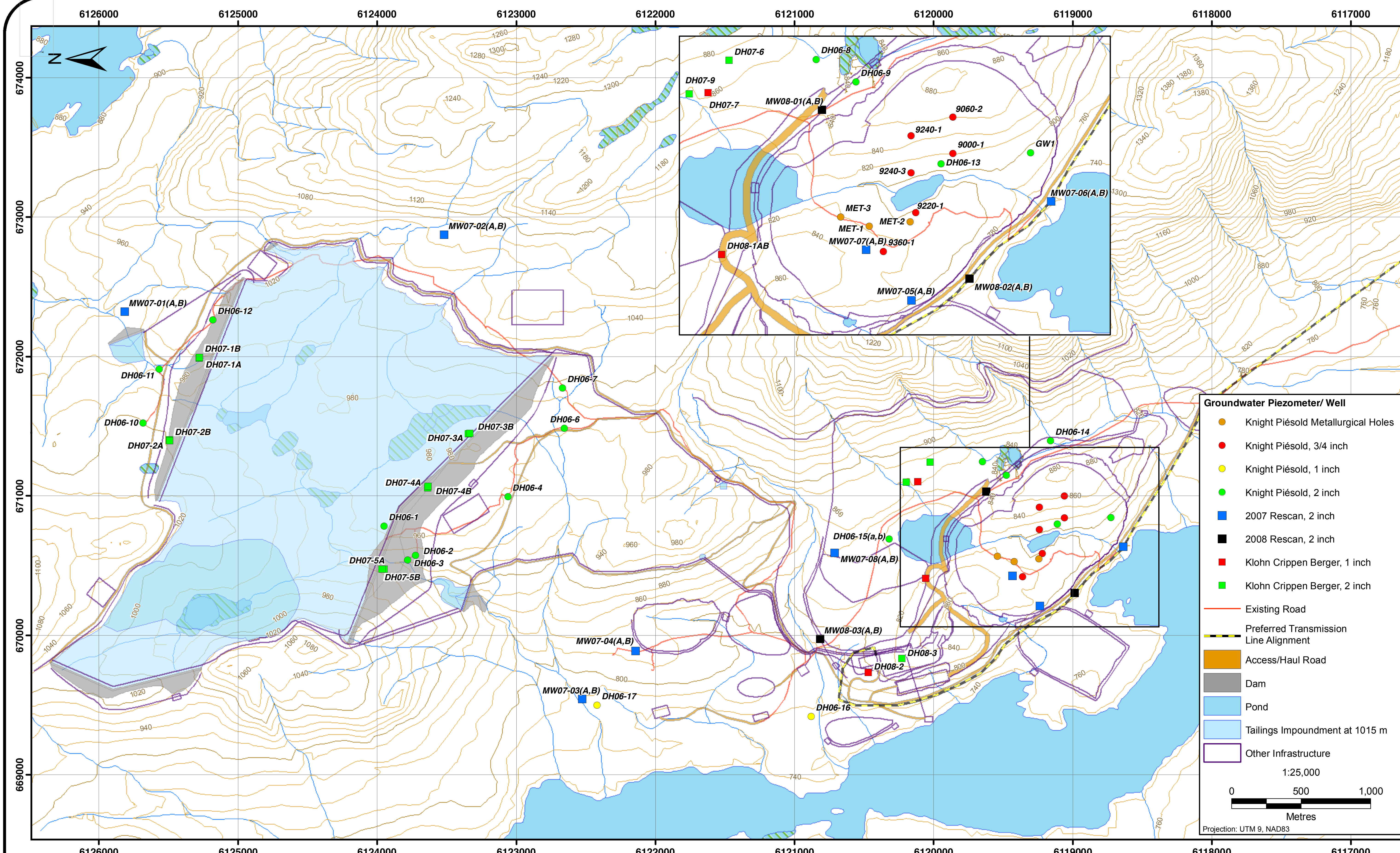


FIGURE 7.7-2

Morrison Copper/Gold Project: General Site with Monitoring Wells and Piezometers

7.7.2.3 Hydrostratigraphy

Based on surficial overburden and bedrock geology data, borehole logs, and hydraulic conductivity (K) test results, the hydrostratigraphy of the Morrison property can be summarized in two units: overburden and bedrock. In general, the overburden unit is a confining layer of dense till with low hydraulic conductivity values overlying locally fractured and faulted bedrock characterized by higher hydraulic conductivity values. With increasing depth, bedrock fracture density is reduced causing the hydraulic conductivity to decrease. Hydraulic conductivity values are presented in tables 7.7-3 and 7.7-4 for the overburden and bedrock respectively.

7.7.2.3.1 Overburden

The thickness of overburden at the proposed open pit location varies from 3 to 10 m, with the exception of ridges where the overburden depth is often less than 1 m. The depth to bedrock at the proposed TSF location varies between a minimum of 0 m on the crests of slopes (i.e., bedrock outcrops) to a maximum of approximately 22 m in the low-lying areas. Glacial till is the main surficial material comprising overburden material. Particle sizes range from clay to gravel, with a majority of silt- and clay-sized particles (Knight Piésold 2006). A summary of the overburden K tests that were conducted on the Morrison property is presented in Table 7.7-3. Measured hydraulic conductivities for the overburden indicate a range from 4.7×10^{-11} to 1.4×10^{-5} m/s. This is in general agreement with the literature, which suggests a range of 1×10^{-12} to 1×10^{-6} m/s for glacial till (Freeze and Cherry 1979).

7.7.2.3.2 Bedrock

The bedrock geology of the area is complex because of the diversity of the geologic units underlying the Project footprint. Many structural features also occur because of the tectonic activities during and after mineralization as well as intrusions and associated hydrothermal alteration of country rocks. Depending on the location and depth, the lithologies encountered in the different drill holes included: glauconitic or andesitic tuff, greywacke, volcanic breccia, fossiliferous limestone, biotite feldspar porphyry, siltstone and sandstone, and mafic dike. Sedimentary structures encountered include concretions and stratification. Occasional alteration was noted including chloritization, silicification, calcification, and argillaceous alteration.

The bedrock can be subdivided into two hydrostratigraphic units: the "upper bedrock," which is more fractured and characterized by a generally higher hydraulic conductivity and the "mid-bedrock," with K values ranging over several orders of magnitude. Typically, hydraulic conductivity tends to decrease with depth below ground surface as the rock mass becomes much less fractured (Rescan 2008). The K tests that were conducted in the bedrock on the Morrison property are summarized in Table 7.7-4. Bedrock hydraulic conductivities vary between 8.1×10^{-11} and 1.23×10^{-5} m/s.

7.7.2.4 Water level measurements

In addition to the 22 Rescan groundwater monitoring wells, groundwater flow directions were established from groundwater levels taken from 20 groundwater monitoring wells and standpipe piezometers installed by Knight Piésold between November 2005, and April 2006, and 16

Table 7.7-3
Morrison Copper/Gold Project: Summary of Overburden Hydraulic Conductivity Testing

Identification	Contractor	Location	Site Elevation (masl) [1]	Test Method	Tested Interval (mbgs) [2]	Tested Interval Midpoint (mbgs)	Midpoint Elevation (masl)	Lithology	Hydraulic Conductivity (m/s)
MW07-03B	Rescan	S of Main Dam	782	Slug Test - FHT	2.89 to 5.94	4.42	777.59	Gravelly Sandy Clay	7.00E-07
				Slug Test - RHT	2.89 to 5.94	4.42	777.59	Gravelly Sandy Clay	9.50E-07
MW07-04A	Rescan	S of Main Dam	822	Slug Test - RHT	37.79 to 40.84	39.32	782.69	Gravelly Sandy Silty Clay	6.26E-08
				Slug Test - RHT	37.79 to 40.84	39.32	782.69	Gravelly Sandy Silty Clay	4.83E-08
				Slug Test - RHT	37.79 to 40.84	39.32	782.69	Gravelly Sandy Silty Clay	4.93E-08
MW07-04B	Rescan	S of Main Dam	822	Slug Test - FHT	3.05 to 6.09	4.57	817.43	Gravelly Sandy Clay	5.63E-07
				Slug Test - FHT	3.05 to 6.09	4.57	817.43	Gravelly Sandy Clay	3.49E-07
MW07-05B	Rescan	Open Pit	807	Slug Test - RHT	18.29 to 21.33	19.81	787.19	Gravelly Silty Sand	5.20E-07
MW07-06B	Rescan	W of Open Pit	746	Slug Test - FHT	2.13 to 5.18	3.66	742.35	Gravelly Silty Sand	1.10E-08
				Slug Test - FHT	2.13 to 5.18	3.66	742.35	Gravelly Silty Sand	1.02E-06
MW07-08B	Rescan	Waste Rock Dump	840	Slug Test - FHT	7.31 to 10.36	8.84	831.17	Gravelly Sandy Silty Clay	1.20E-08
DH07-02B	KCB	North Dam		Falling Head Test	7.6 to 10.7	9.15		Till	1.40E-10
DH07-3B	KCB	Main Dam	974	Falling Head Test	12.0 to 15.1	13.55	960.45	Till	3.10E-10
DH07-1A	KCB	North Dam	973	Falling Head Test	2.7 to 5.8	4.25	968.75	Till	4.70E-11
DH06-2	KP	Tailings Facilities	950	Shelby Tube	1.2 to 1.7	1.45	948.55	Till with silt/clay, trace sand and gravel	1.70E-09
DH06-7	KP	Tailings Facilities	993	Shelby Tube	1.2 to 1.5	1.35	991.65	Till with some gravel and trace sand	1.40E-05
DH06-9	KP	Old Plant Site	835	Shelby Tube	1.2 to 1.5	1.35	833.65	clay	2.40E-08
DH06-11	KP	Tailings Facilities	965	Shelby Tube	2.6 to 2.7	2.65	962.35	Till with silt/clay matrix	5.00E-07
DH06-12	KP	Tailings Facilities	996	Shelby Tube	1.4 to 1.5	1.45	994.55	Till with silt/clay matrix and some gravel	2.00E-10
TP06-15	KP	Tailings Facilities	955	Proctor Compacted	1.4	n/a	n/a	Till	1.50E-10
					2.4	n/a	n/a		
TP06-16	KP	Tailings Facilities	966	Proctor Compacted	1.2	n/a	n/a	Till	1.50E-10
					2.4	n/a	n/a		
TP06-17	KP	Tailings Facilities	967	Proctor Compacted	1.2	n/a	n/a	Till	1.50E-10
					3	n/a	n/a		
TP06-18	KP	Tailings Facilities	963	Proctor Compacted	0.6	n/a	n/a	Till	6.10E-09
					1.5	n/a	n/a		
					4.6	n/a	n/a		
TP06-19	KP	Tailings Facilities	970	Proctor Compacted	0.9	n/a	n/a	Till	6.10E-09
					3	n/a	n/a		
TP06-20	KP	Tailings Facilities	970	Proctor Compacted	0 to 1.5	0.75	969.25	Till	1.60E-07
					1.5	n/a	n/a		
TP06-21	KP	Tailings Facilities	972	Proctor Compacted	5.1	0.6	971.40	Till	1.60E-07
					2.7	n/a	n/a		
TP06-22	KP	Tailings Facilities	973	Proctor Compacted	1.2	n/a	n/a	Till	1.60E-07

Notes:
Rescan = Rescan Environmental Services Ltd.
KCB = Klohn Crippen Berger Limited.
KP = Knight Piesold Limited.
RHT = rising head test.
FHT = falling head test.
[1] masl = metres above sea level.
[2] mags = metres above ground surface.

Table 7.7-4
Morrison Copper/Gold Project: Summary of Bedrock Hydraulic Conductivity Testing

Well ID	Contractor	Location	Test Method	Site Elevation (masl)*	Tested Interval (mbgs)**	Tested Interval Midpoint (mbgs)**	Midpoint Elevation (masl)*	Lithology	Hydraulic Conductivity (m/s)
MW07-01A	Rescan	North Dam	Packer - CHT	970	16.76 to 28.04	22.40	947.60	Glauconitic Volcanoclastic unit	1.20E-06
MW07-02A	Rescan	E of TSF	Packer - CHT	1,091	4.57 to 21.94	13.26	1,077.75	Fossiliferous Limestone	6.78E-07
			Packer - CHT		21.94 to 40.23	31.09	1,059.92	Breccia	7.45E-09
MW07-02B	Rescan	E of TSF	Slug Test - RHT	1,091	6.1 to 9.14	7.62	1,083.38	Fossiliferous Limestone	1.43E-06
MW07-05A	Rescan	Open Pit	Packer - FHT	807	1.22 to 20.42	10.82	796.18	Altered Feldspar Biotite Porphyry	1.77E-07
			Packer - FHT		21.33 to 28.04	24.69	782.32	Altered Feldspar Biotite Porphyry	2.23E-07
			Packer - CHT		30.48 to 40.23	35.36	771.65	Altered Feldspar Biotite Porphyry	7.34E-07
			Slug Test - RHT		37.18 to 40.23	38.71	768.30	Altered Feldspar Biotite Porphyry	6.69E-07
			Slug Test - RHT		37.18 to 40.23	38.71	768.30	Altered Feldspar Biotite Porphyry	6.30E-07
MW07-06A	Rescan	SW of Open Pit	Slug Test - FHT	746	11.58 to 14.63	13.11	732.90	Andesitic Tuff	2.43E-08
			Slug Test - FHT		11.58 to 14.63	13.11	732.90	Andesitic Tuff	3.21E-08
			Slug Test - RHT		11.58 to 14.63	13.11	732.90	Andesitic Tuff	2.16E-07
MW07-07A	Rescan	Open Pit	Packer - FHT	837	9.14 to 15.85	12.50	824.51	Altered Feldspar Biotite Porphyry	3.11E-07
			Packer - CHT		32 to 38.71	35.36	801.65	Altered Feldspar Biotite Porphyry	1.20E-06
			Packer - CHT		54.86 to 57.91	56.39	780.62	Altered Feldspar Biotite Porphyry	6.20E-09
			Packer - FHT		74.67 to 77.22	75.95	761.06	Altered Feldspar Biotite Porphyry	8.50E-07
			Packer - CHT		119.02 to 149.65	134.34	702.67	Altered Feldspar Biotite Porphyry	3.51E-08
			Packer - FHT		146.45 to 149.65	148.05	688.95	Altered Feldspar Biotite Porphyry	5.70E-07
MW07-08A	Rescan	Waste Rock Dump	Slug Test - RHT	840	37.18 to 40.23	38.71	801.30	Sandstone or siltstone	2.08E-09
			Slug Test - RHT		37.18 to 40.23	38.71	801.30	Sandstone or siltstone	1.90E-09
			Packer - CHT		15.39 to 40.23	27.81	812.19	Sandstone or siltstone	8.59E-09
MW08-01A	Rescan	In between Open Pit and Waste Rock Dump	Packer - CHT	832	58.37 to 65.99	62.18	769.82	Tuff	1.55E-07
			Packer - CHT		67.51 to 76.66	72.09	759.91	Tuff	1.56E-06
			Packer - CHT		75.13 to 85.00	80.07	751.94	Siltstone	4.83E-09
			Slug Test - RHT		70.26 to 78.64	74.45	757.55	Siltstone	2.28E-06
MW08-02A	Rescan	W of Open Pit	Packer - CHT	752	42.98 to 49.07	46.03	705.97	Biotite Feldspar Porphyry	5.51E-07
			Packer - CHT		64.31 to 73.46	68.89	683.11	Biotite Feldspar Porphyry	1.23E-05
			Packer - CHT		105.46 to 113.08	109.27	642.73	Biotite Feldspar Porphyry	1.36E-07
			Packer - CHT		135.94 to 151.20	143.57	608.43	Siltstone and Biotite	1.57E-06
			Packer -DT		82.60 to 91.74	87.17	664.83	Biotite Feldspar Porphyry	5.95E-07
			Slug Test - RHT		137.62 to 149.81	143.72	608.29	Siltstone and Biotite	4.62E-06
MW08-03A	Rescan	Low Grade Ore Stockpile	Packer - CHT	800	18.59 to 23.32	20.96	779.04	Sandstone	1.25E-06
			Packer - CHT		30.78 to 35.51	33.15	766.85	Sandstone	3.29E-06
			Slug Test - RHT		28.96 to 35.51	32.24	767.77	Sandstone	1.02E-05
DH07-1A	KCBL	North Dam	Packer Test	973	23.35 to 35.66	29.505	943.50	Sandstone/mudstone	6.00E-07
			Packer Test		35.51 to 49.38	42.445	930.56	Sandstone/mudstone	7.00E-08
DH07-2A	KCBL	North Dam	Packer Test	990	26.2 to 35.1	30.65	959.35	Siltstone	2.40E-07
DH07-3A	KCBL	Main Dam	Packer Test	974	24.23 to 35.51	29.87	944.13	Sandstone	1.60E-06
			Packer Test		35.51 to 41.61	38.56	935.44	Sandstone/siltstone	1.80E-06
			Falling Head Test		24.2 to 35.5	29.85	944.15	Sandstone	2.20E-06
DH07-4A	KCBL	Main Dam	Packer Test	960	15.54 to 27.89	21.715	938.29	Sandstone/siltstone	3.20E-07
			Packer Test		36.12 to 46.18	41.15	918.85	Siltstone	2.30E-07
			Packer Test		27.89 to 36.12	32.005	928.00	Sandstone/siltstone	1.50E-07
DH07-05B	KCBL	Main Dam	Falling Head Test	935	26.4 to 43	34.7	900.30	Volcaniclastic	6.20E-07
			Packer Test		45.26 to 58.22	51.74	883.26	Siltstone/Sandstone	6.60E-08
DH06-1	KPC	Open Pit	Packer Permeability	950	27.4 to 60.8	44.1	911.81	Zs	1.40E-06
					59.4 to 89.9	74.65	885.35	Vol	2.40E-07
					89.9 to 126.5	108.2	841.80	Vol	negligible
DH06-2	KPC	Tailings Facilities	Packer Permeability	950	9.1 to 39.5	24.3	925.70	Vol	5.10E-07
DH06-3	KPC	Tailings Facilities	Packer Permeability	950	6.7 to 36.9	23.3	926.70	Vol	3.30E-07
DH06-4	KPC	Tailings Facilities	Packer Permeability	983	11 to 41.5	26.25	956.75	LM	7.40E-07
DH06-6	KPC	Tailings Facilities	Packer Permeability	960	9.6 to 36.7	23.15	936.85	Vol	1.40E-06
DH06-7	KPC	Tailings Facilities	Packer Permeability	993	12.8 to 43.3	28.05	964.95	Vol/ZS/SST	5.10E-06
DH06-10	KPC	Tailings Facilities	Packer Permeability	1,001	21.9 to 53.6	37.75	963.25	SST/ZS	negligible
DH06-11	KPC	Tailings Facilities	Packer Permeability	965	8.8 to 36.9	22.85	942.15	ZS	7.20E-07
DH06-12	KPC	Tailings Facilities	Packer Permeability	996	13.1 to 58.3	35.7	960.30	SST/Siltst/ZS	2.80E-07
DH06-13	KPC	Open Pit	Packer Permeability	808	11.9 to 20.3	16.1	791.90	BFP	4.50E-07
DH06-14	KPC	Waste Rock Dump	Packer Permeability	840	21.9 to 29.3	25.6	814.40	ZS	8.50E-07
9240-3	KPC	Open Pit	Lugeon	833	62.8 to 64.9	63.85	780.70	Altered Feldspar Biotite Porphyry	3.90E-10
					71.9 to 74.1	73	773.20	Altered Feldspar Biotite Porphyry	1.60E-09
					93.3 to 95.4	94.35	755.71	Altered Feldspar Biotite Porphyry	1.00E-10
					105.5 to 107.6	106.55	745.72	Fine grained sandstone	2.00E-10
9060-2	KPC	Open Pit	Packer	810	20.7 to 22	21.35	792.51	Altered Feldspar Biotite Porphyry	1.70E-08
					148.1 to 150.3	149.2	687.78	Altered Feldspar Biotite Porphyry	8.10E-11
9220-1	KPC	Open Pit	Packer Test	849	34.4 to 75.3	54.85	804.07	Altered Feldspar Biotite Porphyry	1.30E-07
9360-1	KPC	Open Pit	Packer Test	801.9	58.8 to 100	79.4	736.86	Altered Feldspar Biotite Porphyry	1.50E-10

RHT = rising head test.
FHT = falling head test.
CHT = constant head test.
DT = discharge test.
***masl = metres above sea level.**
****mags = metres above ground surface.**

groundwater monitoring wells and standpipe piezometers installed by Klohn Crippen Berger on the Morrison property. Tables 7.7-5 and 7.7-6 present a summary of the water level measurements collected by Rescan in the Project footprint during the baseline studies.

7.7.3 Results and Discussion

7.7.3.1 Groundwater recharge and discharge

Recharge to overburden and bedrock groundwater

The recharge to the overburden groundwater regime is mainly drawn from rainfall and spring snowmelt waters. In 2008, an automated precipitation monitoring system installed by Rescan recorded a total precipitation of 658 mm (Appendix 18). Environment Canada meteorological stations within 100 km of the Morrison property recorded an annual average precipitation of 500 mm over the period from 1971 to 2000. Secondary sources of recharge to overburden groundwater may include up-gradient subsurface flows coming from higher elevation sites on and around the property.

Recharge to bedrock groundwater originates from two main sources: seepage from the overburden, and groundwater flow by infiltration and seepage through the faults and fractures in the Morrison property. Direct recharge to bedrock can also occur where fractured bedrock is directly exposed at the surface (i.e., bedrock outcrop). The groundwater is possibly transmitted through fractures from outcrops at higher elevations. This might explain the flowing artesian conditions of some monitoring wells down-gradient of bedrock outcrops in the Project footprint.

Discharge to surface water

The presence of flowing artesian wells on the property suggests that upward vertical hydraulic gradients contribute groundwater to surface water. Given that upward hydraulics occur generally (but not exclusively) at lower elevations in the Morrison property, this is likely to be where the groundwater contribution to the surface water regime is of higher importance. Groundwater discharge to surface water occurs along creeks, such as those adjacent to MW07-03A and MW07-01A, and smaller waterbodies such as Booker Lake.

7.7.3.2 Groundwater flow directions

Figures 7.7-3a and 7.7-3b present the potentiometric surface map created from the available water level data from monitoring wells and piezometers. In general, the groundwater surface contours follow the overlying topography contours. In the northern area of the Morrison property, groundwater flows in a northeasterly direction away from the proposed north dam of the TSF. The TSF is surrounded by highlands to the east and northwest. The groundwater flows from these highlands into the proposed TSF area, where wetlands are common. From these wetlands, groundwater flows in a southwesterly direction towards Morrison Lake. In the southern portion of the Morrison property, in the proposed open pit location and surrounding area, groundwater flows in a southwesterly direction from the highlands to the east towards Morrison Lake.

Table 7.7-5
Morrison Copper/Gold Project: Water Level Data

Well I.D.	Elevation (masl)*	Average Water Level (mbgs)**	Average Water Level Elevation (masl)*	Minimum Water Level Elevation (masl)*	Maximum Water Level Elevation (masl)*	Number of Measurements	Gradient
MW07-01A	970	artesian	970	970	970	5	up
MW07-01B	970	2.12	967.88	964.82	970.94	5	
MW07-02A	1,091	2.86	1088.14	1,087.45	1,089.15	5	down
MW07-02B	1,091	2.24	1088.77	1,088.16	1,089.49	5	
MW07-03A	782	-0.06	782.02	781.29	782.83	5	up
MW07-03B	782	1.64	780.36	780.24	780.49	5	
MW07-04A	822	24.98	797.02	796.55	798.62	5	down
MW07-04B	822	1.89	820.11	816.58	821.33	5	
MW07-05A	807	17.93	789.07	786.36	790.41	5	none
MW07-05B	807	17.15	789.86	789.22	790.865	5	
MW07-06A	746	3.90	742.11	740.72	744.3	5	down
MW07-06B	746	2.70	743.30	742.73	743.78	5	
MW07-07A	837	40.19	796.81	794.3	798.01	5	down
MW07-07B	837	30.41	806.59	806.18	807.35	5	
MW07-08A	840	0.90	839.10	838.355	839.98	5	up
MW07-08B	840	5.73	834.27	829.69	836.96	5	
MW08-01A	832	24.93	807.07	-	-	1	up
MW08-01B	832	28.64	803.36	-	-	1	
MW08-02A	752	3.83	748.17	-	-	1	down
MW08-02B	752	0	752	-	-	1	
MW08-03A	800	12.66	787.34	-	-	1	up
MW08-03B	800	13.54	786.46	-	-	1	

***Metres above sea level.**

****Metres below ground surface.**

Table 7.7-6
Klohn Crippen Berger and Knight Piésold Water Level Measurements

Well I.D.	Contractor	Average Water Level (mbgs)	Number of Measurements
DH07-1A	KCB	-4.5	4
DH07-1B	KCB	-0.83	3
DH07-2A	KCB	27.86	4
DH07-2B	KCB	6.35	3
DH07-3A	KCB	8.69	3
DH07-3B	KCB	10.76	2
DH07-4A (S1)	KCB	10.11	3
DH07-4A (S2)	KCB	10.86	3
DH07-4B (S1)	KCB	10.77	2
DH07-4B (S2)	KCB	4.05	2
DH07-5A (S1)	KCB	11.47	2
DH07-5A (S2)	KCB	10.62	2
DH07-5B	KCB	11.50	1
DH07-6	KCB	-0.93	2
DH07-7	KCB	8.26	2
DH07-9	KCB	1.45	2
DH08-01A	KCB	6.68	1
DH08-01B	KCB	1.52	1
DH08-02	KCB	4.71	1
DH08-03	KCB	8.60	1
DH06-2	KP	artesian	2
DH06-3	KP	3.63	2
DH06-4	KP	11.165	2
DH06-6	KP	artesian	2
DH06-7	KP	artesian	2
DH06-8	KP	artesian	3
DH06-9	KP	11.91	3
DH06-10	KP	30.07	3
DH06-11	KP	1.66	3
DH06-12	KP	4.03	3
DH06-13	KP	8.8	1
DH06-14	KP	6.90	3
DH06-15a	KP	artesian	2
DH06-15b	KP	3	1
DH06-16	KP	3	1
DH06-17	KP	dry	1
GW1	KP	2.6	1
9000-1	KP	22.48	1
9240-1	KP	51.84	1
9240-3	KP	6.37	1

mbgs = metres below ground surface.
KCB = Klohn Crippen Berger Limited.
KP = Knight Piésold.

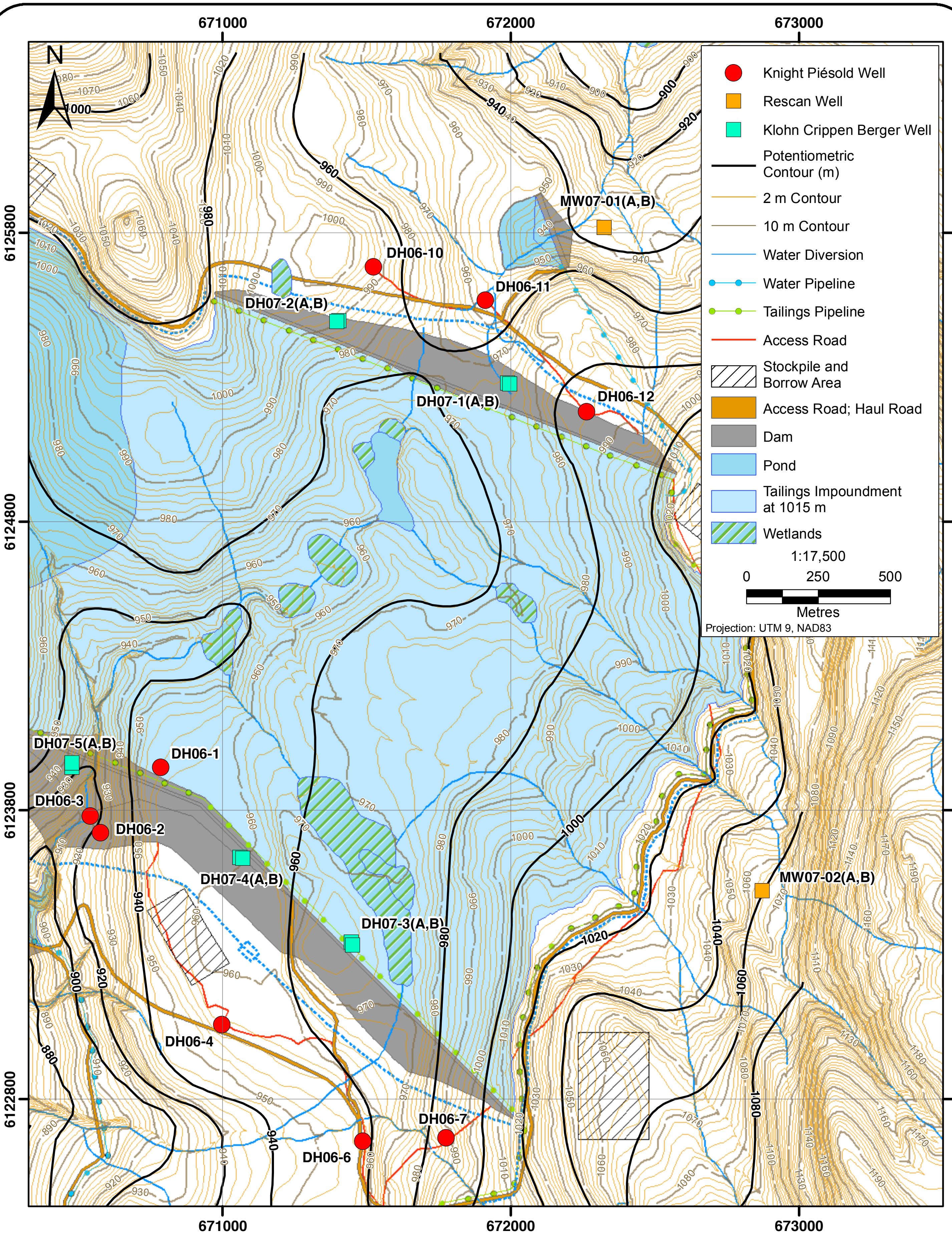


FIGURE 7.7-3a

Morrison Copper/Gold Project : Potentiometric Surface

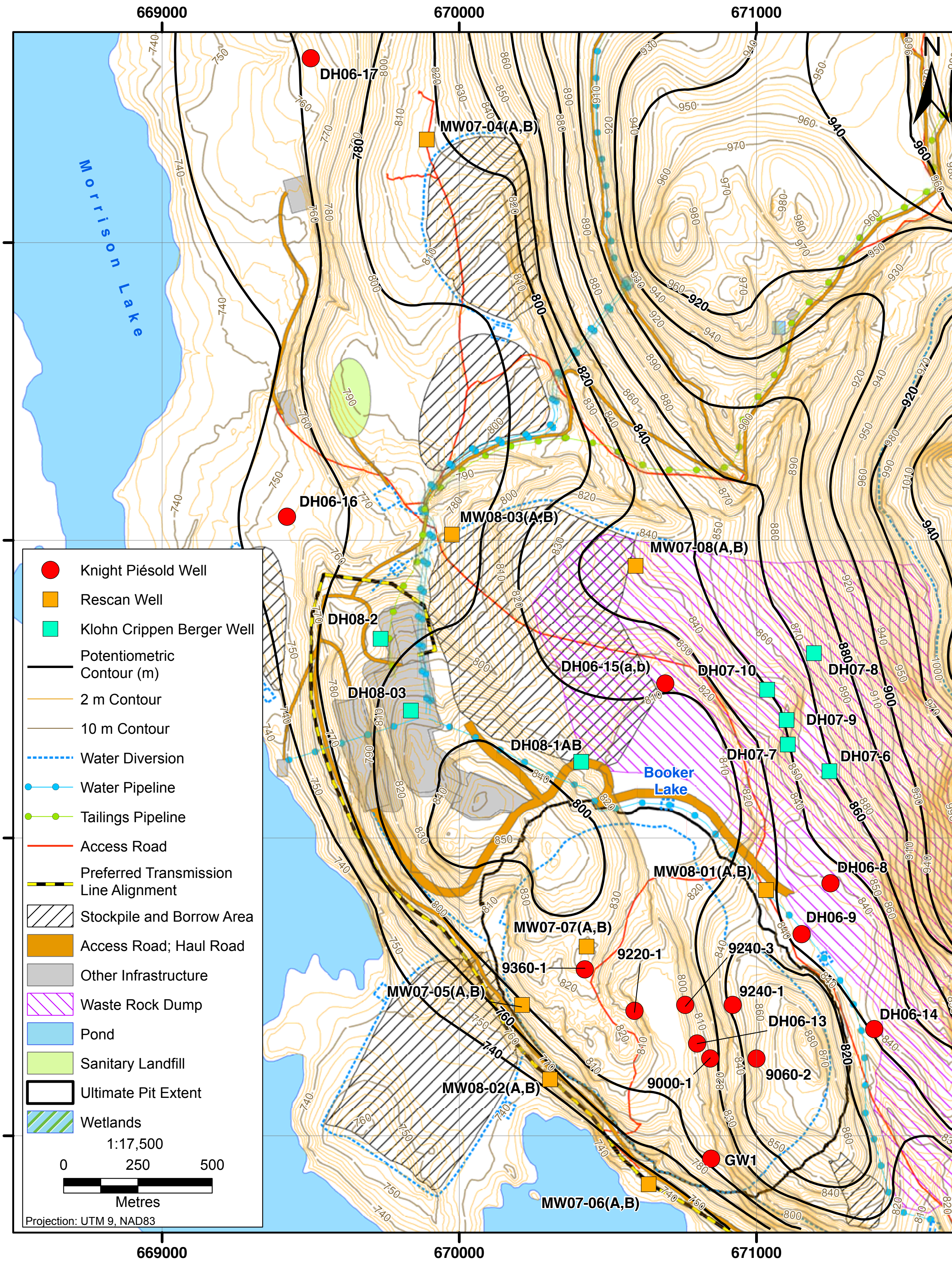


FIGURE 7.7-3b

Morrison Copper/Gold Project : Potentiometric Surface

pbm Rescan

All the Rescan monitoring wells were drilled and installed in nested well pairs consisting of a deep (A) and a shallow (B) monitoring well. This allows for characterization of the vertical flow gradients at the different monitoring well locations by comparing water levels measured near each other (approximately 5 m apart) and with screened units placed at different elevations. A general trend shows that well locations at higher elevations on the Morrison property have negative vertical gradients (i.e., downward vertical groundwater flow component), and monitoring well locations at lower elevations near valley bottoms show an upward groundwater flow component or positive vertical gradient. Exceptions to this trend occur where Morrison Lake or a geological structure, such as a major fault, is close to the monitoring well location.

7.7.3.3 Continuous monitoring station – seasonal variations

In addition to the manual water level field measurements taken regularly in the Project footprint, a single channel vibrating wire piezometer was installed in monitoring well MW07-07A in the open pit area (Figure 7.7-2) in October, 2007. The data logger was installed at a depth of 71.32 mbgs, and recorded the groundwater level every 12 hours. These measurements are presented in Figure 7.7-4 for one full year (October 2007to October 2008) to illustrate the groundwater level variations. Water levels dropped from October, 2007, to April, 2008. Water levels rose by 3.5 m from early April to mid May. Water levels dropped again from mid-May to October, 2008.

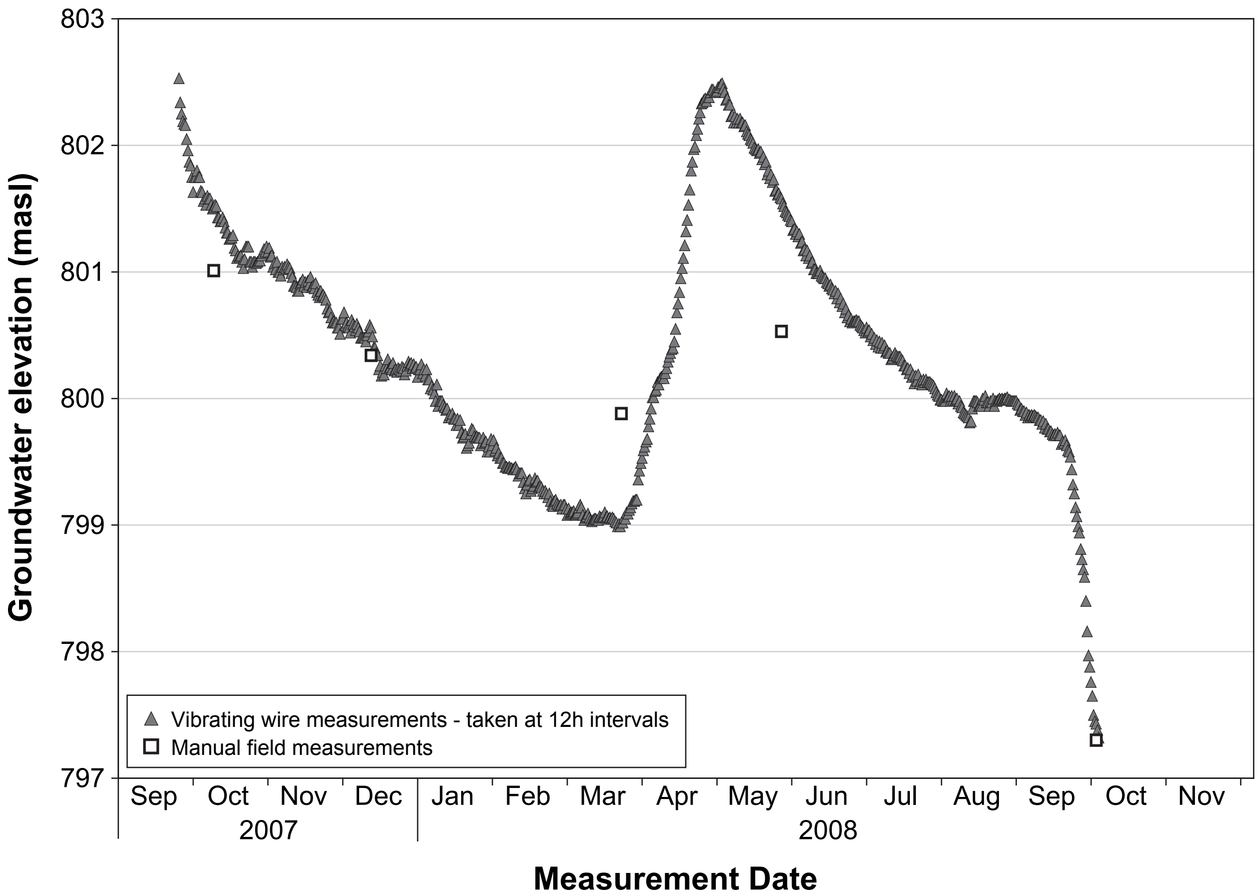
7.7.4 Conclusion

Groundwater tends to flow from the high elevations to the east and northeast of the open pit towards Morrison Lake, and from the higher elevations surrounding the proposed TSF to the wetlands in the centre of the TSF. These observations are in line with the anticipated findings given the physical geology of the area. Fault structures, particularly in the area of the open pit, will dominate localized groundwater flow regimes.

In general, surficial materials (typically glacial till) act as a confining layer to the underlying higher conductivity fractured bedrock at lower elevations. At higher elevations bedrock is exposed or the overburden consists of colluvium; in these zones recharge rates to the groundwater will be greater. As depth increases, the hydraulic conductivity of the bedrock and the density of fracturing decrease. Measured hydraulic conductivities of tested materials at the Morrison site are generally in line with literature values.

7.8 Sediment Quality

Sediment quality was assessed from 2006 to 2008 using standard methods (RISC 1998) concurrently with aquatic biology and surface water quality studies in streams, lakes, and ponds within the Project area (Figure 7.8-1). Complete details of these baseline studies are available in appendices 26 and 27. Sediment quality includes the physical and chemical properties of sediments and is an indicator of long-term patterns in water quality through the adsorption and absorption of water constituents to sediment particles. Aquatic organisms living on or within sediment (periphyton, macrophytes, benthic invertebrates, and fish) can be adversely affected by poor sediment quality (CCME 1995). Contaminants taken up by these organisms can be transferred to higher trophic levels and potentially impair aquatic ecosystem function.



Morrison Copper/Gold Project: Groundwater Levels in MW07-07A from October 2007 to October 2008

FIGURE 7.7-4

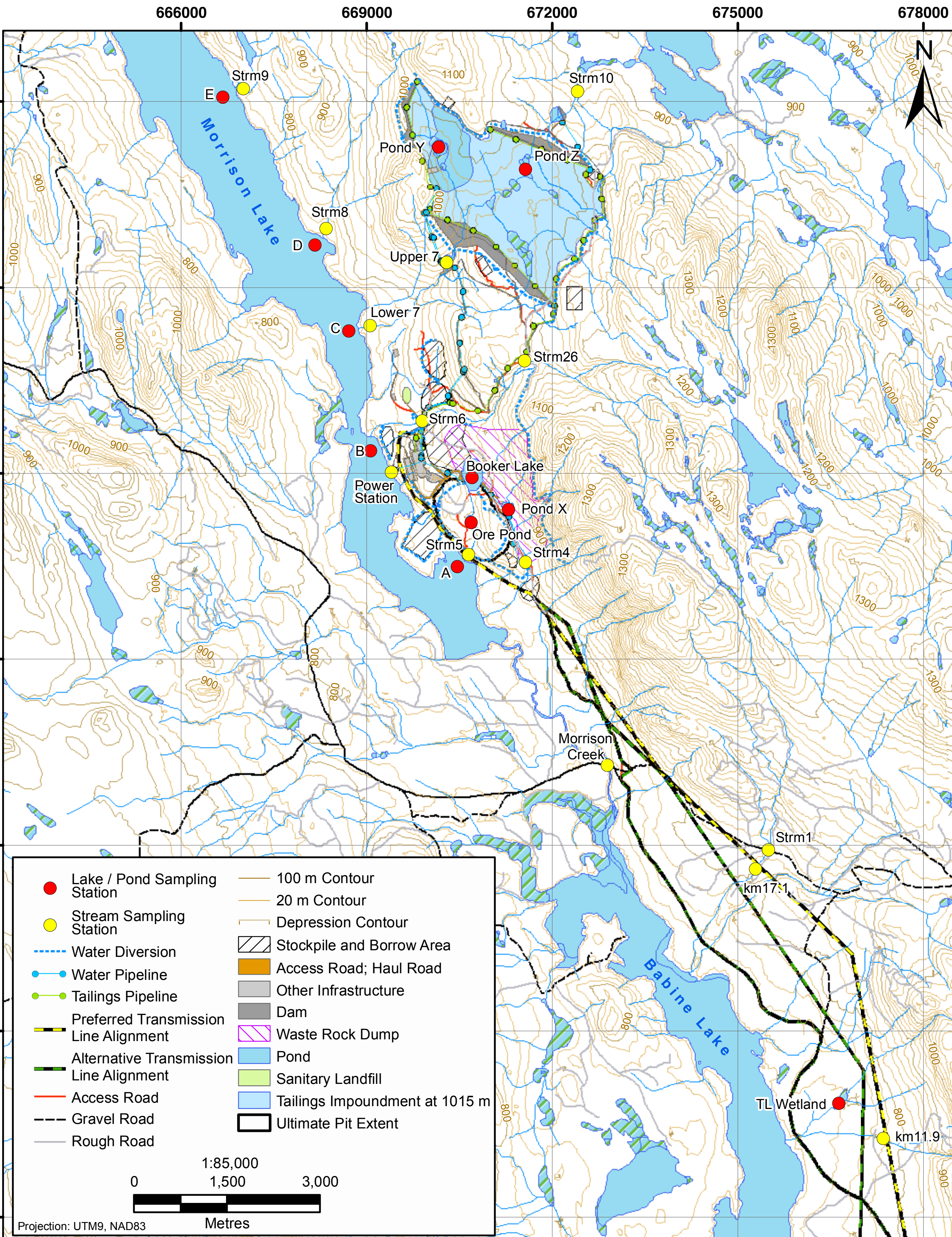


FIGURE 7.8-1

Morrison Copper/Gold Project
Sampling Sites

Sediments can function as a sink for contaminants, which can adhere to sediment particles and accumulate over time if left undisturbed (CCME 1995). Conversely, these sediments may eventually become a source for contaminants even after the original point source of contamination has been addressed. Contaminants can be released suddenly from the sediments due to disturbances such as floods or dredging (Environment Canada 2003b).

Sediment quality at reference sites and from pre-Project periods will be compared to exposure sites throughout the life of the Project to identify potential effects associated with Project activities. Provincial and federal sediment quality guidelines for the protection of aquatic life (Ontario Ministry of the Environment 1993; CCME 2003b) were used to assess sediment quality in the study area. Guidelines are available for arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, and zinc sediment concentrations.

7.8.1 Stream Sites

Sediment was collected at 8 sites in 2006, 10 sites in 2007, and 13 sites in 2008 (Table 7.8-1). Any missing samples at a particular site were a result of the Project details available at the time or site inaccessibility. In 2008, two sites (Strm11.9 and 17.1) were added to characterize the area of the proposed transmission line. Samples were analyzed for moisture, particle size composition, nutrients, TOC, and total metal concentrations.

Table 7.8-1
Stream Sediment Sample Sites, Morrison Project Area

Area	Site	2006	2007	2008
Receiving Environment	Strm1	X	X	X
	Morrison Creek	X	X	X
	Strm4	X	X	X
	Strm5	X	X	X
	Strm6	X	X	X
	Strm26	X	X	X
	Lower7	X	X	X
	Upper7	X	X	X
	Strm8	-	X	X
	Strm10	-	X	X
	Strm9	-	-	X
Transmission Line	Strm11.9	-	-	X
	Strm17.1	-	-	X

Each year, all sites were dominated by sand with smaller proportions of gravel, silt, and clay. The particle size composition gives an indication of flow levels. High flow conditions will wash smaller particles downstream leaving coarser substrates behind. While these sites were dominated by sand, they also contained substantial proportions of gravel, indicating moderate flows in the area. Stream substrate composition can also provide information about the biological relevance of sediment metal concentrations. Metal concentrations can be influenced by particle size and organic content since small particles (<63 µm particles like silt and clay) and organic matter have a higher affinity for metals (Environment Canada 2003a). Strm5 and Strm9 contained higher proportions of silt and clay, which contributed to the higher metals concentrations found at these sites in 2006 and 2008.

The hydrometric data from the area (Section 7.2) indicates that precipitation was generally low, although levels in the summer of 2007 were above average. The physical composition of stream substrates is consistent with what would be expected based on the available hydrometric data and the associated surface runoff.

Nutrient concentrations were generally variable among all sites and years. Strm5 and Strm9 had high concentrations of nitrogen, phosphorus, and TOC. TOC was more variable among years than nutrients, with higher percentages consistently found at sites dominated by silt and clay (e.g., Strm5, Strm9). Cyanide concentrations were below detection limits (3mg/kg) at most sites, with the highest concentration (10.7 mg/kg) found at Upper7 in 2007.

Of the nine metals with provincial and federal guidelines, all except lead exceeded at least one guideline (Table 7.8-2). The CCME guidelines (2003b) include the interim sediment quality guideline (ISQG) and the probable effect level (PEL). The lowest effect level (LEL) and severe effect level (SEL) are commonly used guidelines that are based on observed biological effects to known metal concentrations (Ontario Ministry of the Environment 1993).

Arsenic concentrations exceeded two of the four guidelines at each site and year; the SEL (33 mg/kg) was exceeded at Strm1 in 2006, Strm5 in 2007 and 2008, and Strm9 in 2008. Cadmium concentrations were below detection limits at most sites; however, the LEL and ISQG were exceeded at one site in 2006, two sites in 2007, and three sites in 2008. As with cadmium, chromium concentrations exceeded the LEL and ISQG at several sites. All sites were well below the PEL and the SEL for cadmium and chromium.

Copper concentrations were relatively high in the study area, with a maximum concentration of 1,174 mg/kg found at Strm5 in 2006, although most concentrations were between 10 and 50 mg/kg. Strm5 was the only site to exceed the LEL and ISQG, and these guidelines were exceeded in all years at this site. Iron concentrations were similar across all years, ranging from approximately 20,000 to 50,000 mg/kg, and the LEL was exceeded at all sites each year.

Average mercury concentrations were generally low; however, guidelines were exceeded at Strm4, Strm5, and Upper7. Nickel concentrations ranged between 10 and 35 mg/kg at most sites. The LEL for nickel was exceeded at all sites in 2006 except Morrison Creek and Strm6 and all sites in 2007 and 2008. Zinc concentrations were generally low; however, Strm5 exceeded the LEL and ISQG in all years, and Strm4 exceeded these guidelines in 2006. No sites exceeded the PEL or the SEL for nickel or zinc.

7.8.2 Lake and Pond Sites

Sediment sampling at lake and pond sites was conducted at all 10 sites in 2006, the 5 smaller lake and pond sites in 2007, and the 5 Morrison Lake sites in 2008 (Table 7.8-3).

Table 7.8-2
Summary of Sites Exceeding Provincial and Federal Metals Guidelines

Site	Year	Arsenic				Cadmium				Chromium				Copper				Iron		Lead				Mercury				Nickel		Zinc			
		LEL	ISQG	PEL	SEL	LEL	ISQG	PEL	SEL	LEL	ISQG	PEL	SEL	LEL	ISQG	PEL	SEL	LEL	SEL	LEL	ISQG	PEL	SEL	LEL	ISQG	PEL	SEL	LEL	SEL	LEL	ISQG	PEL	SEL
Guideline Value (mg/kg)		6	5.9	17	33	0.6	0.6	3.5		26	37	90	110	16	36	197	110	21,200	43,766		35	91		0.2	0.170	0.486		16	75	120	123	315	
	2006	X	X	X	X									X				X										X					
Strm1	2007	X	X							X				X	X			X										X					
	2008	X	X	X						X				X	X			X										X					
	2006	X	X															X															
Morrison Creek	2007	X	X											X				X										X					
	2008	X	X															X										X					
	2006	X	X	X						X	X			X	X			X	X						X			X		X	X		
Strm4	2007	X	X	X										X	X			X										X					
	2008	X	X	X										X	X			X										X					
	2006	X	X			X	X			X	X			X	X	X	X	X						X	X			X		X	X		
Strm5	2007	X	X	X	X					X	X			X	X	X	X	X	X					X	X			X		X	X		
	2008	X	X	X	X	X	X							X	X	X	X	X						X	X			X		X	X		
	2006	X	X															X															
Strm6	2007	X	X	X										X				X										X					
	2008	X	X											X				X										X					
	2006	X	X											X				X										X					
Strm26	2007	X	X											X				X										X					
	2008	X	X	X						X	X			X	X			X	X									X					
	2006	X	X							X	X			X				X										X					
Lower7	2007	X	X	X						X	X			X				X	X									X					
	2008	X	X											X				X										X					
	2006	X	X	X										X				X										X					
Upper7	2007	X	X	X										X				X	X									X					
	2008	X	X	X						X	X			X	X			X	X					X	X	X		X					
Strm8	2007	X	X	X														X										X					
	2008	X	X	X										X				X										X					
Strm9	2008	X	X	X	X	X	X							X				X										X					
Strm10	2007	X	X	X		X	X							X				X	X									X					
	2008	X	X	X		X	X							X				X										X					
Strm11.9	2008	X	X											X				X										X					
Strm17.1	2008	X	X	X										X				X										X					

LEL=lowest effect level
ISQG=interim sediment quality guideline
PEL=probable effect level
SEL=severe effect level

Table 7.8-3
Lake and Pond Sediment Sampling Sites, Morrison Project Area

	Site	2006	2007	2008
Lake	Lake A	X	-	X
	Lake B	X	-	X
	Lake C	X	-	X
	Lake D	X	-	X
	Lake E	X	-	X
	Ore Pond	X	X	-
	Booker Lake	X	X	-
Pond	Pond X	X	X	-
	Pond Y	X	X	-
	Pond Z	X	X	-

An Ekman sampler was used to collect bottom sediments. These whole sediment samples were tested for particle size composition, TOC, nutrient concentrations, and total metals. Details of these analyses are provided in appendices 26 and 27.

Particle size data indicate that sediments at the Morrison Lake sites were primarily composed of clay and silt, with smaller proportions of sand, and minimal amounts of gravel. These proportions were similar in 2006 and 2008. The remaining five lake and pond sites were all similar in 2006; however, compositions were quite different in 2007 at Booker Lake, Pond X, and Pond Y. These sites contained larger amounts of sand, with only small percentages of silt, and Pond Y contained over 30% gravel. These differences may be due to differences in the locations of the sediment grabs but clearly represent the diversity of substrate at these sites.

Sediments dominated by clay and silt are typical in lakes as smaller particles are washed downstream and settle in lake basins. These smaller sediments provide greater surface area for nutrients and metals to adhere to, generally resulting in greater concentrations of nutrients and metals at these lake sites, as compared to stream sites that have sediments composed of sand or gravel.

Total nitrogen and total phosphorus concentrations were similar among years at each site. The Morrison Lake sites contained low levels of total nitrogen, ranging from approximately 0.4 to 0.8%, while the smaller lakes and pond sites had higher levels, between 1.5 and 2.5%. Phosphorus showed the opposite pattern, with generally higher concentrations measured at the Morrison Lake sites, ranging widely from 1,313 to 3,113 mg/kg, while the lake and pond sites contained lower concentrations and a smaller range of values from 686 mg/kg to 1,983 mg/kg.

TOC concentrations remained consistent among years. Concentrations at the Morrison Lake sites were low, ranging from 6 to 10%, while the concentrations at the smaller lakes and ponds were higher, ranging from 21 to 32%. Cyanide concentrations were generally low, with sites ranging from below detection limits to 7.3 mg/kg. The Morrison Lake sites had slightly higher concentrations, as more sites had detectable concentrations. The notable exception was Ore Pond in 2007, which contained a cyanide concentration of 55.2 mg/kg.

Nine metals are subject to provincial and federal guidelines and of these nine, eight were exceeded at one or more sites (Table 7.8-4). Lead was the only metal for which guidelines were not exceeded. Arsenic concentrations were generally high, with all Morrison Lake sites exceeding all four guidelines. Concentrations were slightly lower at the remaining five sites, although at least one guideline was exceeded at every site.

Cadmium concentrations were similar across all sites, with most sites within a 0.5 mg/kg range. Nearly all sites exceeded the LEL and CCME ISQG, with the exception of Lake B and Lake C. Chromium concentrations were similar across years, with the Morrison Lake sites showing slightly higher concentrations in 2008. All sites exceeded at least one guideline except for Pond Y and Pond Z. No sites exceeded the SEL or the CCME PEL for cadmium or chromium.

Copper concentrations were highly variable between sites. All sites exceeded the LEL and the ISQG for at least one year. Two sites contained high concentrations: Lake A, which exceeded the SEL in 2006, and Ore Pond which exceeded both the SEL and the PEL in both 2006 and 2007. Iron concentrations were higher at the Morrison Lake sites, with all sites exceeding both guidelines during at least one year. The smaller lake and pond sites contained lower levels of iron although all sites except Pond Z exceeded the LEL and SEL.

Mercury levels were fairly high and similar across all sites and years. Every site exceeded the LEL and the ISQG during at least one sampling year. Nickel concentrations were high across all sites, with all sites exceeding the LEL. Zinc concentrations were also high, with only Lake C, Pond Y, and Pond Z concentrations below available guidelines. No sites exceeded the SEL or the PEL for mercury, nickel, or zinc.

Since lake sediments are more likely to remain undisturbed than stream sediments, lakes can act as sinks for the metals sequestered in their undisturbed sediments (CCME 1995). The concentrations found within the Morrison study area reflect the natural conditions, and are similar to typical levels observed in lakes within the northern interior plateau physiographic region (BC MELP 1992).

7.9 Aquatic Resources

7.9.1 Overview

Aquatic resources were assessed from 2006 to 2008 at various streams, lakes, and ponds within the Project area (Figure 7.9-1). Detailed baseline data on aquatic resources were collected to characterize the aquatic environment within the Project area before development (appendices 26 and 27), and to satisfy the criteria required for the submission of the Environmental Assessment (EA) application. These studies included biological assessments and were conducted using standard methods (RISC 1997). This environmental setting for aquatic resources will focus on the following components of the freshwater environment:

Table 7.8-4
Summary of Sites Exceeding Provincial and Federal Metals Guidelines

		Arsenic				Cadmium				Chromium				Copper				Iron		Lead				Mercury				Nickel		Zinc			
Site	**Year**	LEL	ISQG	PEL	SEL	LEL	ISQG	PEL	SEL	LEL	ISQG	PEL	SEL	LEL	ISQG	PEL	SEL	LEL	SEL	LEL	ISQG	PEL	SEL	LEL	ISQG	PEL	SEL	LEL	SEL	LEL	ISQG	PEL	SEL
Guideline Value (mg/kg)		6	5.9	17	33	0.6	0.6	3.5		26	37	90	110	16	35.7	197	110	21,200	43,766		35	91		0.2	0.17	0.486		16	75	120	123	315	
LakeA	2006	X	X	X	X	X				X	X			X	X		X	X	X					X	X			X		X	X		
	2008	X	X	X	X	X	X			X				X	X			X	X					X	X			X		X	X		
LakeB	2006	X	X	X	X					X				X	X			X	X					X	X			X		X	X		
	2008	X	X	X	X									X				X						X	X			X					
LakeC	2006	X	X	X	X					X	X			X	X			X	X					X	X			X					
	2008	X	X	X	X					X				X	X			X	X					X	X			X					
LakeD	2006	X	X	X	X	X	X			X	X			X	X			X	X					X	X			X		X	X		
	2008	X	X	X	X	X	X			X				X	X			X	X					X	X			X		X	X		
LakeE	2006	X	X	X	X	X	X			X	X			X	X			X	X					X	X			X		X	X		
	2008	X	X	X	X									X				X										X					
Ore Pond	2006	X	X	X	X	X	X			X				X	X	X	X	X	X					X	X			X		X	X		
	2007	X	X	X	X										X	X	X	X						X	X			X		X	X		
Booker Lake	2006	X	X	X	X	X	X			X				X	X			X						X	X			X		X	X		
	2007	X	X	X		X	X			X				X	X			X						X	X			X		X	X		
PondX	2006	X	X			X	X							X	X			X										X		X	X		
	2007	X	X	X		X	X			X	X			X	X			X	X					X	X			X		X	X		
PondY	2006	X	X			X	X							X	X									X	X			X					
	2007	X	X			X	X							X										X	X			X					
PondZ	2006													X																			
	2007	X	X			X	X							X										X	X			X					

LEL=lowest effect level

ISQG=interim sediment quality guideline

PEL=probable effect level

SEL=severe effect level

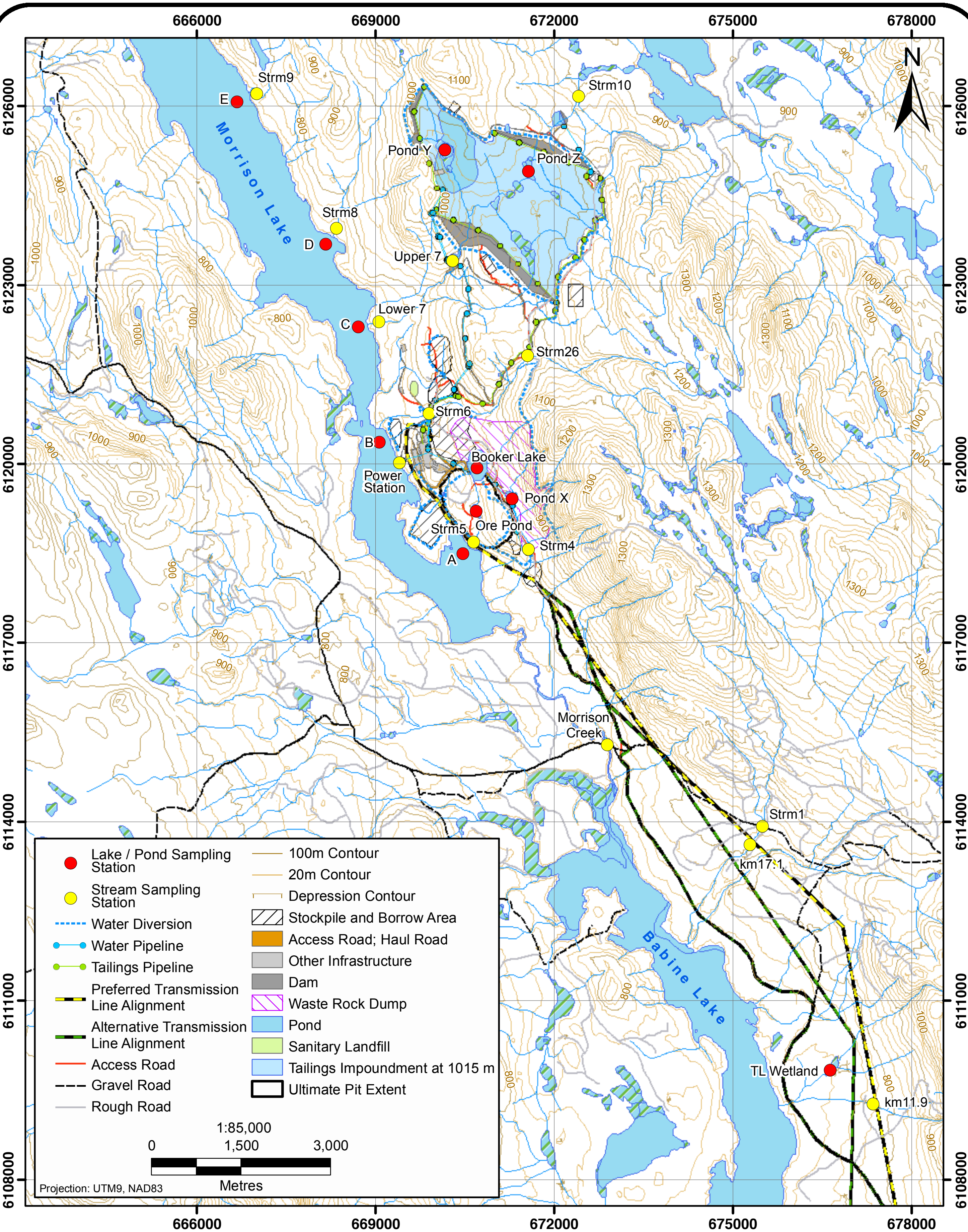


FIGURE 7.9-1

Morrison Copper/Gold Project
Sampling Sites

- stream periphyton
- stream benthic invertebrates
- lake and pond phytoplankton
- lake and pond benthic invertebrates
- lake zooplankton

Aquatic resources refer to all primary and secondary producer communities within freshwater environments. These organisms are fundamental components for aquatic ecosystem function, processing available nutrients and providing the biomass to support higher trophic levels (i.e., fish, birds, etc.). As a result of their limited mobility and life history characteristics (e.g., living on or in sediment) aquatic communities are closely linked to the physical features of their habitat. For this reason, monitoring aquatic resources is useful for detecting changes to the quality of sediment, water, and aquatic habitat in general. The federal Metal Mining Effluent Regulations (MMER) require, at a minimum, the implementation of benthic invertebrate surveys to monitor for potential effects of metal mines on the aquatic environment (Environment Canada 2003a).

Because of their sensitivity and rapid response to changes in the environment, aquatic resources are useful as early indicators of potential shifts or disturbances to ecosystems. Monitoring the changes in macro-invertebrate assemblages by considering several community variables can indicate a disturbance to the aquatic environment (Fore, Karr, and Wisseman 1996). During baseline studies, primary and secondary producers were assessed for community composition, productivity, abundance, and diversity. These studies provide several different variables that can be used to monitor effects during the construction and operation phases of the mine site.

7.9.2 Stream Sites

Thirteen streams near the proposed Project site were surveyed for aquatic resources between 2006 and 2008 (Table 7.9-1). In some instances, only periphyton communities were sampled because of insufficient flow. These stream sites are associated with the following Project components:

- access road sites (strm1, strm6, and strm26)
- proposed pit/stock pile sites (strm4 and strm5)
- sites draining the tailings facility (upper7, lower7, strm8, and strm10)
- reference sites (strm1 and strm9)
- Morrison Creek, which is the outlet of Morrison Lake

In addition, two sites along the proposed transmission line were sampled in 2008 (strm17.1 and strm11.9). Results for some sites were not available for all years because of low flows or dry streambeds at the time of survey. Locations of all sites are shown in Figure 7.9-1.

Table 7.9-1
Stream Sites Sampled for Aquatic resources, Morrison Copper/Gold Project, 2006 to 2008

Area	Site	2006	2007	2008
Access Rd Sites	Strm6	P, B	P, B	P, B
	Strm26	P, B	P, B	P, B
Pit/Stock Pile	Strm4	P, B	P, B	P, B
	Strm5	P	P, B	P, B
Tailings Facility	Upper7	P	P, B	P, B
	Lower7	P	P, B	P, B
	Strm8		P, B	P, B
	Strm10		P, B	P
Reference	Strm1	P	P, B	P, B
	Strm9			P, B
Morrison Creek	Morrison Creek	P, B	P, B	P, B
Transmission Line	Strm11.9			P, B
	Strm17.1			P, B

Note: P: periphyton B: benthic invertebrates.

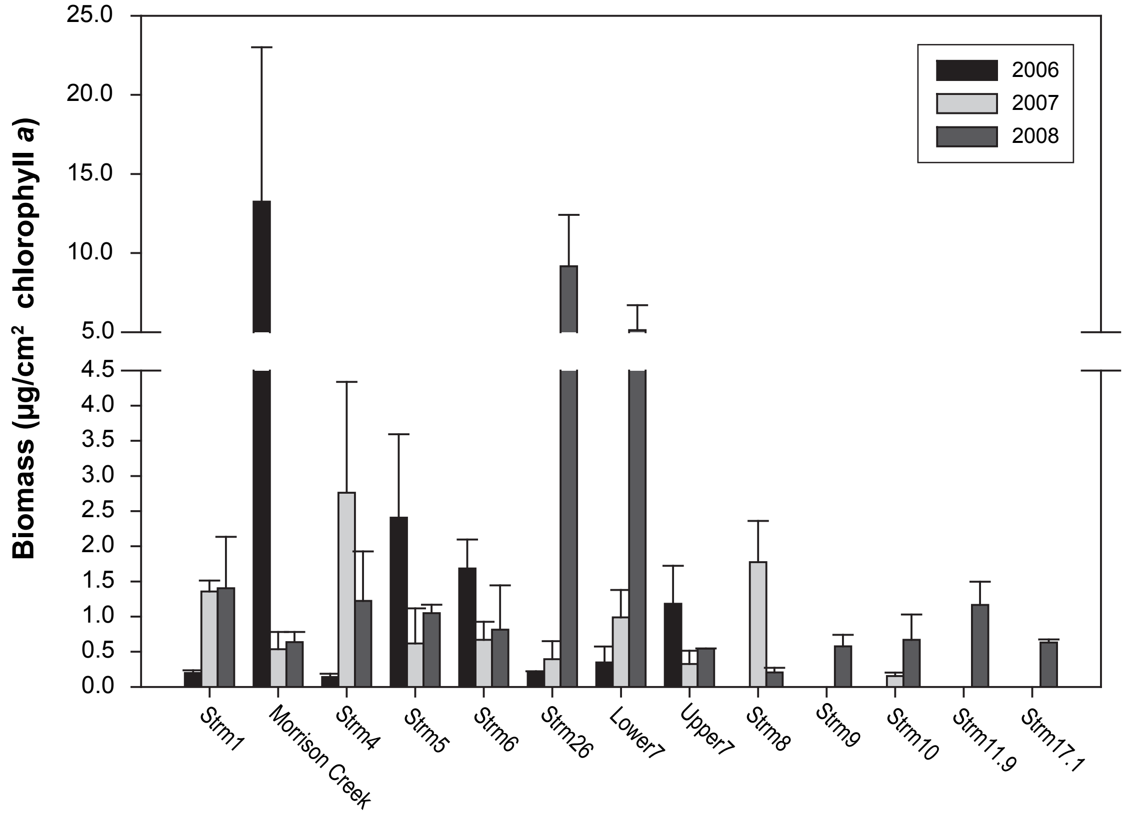
7.9.3 Periphyton

Periphyton are algae that are attached to the streambed and function as the base of the stream environment food web. These primary producers provide vital nutrients to benthic and terrestrial invertebrates as well as fish and birds. Periphyton sampling was conducted at 8 sites in 2006, 10 sites in 2007, and 13 sites in 2008. Analyses included assessments of stream productivity (as biomass of chlorophyll *a*), density, and taxonomic diversity.

Generally, biomass concentrations were low, ranging between 0.5 and 1.5 $\mu g/cm^2$ (Figure 7.9-2). In 2006, concentrations at Morrison Creek were exceptionally high (15 $\mu g/cm^2$), while in 2008, Strm26 and Lower7 contained higher than average biomass levels. Periphyton density for all years ranged from 5×10^6 cells/m^2 to $3{,}196 \times 10^6$ cells/m^2, with density at most sites falling below 500×10^6 cells/m^2.

Chrysophytes were the dominant taxa at all sites in 2006, 2007, and most sites in 2008, although in 2008 Cyanophyta were dominant at Strm1, Strm4, Lower7, and Strm26. A total of 39 genera were observed throughout the survey period; however, 17 genera were sampled in 2008 that had not been observed in either 2006 or 2007, making 2008 the most diverse year. The differences in sampling periods (late August versus July) potentially contributed to the variation in the number of genera found in the samples.

Simpson diversity and Pielou evenness indices were used to quantify the biodiversity of the periphyton communities. These indices consider the number of organisms and genera present, and generate a value that ranges between 0 and 1. A value of 0 represents a low diversity community or an unevenly distributed community, and a value approaching 1 indicates a higher



Note: Error bars represent one standard error of the mean.

FIGURE 7.9-2

Morrison Copper/Gold Project:
Stream Periphyton Biomass as Chlorophyll a

pbm Rescan™

level of diversity and evenness. The Simpson diversity index values ranged from 0.05 to 0.75 for all years; however, most sites ranged between 0.45 and 0.70, with Strm1 and Lower7 having extremely low values in 2008. Similarly, Pielou evenness values ranged from 0.06 to 0.75, with most values ranging between 0.4 to 0.75, except for Strm1 and Lower7 in 2008.

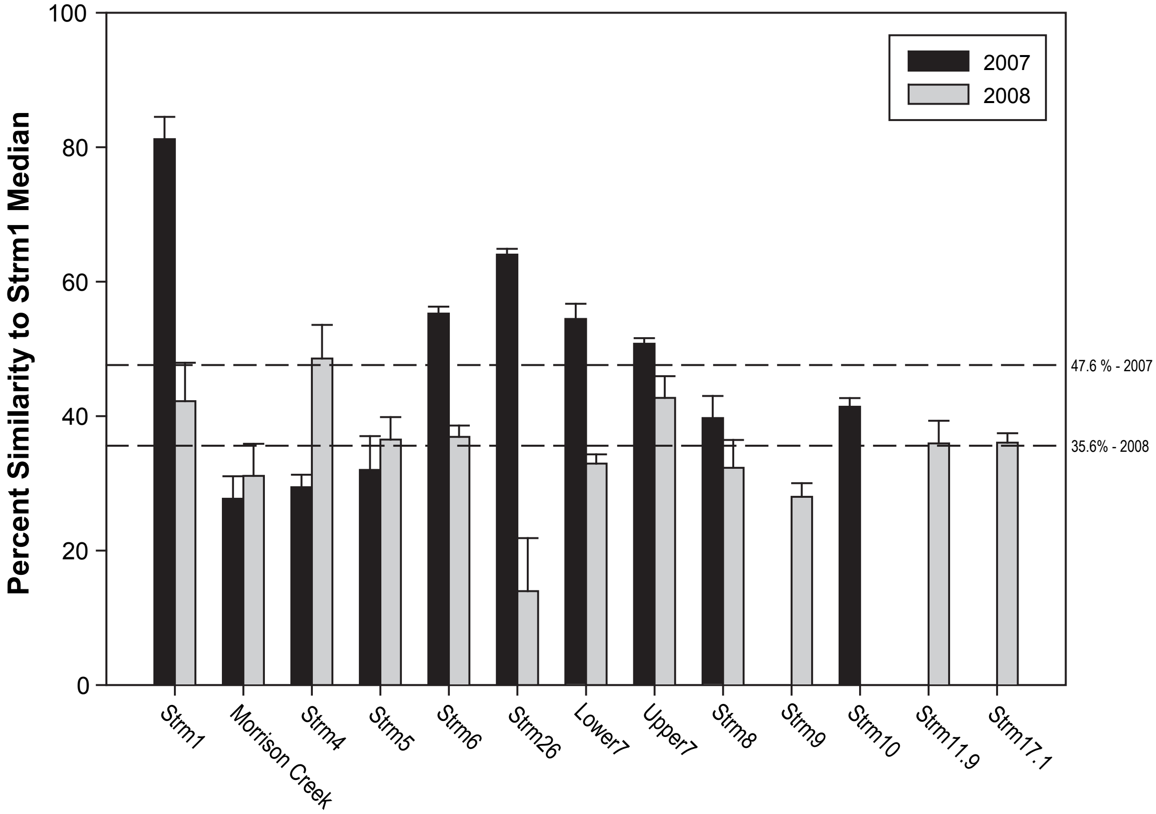
7.9.4 Benthic Invertebrates

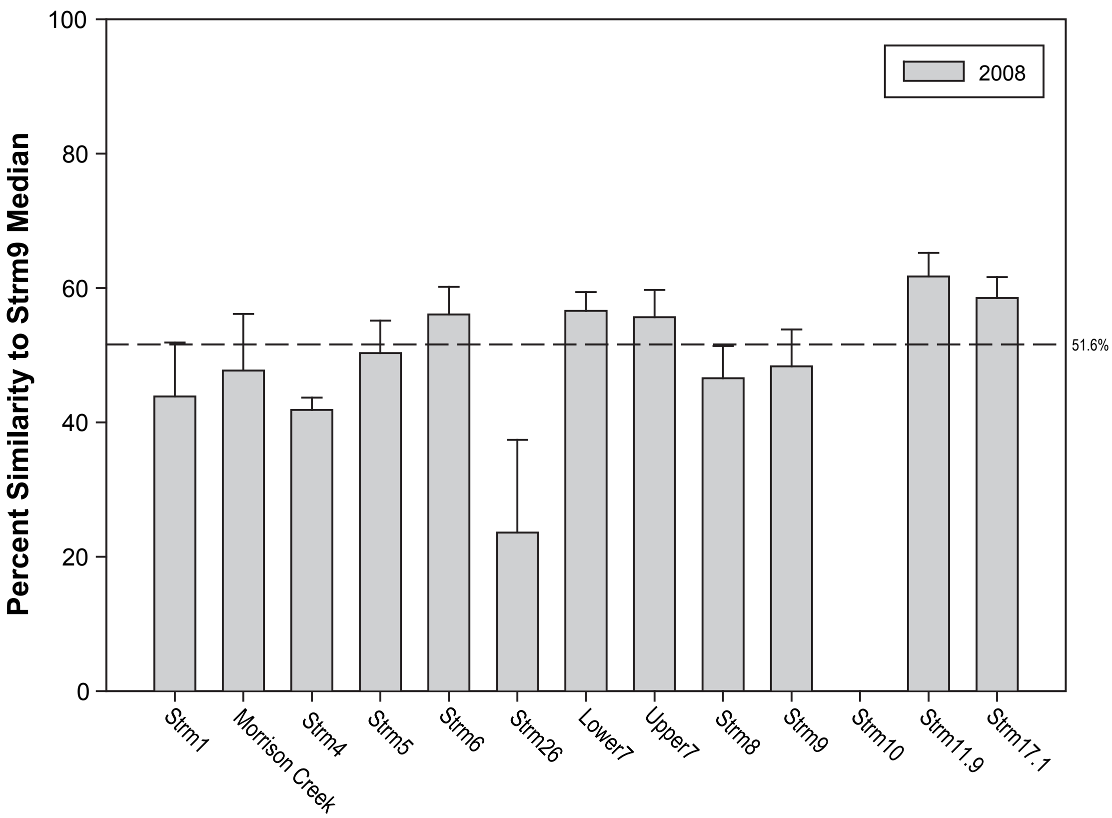
Secondary producers include benthic invertebrates, which are confined to living in the sediments or on substrates (e.g, rocks, detritus and macrophytes), and zooplankton, which are free-floating organisms. Benthic invertebrates feed on periphyton, smaller invertebrates and other organic matter. Benthic invertebrates were sampled at four sites in 2006, 10 sites in 2007, and 12 sites in 2008. Flow conditions were generally extremely low, and some sites were completely dry in 2006, resulting in the variance in the number of sites sampled. Sampling in 2007 and 2008 was conducted earlier in the year to obtain conditions with higher water levels.

Average density ranged from 841 to 30,090 organisms/m^2, with values increasing from 2006 to 2008. This was likely caused by differences in sampling dates and yearly conditions. The invertebrate communities were often dominated by dipterans. Strm4 was a clear exception as it was dominated by ostracods in all years. Plecoptera and Ephemeroptera frequently composed substantial proportions of the remaining communities.

The Bray-Curtis similarity coefficient is used to determine the percent similarity between sites based on the genera present and relative abundance of organisms. Bray-Curtis values range from 0% to 100%, with values approaching 0% indicating that sites are dissimilar, and 100% signifying that sites are similar. In 2007, Bray-Curtis values were calculated that compared sampling sites to the reference site Strm1 (Plate 7.9-1). In 2008, sites were also compared to the additional reference site, Strm9 (Plate 7.9-1). A similar comparison was not conducted for 2006 data, since the reference site for that year was dry and could not be sampled. The average similarity of sampling sites to reference site Strm1 was 47.6% in 2007, while in 2008 similarity averaged 35.6%. In 2008, sites showed a greater similarity to reference site Strm9 with an average similarity of 51.6% (Figure 7.9-3).

Plate 7.9-1. Reference sites, Strm1 (left) and Strm9 (right).





Note: Error bars represent standard error of the mean.
Dashed lines denote mean similarity of all sites.

Morrison Copper/Gold Project:
Average Bray-Curtis Percent Similarity for Stream Benthic Invertebrate Communities, 2007 and 2008

FIGURE 7.9-3

Average genus richness ranged from 16 to 52 taxa between 2006 and 2008, with the highest values occurring in 2006. Average Simpson diversity index values ranged from 0.3 to 0.9. Strm4 showed the lowest diversity in all years. Pielou evenness values ranged from 0.3 to 0.8 for all years. As with the diversity values, evenness was consistently lowest at Strm4.

7.9.5 Lake and Pond Sites

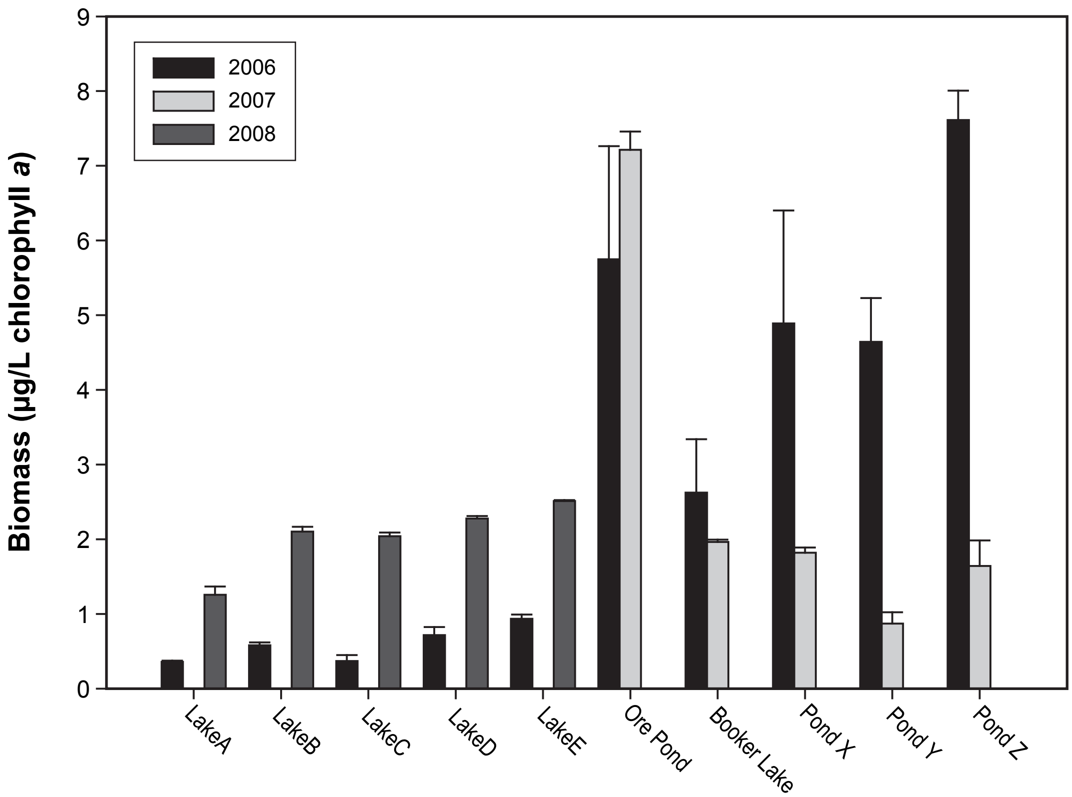
Primary and secondary producers were sampled at seven lake sites and three pond sites within the Morrison study area (Table 7.9-2). Five sites were established within Morrison Lake, which could be affected by various stages of Project activities. These five sites were sampled in 2006 and again in 2008. Additionally, five other lake/pond sites (Booker Lake, Ore Pond, Pond X, Pond Y, and Pond Z) were established to provide detailed information on the composition and productivity of their communities, as these sites will be directly affected by the mine site and proposed tailings facility. These sites were sampled in 2006 and 2007.

Table 7.9-2
Lake and Pond Sites Sampled for Aquatic resources, Morrison Copper/Gold Project, 2006 to 2008

Type	Site	2006	2007	2008
Lake	Lake A	Y	N	Y
	Lake B	Y	N	Y
	Lake C	Y	N	Y
	Lake D	Y	N	Y
	Lake E	Y	N	Y
	Ore Pond	Y	Y	N
	Booker Lake	Y	Y	N
Pond	Pond X	Y	Y	N
	Pond Y	Y	Y	N
	Pond Z	Y	Y	N

7.9.6 Phytoplankton

Phytoplankton are free-floating algae that form the foundation of the aquatic food web in lakes, making them useful indicators of change in aquatic ecosystems. Phytoplankton sampling was conducted at 10 sites in 2006, five sites in 2007, and five sites in 2008. Communities were analyzed for biomass (µg/L chlorophyll *a*) and taxonomic composition. Generally, biomass concentrations were substantially lower at the Morrison Lake sites than at the smaller lake and pond sites (Figure 7.9-4). Concentrations within Morrison Lake ranged from 0.4 to 2.5 µg/L, with biomass higher in 2008 than 2006. Most lake and pond sites contained greater biomass in 2006 than in 2007, ranging from 0.87 to 7.61 µg/L for both years. These differences may partially be attributed to variability in sampling date, as 2006 sampling was conducted in August and 2007 sampling in mid-July.



Note: Error bars represent one standard error of the mean.

Morrison Copper/Gold Project:
Lake and Pond Biomass as Chlorophyll *a*

FIGURE 7.9-4

Average density values were highly variable between both sites and years. Density ranged from 150×10^3 cells/L at Booker Lake to $1,752 \times 10^3$ cells/L at Lake A among years. Density values increased each year, with large increases observed at Lake B, Lake C, Lake D, Lake E, and Ore Pond. Phytoplankton communities were primarily dominated by various combinations of cyanophytes, cryptophytes, and chrysophytes. Generally, cyanophytes dominated the phytoplankton assemblage in Morrison Lake sites, while smaller lake and pond sites contained a more even distribution among the major taxa.

A total of 49 genera were identified in 2006, 38 genera in 2007, and 94 genera in 2008. The high numbers in 2008 are due to the different taxonomy enumeration method used. Simpson diversity index values ranged from 0.44 to 0.88 across all sites and years. Pielou evenness values ranged from 0.41 to 0.76 for all three years. Diversity and evenness values were similar among the smaller lake and pond sites between 2006 and 2007, while values for the five Morrison Lake sites showed more variation, with greater diversity and evenness in 2008 than in 2006. Lake A contained the lowest levels of diversity and evenness in 2006, and the highest levels in 2008.

7.9.7 Benthic Invertebrates

Benthic invertebrates were sampled at the same locations as phytoplankton. The average density of benthos was greater at the smaller pond and lake sites than the Morrison Lake sites. Average density ranged from approximately 200 to 2,500 organisms/m^2 for all years and sites, with Pond Y consistently having the highest density. The Morrison Lake sites were dominated in 2006 by dipterans at all sites except Lake E, while in 2008, these sites showed larger proportions of other taxa and were dominated by either dipterans or copepods. The smaller lake and pond sites were not as strongly dominated by one genera, and were instead composed of various combinations of dipterans, copepods, molluscs, nematodes, amphipods, and crustaceans.

Average genus richness ranged from 3 to 16 genera among sites and years. Richness at the Morrison Lake sites was less variable, with most sites having between five and eight genera, while the lake/pond sites showed more variability both among sites and years. Diversity and evenness indices were calculated to provide a measure for both the number of taxonomic groups at each site and their abundance. Simpson diversity index values were consistent across all sites and all years, ranging from 0.5 to 0.9, with most values falling between 0.7 and 0.9. Pielou evenness values exhibited the same pattern, with values ranging between 0.5 and 0.9 overall, and 0.7 and 0.9 at most sites. Ore Pond consistently had the lowest evenness values for 2006 and 2007.

7.9.8 Zooplankton

Zooplankton are free-swimming invertebrates that feed on planktonic microbes, smaller invertebrates, and phytoplankton. Zooplankton samples were collected in triplicate at each site, over two separate years. The Morrison Lake sites were sampled in 2006 and 2008, while the smaller lake and pond sites were sampled in 2006 and 2007. Density data for Lake B and Lake C were not obtained in 2006, as volume data were not available for these sites. For the remaining sites density values had a large range, from 3,431 organisms/m^3 (Pond Z) to 101,934 organisms/m^3 (Booker Lake). Density values for the lake/pond sites were several times higher in 2007, primarily because of the large numbers of immature (nauplii and copepodite) cyclopoid copepods present in the samples. Density values for the Morrison Lake sites were similar across years, with most sites ranging from 20,000 organisms/m^3 to 50,000 organisms/m^3.

The Morrison Lake sites were dominated by calanoid and cyclopoid copepods during both 2006 and 2008, although rotifers increased in number in 2008. The smaller lake/pond sites were more variable in composition. In 2006 they were most often dominated by rotifers, although some sites contained large numbers of cyclopoid copepods and daphnids. In 2007, these sites were most often dominated by daphnids, followed by cyclopoid copepods and rotifers.

Average genus richness ranged from 6 to 13 genera, with most sites having between 8 and 10 genera. There was no substantial difference in richness between the Morrison Lake sites and the smaller lake and pond sites. Simpson diversity and Pielou evenness showed similar patterns. The Morrison Lake sites were the most diverse and even, while the smaller lake and pond sites showed lower diversity and evenness.

7.10 Fish and Fish Habitat

7.10.1 Introduction

The freshwater environment is critical to many fish species captured for subsistence or sport such as salmonids. Many smaller fish species can be useful indicators of good water quality and environmental health that are required for all fish populations.

The Project area on the eastern side of Morrison Lake (surface area of 1,326 ha), is within the Skeena River system (Figure 7.1-1). Morrison Creek originates from Morrison Lake and discharges into Babine Lake. Babine Lake flows into the Babine River, which in turn discharges into the Skeena River. The Project will be on the southeastern side of Morrison Lake within a group of the smaller order tributaries that flow down steep slopes into the lake. The proposed transmission line will originate at the Bell Mine substation, near Babine Lake, and terminate at the mine site. The proposed transmission line crosses numerous streams that drain into Morrison Lake, Morrison Creek, and Babine Lake.

Water flow data collected for baseline studies showed minimum flows occurring in late winter at all sampling stations. Maximum flows typically were recorded during the spring freshet (i.e., incremental flooding resulting from a spring thaw), with smaller tributaries peaking earlier than major waterways.

7.10.2 Background Overview

Baseline studies were undertaken from 2006 to 2009 to collect comprehensive data on fish communities and fish habitat specific to the Project. Complete baseline reports are presented in appendices 28 and 29 and other historical information is available for fish communities in the Project area. In 2004, David Bustard and Associates Ltd. (Bustard) provided a detailed review of historical studies in the Morrison Lake Watershed (2004). The most detailed stream habitat descriptions specific to the Morrison Lake Watershed were undertaken as part of forestry planning activities during the past decade. This work was coordinated by two forest companies operating in the watershed: Houston Forest Products Ltd. (SKR 2000, 2001) and Canadian Forest

Products Ltd. (Canfor; Triton 1999, 2003). Extensive research studies mainly associated with sockeye salmon population enhancement were undertaken on Babine Lake from the 1940s to the present. Although most of this work was conducted in Babine Lake itself, fieldwork was often conducted in Morrison Lake because it is one of the key sockeye basins (Groot 1972).

These historical studies reveal a diverse fish community in Morrison Lake and its drainages. Species observed included: rainbow trout (*Oncorhynchus mykiss)*, cutthroat trout (*O. clarkii clarkii*), kokanee (*O. nerka*), sockeye salmon (*O. nerka*), coho salmon (*O. kisutch*), chinook salmon (*O. tshawytscha*), lake trout (*Salvelinus naymaycush*), lake whitefish (*Coregonus clupeoformis*), mountain whitefish (*Prosopium williamsoni*), longnose sucker (*Catostomus catostomus*), largescale sucker (*Catostomus macrocheilus*), northern pikeminnow (*Ptychocheilus oregonensis*), burbot (*Lota lota*), redside shiner (*Richardsonius balteatus*), prickly sculpin (*Cottus asper*), and peamouth chub (*Mylocheilus caurinus*).

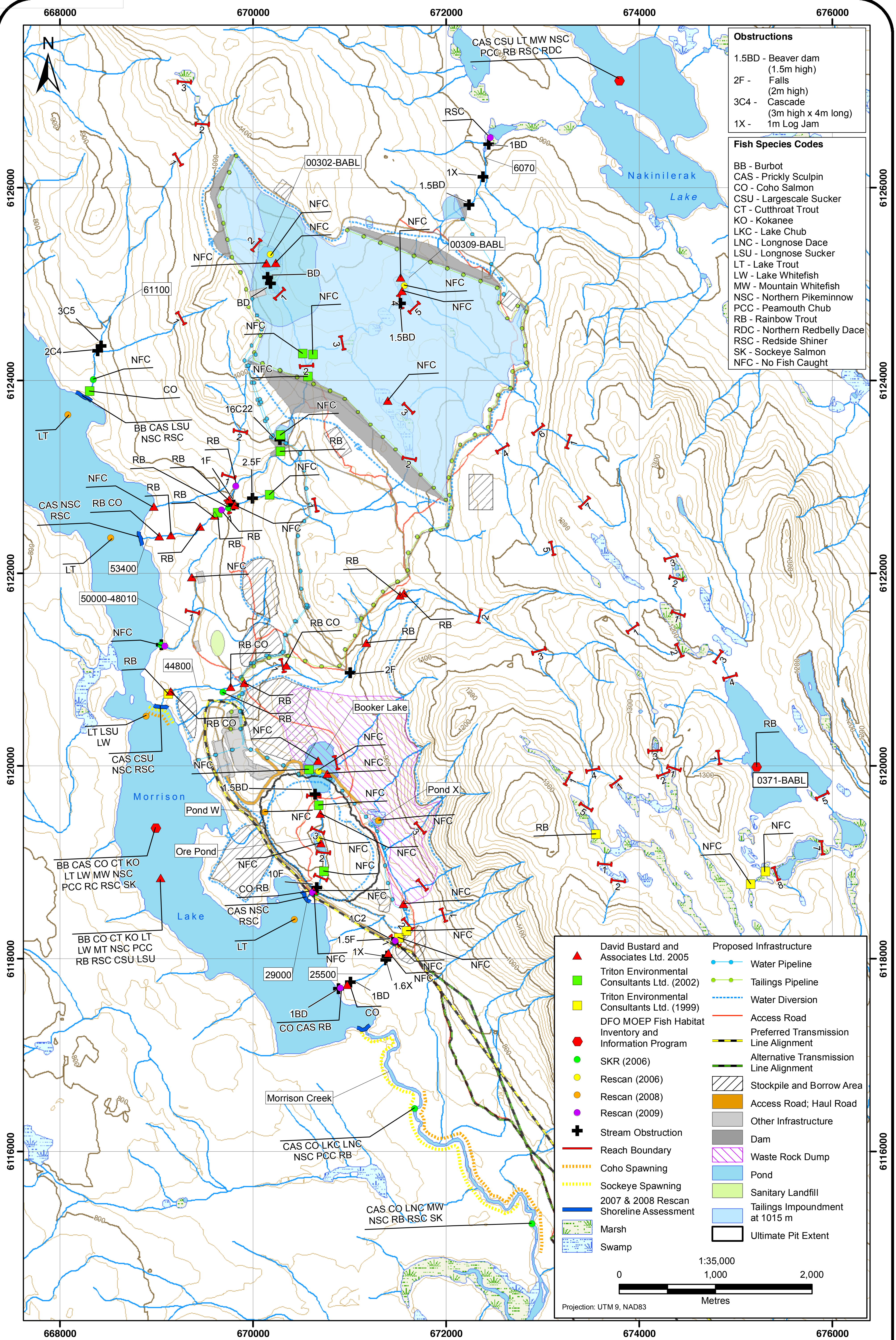
Bustard also performed further fisheries field studies in the Morrison Lake area for PBM in 2004 (2005). These studies included juvenile fish sampling in potentially affected Morrison Lake tributaries, small lake sampling, trout and salmon spawning surveys, and fish sampling in Morrison Lake.

All three streams with the highest potential for Project-related effects were found to be important rearing sites for rainbow trout and coho salmon (Figure 7.10-1). The lower 1.8 km of stream 53400, from a significant cascade barrier downstream to Morrison Lake, is used for rearing. The entire length of stream 44800, including upstream to its headwaters, is used by both fish species for rearing and spawning. The majority of stream 29000 and its associated lake and pond, that flow directly over the main ore body, were identified as non-fish-bearing. However, the lower 150 m of this small tributary that flows from a 10 m waterfall to Morrison Lake was found to contain rearing rainbow trout and coho salmon.

Morrison Creek was identified as an important spawning and rearing stream for rainbow trout. Studies prior to 2006 have shown this creek also contains critical spawning habitat for sockeye and coho salmon, as well as rearing habitat for many species of small-bodied fish (Bustard 2004).

Morrison Lake was surveyed for potential salmon and trout shoreline spawning sites (Bustard 2005). Only the shoreline at the mouth of stream 44800 supported active sockeye salmon spawning activity. Lake trout spawning was not verified at any of the potential sites, but the majority of these sites are in the northern basin of the lake away from any potential mine activity. Gillnet sampling in Morrison Lake revealed similar fish distributions as past studies, with lake trout being the most abundant sport fish (Bustard 2004).

Additional baseline environmental studies were conducted by SKR Consultants Ltd. (SKR) and Rescan Environmental Services Ltd. (Rescan) in 2006, 2007, 2008, and 2009 (appendices 28 and 29). These studies were designed to aid in planning and monitoring mine and transmission line development, and to address concerns that Project development may affect the surrounding fisheries resources. The main objective of this research was to characterize the aquatic environment and meet the federal and provincial regulatory requirements. This goal was



Sample Site Locations and Fish Distributions in Morrison Lake and Tributaries, Morrison Copper/Gold Project

FIGURE 7.10-1

accomplished by sampling watersheds near the proposed mine area, and along the access road and transmission line. Ponds, small lakes, streams, and large lakes (Morrison Lake and Tochcha Lake, the latter being used as a reference lake) were surveyed for fish habitat and community composition. The following sections summarize the fish habitat and community components of the aquatic ecosystem surveyed.

7.10.3 Ponds and Small Lakes

In 2006 and 2008, a total of six ponds and small lakes in the mine site area were assessed for fish habitat and community (Table 7.10-1). The sampling objective was to survey fish habitat and community in ponds and lakes that will be directly affected during mine construction and operations.

Table 7.10-1
Ponds and Small Lakes Surveyed within the Mine Footprint of the Morrison Copper/Gold Project

Sampling Site	Future Effect (Direct/ Potential/ Reference)	UTM		Habitat Type	Community Survey Techniques	Year of Sampling Visit
		Easting	Northing			
Pond X	Direct	671287	6119420	Pond	GN, MT	2006
Ore Pond	Direct	670689	6119241	Pond	GN, MT	2006
Booker Lake	Direct	670643	6119951	Lake	GN, MT	2006
00309-BABL	Direct	671568	6124987	Pond	GN, MT	2006
00302-BABL	Direct	670122	6125246	Pond	GN, MT	2006
Pond W	Direct	670122	6119522	Pond	MT	2008
Pond X	Direct	671299	6119434	Pond	MT	2008

MT = minnow traps, GN = gillnets.

Habitat quality varied among ponds and small lakes. The four small ponds (Pond W, Pond X, 00302-BABL, and 00309-BABL) are shallow with silt substrate and surrounding wetland areas. Booker Lake and Ore Pond are relatively deep; Booker Lake approaches a maximum depth of 24 m.

Fish communities were assessed using gillnet and minnow trapping gear following standardized sampling techniques (RISC 2001). No fish were captured in any of the ponds or small lakes despite using two gear types (minnow traps and gillnets). This result combined with the lack of connectivity of all waterbodies to any potential fish passage migratory corridors and the presence of downstream barriers suggests that these waterbodies are non-fish-bearing.

7.10.4 Streams

7.10.4.1 Mine Site

The sampling objective was to quantify fish habitat and community within the mine footprint streams and those crossed by the transmission line that may be directly affected during mine operations. In 2006, a total of nine sites near the proposed mine site were assessed for fish habitat and community (Table 7.10-2). Two supplementary surveys were performed in 2009 at nine sites (Rescan 2009) to corroborate fish presence results in several tributaries of Morrison Lake and gain new information from the Nakinilerak Lake Watershed (Table 7.10-3).

Additionally, 37 locations along watercourses crossed by the proposed transmission corridor were surveyed (Figure 7.10-2) in 2008 (Appendix 29). Habitat assessments were based on the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory Standards and Procedures* (RISC 2001). The surveyed streams had low channel gradients, with average gradients ranging between 1% and 3%. Stream width varied considerably among the surveyed streams, with bankfull widths ranging between 1 and 20 m. The larger order stream systems, Morrison Creek and Tahlo Creek, possessed wider bankfull widths and deeper pool depths than the smaller order stream systems surveyed.

Table 7.10-2
Streams Surveyed in 2006 at the Morrison Copper/Gold Project

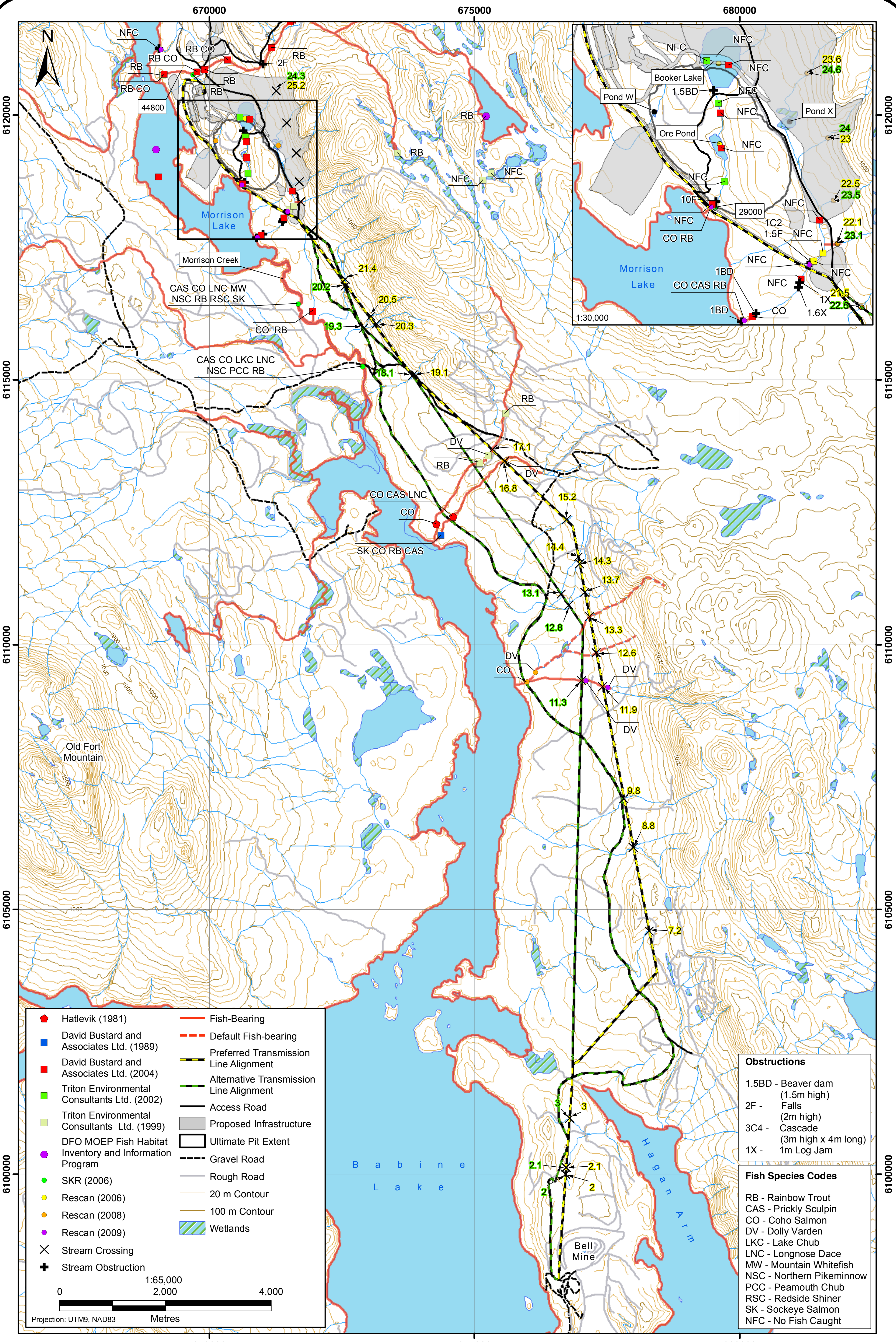
Stream Site	Future Effect (Direct/ Potential/ Reference)	UTM		Community Survey Techniques	Year of Sampling Visit
		Easting	Northing		
29000	Direct	670652	6118685	EF	2006
44800	Direct	669692	6120766	EF	2006
50000 – 48010	Direct	669065	6121312	EF	2006
53400	Direct	669757	6122734	EF	2006
61100	Potential	668424	6123900	EF	2006
Morrison Creek 1	Potential	672985	6115253	EF	2006
Morrison Creek 2	Potential	671850	6116150	EF	2006
Reference Site					
Tahlo Creek 1	Reference	663868	6130787	EF	2006
Tahlo Creek 2	Reference	664296	6131931	EF	2006

EF = electrofishing.

Table 7.10-3
Streams Surveyed for Fish Presence in 2009 at the Morrison Copper/Gold Project

Stream Site	Future Effect (Direct/ Potential/ Reference)	UTM		Community Survey Techniques	Year of Sampling Visit
		Easting	Northing		
6070 (Nakinilerak Lake tributary)	Direct	672440	6126455	EF	2009
25500	Direct	671472	6118181	EF	2009
29000	Direct	670652	6118685	EF	2009
50000 – 48010	Direct	669065	6121312	EF	2009

EF = electrofishing.



Stream Crossing Sites Surveyed for the Proposed Transmission Line Options of the Morrison Copper/Gold Project

FIGURE 7.10-2

The dominant channel morphology of the surveyed streams was riffle-pool. Channel bed substrates in the surveyed streams were typically dominated by either cobble or gravel. Total instream cover was moderate at 5% to 20% of the wetted area providing cover for fish for all surveyed streams. Dominate instream cover types varied between surveyed stream sites. Deep pools were not present in all surveyed stream sections, except in Morrison and Tahlo creeks. Overhanging vegetation and small woody debris were the most dominant cover types present in the smaller order streams. Boulders and large woody debris were the most dominant cover types present in the larger order streams.

Table 7.10-4 summarizes the habitat quality for different fish life history stages. Generally, the best habitat for all life history stages was found in the two largest streams, Morrison and Tahlo creeks. Four of the seven smaller streams contain good rearing habitat for rainbow trout and coho salmon, but only stream 44800 had a high enough flow rate (13 $L \cdot s^{-1}$) combined with undercut banks and interstitial spaces in the cobble substrate to provide good overwintering habitat. The presence of resident rainbow trout in the lower reaches between sets of waterfall barriers confirms the quality of this habitat (Bustard 2005). However, even stream 448000 is listed as providing only fair migration habitat because of the existence of upstream barriers, which are present in all of the small streams. These barriers are most evident in the first 150 m of stream 25500 and the lower reach of stream 6070 (tributary of Nakinilerak Lake) where a series of small beaver dams prevents fish passage into high quality upstream habitat.

Table 7.10-4
Habitat Quality for Different Life History Stages in Stream Sites of the Morrison Copper/Gold Project

	Life History Stage			
Stream Site	**Overwintering**	**Rearing**	**Spawning**	**Migration**
6070 (Nakinilerak tributary)	fair	good	fair	poor
25500	fair	good	fair	poor
29000	poor	fair	fair	poor
44800	good	good	good	fair
50000 - 48010	poor	fair	poor	poor
53400	fair	good	fair	fair
61100	poor	fair	fair	fair
Morrison Creek 1	good	good	good	good
Morrison Creek 2	good	good	good	good
Reference Site				
Tahlo Creek 1	good	good	good	good
Tahlo Creek 2	good	good	good	good

Table 7.10-5 provides a summary of fish species caught electrofishing for each stream. Fish were captured in seven of the nine streams, with a total of 12 species caught. Morrison Creek had the highest diversity with 10 fish species, followed by Tahlo Creek with 8 species. Coho salmon was the most widespread species captured, found in seven of the nine streams surveyed.

Rainbow trout was the second most widespread species captured in the Project area, found in six of the nine streams surveyed. Coho salmon and rainbow trout also had the highest relative abundance within streams. Sizes of rainbow trout coho salmon captured in mine site streams of the Project area are presented in Table 7.10-6.

Table 7.10-5
Fish Species Captured in Streams near the Mine Site of the Morrison Copper/Gold Project

Stream Site	Species											
	Prickly Sculpin	Coho Salmon	Sockeye	Kokanee	Mountain Whitefish	Rainbow Trout	Lake Chub	Peamouth Chub	Longnose Dace	Longnose Sucker	Redside Shiner	Northern Pike Minnow
6070	--	--	--	--	--	--	--	--	--	--	✓	--
25500	✓	✓	--	--	--	✓	--	--	--	--	--	--
29000	--	✓	--	--	--	✓	--	--	--	--	--	--
44800	--	✓	--	--	--	✓	--	--	--	--	--	--
50000 - 48010	--	--	--	--	--	--	--	--	--	--	--	--
53400	--	✓	--	--	--	✓	--	--	--	--	--	--
61100	--	✓	--	--	--	--	--	--	--	--	--	--
Morrison Creek	✓	✓	✓	--	✓	✓	✓	✓	✓	--	✓	✓
Reference Site												
Tahlo Creek	✓	✓	--	✓	--	✓	--	--	✓	✓	✓	✓

✓ indicates fish species present.
-- indicates fish species not present.

Table 7.10-6
Measurements of Coho Salmon and Rainbow Trout in Mine Site Streams of the Morrison Copper/Gold Project

Stream Site	Fish Species	# Fish	Length (mm)			Weight (g)		
			Mean	Minimum	Maximum	Mean	Minimum	Maximum
25500	CO	3	83	80	86	8.9	5.9	11.3
25500	RB	2	96	94	98	10.0	8.7	11.3
29000	CO	1	68	--	--	4.4	--	--
29000	RB	4	116	106	123	19.3	15.7	24.5
44800	CO	29	69	44	97	--	--	--
44800	RB	29	76	38	139	6.6	0.4	28.6
53400	CO	8	63	57	70	--	--	--
53400	RB	29	63	38	89	3.3	0.6	9.1
61100	CO	19	51	41	66	1.4	0.7	3.1
Morrison Creek	CO	28	67	52	83	3.3	1.6	6.4
	RB	2	187	64	310	--	2.8	--
Reference Site								
Tahlo Creek	CO	35	69	61	84	3.7	2.2	6.0
	RB	9	102	54	154	14.2	1.9	40.7

-- not available.
CO = coho salmon.
RB = rainbow trout.

In stream 29000 (Figure 7.10-1), a 10 m bedrock waterfall is present and is considered a permanent barrier to fish movement. No fish were captured above this waterfall, therefore, the reach above the waterfall is considered to be non-fish-bearing. However, a survey performed in 2009 found the final 150 m of stream 29000 below the 10-m falls is used for rearing by coho salmon and rainbow trout. As well, several other fish species are present at the mouth of stream 29000 along the Morrison Lake shoreline.

No fish were captured in stream 50000-48010 where a temporary barrier is present 10 m upstream of Morrison Lake in the form of a 1 m waterfall created by large and small woody debris. Although potential juvenile rearing habitat is present, the barrier restricts fish access beyond the lower 10 m of this reach. The substrate of this stream consists of fines only, with no gravels present. In stream 53400, a 2.5 m falls and 16 m cascade are present 1.6 km upstream from Morrison Lake and considered permanent barriers to fish movement. The reach above these barriers is non-fish-bearing, with no fish being captured, but rainbow trout are prevalent below the falls downstream to Morrison Lake. The entire length of stream 44800, upstream to its headwater lake, is considered fish-bearing because of the presence of rainbow trout throughout the stream system despite some fish-passage barriers. Coho salmon are present in stream 61100, but low flows and moderately sized temporary barriers limit seasonal fish use.

7.10.4.2 Transmission Line

The 37 stream crossings along the preferred and alternative transmission line alignments were surveyed using visual assessments and electrofishing where enough water was present (Figure 7.10-2). The proposed 138 kV transmission line alignment of the Project extends 25 km from the mine site south along Babine Lake to the 138 kV substation at Bell mine on the Newman Peninsula. An alternate transmission line alignment along the access road was not surveyed because stream crossings are already in place. After the surveys were completed the proposed transmission line alignment was altered in the mine site area. Therefore, the five stream crossings closest to the mine site are no longer along the proposed transmission line alignment. These sites are now within the mine infrastructure footprint.

The majority of the 37 stream crossings (79%) were ranked as possessing no or poor fish habitat and only 11 (30%) contained enough water to be electrofished. The stream sites found to contain fish (4 total) or classified as default fish-bearing (2 total) possessed water conditions typical to the area with a mean temperature of 13.9°C, pH of 8.1, and conductivity of 95 μS.

The average bankfull width (1.91 m) of streams classified as fish-bearing or default fish-bearing were larger than those classified as non-fish-bearing streams (0.90 m). Similarly, general habitat characteristics, such as average wetted width (1.25 m), wetted depth (0.26 m), and watershed area (690 ha), also increased in streams classified as fish-bearing or default fish-bearing compared to non-fish-bearing streams (0.75 m, 0.12 m, and 173 ha, respectively). Average gradients were lower in streams containing fish (7.0%) compared to non-fish-bearing streams (8.2%).

The channel morphology of the majority of streams with flowing water was riffle-pool with gravel and functional large woody debris. This morphology type included the five default fish-bearing streams. However, the channel morphology at the one site at which fish were captured (16.8 km along the preferred alignment) was cascade-pool with cobble and only minor functional large woody debris.

Fish have been captured previously at the 17.1 km stream crossing (Figure 7.10-2) of the preferred alignment. This relatively large stream was found to contain Dolly Varden char and rainbow trout. Three Dolly Varden char (138.7 ± 18.4 mm; range of 115 to 175 mm) were captured at the 16.8 km stream crossing (Figure 7.10-2) of the preferred alignment. Another two Dolly Varden char (135.5 ± 2.5 mm; range of 132 to 139 mm) were captured at the 11.9 km stream crossing of the preferred alignment. Rainbow trout is the only other fish species known to inhabit the upper reaches of streams in the Project area. Coho salmon is known to inhabit the lower reaches of some streams that flow into Morrison and Babine lakes, but this species has not been found to penetrate as far upstream as Dolly Varden char or rainbow trout. Both rainbow trout and coho salmon were found in the first reach of stream 29000, a 150 m section between Morrison Lake and a 10 m waterfall, during additional sampling in 2009. This reach will be crossed by the proposed transmission line and road, but the entire stream will be lost due to the proposed open pit.

7.10.5 Morrison Lake and Reference Site

In 2007 and 2008, Morrison and Tochcha lake sites were assessed for fish habitat and community (Table 7.10-7). The three objectives of the surveys were first to determine whether sockeye salmon were repeatedly using the shore spawning area within the Project area, second to identify other sockeye salmon shore spawning areas, and third to identify late-spawning coho salmon along the Morrison Lake shoreline. Visual spawning surveys were performed by walking streams, boating along shorelines, and snorkelling to obtain proper fish identification.

The objective of the fish habitat and community sampling was to quantify fish habitat and community at lake shoreline sites that will be potentially affected during mine operations.

Table 7.10-7
Lake Sites Surveyed in the Morrison Copper/Gold Project Area

Lake Site	Future Effect (Direct/ Potential/ Reference)	UTM		Associated Stream Site	Habitat Survey Technique	Community Survey Techniques	Year of Sampling Visit
		Easting	Northing				
Morrison Lake Site A	Potential	670429	6118408	29000	SA	GN, MT	2007, 2008
Morrison Lake Site B	Potential	668894	6120517	44800	SA	GN, MT	2007, 2008
Morrison Lake Site C	Potential	668527	6122366	53400	SA	GN, MT	2007, 2008
Morrison Lake Site D	Reference	668164	6123640	61100	SA	GN, MT	2007, 2008
Reference Site							
Tochcha Lake	Reference	309735	6098431	-	-	GN	2008

GN = gillnet, MT = minnow trap.
SA = shoreline assessment.
Dashes indicate not applicable.

Sockeye salmon were confirmed to repeatedly use the shoreline spawning area at the mouth of stream 44800. Sockeye were observed spawning along this 100 m section of Morrison Lake from 25 to 26 September, 2007. This same shoreline was used by coho salmon for spawning from 11 to 12 October, 2007, alongside spawning sockeye salmon. This observation was the first to confirm coho salmon shoreline spawning in Morrison Lake. Also, schools of small fish were observed at the mouth of the creek and many were captured in minnow traps along the shoreline.

Habitat quality varied among the other four lake shoreline sites, from cobble/boulder at the lake outlet to sand- and gravel-dominated substrates at the small tributaries. While the outlet was suitable for some salmon spawning activities, the other shoreline sites provided high productivity for smaller fish species. This productivity was due to the presence of filamentous algae, fallen trees providing complex habitat structure, and shoreline vegetation (e.g., lily pads and grasses).

Fish communities were assessed using gillnet and minnow trapping gear following standardized sampling techniques (RISC 2001). Fish were captured in all sites fished in 2007 and 2008, with a total of seven species caught in Morrison Lake and three species caught in Tochcha Lake (Table 7.10-8). Small-bodied fish species were not captured in Tochcha Lake because only gillnetting was performed. Lake trout and lake whitefish were present in both lakes. Rainbow trout were not captured in Morrison Lake in 2008, but were angled and gillnetted in 2007 during other sampling activities (Rescan 2007). Lake trout were the most prevalent fish species caught in Morrison Lake (67% of total fish caught) and Tochcha Lake (70% of total fish caught) by gillnet sampling.

Table 7.10-8
Fish Species Captured in Lakes of the Morrison Copper/Gold Project in 2007 and 2008

Lake	Species								
	Burbot	Prickly Sculpin	Lake Trout	Lake Whitefish	Rainbow Trout	Largescale Sucker	Longnose Sucker	Redside Shiner	Northern Pikeminnow
Receiving Environment									
Morrison Lake	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reference Environment									
Tochcha Lake	--	--	✓	✓	✓	--	--	--	--

✓ indicates fish species present.
-- indicates fish species not captured.

Northern pikeminnow (36% of total fish captured) and prickly sculpin (36% of total fish captured) were the most prevalent fish species captured using minnow traps in Morrison Lake. Lake trout were also the largest fish species captured in the two lakes, followed by lake whitefish and rainbow trout (Table 7.10-9). Lake trout in Morrison Lake averaged 570 mm in length and 2,014 g in weight, while those in Tochcha Lake averaged 485 mm and 1,287 g.

Table 7.10-9
Measurements of Larger-bodied Fish Species of the Morrison Copper/Gold Project

Lake Site	Fish Species	# Fish	Length (mm)			Weight (g)		
			Mean	Minimum	Maximum	Mean	Minimum	Maximum
Morrison Lake	LT	16	570	442	675	2,014	910	3,668
	LW	5	304	279	322	311	252	346
	RB	2	348	332	363	518	483	554
Reference Lake								
Tochcha Lake	LT	14	485	337	608	1,287	389	2,544
	LW	2	321	275	367	--	--	--
	RB	4	268	242	305	188	141	248

-- not available.
LT = lake trout.
LW = lake whitefish.
RB = rainbow trout.

The tissue concentrations of four important metals (cadmium, copper, zinc, and mercury) are presented for lake trout in both Morrison and Tochcha lakes in Table 7.10-10. Metals can accumulate in large-bodied fish species with longer life spans. Therefore, the mercury tissue residue guideline set by Health Canada for commercially consumed fish is 0.5 mg/kg wet weight (Health Canada 2007). Lake trout in Morrison Lake exceeded this level in 2004 and 2008, with an average mercury level of 0.68 mg/kg wet weight. However, it is not unusual for piscivorous fish (i.e., fish that eat other fish) such as lake trout in boreal watersheds to exceed the recommended tissue residue guideline. For example, larger northern pike (>700 mm in length) from 59 undisturbed lakes in northern Quebec ranged in mean mercury concentration from 0.30 to 1.81 mg/kg wet weight (Schetagne and Verdon 1999). Fish tissue exceeding the guideline does not necessarily pose a health risk because risk is also dependent on the quantity of fish consumed.

Table 7.10-10
2004 and 2008 Mean Metal Levels of Lake Trout in Morrison Lake and Tochcha Lake, Morrison Copper/Gold Project

Year Sampled	Lake Site	N	Mean Length (mm)	Mean Weight (g)	Mean Metal Content (mg/kg wet weight)			
					Cadmium	Copper	Zinc	Mercury
2004	Morrison	4	605	2,575	<0.005	1.03	4.5	0.77
2008	Morrison	10	563	1,938	<0.005	0.22	3.0	0.58
2008	Tochcha	10	463	1,120	<0.005	0.29	3.8	0.26
[1]Metal Tissue Residue Guideline					--	--	--	**0.50**

-- not available.
[1]Health Canada (2007).

7.11 Navigable Waters

7.11.1 Introduction

The Project area is on the eastern side of Morrison Lake (surface area of 1,326 ha) in the Skeena River system (Figure 7.1-1). The mine footprint may displace several streams, ponds, and a lake and cross numerous streams (Figure 7.11-1). However, some of these streams possess existing crossing structures. This setting summarizes the baseline conditions of navigable waterways in the Project area, and presents the proposed mine footprint and infrastructure during the operational phase. The Project's effects of on navigability will be analyzed in the effects assessment section.

A baseline study of streams within the mine footprint was conducted by Rescan (Appendix 30). The baseline contains information from previous baseline studies performed by Bustard (2005) and SKR (2006). The mine footprint includes all mine site features such as roads, pipelines, tailings management facility, tailings dam, stockpiles, mine pit, and all other features.

Currently, three electrical transmission line alternative alignments have been proposed (Figure 7.11-2). The preferred transmission line alignment would require a new right-of-way east of Babine Lake. One of the alternative alignments, west of the preferred alignment and joining it at several locations, also would require a new right-of-way while a second alternative would closely follow existing forest roads. Because the stream crossings of the alternative alignment along the road are already in place, this option was not surveyed.

All of the proposed transmission line alignments will originate from the Bell Mine Substation, near Babine Lake, and terminate at the Project area. The proposed 138 kV transmission line crosses numerous streams that drain into the Morrison Lake, Morrison Creek, and Babine Lake. This setting summarizes the baseline conditions of navigable waterways along the proposed Project transmission line. Construction and maintenance effects from the 25 km line from the Project area to the Bell Mine substation on navigable waterways will be analyzed in the effects assessment section.

A baseline study of the transmission alignments was conducted by Rescan (Appendix 13). Transmission line construction would be scheduled to commence at the beginning of the mine construction period to supply electrical power during the pre-production phase. Transmission line and right-of-way maintenance activities will occur over the life of the mine. The transmission line will remain after mine closure to supply electricity at a reduced level to any remaining facilities. Water flow data for streams crossing the right-of-ways collected by Rescan showed minimum flows occurring in late winter (Section 7.5). Maximum flows were typically recorded during spring freshet with smaller tributaries peaking earlier than major waterways.

7.11.2 Mine Footprint Waterbodies and Streams

There is little human requirement for navigation at the majority of stream crossings within the Project. For the ten streams with habitat data, many are narrow (<3 m wide) and shallow, which would severely limit navigable value as recreational or commercial waterways. Four of the ten streams possessed bankfull widths greater than 3 m. Navigability was based on the potential for the waterway to at least be navigable by kayak. A summary of the stream location, bankfull width, wetted width, wetted depth, and gradient of each stream crossing is presented in Table 7.11-1.

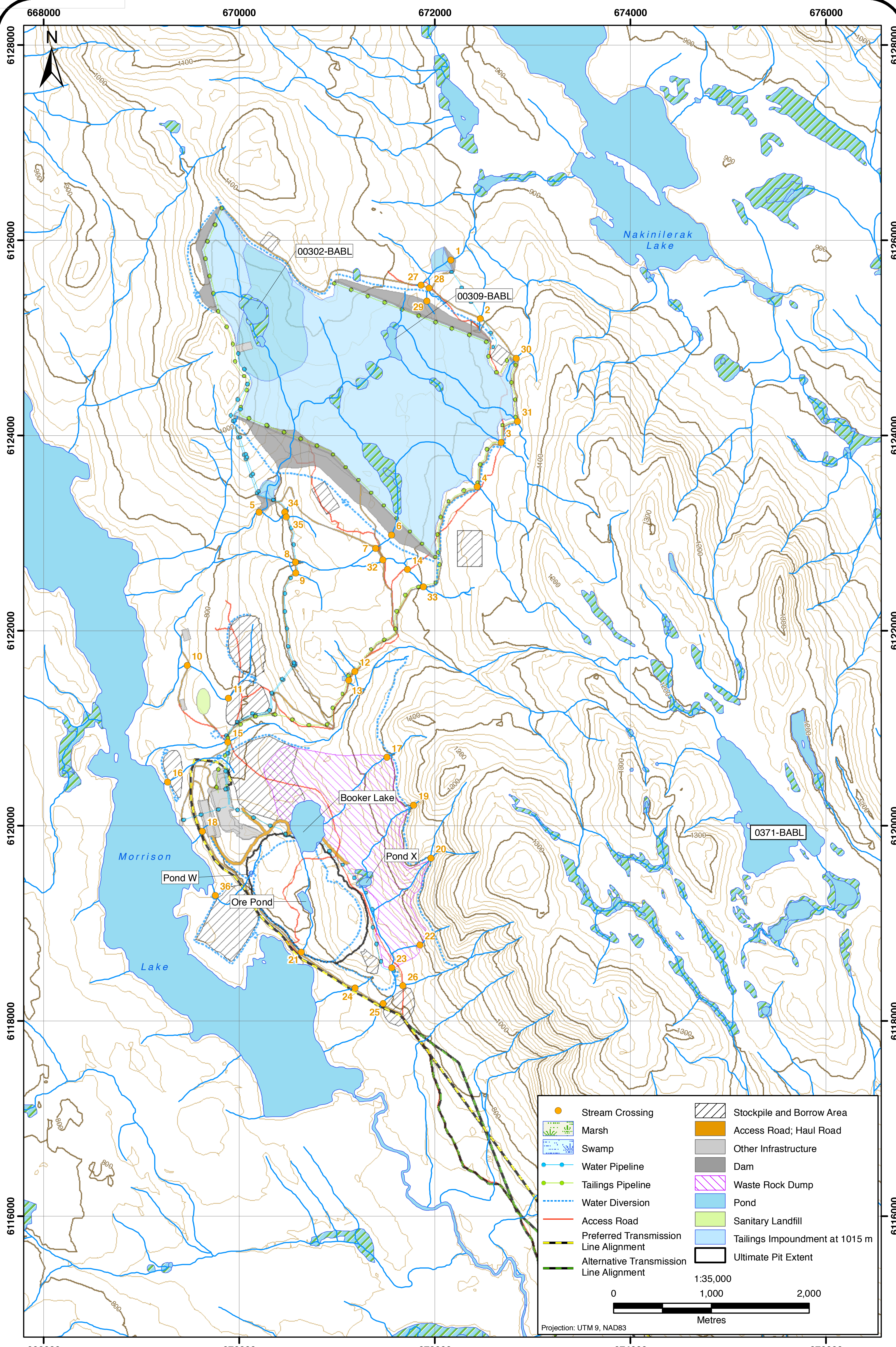
Table 7.11-1
Mine Footprint Stream Habitat Information for the Morrison Copper/Gold Project

ID	Watershed Basin	Latitude (north)	Longitude (west)	Stream Drainage Watershed Code	Distance Upstream from Lake Basin (m)	Average Gradient (%)	Average Bankfull Width (m)	Average Wetted Width (m)	Average Wetted Depth (m)	Data Source	Existing Stream Crossing	Proposed Infrastructure Type
1	Nakinilerak Lake	55° 14' 54.979"	126° 17' 29.318"	6070-429	1,961	n/a	n/a	n/a	n/a		No	Dam
2	Nakinilerak Lake	55° 14' 35.132"	126° 17' 13.639"	6070-494	2,558	n/a	n/a	n/a	n/a		Yes	Road
3	Morrison Lake	55° 13' 53.790"	126° 17' 4.292"	53400	5,897	n/a	n/a	n/a	n/a		Yes	Road/Pipeline
4	Morrison Lake	55° 13' 39.440"	126° 17' 19.165"	53400-12700	4,926	n/a	n/a	n/a	n/a		Yes	Road/Pipeline
5	Morrison Lake	55° 13' 33.876"	126° 19' 25.932"	53400	1,805	3.3	2.4	1.1	0.2	SKR 2006[1]	No	Dam
6	Morrison Lake	55° 13' 24.605"	126° 18' 9.738"	53400-12700	3,040	n/a	n/a	n/a	n/a		No	Dam
7	Morrison Lake	55° 13' 20.401"	126° 18' 19.308"	53400-12700	2,822	n/a	n/a	n/a	n/a		Yes	Road
8	Morrison Lake	55° 13' 16.852"	126° 19' 5.882"	53400-12700	1,918	12.0	1.2	0.8	0.2	Bustard 2005[2]	Yes	Road/Pipeline
9	Morrison Lake	55° 13' 13.276"	126° 19' 6.012"	53400-12700	2,051	n/a	n/a	n/a	n/a		Yes	Road/Pipeline
10	Morrison Lake	55° 12' 44.036"	126° 20' 10.806"	50000-48010	739	0.7	1.0	1.0	0.3	SKR 2006[1]	Yes	Road
11	Morrison Lake	55° 12' 32.676"	126° 19' 47.646"	50000-48010	1,326	n/a	n/a	n/a	n/a		No	Stockpile/Borrow pit
12	Morrison Lake	55° 12' 39.854"	126° 18' 34.131"	44800	2,966	9.0	5.0	5.0	0.2	Bustard 2005[2]	Yes	Road/Pipeline
13	Morrison Lake	55° 12' 37.014"	126° 18' 37.750"	44800	2,930	9.0	5.0	5.0	0.2	Bustard 2005[2]	Yes	Road/Pipeline
14	Morrison Lake	55° 13' 12.970"	126° 18' 1.245"	53400	3,170	n/a	n/a	n/a	n/a		Yes	Road
15	Morrison Lake	55° 12' 18.136"	126° 19' 48.993"	44800	968	4.0	3.5	3.5	0.4	Bustard 2005[2]	Yes	Road/Pipeline
16	Morrison Lake	55° 12' 6.715"	126° 20' 20.693"	n/a	129	n/a	n/a	n/a	n/a		No	Stockpile/Borrow pit
17	Morrison Lake	55° 12' 11.068"	126° 18' 17.404"	29000	2,443	3.3	1.1	0.3	0.2	SKR 2006[1]	No	Waste rock pile
18	Morrison Lake	55° 11' 48.917"	126° 20' 5.739"	n/a	172	n/a	n/a	n/a	n/a		No	Road/Transmission line
19	Morrison Lake	55° 11' 54.909"	126° 18' 3.128"	25500	4,179	n/a	n/a	n/a	n/a		No	Waste rock pile
20	Morrison Lake	55° 11' 37.108"	126° 17' 54.256"	25500	2,722	n/a	n/a	n/a	n/a		No	Waste rock pile
21	Morrison Lake	55° 11' 7.615"	126° 19' 11.245"	29000	120	8.0	4.9	1.5	0.2	Bustard 2005[2]	No	Road/Transmission line
22	Morrison Lake	55° 11' 8.494"	126° 18' 2.575"	25500	1,716	n/a	n/a	n/a	n/a		No	Waste rock pile
23	Morrison Lake	55° 11' 1.369"	126° 18' 19.335"	25500	1,262	3.0	1.5	1.3	n/a	Bustard 2005[2]	No	Waste rock pile
24	Morrison Lake	55° 10' 55.115"	126° 18' 40.958"	n/a	445	n/a	n/a	n/a	n/a		No	Road/Transmission line
25	Morrison Lake	55° 10' 49.603"	126° 18' 25.146"	25500	831	6.0	2.1	1.5	n/a	Bustard 2005[2]	No	Road/Transmission line
26	Morrison Lake	55° 10' 55.217"	126° 18' 13.369"	25500	1,134	n/a	n/a	n/a	n/a		Yes	Road
27	Nakinilerak Lake	55° 14' 47.031"	126° 17' 47.121"	6070-429	2,375	n/a	n/a	n/a	n/a		Yes	Road
28	Nakinilerak Lake	55° 14' 45.997"	126° 17' 42.394"	6070-429	2,373	n/a	n/a	n/a	n/a		Yes	Road
29	Nakinilerak Lake	55° 14' 41.645"	126° 17' 44.072"	6070-429	2,516	n/a	n/a	n/a	n/a		No	Dam
30	Nakinilerak Lake	55° 14' 21.615"	126° 16' 53.682"	6070	2,615	n/a	n/a	n/a	n/a		Yes	Dam/Road/Pipeline
31	Morrison Lake	55° 14' 0.581"	126° 16' 54.506"	53400	6,409	n/a	n/a	n/a	n/a		Yes	Road/Pipeline
32	Morrison Lake	55° 13' 16.489"	126° 18' 15.380"	53400-12700	2,860	n/a	n/a	n/a	n/a		Yes	Road
33	Morrison Lake	55° 13' 7.073"	126° 17' 52.496"	53400-12700	3,412	n/a	n/a	n/a	n/a		No	Road/Pipeline
34	Morrison Lake	55° 13' 33.539"	126° 19' 10.985"	53400	2,152	n/a	n/a	n/a	n/a		No	Road/Pipeline
35	Morrison Lake	55° 13' 31.920"	126° 19' 10.252"	53400	2,135	n/a	n/a	n/a	n/a		No	Road/Pipeline
36	Morrison Lake	55° 11' 27.519"	126° 19' 59.547"	Pond W	112	n/a	n/a	n/a	n/a		No	Stockpile

n/a = not available

[1] survey performed in summer

[2] survey performed in spring

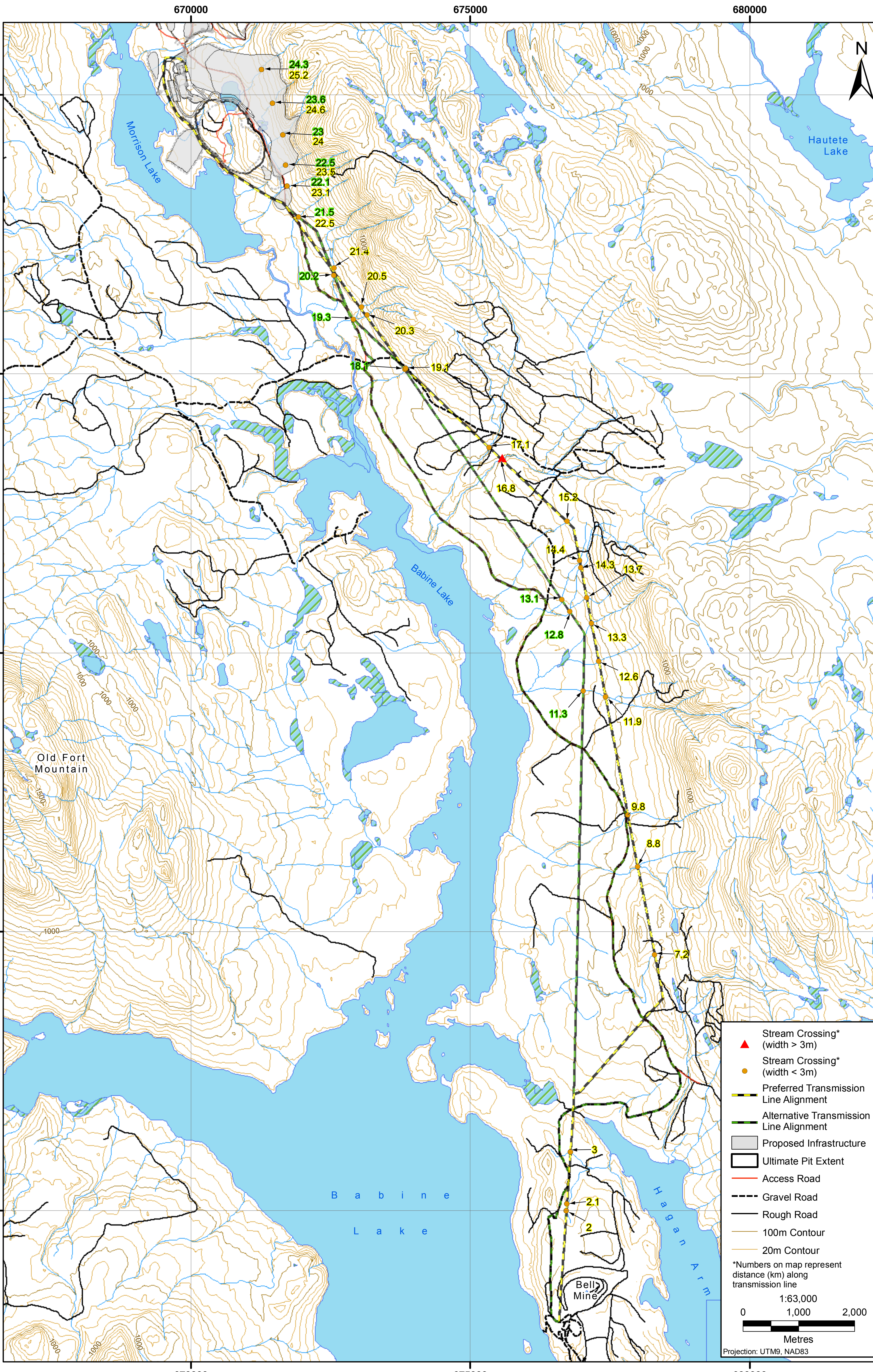


pbm

Mine Footprint Stream Crossing Locations of the Morrison Copper/Gold Project

FIGURE 7.11-1

Rescan™



Stream Crossings for the Proposed Transmission Line Options of the Morrison Copper/Gold Project

FIGURE 7.11-2

pbm

Rescan

There is little human requirement for navigation of the ponds within the mine site with the possible exception of Booker Lake. A summary of the waterbody location, surface area, maximum length, and average depth and distance to nearest road of each waterbody is presented in Table 7.11-2. The distance to nearest road varied between 15 and 1,137 m.

7.11.3 Proposed Transmission Line Stream Crossings

There is no apparent human requirement for navigation at the majority of stream crossings along the proposed transmission line alignments. Many of the streams that would intersect the transmission line are narrow (<3 m wide), shallow, or ephemeral, which would severely limit navigable value as recreational or commercial waterways.

Detailed habitat and photographic information was provided to Transport Canada for the single proposed stream crossings that exceeded 3 m mean bankfull width. As well, photographic documentation of all other proposed stream crossings was included. These photographs were used to confirm the navigability of each waterway by Transport Canada. Navigability was based on the potential for the waterway to be at least navigable by kayak. A summary of the transmission crossing location, bankfull width, wetted width, wetted depth, and gradient of each stream crossing is presented in Table 7.11-3. After the surveys were completed, the alignment of the proposed transmission line was altered in the area of the mine site. Therefore, the five stream crossings closest to the mine site are no longer along the alignment of the proposed transmission line. These sites are now within the mine footprint.

Table 7.11-2
Size and Accessibility of Small Lakes and Ponds in the Morrison Copper/Gold Project Area

Waterbody	Surface Area (ha)	Maximum Length (m)	Average Depth (m)	Distance to Nearest Road (m)	Comments
Booker Lake	15.04	559	8.6	41	Narrow, broken access trail with fallen and cut trees. Dead trees and snags along lake perimeter.
Ore Pond	2.11	267	n/a	15	Access down steep, forested slope. Pond is flooded forest area with dead trees and snags
Pond X	0.81	137	n/a	73	Access through surrounding forest and wetland area.
Pond W	0.07	41	n/a	20	Nearest logging road overgrown with tall saplings.
00302-BABL	5.95	544	n/a	1,137	Forested access across hilled plateau with wetlands.
00309-BABL	3.01	361	n/a	448	Forested access across hilled plateau with wetlands.

n/a = not available.

Table 7.11-3
Stream Crossings Along Proposed Transmission Line Options, Morrison Copper/Gold Project

Transmission Line Alignment	km Marker	Latitude	Longitude	Survey Length (m)	Slope (%)	Wetted Depth (m)	Wetted Width (m)	Bankfull Width (m)	Watershed Area (ha)	Wetted Stream Discharge (m^3/s)	Fish-bearing
Preferred	2.0	55° 0' 55.555" N	126° 14' 9.730" W	100	N/A	NVC	NVC	NVC	30.2	N/A	N
Preferred	2.1	55° 0' 59.576" N	126° 14' 8.954" W	100	N/A	NVC	NVC	NVC	44.0	N/A	N
Preferred	3.1	55° 1' 29.518" N	126° 14' 3.205" W	100	2	no water	no water	0.65	11.0	N/A	N
Preferred	7.2	55° 3' 22.011" N	126° 12' 30.897" W	100	5	no water	no water	1.30	29.8	N/A	N
Preferred	8.8	55° 4' 13.489" N	126° 12' 44.184" W	100	5	0.02	0.97	1.30	378.8	N/A	N
Preferred	9.8	55° 4' 43.391" N	126° 12' 51.908" W	100	3	0.02	0.55	1.35	204.1	N/A	N
Preferred	11.9	55° 5' 52.364" N	126° 13' 9.735" W	100	4	0.17	1.05	1.67	613.4	N/A	D
Preferred	12.6	55° 6' 13.201" N	126° 13' 15.124" W	100	10	0.67	0.57	0.80	53.9	N/A	D
Preferred	13.3	55° 6' 35.340" N	126° 13' 20.851" W	100	12	0.07	0.57	0.90	200.6	N/A	D
Preferred	13.7	55° 6' 50.182" N	126° 13' 24.691" W	100	5	0.02	0.30	0.60	36.3	N/A	N
Preferred	14.3	55° 7' 7.832" N	126° 13' 29.259" W	100	5	0.02	0.30	0.60	94.8	N/A	N
Preferred	14.4	55° 7' 11.935" N	126° 13' 30.321" W	100	5	0.02	0.30	0.60	14.1	N/A	N
Preferred	15.2	55° 7' 34.917" N	126° 13' 41.346" W	100	N/A	NVC	NVC	NVC	10.5	N/A	N
Preferred	16.8	55° 8' 12.168" N	126° 14' 44.657" W	200	7	0.27	2.55	4.00	1993.7	0.08	Y
Preferred	17.1	55° 8' 19.573" N	126° 14' 57.249" W	100	5	0.23	1.73	2.43	655.1	N/A	D
Preferred	19.1	55° 9' 7.040" N	126° 16' 18.004" W	100	4	no water	no water	0.65	30.9	N/A	N
Preferred	20.3	55° 9' 39.129" N	126° 16' 55.197" W	100	10	NCD	NCD	NCD	62.7	N/A	N
Preferred	20.5	55° 9' 43.947" N	126° 17' 0.586" W	100	10	NCD	NCD	NCD	39.0	N/A	N
Preferred	21.4	55° 10' 7.183" N	126° 17' 26.581" W	100	4	NVC	NVC	NVC	167.2	N/A	N
Preferred	22.5	55° 10' 37.408" N	126° 18' 0.409" W	100	10	0.03	0.53	0.86	49.5	N/A	N
Preferred	23.1	55° 10' 55.546" N	126° 18' 10.902" W	100	22	0.04	0.50	0.90	72.9	N/A	N
Preferred	23.5	55° 11' 7.639" N	126° 18' 11.687" W	100	6	0.17	0.88	1.25	22.1	N/A	D
Preferred	24.0	55° 11' 25.277" N	126° 18' 13.367" W	100	10	no water	no water	1.28	102.0	N/A	N
Preferred	24.6	55° 11' 43.806" N	126° 18' 22.548" W	100	20	NVC	NVC	NVC	20.6	N/A	N
Preferred	25.2	55° 12' 3.610" N	126° 18' 32.364" W	100	7	0.13	0.65	0.75	35.4	N/A	N
Alternative	11.3	55° 5' 56.391" N	126° 13' 31.984" W	100	4	0.17	1.05	1.67	626.1	N/A	D
Alternative	12.8	55° 6' 42.733" N	126° 13' 42.333" W	100	5	0.02	0.30	0.60	176.5	N/A	N
Alternative	13.1	55° 6' 49.798" N	126° 13' 50.028" W	100	5	0.02	0.30	0.60	25.9	N/A	N
Alternative	18.1	55° 9' 6.478" N	126° 16' 19.055" W	100	4	no water	no water	0.65	31.3	N/A	N
Alternative	19.3	55° 9' 36.844" N	126° 17' 8.997" W	100	10	NVC	NVC	NVC	109.2	N/A	N
Alternative	20.2	55° 10' 2.792" N	126° 17' 27.213" W	100	4	NVC	NVC	NVC	172.2	N/A	N
Alternative	21.5	55° 10' 37.295" N	126° 18' 0.687" W	100	10	0.03	0.53	0.86	49.6	N/A	N
Alternative	22.1	55° 10' 55.546" N	126° 18' 10.921" W	100	22	0.04	0.50	0.90	72.9	N/A	N
Alternative	22.5	55° 11' 7.637" N	126° 18' 11.698" W	100	6	0.17	0.88	1.25	22.1	N/A	D
Alternative	23.0	55° 11' 25.277" N	126° 18' 13.367" W	100	10	no water	no water	1.28	102.0	N/A	N
Alternative	23.6	55° 11' 43.805" N	126° 18' 22.548" W	100	20	NVC	NVC	NVC	20.6	N/A	N
Alternative	24.3	55° 12' 3.610" N	126° 18' 32.364" W	100	7	0.13	0.65	0.75	35.4	N/A	N

Fish-bearing : Y = fish-bearing, N = none, D = no fish caught, but default fish-bearing.

N/A = not available.

NCD = no classified drainage.

NVC = no visible channel.

7.12 Wetlands

7.12.1 Introduction

Wetlands are defined as "land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment" (National Wetlands Working Group 1988). Wetlands perform a variety of chemical, biological, and physical functions that contribute to the maintenance of healthy ecosystems.

Baseline studies have been conducted that describe the wetlands within the Project area (Appendix 31). Field surveys and provincial inventory data were used to classify and map wetlands within the immediate vicinity of the proposed mine infrastructure and transmission line. Also, baseline descriptions of hydrological, biological, and chemical characteristics of wetlands were made. This information was combined with ecosystem survey results to identify wetland function.

7.12.2 Methodology Overview

7.12.2.1 Wetland Ecosystem Mapping and Classification

Field surveys and provincial Terrain Resource Information Management (TRIM) data were used to map and classify wetland ecosystems within the Project site (Figure 7.12-1). Ecosystem surveys followed (MacKenzie 1999; MacKenzie and Moran 2004). The following parameters were recorded at each site:

- aspect (slope direction) and elevation
- meso-slope position (site position in the overall landscape)
- relative soil moisture and nutrient regimes
- soil drainage, texture, and horizon
- list of vegetation (dominant/indicator plant species)

Wetlands were classified into one of the federal wetland classes (bog, fen, marsh, swamp, and shallow open water) using descriptions from the *Canadian Wetland Classification System* (Warner and Rubec 1997). For this report, shallow open water wetlands were not mapped as individual communities, instead they were included within the overall wetland complex at a given site. Wetlands were further classified into provincial site associations following *Wetlands of British Columbia: A Guide to Identification* (MacKenzie and Moran 2004).

7.12.2.2 Rare and Endangered Ecosystems

Ecosystem survey notes were compared against information compiled by the BC Conservation Data Centre (CDC) for consideration as provincially rare ecosystems. This was done to ensure due diligence and to identify whether ecosystems in the study area have been classified by the BC Ministry of Environment (BC MOE) as:

- Red-listed: Any ecological community that is extirpated, endangered, or threatened in BC (BC MOE 2007a).
- Blue-listed: Any ecological community considered to be of special concern (formerly vulnerable) in BC (BC MOE 2007a).

7.12.2.3 Hydrological Surveys

Hydrological monitoring was conducted on July 22, 2007, and again on August 15, 2007, in two representative wetland sites (Pond X and Pond Y; Figure 7.12-2). The wetland hydrology study was conducted using static surveys of the wetland water table in monitoring wells. Seven shallow (<1.0 m below ground surface) groundwater wells were installed at Pond X and four similar wells were installed at Pond Y.

7.12.2.4 Aquatic Surveys

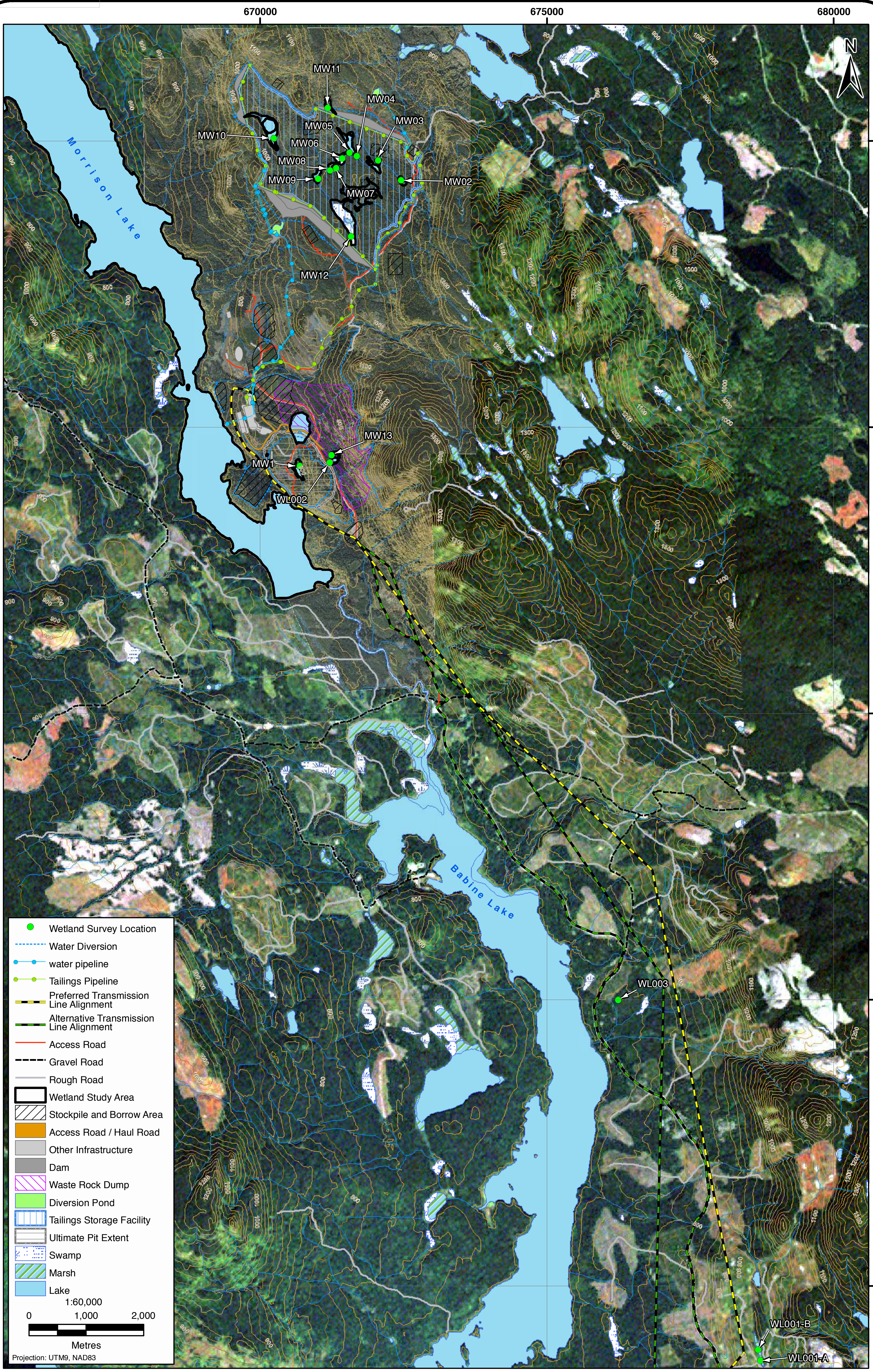
In the summer months of 2006 and 2007, the aquatic resources of four ponds (Ore, X, Y, and Z) and one small lake (Booker Lake) were sampled (Figure 7.12-2). Surveys assessed primary and secondary production and the chemical characteristics of water and sediment. Wetlands were also assessed to determine fish presence. Detailed methods regarding field sampling and sample and data analyses are provided in Appendix 26.

7.12.2.5 Determining Wetland Function

The field data collected during the hydrology survey, ecosystem assessment, and aquatic biology sampling were used to identify wetland function in the study area. Wetland function is described following Environment Canada (2003c) and refers to the functions that substantially contribute to the integrity of the wetland ecosystem; are important in a local, regional, or national context; or can be used as indicators of the direct or indirect effects on other functions or components of the ecosystem. Table 7.12-1 lists the wetland functions that are described by the field data.

Table 7.12-1
Wetland Function and Associated Fieldwork Component

Wetland Function	Fieldwork Component
Hydrological Function	Hydrology Monitoring and Ecosystem Survey (hydrodynamics)
Biochemical Function	Aquatic Biology(sediment and water quality) and Ecosystem Survey (soil water pH and soil horizon identification)
Ecological Function	Aquatic Biology (productivity) and Ecosystem Survey (classification)
Habitat Function	Fisheries Sampling/Habitat Assessment and Ecosystem Survey (classification and wildlife observations)

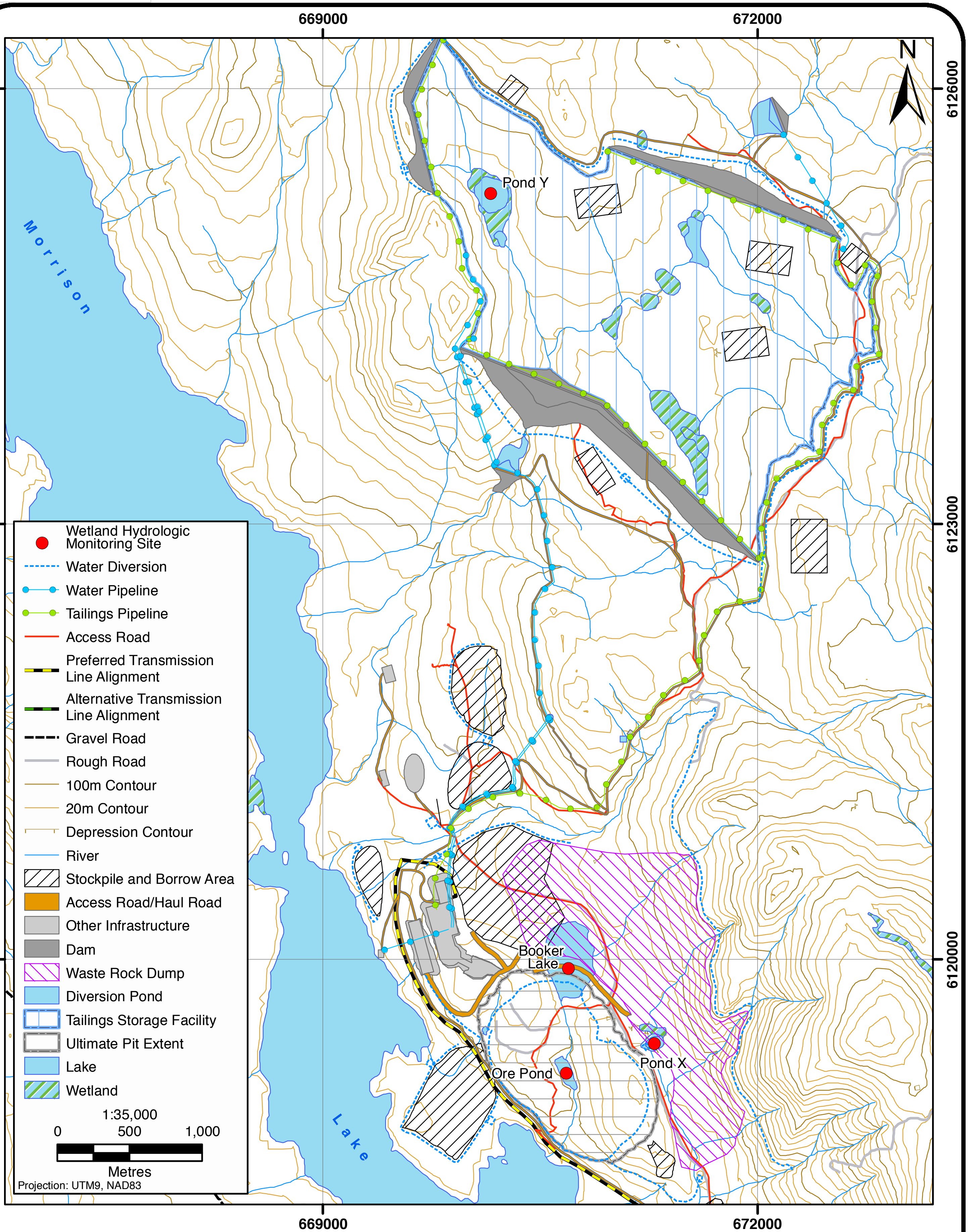


pbm

FIGURE 7.12-1

Morrison Copper / Gold Project
Wetland Survey Locations

Rescan™



Morrison Copper / Gold Project
Wetland Hydrological Monitoring Sites

FIGURE 7.12-2

pbm Rescan™

7.12.3 Results and Discussion

7.12.3.1 Wetland Ecosystem Mapping

Wetlands cover 66.75 ha in the study area. All five federally recognized wetland classes, encompassing eight provincial wetland ecosystem associations, were mapped. Two shrub-carr transitional ecosystems (4.19 ha) were also identified. Bogs (plates 7.12-1 and 7.12-2) covered the greatest amount of area within the study area (33.15 ha; Table 7.12-2), although swamps (Plate 7.12-3) were the most commonly observed wetland class (Table 7.12-3).

Table 7.12-2
Wetland Class Areas in the Morrison Wetland Study Area

Wetland Class	Wetland Area (ha)
Bog[1]	33.16
Swamp	7.63
Marsh[1]	16.72
Fen	9.24

[1] Includes shallow open water wetlands.

The most commonly occurring wetland ecosystem association was beaked sedge-water sedge marsh (Wm01; Plate 7.12-4), while the association covering the greatest area was spruce-creeping snowberry-peat moss (Wb01; Plate 7.12-2).

Plate 7.12-1. Wb05 Bog Ecosystem at Site MW04.

Plate 7.12-2. Wb01 Bog Ecosystem at Site MW13.

Plate 7.12-3. Ws06 Swamp Ecosystem at Site MW06.

Plate 7.12-4. Wm01 Marsh Ecosystem at Site MW10.

Table 7.12-3
Morrison Copper/Gold Project Wetland Ecosystems

Plot	Location	Wetland Class	Site Association	Site Association Name
MW04	Tailings Storage Facility	Bog	Wb05	Black spruce – Water sedge – Peat moss
MW12	Tailings Storage Facility	Bog	Wb01	Black spruce – Creeping snowberry – Peat moss
MW13	Waste Rock Dump	Bog	Wb01	Black spruce – Creeping snowberry – Peat moss
WL003	Transmission Line	Bog	Wb01	Black spruce – Creeping snowberry – Peat moss
WL001a	Transmission Line	Fen	Wf02	Scrub birch – Water sedge
WL001b	Transmission Line	Fen	Wf02	Scrub birch – Water sedge
MW05	Tailings Storage Facility	Marsh	Wm01	Beaked sedge – Water sedge
MW07	Tailings Storage Facility	Marsh	Wm01	Beaked sedge – Water sedge

(continued)

Table 7.12-3
Morrison Copper/Gold Project Wetland Ecosystems (completed)

Plot	Location	Wetland Class	Site Association	Site Association Name
MW10	Tailings Storage Facility	Marsh	Wm01	Beaked sedge – Water sedge
WL002	Waste Rock Dump	Marsh	Wm01	Beaked sedge – Water sedge
MW03	Tailings Storage Facility	Shrub-Carr		
MW11	Tailings Storage Facility	Shrub-Carr		
MW01	Open Pit	Swamp	Ws01	Mountain alder – Skunk cabbage – Lady fern
MW02	Tailings Storage Facility	Swamp	Ws07	Spruce – Common horsetail – Leafy moss
MW06	Tailings Storage Facility	Swamp	Ws06	Sitka willow – Sitka sedge
MW08	Tailings Storage Facility	Swamp	Ws06	Sitka willow – Sitka sedge
MW09	Tailings Storage Facility	Swamp	Ws06	Sitka willow – Sitka sedge

7.12.3.2 Rare and Endangered Ecosystems

A spruce- creeping snowberry- peat moss (Wb01) blue-listed bog was identified at three sites (Plate 7.12-5; Table 7.12-4) covering a total area of 31.10 ha. Dominant plant species in this association are spruce (*Picea* spp.), Labrador tea (*Ledum groenlandicum*), creeping snowberry (*Gaultheria hispidula*), and peat moss (*Sphagnum* spp.). These bogs are uncommon in the boreal and sub-boreal forests at elevations between 500 and 1,000 m. They form in closed basins and in complexes with peripheral peatlands where there is little influence from groundwater. Groundwater studies of the area identified that the general groundwater chemistry is influenced by precipitation, which supports the observed vegetation which tended to be ombrotrophic (Appendix 24: Hydrogeology Baseline). Regional climatic conditions likely limit the widespread development of this association (MacKenzie and Moran 2004).

Table 7.12-4
Distribution of Rare Bog Ecosystem (Wb01)

Site	Location	Area (ha)
Mw12	Proposed tailings storage facility	26.65
Mw13	Proposed waste rock dump	1.21
WL003	Transmission Line Study Corridor	3.24

Plate 7.12-5. Wb01 Bog Ecosystem at Site MW13.

7.12.3.3 Hydrological Qualities

Water levels of the monitored wetlands ranged from approximately 0.21 m below the ground surface to 0.17 m above the ground surface. The water table in each wetland was observed to decrease from July to August.

7.12.3.4 Aquatic Biology

Primary and Secondary production

Primary producer (phytoplankton) density and biomass varied greatly among the lake and four ponds, with considerable variation observed between 2006 and 2007. Phytoplankton biomass ranged from 0.87 to 7.61 µg/L, while densities ranged from 150 to 1,002 × 103 cells/L. A total of 49 genera were identified in 2006, and 38 in 2007. The taxonomic composition varied depending on the site, and community shifts were observed between the years at Ore Pond, and ponds X and Z.

Densities of secondary producers (zooplankton and benthic invertebrates) varied significantly between waterbodies and years. The average density of benthic invertebrates ranged from 7 organisms/m^2 at Booker Lake in 2007 to 2,560 organisms/m^2 at Pond Y in 2007. Benthic invertebrate densities were consistently higher at Pond Y and Pond Z in both years than at Booker Lake and Pond X in 2007, where densities were substantially lower. Zooplankton densities were lower in 2006 than in 2007, ranging from 3,431 to 24,004 organisms/m3 in 2006, and 23,896 to 101,934 organisms/m^3 in 2007.

Average benthos genus richness ranged from 2.5 to 16 genera, with most sites ranging from 6 to 9 genera. Most sites were dominated by or had high proportions of dipterans (16 to 83%). Amphipods dominated the community at Pond X in both years, and represented a large proportion of the communities at Booker Lake and Ore Pond in 2007. Nematodes composed a large proportion of the community at Pond Y in both years and Pond Z in 2006. Cladocerans and copepods were prevalent only in 2007 in Ore Pond and Booker Lake, respectively.

Zooplankton genus richness was similar in both years, ranging from 6 genera at Ore Pond to 13 genera at Pond Z in 2006. Communities in 2006 were dominated at most sites by cyclopoid copepods and rotifers; however, Pond X was dominated by *Daphnia*. In 2007, sites were dominated by *Daphnia*, rotifers, and calanoid copepods. The differences in community composition are likely due to seasonal differences. Complete details of the aquatic resources are provided in Appendix 26.

Water Quality

All dissolved metal and nutrient concentrations were below posted guideline limits with the exception of cyanide and aluminum. At least once at all lake and pond sites, naturally occurring cyanide concentrations exceeded the limit specified in federal (CCME) and provincial (BC MOE) guidelines for the protection of aquatic life. In 2007, cyanide concentrations in the surface waters of two ponds were approximately double the B.C. freshwater aquatic life guideline for cyanide. Dissolved aluminum concentrations exceeded the BC MOE mean guideline in 2007 in the surface waters of two tested ponds (Appendix 26).

Sediment Quality

In 2006, sediment samples consisted primarily of clay and silt and in 2007 were silt and sand. Nitrogen contents were low across all sites in both years, ranging from 1.6 to 2.4%. Total phosphorous ranged from 686 to 1,983 mg/kg. TOC concentrations were moderate and similar across years and sites, ranging from 21 to 32%. Total cyanide concentrations were below detectable limits at all sites except Ore Pond, which contained an average concentration of 55.2 mg/kg.

7.12.3.5 Wetland Functions

Hydrological Function

Static water-level monitoring at wetland sites indicates that the water continually drains from wetlands throughout the summer. In this respect, the two wetlands (Pond X and Pond Y) are assumed to be typical of others in the Project area and of many wetlands in general. Water levels in wetlands are high in the spring months following snowmelt; they hold and store water preventing all of the water from immediately entering streams, which would likely result in flooding. Throughout the summer months, wetlands slowly release the water, allowing small streams to maintain flow during this time.

Additionally, the presence of minerotrophic plant species such as *Carex aquatilis*, *Equisetum* spp., and *Comarum palustre* in certain wetlands indicates that mineral rich groundwater supplies these wetlands with water. Therefore, the wetlands are important groundwater-receiving environments.

Biochemical Function

The change in some chemical characteristics of wetland sediments from year to year suggests that wetlands in the study area play a prominent role in the aquatic biochemical cycle. The slow-moving water in wetlands allows sediments and particles (and the nutrients, metals, and toxins bound to these particles) to settle out. Plants, micro-organisms, and chemical processes specific to wetlands help to breakdown, sequester, and metabolize nutrients, metals, and toxins. These various biochemical processes effectively remove these elements from the larger surface water network. These biochemical cycles also facilitate the energy transfer of nutrients from aquatic species to terrestrial ecosystems.

Ecological Function

Wetlands in the study area have many important ecological functions. They often exist as complexes of multiple wetland associations including aquatic, semi-aquatic, and terrestrial components. This diversity in the ecosystem structure provides a number of habitat types and unique ecological niches within the region. One provincially blue-listed wetland ecosystem was also identified in the area. The presence of a community recognized by the province as a community of special concern also underscores the importance of wetlands for the maintenance of ecology and biodiversity within the region.

Habitat Function

Wetlands in the area provide important habitat for wildlife, including browse habitat for moose (*Alces americanus*). In the summer, moose feed upon aquatic vegetation such as lily (*Nuphar* spp.) rhizomes and pondweed (*Potamogeton* spp.) that grow in marshes and shallow-water wetlands (Belovsky and Jordan 1981). Moose also visit marshes and shallow-water wetlands in the summer to cool down and escape from insect pests (Flook 1959; Renecker and Hudson 1986). In the winter, willows (*Salix* spp.), found in many of the study area's fens and swamps, provide valuable forage for moose. Wetlands in the study area also provide habitat for bears (*Ursus* spp.) and for various species of amphibians. During the amphibian survey (Appendix 38), western toads, (*Bufo boreas*), a COSEWIC species of special concern, as well as Columbia spotted frogs (*Rana luteiventris*) and wood frogs (*Rana sylvatica*) were all observed in multiple wetlands within the study area.

7.13 Terrain, Surficial Materials, Overburden, and Soils

7.13.1 Introduction

The Project footprint for the terrain, surficial materials, overburden, and soils setting comprises two connected areas: the mine facilities area (MFA; 1,944 ha) and the transmission line study corridor (TLSC; 1,216 ha). The MFA principally includes the proposed pit, plant site, TSF, WRD, overburden stockpiles, soil stockpiles, low grade ore stockpile, haul routes and pipelines connecting the facilities, and the non-developed intervening area. The TLSC currently includes three optional (100 m) buffered transmission line routes extending north from the Bell Mine substation to the MFA. The study area extends beyond this footprint and includes approximately 19,100 ha (Figure 7.13-1).

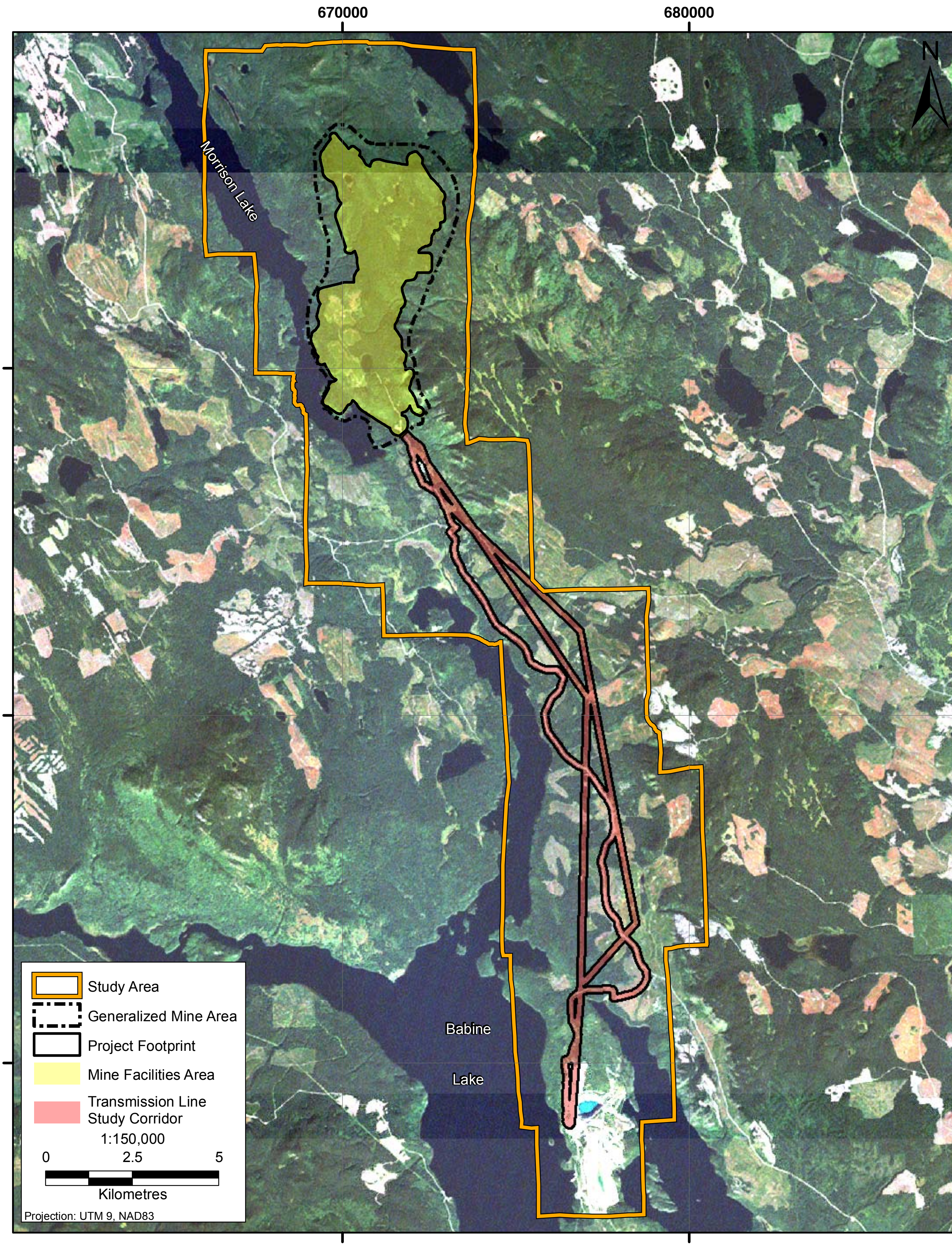


FIGURE 7.13-1

Morrison Copper/Gold Project Study Area and Project Footprint Boundary

7.13.2 Setting Objectives

This setting provides an overview of the existing terrain, surficial materials, overburden, and soils in the study area; complete details of this study are included in Appendix 32.

7.13.3 Methods

7.13.3.1 Review of Existing Information

The regional physiography, as presented by Holland (1976), was used to introduce the regional setting. The Project area's geology and surficial material have been previously described by Simpson (2007). Soil climate was inferred using the BEC concept, as discussed by Banner et al. (1993), in conjunction with temperature and precipitation data from an on-site station (Appendix 18) and from Environment Canada meteorological stations at Topley Landing, Babine Lake, and Pinnut Creek. Soil Survey Report No. 47 (*Soils of the Hazelton Map Area, NTS 93M NW, NE, SE),* prepared at a scale of 1:100,000, covers all areas of the proposed Project (Wittneben 1984). However, this map was not meant for site-specific purposes and does not provide sufficient detail for a soils setting of the Project area.

The depth, spatial extent, and type of overburden within the proposed development areas were determined primarily from drill-hole and test-pit data collected by Klohn Crippen Berger Ltd. (appendices 6 and 9) and Knight Piésold Consulting Engineers (Appendix 4; 2006). In 2007, six electrical resistivity lines were undertaken by Frontier Geosciences Inc. (appendices 6 and 9). This information was used to confirm the relationship between the depth of overburden and local topography.

7.13.3.2 Slope Analysis

Two slope maps were produced, each at a scale of 1:50,000, to include both the MFA (north sheet) and the TLSC (south sheet and a portion of the north sheet). Slope classes were created using the standard terrain classification categories developed by Howes and Kenk (1997). These classes were adjusted to provide a better differentiation of local slope conditions that affect the soil resources, especially in this area of relatively complex slopes of generally low relief. The Howes and Kenk "gentle" slope class, representing slopes >5% to 26%, was further divided into two classes: gentle (>5% to 15%) and moderately gentle (>15% to 26%). Slope classes were defined and are described in the text as follows:

- Class 1: 0% to 5% level to very gently sloping
- Class 2: >5% to 15% gently sloping
- Class 3: >15% to 26% moderately gently sloping
- Class 4: >26% to 49% moderately sloping
- Class 5: >49% to 70% moderately steeply sloping
- Class 6: >70% steeply sloping

7.13.3.3 Bioterrain and Soil Mapping

Bioterrain Mapping

Bioterrain mapping was undertaken as the basis for both the soils mapping and the terrestrial ecosystem mapping (TEM) for the study area. Preliminary terrain polygons for the MFA were delineated using 80 1:10,000-scale, colour air photos taken in 2006. Terrain polygons for the TLSC were delineated using 1:30,000-scale, colour air photos taken in 2001. The bioterrain maps are presented at a scale of 1:15,000 on a 20-m contour TRIM base. This includes two mapsheets: the MFA and the north end of the TLSC and the TLSC. Bioterrain information includes surficial material, texture, surface expression (e.g., slope, thickness of surficial material, landform type), and geomorphic processes (e.g., seepage, gully erosion) based on the terrain classification system for BC (Howes and Kenk 1997).

Soil Mapping

Soil maps were produced at a scale of 1:15,000, on a 20-m contour TRIM base, comprising two mapsheets: one that includes the MFA and one that includes the TLSC (Appendix 32). The soil maps were developed using five principal sources of information:

- BEC subzone boundaries (synonymous with soil climates)
- terrain mapping polygons and attributes
- polygon slope information
- TEM site series (interpreting site series to infer soil drainage and probable soil development, as related to soil classification)
- soil inspection site information to confirm the characteristics of the soils observed within the study area

Information from 178 inspection sites was used in the development of the soil map in the areas of proposed development (127 sites in the MFA and 51 along the TLSC). The average inspection intensity was equivalent to 17 ha per inspection, which corresponds to a survey intensity level (SIL) of 2. This includes inspection intensities of 14 ha per inspection for the MFA (SIL 2) and 24 ha per inspection for the TLSC (SIL 3).

Soil Associations and Soil Map Units

A soil association is a group of related soils developed on similar parent materials that may differ in horizon development because of differences in soil water regimes or other characteristics such as disturbance history or depth to bedrock. Within the Project area, soil associations were differentiated primarily on the basis of parent material and the most common soil-drainage conditions. Simple soil map units (SMU) are shown where one soil association was predominant. More commonly, compound map units are used to indicate where soil associations were too intimately mixed to be shown separately and/or the individual polygons were too small (less than the minimum polygon size of 0.5 cm^2) to be shown separately on the maps.

7.13.3.4 Field Program

A total of 81 soil inspection sites were observed within the study area: 45 in the summer of 2006 and 36 in the summer of 2008 (figures 7.13-2 and 7.13-3). Ground inspections in the study area were carried out following guidelines established in the *Field Manual for Describing Terrestrial Ecosystems* (BC MELP and BC MOF 1998). Most soil pits were excavated to a depth ranging from 30 cm to 80 cm. Ground inspection forms (GIF) were completed for the TEM component, and detailed soil and site information was recorded for all sites.

7.13.3.5 Soil and Overburden Sampling and Analyses

Soil

A total of 45 samples (surface and subsurface) were collected from 23 selected sites for suitability/fertility and metals testing. Generally, two samples were collected at each selected site, one from the 0-cm to 20-cm depth interval and one from the 20-cm to 40-cm depth interval. Samples were analyzed by ALS Laboratories in Vancouver, BC.

All soil samples collected were analyzed for the following fertility parameters: soil reaction (pH), electrical conductivity (EC), available sulphate ion, available phosphate, cation exchange capacity (CEC), total nitrogen, and total sulphur. Samples from the 2008 sampling program were also analyzed for calcium carbonate ($CaCO_3$) equivalent, inorganic carbon, and total carbon. In addition, all samples were tested for a total of 28 metals to determine the potentially bio-available levels of the metals in the soils tested. These values were compared against the BC *Contaminated Sites Regulation* (CSR) guidelines for industrial and parkland land use criteria (CSR 2005).

Overburden

As part of the Klohn Crippen Berger 2007 site investigations, 98 overburden samples were collected from 10 drill holes near the TSF and WRD (DH07 series; Figure 7.13-4; Appendix 6). From this group, 20 samples that had not been formerly analyzed were selected from seven of the drill holes (DH07-2, DH07-3, DH07-4, DH07-5, DH07-6, DH07-7, and DH07-9) for chemical and physical analyses. The samples were selected based on: (i) the proximity to the pit, (ii) the type of material (as identified on the drill-hole log), (iii) the depth, and (iv) the frequency of occurrence of material type. An additional 18 samples were collected and analyzed from seven sites (TP08-1, TP08-2, TP08-3, TP08-4, TP08-5, TP08-6, and TP08-7) in the proposed pit area during the Klohn Crippen Berger fall 2008 field investigation program (TP08 series; Appendix 9).

Samples collected for analysis in 2007 and 2008 represent two overburden material types and several depths. These include 23 morainal (M) materials collected from between 0.8-m and 22.9-m depth and 15 undifferentiated (U; colluvium and weathered bedrock) materials collected between 1-m and 21.3-m depth.

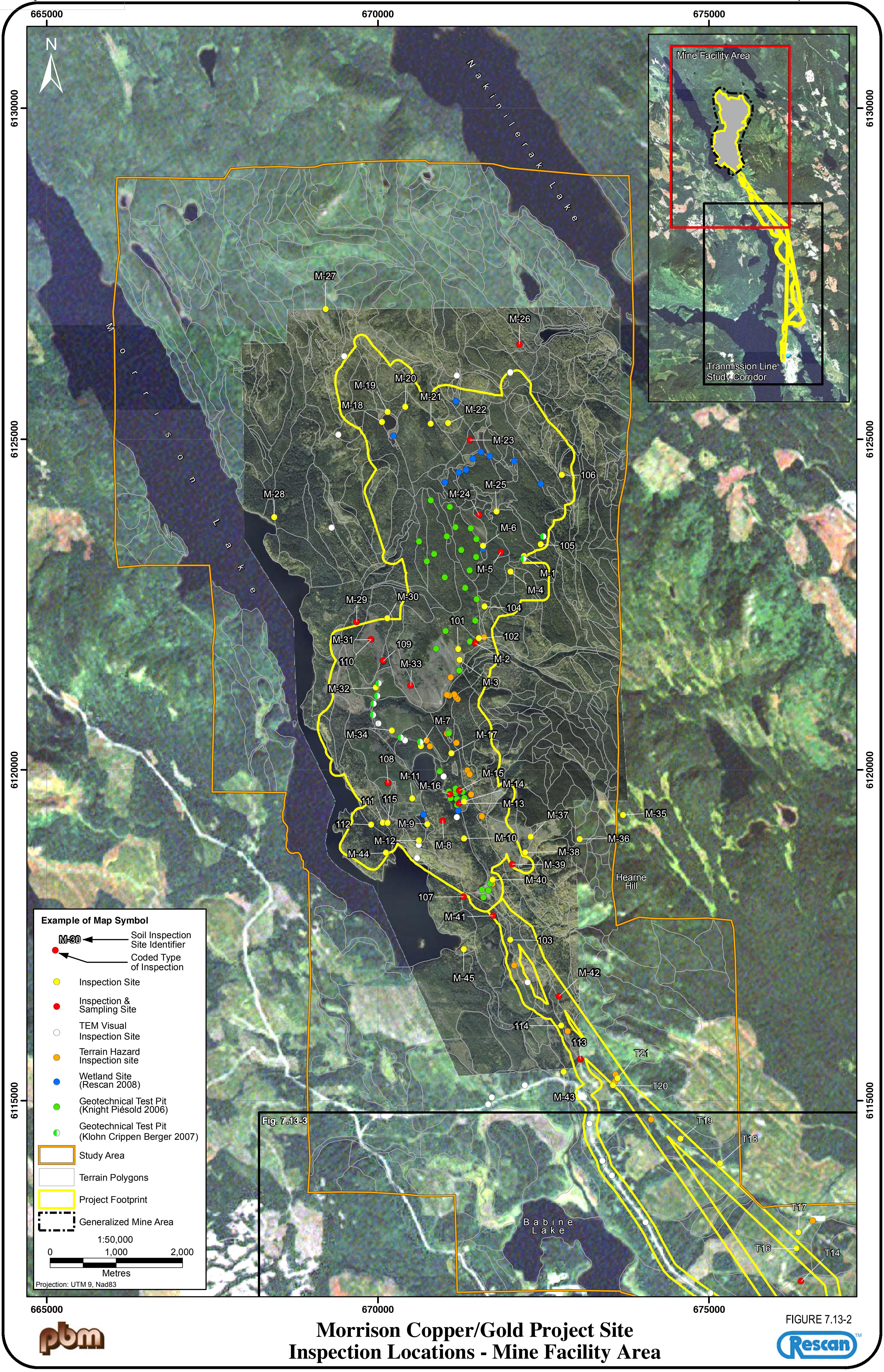


FIGURE 7.13-2

Morrison Copper/Gold Project Site
Inspection Locations - Mine Facility Area

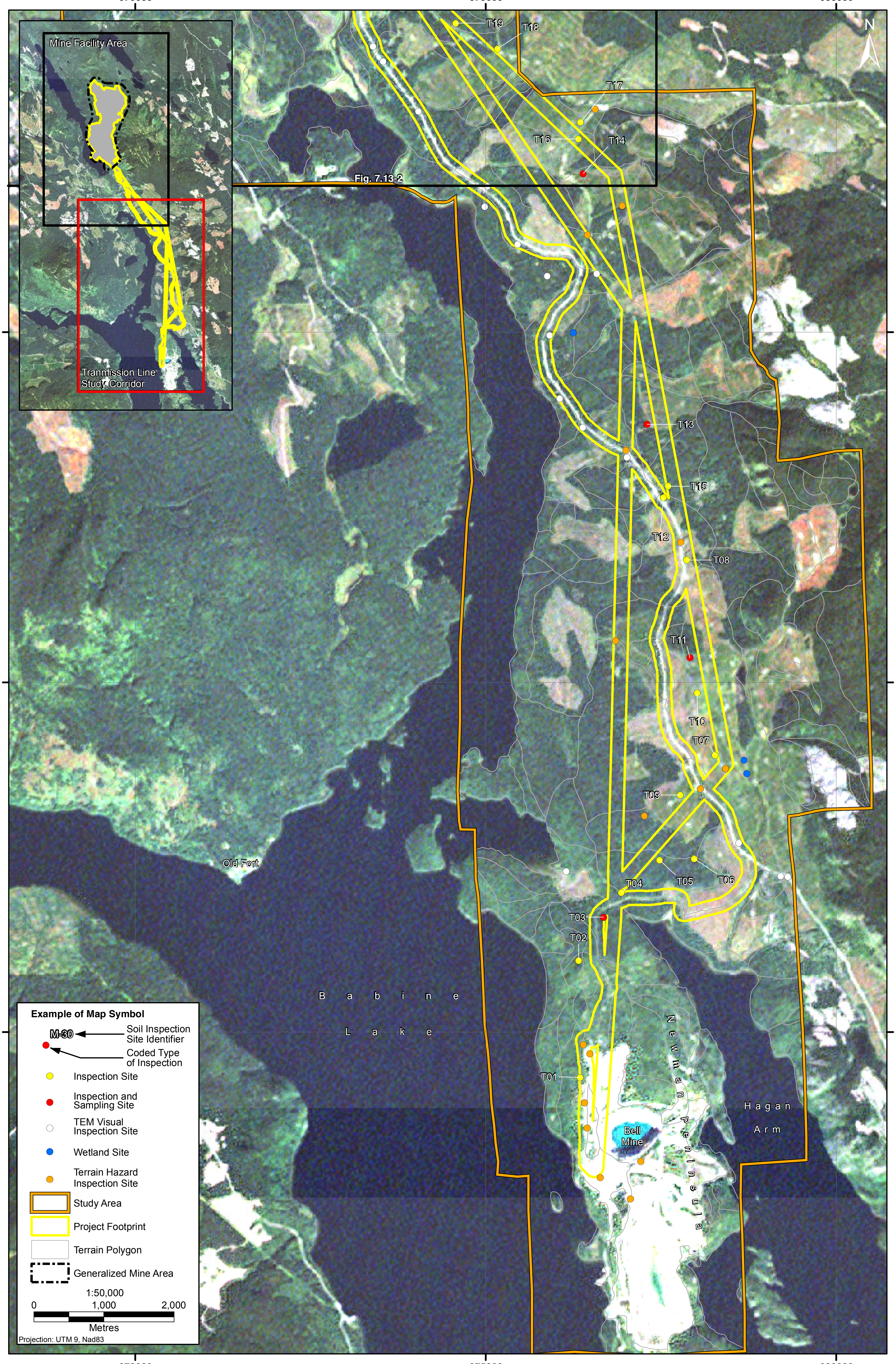
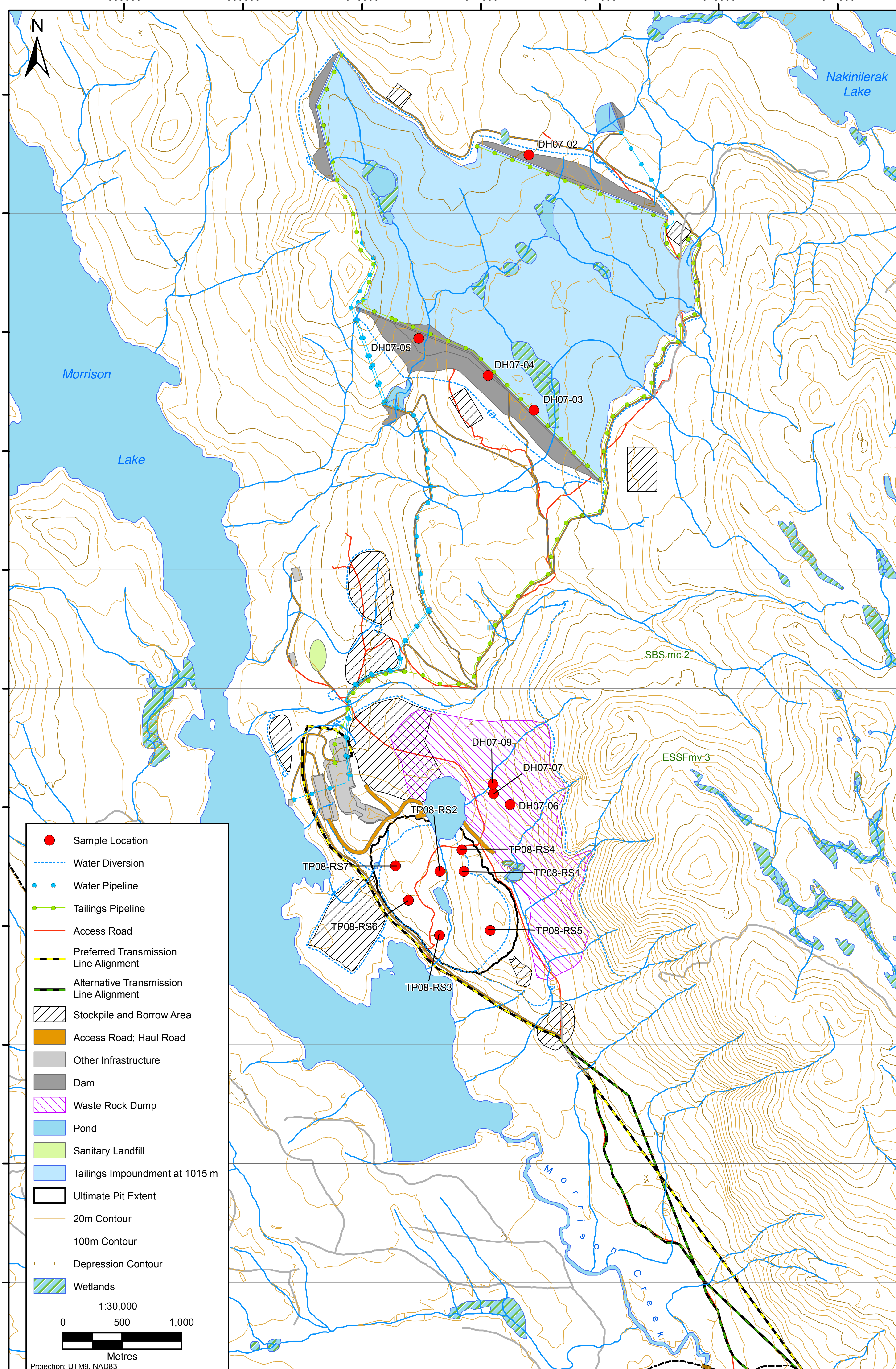


FIGURE 7.13-3

Morrison Copper/Gold Project Soil Inspection Site Locations - Transmission Line Study Corridor



pbm

FIGURE 7.13-4

Morrison Copper/Gold Project Overburden Sample Locations

Rescan™

The following analyses were carried out on overburden samples: moisture, EC, pH, coarse fragment content, texture, and metals. Select samples were also tested for calcium carbonate equivalency, sodium adsorption ratio (SAR), and percent saturation (water content at saturation).

7.13.4 Results and Discussion

7.13.4.1 Climate

The mean annual temperature based on data from the on-site meteorological station, which has been operational since 2006, is 1.5ºC (Appendix 18). Total mean annual precipitation is estimated at 550 mm. Monthly precipitation is generally lowest between February and May and peaks in June and in the November through January period. Precipitation in the form of snow is estimated to represent 40% of total precipitation in the Project area and is common between October and April.

7.13.4.2 Physiography

The entire study area, mine site, and transmission line components occur within the Nechako Plateau portion of the Interior Plateau. This is a component of the Southern Plateau and Mountain Area subdivision of the Interior System (Holland 1976).

7.13.4.3 Geology

The Morrison deposit is on the edge of the Skeena Arch in a region underlain primarily by volcanic, clastic, and epiclastic rocks (Simpson 2007). These have been block faulted by a series of northwesterly trending faults that have created a sequence of horsts and grabens. Intrusive rocks include diorite, granodiorite, rhyolite, and rhyodacite as well as the Eocene Babine igneous suite consisting of quartz, hornblende, biotite, and plagioclase phyric intrusions (PBM 2007).

7.13.4.4 Topography and Slopes

The study area's topography varies widely, with the elevation ranging between roughly 711 metres above sea level (masl; Babine Lake) and 1,380 masl (Hearne Hill). The most common slope gradient classes range from near level to very gently sloping (0% to 5% gradient) to moderately sloping (26% to 49% gradient).

7.13.4.5 Surficial Materials and Soil Development

Surficial Materials and Bioterrain Mapping

The bioterrain map produced for the Project illustrates the range of surficial materials and their distribution in the Project footprint. These include glacial till (morainal), colluvial, lacustrine and/or glaciolacustrine, glaciofuvial, fluvial, and organic deposits. A brief summary of the key attributes of the surficial materials and their areal extent is provided in tables 7.13-1 and 7.13-2.

Soil Development on Surficial Materials

Typical soil development on the soil parent materials common to the Project footprint is briefly described in the following sections based on surficial material type. A detailed description of the soils within the Project footprint and a characterization of the overburden materials on which the soils have developed are available in appendices 32 and 33.

Table 7.13-1
General Characteristics of Surficial Materials - Study Area

Surficial Material	Typical Topographic Landscape	Coarse Fraction (>2 mm)	Fine Fraction (<2 mm)
Colluvial	gentle to moderately steep	angular to sub-angular fragments, high but variable content	typically coarse, may include sands to silts
Fluvial	near level floodplains to very gentle slopes	rounded to sub-rounded; high content to none	sands to silts
Glaciofluvial	gentle to moderately steep	rounded; typically high content but variable	sands to silts
Lacustrine or Glaciolacustrine	level to gentle	low content to none (occasional drop-stone in glaciolacustrine material)	moderately fine to fine; clays with varying content of silt (minor sand)
Morainal	Gentle to moderately steep, often complex	Sub-rounded to sub-angular; very low to moderate content	moderately fine; clay with some silt and varying content of sands
Organic	depressional to flat or very gently sloping; high water table	none	varying degree of decomposition, generally thin (<1 m)
Bedrock	steep to ridged	not applicable	not applicable
Anthropogenic (areas of disturbance from past activities)	variable	variable	variable

Table 7.13-2
Summary of Area Extent of Surficial Materials – Project Footprint (MFA and TLSC)

	Mine Facilities Area	Transmission Line Study Corridor	Project Footprint Area	
Surficial Material	**Area (ha)**	**Area (ha)**	**Area (ha)**	**Area (%)**
Colluvial	427	146	573	18
Fluvial	40	111	151	5
Glaciofluvial	37	30	67	2
Lacustrine[1]/Glaciolacustrine	29	7	36	1
Morainal	1,283	824	2,107	67
Organic	81	9	90	3
Bedrock	16	17	33	1
Water and Other	31	0	31	1
Anthropogenic	n/a	72	72	2
Total	1,944	1,216	3,160	100

Note:
n/a – not available.
[1] the mapping of an organic veneer overlying lacustrine material is common in the area. The current extent noted may under-represent the amount of lacustrine material at the surface.

Morainal

Morainal material is generally composed of a matrix of silt and clay with some fine gravel (Appendix 9). Some samples of morainal material are coarser textured, gravelly, sandy clays, and clayey sands (Appendix 6). Coarse fragment content (>2 mm) ranges from approximately 15% to 35%. Morainal material in the area has been reported as generally firm, stiff, and moist, with low to intermediate plasticity. Deposits vary greatly in thickness. This material is relatively uniform and structureless.

The soils developed on morainal (till) materials are the most common soil types within the proposed Project footprint and occupy nearly 67% of the MFA. The most common soils developed on till include those of SMU M1. They are generally classified as Orthic Gray Luvisols (Plate 7.13-1), which have a strongly developed subsurface horizon enriched with clay (Bt) and Brunisolic Gray Luvisols (Plate 7.13-2), which have a moderately deep, weathered, non-compact layer above the darker, compact Bt horizon.

Plate 7.13-1. A moderately well-drained Orthic Gray Luvisol with a deep Ae (gray) horizon developed on coarse textured, morainal material (SMU M1; Site M15).

Plate 7.13-2. A well-drained, brownish Brunisolic Gray Luvisol developed on moderately fine-textured, morainal material displays a dark brown Bt (clay enriched) horizon at depth (SMU M1; Site M36).

SMU M1 soils are typically associated with SMU M3 soils, Gleyed Gray Luvisols, which are imperfectly drained and commonly occur in the lower portions of the same terrain (plates 7.13-3 and 7.13-4). Soils mapped as SMU M2 are more commonly found at higher elevations in a cooler and moister BEC subzone. These soils are classified as Orthic Dystric Brunisols, Gleyed Eutric Brunisols, and Humo-Ferric Podzols.

Plate 7.13-3. Nearly level topography typical of SMU M3 (Site M31).

Glaciofluvial

Glaciofluvial (glacial melt water) deposits vary from stratified to unsorted. These materials are described as loose, sandy gravel with rounded coarse fragments up to trace (10%) cobbles, with little to no fine material. Permeable, glaciofluvial sand and gravel were reported in the proposed WRD area (Appendix 6). Permeable (coarser) glaciofluvial materials are present in some gullies in the TSF. These materials often overlie impermeable morainal material.

Glaciofluvial materials occur rarely and sporadically throughout the Project footprint. They occur as both deep (>1 m thick), gravelly deposits (SMU G1) and as thin veneers (20 cm to 50 cm thick) overlying finer, compact till (SMU G2). They are generally coarse textured but may vary to medium textured, especially at the surface. These deposits occur at relatively low elevations over a range of near level to moderately steep slope gradients. SMU G1 are the most dominant soils that are developed on very gravelly to gravelly, coarse-textured glaciofluvial materials. These soils are often classified as Eluviated Dystric and Orthic Eutric Brunisols (Plate 7.13-5).

SMU G2 soils have a similar profile development as those mapped as SMU G1. However, they have a thin litter layer and shallow rooting. The surface mineral layer is gravelly to very gravelly and the deeper subsurface horizons contain less gravel.

Lacustrine and Glaciolacustrine

Lacustrine (recent lake) and glaciolactustrine (glacial lake) materials occur in the study area and have not been differentiated for soil mapping purposes. Lacustrine sediments range in texture from fine sands to clays and characteristically have low coarse fragment content. Observed lacustrine material typically consists of very fine silt and clay (Appendix 4). This material was found to be well sorted with few to no coarse fragments. The thickness of lacustrine material in the area is generally less than 1.5 m. It often occurs as an overlay on morainal material. Lacustrine materials appear to be of limited extent within the proposed Project footprint, occurring primarily in the MFA, and are restricted to near level or depressional areas.

Plate 7.13-4. An imperfectly drained soil with a weakly mottled near surface horizon overlying a dull-coloured, clay enriched (Btgj) horizon (SMU M3; Site M31).

Plate 7.13-5. An Eluviated Dystric Brunisol developed on coarse textured, very gravelly, rapidly drained glaciofluvial material (SMU G1; Site M32).

Typical soils in SMU L1 are poorly drained, slowly permeable, and are classified as Orthic Gleysols and Orthic Humic Gleysols (Plate 7.13-6). Soils mapped as SMU L2 are developed on the same non-gravelly, moderately fine deposits, often occurring as shallow veneers overlying morainal materials. These are classified as moderately well-drained Orthic Gray Luvisols.

Fluvial

Soils developed from fluvial (stream or fan) deposits are not extensive within the Project footprint, although they are relatively more common in the TLSC than the MFA. They occur in the lowland between Morrison and Babine lakes and may occur as fan-like deposits at lower elevations along the eastern edge of the hills along Morrison Lake, often at the outlet to natural draws.

Two soil groups have been identified in the Project footprint: well-drained SMU F1 (fan deposits) and poorly drained SMU F2 (floodplain deposits). Soils common to SMU F1 are described as moderately well developed Eluviated Dystric or Eutric Brunisols. They occur in very gravelly to gravelly, coarse-textured (sandy loam to loamy sand), fluvial fan deposits. Soils of SMU F2 are poorly drained because of high water tables common in the near level floodplains where they occur. These soils are classified as Orthic Gleysols (Plate 7.13-7) and may include Humic Gleysols and Rego Gleysols. They are relatively deep, coarse- to medium- (loam) textured soils.

Plate 7.13-6. A poorly drained Orthic Humic Gleysol developed on moderately fine textured, non-gravelly glaciolacustrine material at Site M24 (SMU L1 peaty phase).

Plate 7.13-7. This poorly drained soil profile, developed in fluvial materials, is typical of SMU F2 (Site M43; Orthic Gleysol).

Colluvial

Colluvial-derived soils are the second most common soils within the Project footprint. These soils are developed in rubbly, coarse- to medium-textured materials, commonly on sloping terrain (Plate 7.13-8). Colluvium is commonly found as a veneer (less than 1 m thick) on moderate to steep slopes in upper slope and crest positions of the landscape. Soils developed on these materials are often well to rapidly drained.

Soils mapped as SMU C1 are commonly associated with bedrock outcrops on the moderately steep to steep slopes as well as the undulating surface of some hill tops. The typical soils are well-drained and include yellowish-brown Eluviated/Orthic Dystric or Eutric Brunisols (Plate 7.13-9). Soils of SMU C2 are similar to those of SMU C1 except that they are developed on generally shallow colluvium or colluvium mixed with or overlying morainal material.

Plate 7.13-8. An upper, moderately steeply sloping site (Site M38), is typical of the often stony, sometimes rocky terrain of SMU C1.

Plate 7.13-9. A rapidly drained Orthic Eutric Brunisol developed on colluvial material (Site M10; SMU C1li).

Organic

Organic surficial materials occur most often as a thin veneer over slowly permeable material. Water saturated organic deposits, typically 0.5 m to 2 m thick, occur in small low-lying areas, including pockets in the flat, poorly drained areas of the TSF. The organic deposits are soft, dark brown, wet, and massive (Appendix 6).

Organic soils varying in depth and degree of decomposition are found scattered throughout the area, occupying approximately 90 ha. They are associated with wetlands representing approximately 3% of the Project footprint. SMU O1 soils are typically found in nearly level or depressional areas (Plate 7.13-10). Soil drainage is very poor to poor with the water table remaining near or at the surface for most of the year. Soils that have developed on these organic deposits are commonly classified as Terric (shallow) Fibric Mesisols and Terric Mesic Humisols (Plate 7.13-11). These soils contain a mix of fresh (fibric) and partially decomposed (mesic) organic layers.

Plate 7.13-10. View of a typical valley bottom wetland-lake complex, SMU O1 and SMU L1 (peaty phase; Site M19).

Undifferentiated (Weathered Bedrock and Colluvium)

Undifferentiated materials are those that do not fit the description of the previously mentioned materials and generally include weathered bedrock and colluvial materials. Undifferentiated material in the area has been described as gravelly with angular to sub-angular coarse fragments. These materials may vary in thickness. Weathered bedrock generally has high coarse fragment content. Near the surface, weathered bedrock material is often less than 1-m thick and found associated with the bedrock (appendices 6 and 9).

Plate 7.13-11. A Terric Mesic Humisol developed on organic deposits (Site M14; SMU O1).

7.13.4.6 Soil Analytical Results

Chemical Analyses

The typical pH range for these soils is medium to slightly acidic (pH 5.5 to 6.5), although lower pH values (as low as 4.8) indicating higher acidity were found occasionally in the surface layers. The highest pH noted was 6.9. Medium acidic and slightly acidic to near neutral pH ranges are considered optimal for most forest tree species and grasses, respectively.

Total carbon in the upland mineral soils (based on 14 samples tested) ranged from 0.4% to 3.7% in the 40-cm surface layer, with the 20-cm surface layer averaging 1.5%. Lowland organic soils contained very high total carbon contents (up to 35%). Surface samples (0 cm to 20 cm) were usually more acidic and had generally higher CEC, total nitrogen, sulphur, available phosphorus, and soluble SO_4 contents than subsurface samples (20 cm to 40 cm).

CEC, along with many other parameters, is a direct indicator of the nutrient-holding capacity of soils. Most local mineral soil horizons had CECs of 10 to 20 meq $100g^{-1}$, though they ranged from 6 to 25 meq $100g^{-1}$. Surface soils from three sites, 109, M5, and M24, were classified as organic soil layers (estimated to contain more than 30% organic carbon). These had the highest CEC of all soils tested (>150 meq $100g^{-1}$). The subsoil layer of Site M5 also had a moderately high CEC (42 meq $100g^{-1}$), likely because it is a mixed organo-mineral complex.

All samples, both surface and subsurface, were non-saline (with very low EC values, <0.1 dS/m).

Metals Analyses

The results of all metal analyses carried out on the soil samples were compared to the CSR guidelines. The soils at three sites, M8, M24, and 109, currently exceed at least one of the CSR land use guideline criteria for one or more of the metals tested (Table 7.13-3). Copper concentrations in surface and subsurface samples collected at Site M8 significantly exceed both CSR urban park/residential and industrial land use criteria (250 mg kg^{-1}).

Thallium concentrations in these samples also exceed the criteria (2 mg kg^{-1}), but only marginally. This is a well-drained site within the proposed mine pit footprint, in the zone of known mineral enrichment. Both arsenic and barium concentrations in soil samples at Site M24 exceed the CSR urban park/ residential limit (criteria: As - 50 mg kg^{-1}; Ba - 500 mg kg^{-1}), but only marginally. Barium concentrations in the surface sample at Site 109 exceed the urban park/residential limits for barium. Both sites M24 and 109 are in peat capped depressions.

The mean metals concentrations of the samples collected in the Rescan soil survey of the Project area show similar trends as those reported for the Skeena Region (BC MOE 2000).

7.13.4.7 Overburden Thickness Assessment

Overburden thickness in the study area ranges from <1 m to over 50 m and is typically between 2-m and 10-m deep (Appendix 9) in the proposed pit area and is approximately 25-m deep in the low-lying trough areas surrounding Ore Pond and to the northeast of the pit area. The overburden depth ranges from 3 m to over 40 m within the proposed WRD area, but is more commonly between 20-m and 33-m deep. The deepest material (over 50 m) was found in the low-lying area between the northeastern side of the proposed pit and the WRD. The depth to bedrock in the TSF varies from little, if any, on the crests or upper slopes of ridges to a maximum of approximately 22 m in the low-lying areas.

7.13.4.8 Overburden Physical and Chemical Characterization

Texture and Coarse Fragment Content

The textural classification of the overburden suggests that the majority of the morainal material in this area is moderately fine- to moderately coarse-textured. It includes clay loams, sandy clay loams, loams, and sandy loams. Undifferentiated materials were found to be moderately fine to moderately coarse textured with predominantly angular to sub-angular coarse fragments with >30% coarse fragments by volume.

Saturation Percentage

The saturation percentage of the overburden materials generally ranged from 36% to 54% and averaged 49%. These results indicate that the overburden materials in the Project area have high moisture-holding capacity, except in samples with high coarse-fragment content.

Table 7.13-3

Morrison Copper/Gold Project: Samples of Soil Exceeding BC Contaminated Sites Regulation (CSR) Guidelines

Sample ID	Antimony (Sb)[1] (mg/kg)		Arsenic (As) (mg/kg)		Barium (Ba) (mg/kg)		Copper (Cu) (mg/kg)		Molybdenum (Mo)[2] (mg/kg)		Thallium (Tl)[3] (mg/kg)	
	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm
Mine Facilities Area												
M2	<20		20.6		175		19.4		<4.0		<1.0	
M5	<60*	<20	9.45	17.0	439	274	50.5	36.4	<12*	<4.0	<1.0	<1.0
M8	<20	<20	4.84	22.9	304	202	405	466	<4.0	<4.0	1.0	2.1
M13	<60*	<40*	6.19	1.60	257	194	16.2	31.3	<12*	<8.0	<1.0	<1.0
M15	<20	<20	15.0	<0.50	209	154	17.7	16.6	<4.0	<4.0	<1.0	<1.0
M16	<20	<20	9.40	8.48	307	281	26.5	21.4	<4.0	<4.0	<1.0	<1.0
M23	<20	<20	21.1	23.5	157	159	17.6	21.4	<4.0	<4.0	<1.0	<1.0
M24	<60*	<20	13.8	51.9	528	475	8.6	34.5	<12*	<4.0	<1.0	<1.0
M26	<20	<20	22.2	13.7	217	177	22.6	20.1	<4.0	<4.0	<1.0	<1.0
M29	<20	<20	14.1	15.9	268	228	23.2	17.6	<4.0	<4.0	<1.0	<1.0
M33	<20	<20	14.8	14.8	230	181	21.4	20.1	<4.0	<4.0	<1.0	<1.0
M39	<20	<20	17.8	15.5	197	196	18.7	28.2	<4.0	<4.0	<1.0	<1.0
M41	<20	<20	13.3	16.0	243	220	23.8	31.4	<4.0	<4.0	<1.0	<1.0
M42	<20	<20	13.7	16.1	270	179	21.6	38.0	<4.0	<4.0	<1.0	<1.0
107	<10	<10	26.4	35	185	110	35.1	26.1	<4.0	<4.0	<1.0	<1.0
108	<10	<10	7.6	12.9	186	180	11.9	26.5	<4.0	<4.0	<1.0	<1.0
109	<10	<10	5.7	28.6	755	458	9	17.6	<4.0	<4.0	<1.0	<1.0
110	<10	<10	30.4	24.2	159	213	13	14.1	<4.0	<4.0	<1.0	<1.0
113	<10	<10	12.9	14.8	175	237	20.1	33.4	<4.0	<4.0	<1.0	<1.0
Linear Infrastructure Corridor												
T3	<10	<10	5.1	15.1	216	393	12.8	38.5	<4.0	<4.0	<1.0	<1.0
T11	<10	<10	8.4	14.3	157	138	13.6	33.3	<4.0	<4.0	<1.0	<1.0
T13	<10	<10	5.9	15.8	262	155	8.4	24.5	<4.0	<4.0	<1.0	<1.0
T14	<10	<10	10.3	14.5	185	213	15.3	31.5	<4.0	<4.0	<1.0	<1.0
CSR Urban Park/ Residential Criteria	20	20	50	50	500	500	150	150	10	10	2	2
CSR Industrial Criteria	40	40	100	100	1000	1000	250	250	40	40	2	2

Exceeds CSR Urban/Park, Residential Criteria (yellow)

Exceeds CSR Industrial Criteria (red)

[1] **Results for Antimony (Sb) were not definitive for 4 samples [M5 (0-20cm), M13 (0-20 cm), M13 (20-40 cm), M24 (0-20 cm)] as detection limits exceeded criteria limits.**

[2] **Results for Molybdenum (Mo) were not definitive for 3 sample [M5 (0-20 cm), M13 (0-20 cm), M24 (0-20 cm)] as detection limits exceeded criteria limits.**

[3]**Thallium exceedance again Agricultural Criteria, no Urban Park/Residential or Industrial Criteria.**

pH and Calcium Carbonate ($CaCO_3$)

The pH of the overburden samples ranged from very strongly acid (5.0) to strongly alkaline (8.6). Generally, neutral to lower pH values were found in the near-surface samples collected from within 3 m of the ground surface.

The $CaCO_3$ equivalence rating ranged from non-calcareous (0% to 2% $CaCO_3$) to weakly calcareous (2% to 5% $CaCO_3$). All samples with pH below 7.9 were non-calcareous and all occurred within 3 m of the surface. Over half of the morainal material samples had high calcium carbonate ratings.

Salinity

Two samples were rated as very weakly saline. Both of these samples were collected from depths below 10 m (Sample DH07-3 at 21.3 m depth with an EC value of 2.39 dS/m and Sample DH07-5 at 12.2 m depth with an EC value of 2.05 dS/m). All other samples were non-saline.

Sodium Adsorption Ratio

The SAR ranged from 0.9 to 2.3, with an average of 1.7. Soils within SAR values of <4 are not considered a potential problem.

Metal Analysis

The metal concentrations in the overburden sampled exceeded the CSR guidelines for six metals (arsenic, barium, cobalt, copper, molybdenum, and selenium). Of the 38 samples collected, 10 (26%) exceeded CSR urban park/residential and industrial land use criteria (Table 7.13-4). Multiple exceedances (two or more metals) occurred in eight samples. Metal concentrations of 10 samples exceeded CSR criteria for industrial land use for copper. Three of these samples also exceeded industrial land use guidelines for molybdenum. Of the six metals of concern, three metals (As, Cu, and Mo) commonly occur in concentrations exceeding the CSR criteria. The remaining three metals (Ba, Co, and Se) do not exceed the industrial land use criteria and exceed the urban park/residential criteria two times or fewer. From metal concentration comparisons with CSR criteria, it appears that naturally elevated concentrations of Cu, Mo, and As occur frequently in the overburden in the proposed pit area in the undifferentiated deposits.

Comparison of Overburden, Regional, and Project Area Surface Soils

Mean metal concentrations in the overburden are approximately equal to or lower than regional soil quality estimates (BC MOE 2000) for 13 metals (Table 7.13-5). The exceptions are Cu, Mo, As, and Se. This is due to the considerably higher mean overburden concentrations of Cu, Mo, and As in the pit area resulting from the inclusion of undifferentiated materials. Mean metal concentrations in the overburden are approximately equal to or lower than surface soil (samples from within 1 m of the surface) for the majority of the metals (Table 7.13-5). Overburden was found to have elevated mean values of Cu, Mo, As, and Se as well as higher concentrations of Co, Be, and Hg compared to the surface soils, because of the influence of the high metal content of the weathered rock and colluvium.

Table 7.13-4
Overburden Samples Exceeding CSR Metal Guideline

Drill Hole/Test Pit ID	Sample ID	Material	Depth (m)	pH	Arsenic (As) (mg/kg)	Barium (Ba) (mg/kg)	Cobalt (Co) (mg/kg)	Copper (Cu) (mg/kg)	Molybdenum (Mo) (mg/kg)	Selenium (mg/kg)	No. of exceedances
Non-Pit Area											
DH07-2	L691076-20	M	7.6	8.1	22.9	203	12.5	33.7	<4.0	<2.0	0
	L691076-18	M	13.7	8.0	21.6	164	11.6	30.9	<4.0	<2.0	0
	L691076-12	M	16.8	8.3	22.4	180	12.2	33.1	<4.0	<2.0	0
	L691076-10	M	21.3	8.0	23.9	159	12.2	32.5	<4.0	<2.0	0
DH07-3	L691076-7	M	7.6	8.0	20.7	221	12.4	31.3	<4.0	<2.0	0
	L691076-13	M	9.1	8.1	22.3	218	12.9	32.8	<4.0	<2.0	0
	L691076-11	M	12.2	8.0	19.3	233	12.1	31.0	<4.0	<2.0	0
	L691076-8	M	13.7	8.1	16.8	187	13.0	32.9	<4.0	<2.0	0
	L691076-1	U	21.3	7.9	17.5	128	10.5	26.9	<4.0	<2.0	0
DH07-4	L691076-16	M	7.6	8.0	20.2	185	13.0	34.3	<4.0	<2.0	0
	L691076-17	M	9.1	8.1	24.9	184	12.8	32.2	<4.0	<2.0	0
	L691076-19	M	12.2	8.0	24.1	179	13.0	32.9	<4.0	<2.0	0
DH07-5	L691076-15	M	7.6	8.1	20.8	132	10.5	27.6	<4.0	<2.0	0
	L691076-14	M	9.1	8.0	16.6	136	9.4	31.3	<4.0	<2.0	0
	L691076-9	M	12.2	8.0	15.7	129	9.3	25.0	<4.0	<2.0	0
	L691076-4	M	15.2	8.2	16.4	117	9.0	22.9	<4.0	<2.0	0
	L691076-6	M	18.3	8.1	14.0	154	19.5	51.6	<4.0	<4.0	0
DH07-6	L691076-3	M	22.9	8.2	19.0	160	12.3	30.5	<4.0	<2.0	0
DH07-7	L691076-5	M	19.8	8.2	25.8	208	12.4	32.6	<4.0	<2.0	0
DH07-9	L691076-2	M	19.8	8.2	24.9	184	12.8	32.1	<4.0	<2.0	0
Pit Area											
TP08-RS1	L686442-1	M	1.0	6.8	19.4	305	15.6	43.2	2.0	0.25	0
TP08-RS2	L686442-2	U	1.0	6.0	31.8	281	15.1	624.0	4.1	0.55	1
	L686442-3	U	2.0	6.7	21.2	164	11.2	42.4	2.0	0.25	0
TP08-RS3	L686442-4	M	0.8	6.6	19.5	168	11.9	39.6	2.0	0.25	0
	L686442-5	U	2.0	8.1	33.2	271	15.5	330.0	2.0	0.25	1
	L686442-6	U	3.0	8.1	77.5	306	16.7	491.0	2.0	0.25	2
TP08-RS4	L686442-7	M	1.0	6.3	22.4	206	13.0	31.3	2.0	0.25	0
	L686442-8	M	2.0	7.0	20.0	252	13.2	35.7	2.0	0.25	0
	L686442-9	U	3.0	8.1	17.8	431	20.6	42.0	2.0	0.25	0
	L691076-22	U	7.5	8.3	14.7	232	14.1	37.7	<4.0	<2.0	0
	L691076-21	U	9.0	8.6	14.0	268	14.2	37.2	<4.0	<2.0	0
TP08-RS5	L686442-10	U	1.0	5.3	48.2	86	36.6	1910.0	31.6	5.43	3
	L686442-11	U	2.0	5.2	85.4	53	54.4	2140.0	90.7	5.12	5
TP08-RS6	L686442-12	U	1.0	6.1	20.4	711	14.0	2860.0	57.5	0.75	3
	L686442-13	U	2.0	6.2	15.7	781	16.7	2780.0	74.2	0.90	3
TP08-RS7	L686442-14	U	1.0	6.0	67.6	133	28.8	886.0	27.3	0.66	3
	L686442-15	U	2.0	5.2	45.1	182	22.1	363.0	10.2	1.07	2
	L691076-23	U	3.0	5.0	77.1	98	21.0	744.0	18.1	<4.0	3
Average					30.9	236.4	17.3	526.6	20.6	1.1	
Median					20.6	183.0	14.2	42.2	3.1	0.3	0
Minimum					14.0	52.5	9.0	22.9	2.0	0.3	0
Maximum					85.4	781.0	54.4	2860.0	90.7	5.4	5
n					26	26	26	26	16	15	26
CSR Urban Park/ Residential Criteria					50	500	50	150	10	3	
CSR Industrial Criteria					100	1000	300	250	40	10	
Regional Background- Skeena					15	400	15	50	1	0.25	

(Yellow) Exceeds CSR Urban Park/ Residential Criteria
(Red) Exceeds CSR Industrial Criteria
1 BC MOE Regional Background Estimates for Inorganic Substances (detection limit)

Table 7.13-5
Mean Metal Concentrations (mg/kg) of Regional Background Soils, Project Area Soils, and Overburden

Metal Species		Regional Background Soils (mg/kg)[1]	Project Area Soils (n=45) mean metal concentration (mg/kg)[2]	Mine Facilities Overburden (n=38) mean metal concentration (mg/kg)
Antimony	Sb	(4.0) [3]	9.6***	5.0***
Arsenic	As	15	15.9	27.9
Barium	Ba	400	247	221
Beryllium	Be	1.5	0.4**	0.7
Cadmium	Cd	0.6	0.3**	0.3**
Chromium	Cr	65	26.6*	25.8
Cobalt	Co	15	10.5*	15.7
Copper	Cu	50	41	370
Lead	Pb	15	11**	16**
Mercury	Hg	0.15	0.11	0.19
Molybdenum	Mo	(1.0)	2.3***	9.8**
Nickel	Ni	50	22*	33
Selenium	Se	(0.25)	0.5**	1.1**
Silver	Ag	(1.0)	1.1***	1.0***
Thallium	Tl	--	0.5**	0.5***
Tin	Sn	(4.0)	4.8***	2.5***
Vanadium	V	100	70	61
Zinc	Zn	150	87	97

[1]Region 6 Skeena (BC MOE 2000).
[2] Measured by Rescan in 2006 and 2008 (Appendix 32).
[3] Values in brackets indicate that greater than 50% of values were less than the mean detection concentration (MDC) for the substance, consequently the tabled regional estimate is one-half MDC.
*** >0% but <10% soil/overburden results below detection.**
**** >40% but <100% soil/overburden results below detection.**
***** 100% of soil/overburden results below detection.**

7.14 Terrain Hazards

7.14.1 Introduction

An assessment of terrain stability and natural hazards was completed along the proposed power transmission corridor between the Bell Mine and the proposed Morrison mine site. Terrain mapping completed by Klohn Crippen Berger Ltd. provided additional information to assess terrain conditions at the proposed mine site. The assessment of terrain stability considers the process of gravity-induced movement or mass wasting. The assessment of natural hazards considers the presence or evidence of landslides, rock fall, debris flows, and snow avalanche and also considers the potential for earthquakes and volcanic activity.

The TLSC consists of three alternatives routes, each with a 100 m wide buffer, and covering an area of approximately 1,216 ha. The MFA covers 1,789.5 ha and includes the open pit, plant site, TSF, WRDs, overburden stockpiles, soil stockpiles, low grade ore stockpile, and associated haul roads and pipeline corridors. The study area is shown in Figure 7.1-1.

7.14.2 Study Objectives

The study was undertaken to provide a summary of baseline information on terrain stability and natural hazards for the EA of the proposed Project. The main objective of the study was to provide an assessment of the geohazards that could potentially affect construction and operation of the mine and power transmission line.

The terrain stability information presented in the baseline report may be used by design engineers to select locations for transmission towers or mine infrastructure that will avoid areas of soil or rock instability or snow avalanche. Alternatively, this information can also be used to plan more detailed terrain stability field assessments and associated geotechnical investigations in areas where existing or potential terrain hazards cannot be avoided.

7.14.3 Methods

7.14.3.1 Terrain Mapping

Terrain Classification

Terrain classification maps for the area were prepared by Rescan based on interpretation of air photographs followed by fieldwork undertaken from 2006 to 2008. Terrain polygons were delineated using colour aerial photographs taken in 2001 at a scale of 1:30,000. The terrain maps were developed to show surficial material, surface expression (e.g., slope, thickness of surficial material, landform type) and geomorphic process (e.g., seepage, gully erosion) based on the terrain classification system for BC (Howes and Kenk 1997).

Additional terrain mapping information for the area of the proposed mine site was provided by Klohn Crippen Berger Ltd. based on surficial mapping and terrain stability mapping carried out in 2008 (Appendix 9). Information from previous reconnaissance-scale mapping undertaken by Klohn Crippen in 1998 was also incorporated.

Terrain hazard mapping along the TLSC was undertaken by Rescan in 2008 to assess the presence of landslides, rock fall, debris flow, or other natural terrain stability processes. The mapping consisted of a review of colour aerial photographs taken in 2001 at a scale of 1:30,000 and a review of available published terrain classification maps (BC MEMPR 1980), followed by field observations at selected sites.

Slope Gradient

Slope gradient maps were prepared using the following standard terrain classification categories (RIC 1996).

- Class 1 0% to 5% plain or level slope
- Class II 6% to 27% gentle slope
- Class III 28% to 49% moderate slope
- Class IV 50% to 70% moderately steep slope
- Class IV >70% steep slope

Terrain Stability

Terrain stability maps were prepared at a scale of 1:20,000 using the information developed for the terrain classification maps and the slope gradient maps. The general guidelines for terrain stability classification used in the TLSC baseline study are shown in Table 7.14-1. Terrain stability has been classified based primarily on slope angle, material type, and active slope process. Slope stability class was adjusted if seepage was identified within the terrain polygon, because poorly drained or wet slopes may be susceptible to slope failures caused by reduced shear strength or high soil pore-water pressure.

Table 7.14-1
Terrain Stability Classes

Slope Stability Class	Dominant Slope Class %	Surficial Material	Wet Soil or Poor Drainage	Active Process	Stability Hazard
I	0 – 5	A, C, F, F^G, M, R	*Class II*	none	Stable
	0 – 5	L, L^G, O		none	
	0 – 5	C, F, M		none	
II	6 – 27	C	*Class III if slope > 20%*	none	Generally stable
	6 – 27	L, L^G, M		none	
	6 – 49	A, C, F ,F^G, M, R	*Class III if slope > 45%*	none	
III	28 – 49	C	*Class IV if slope > 45%*	none	Moderately stable
	28 – 49	L, L^G, M		none	
	50 – 70	A, C, M	*Class IV if slope > 65%*	none	
	50 – 70	F, F^G, R		none	
IV	50 – 70+	L, L^G		none	Marginally stable
	65 – 70+	C, F^G, M		none	
	50 – 70+	C, M, R		-V, Rb”	
V	0 – 70+	C, M, R		-F, -Rd”, -Rs”	Unstable

Notes: M = Moraine, C = Colluvium, F = Glaciofluvial, L = Lacustrine, L = Glaciolacustrine, F = Fluvial, O = organic deposits , A = anthropogenic deposits, R = bedrock.

Terrain stability classifications range from Class I (stable) to Class V (unstable). These classifications can be used qualitatively to indicate the likelihood of instability resulting from ground disturbance such as logging or road construction activities. The terrain stability maps provide a relative assessment of stability but give no indication of the expected frequency, magnitude, or effect of failure.

7.14.3.2 Avalanche Mapping

A snow avalanche study was completed for the Morrison Lake/Hearne Hill area by Chris Stethem & Associates (2007). This study identified one avalanche path and potential avalanche initiation zones on the lower slopes of Hearne Hill, uphill of the TLSC and on the east side of the MFA.

The avalanche study was carried out to identify avalanche paths, the frequency and magnitude of snow avalanches that could affect the mine infrastructure, and to provide options for avalanche protection if the operation is exposed to avalanche hazards. The study included a review of aerial photographs and topographic mapping, an analysis of snow supply records, a helicopter reconnaissance, and an analysis of the potential frequency and magnitude of avalanches at the site.

Avalanche frequency estimates are described in terms of "avalanche return periods," which can range from 1 year (high frequency) to 100 years (very low frequency). Magnitude estimates are described in terms of the "Canadian avalanche size classification," which is based on destructive potential as shown in Table 7.14-2. However, there is considerable uncertainty in the estimates of frequency and magnitude since snow avalanches are erratic natural phenomena.

Since there are no historical observations for the potential avalanche areas identified in the study area, the patterns of vegetation, terrain characteristics, snow supply, and experience were used in the avalanche assessment.

Table 7.14-2
Canadian Avalanche Size Classification

Size	Description (Destructive Potential)	Typical mass (t)	Typical path length (m)	Typical impact pressure (kPa)
1	Relatively harmless to people.	<10	10	1
2	Could bury, injure, or kill a person.	102	100	10
3	Could bury a car, destroy a small building (e.g., wood frame house), or break a few trees.	103	1,000	100
4	Could destroy a railway car, large truck, several buildings, or a forest with an area up to 4 ha.	104	2,000	500
5	Largest snow avalanches known; could destroy a village or forest up to 40 ha.	105	3,000	1,000

Source: (McClung and Schaerer 1981).

7.14.4 Physiography

7.14.4.1 Topography

The study area is within the Nechako Plateau area of the Central (Interior) Plateaux Physiographic Region. The area is characterized by folded and faulted volcanic and sedimentary strata that form northwesterly trending ridges and valleys.

Elevations near the study area range from approximately 711 masl at Babine Lake to 1,380 masl on the summit of Hearne Hill.

The TLSC follows predominantly gentle to moderate slopes (less than 49%) on the east side of Babine Lake and crosses the lower western slopes of Hearne Hill near the Morrison mine site. The terrain in the area of the MFA consists of gentle to moderate slopes (less than 49%) with local areas that are moderately steep (50 to 70%). The terrain on the east side of the MFA, in the area of the proposed WRD, is also moderately steep. Several creek channels with steep banks (more than 70%) were identified on the mid- to lower slope of Hearne Hill.

7.14.4.2 Surficial Materials

Typical characteristics of the surficial materials encountered within the area of the TLSC and MFA are described in the following section.

Moraine or Till

A moraine, often referred to as glacial till, was deposited directly from glacier ice that occupied the area during the last period of major glaciation between approximately 30,000 and 10,000 years before present. Moraine material contains a heterogeneous mixture of particle sizes reflecting the mode of deposition and the source of debris. Typically, the glacial till is a poorly sorted and loosely to highly consolidated deposit composed of clasts (particles >2mm) that are usually contained in a fine-grained matrix (particles <2 mm). Clasts (particles >2 mm) are usually contained in a fine-grained matrix (particles <2 mm).

In the TLSC, the glacial till consists predominantly of silt with some clay and variable sand content with rounded to sub-angular gravel. In the MFA, silt- and clay-rich glacial till is the most common soil unit. The till occurs as a blanket more than 1 m thick, or as a veneer 10 cm to 1 m thick on gentle to moderate slopes.

Colluvium

Colluvium is unconsolidated material that has formed in relatively recent times as a result of gravity-induced movement including soil creep, landslide, rockfall, or surface erosion such as debris flow. Colluvial material is generally non- to poorly sorted with a wide range of particle sizes and texture depending on the source area.

In the Project area, the colluvial soils are typically coarse-grained, composed of sand, silt, and variable sub-angular to angular gravel. Colluvial soils generally occur as a veneer 10 cm to 1 m thick on gentle to moderate slopes. Thicker deposits of colluvium occur as a blanket more than 1 m thick in places.

Colluvial fan deposits have been identified at the base of some steeper slopes near the proposed mine site but were not identified along the transmission line corridors. Colluvial fan deposits generally form slopes of less than 15º and are commonly formed and affected by active geomorphic processes originating on the slopes above. They may be subject to rockfall, avalanches, debris flows, and shifting creek channels (avulsion), which could damage any structures built on or near their surface.

Glaciofluvial

Glaciofluvial materials are typically coarse, sandy gravels that were deposited by glacial meltwater streams or outwash floods at the end of the last glaciation period. The deposits are composed of stratified sands and gravels with a trace of silt, and are generally well-drained.

In the Project area, the glaciofluvial deposits are composed of sands to silts with rounded gravel and occur on gentle to moderate slopes. These materials are often a good source of construction aggregate.

Lacustrine and Glaciolacustrine

Lacustrine materials were deposited in a lake environment and generally consist of layered silt, clay, and sand. Glaciolacustrine materials are lake-bed deposits formed during periods of glaciation.

In the Project area, the lacustrine deposits consist of silt, some clay, and varying sand content, and are encountered on level to gentle terrain.

Fluvial

Fluvial deposits are sediments that have been transported by flowing water. The deposits generally consist of stratified, loose, non-cohesive gravelly sand or sandy gravel.

In the Project area, the fluvial deposits are composed of sands to silts with variable rounded to sub-rounded gravel content. The deposits are near level floodplains or on gentle slopes.

Fluvial fan deposits were identified along a short section of the TLSC.

Organic

Organic deposits are common on poorly drained, flat to gently sloping terrain, and in topographic depressions where they can form peat bogs. These deposits erode readily when disturbed and provide an extremely poor foundation for construction.

In the TLSC, the organic deposits are generally less than 1 m thick. In the MFA, organic deposits 1 to 2 m thick were encountered.

Anthropogenic

Anthropogenic deposits represent reworked or disturbed surficial soil and/or bedrock materials from previous human activity.

These materials are present at the Bell Mine site at the southern end of the TLSC. Much of the disturbed material is waste rock from open-pit mining operations that was dumped and spread by mining equipment and subsequently re-sloped and reclaimed as part of the mine closure requirements.

7.14.4.3 Bedrock Geology

The bedrock geology consists primarily of volcanic rock with minor interbedded sedimentary strata of the Hazelton Group, porphyry dykes and plugs of the Babine Intrusions, sedimentary strata or porphyry intrusions of the Skeena Group, and sedimentary strata associated with the Bowser Lake Group near the Morrison deposit.

The bedrock at the proposed Morrison mine open pit is dominated by copper-bearing porphyry. The bedrock strata have been impacted by north-northwest trending high-angle faults, including the Morrison Fault and occasional northeast trending faults.

7.14.5 Terrain Assessment

Terrain stability and snow avalanche areas are shown in the Terrain Stability maps in figures 7.14-1 and 7.14-2. The avalanche areas are shown in Figure 7.14-2.

7.14.5.1 Slope Stability

Most of the TLSC crosses stable, gently to moderately sloping Class I or Class II terrain to the southern boundary of the mine site. No significant stability problems are expected in Class I terrain, and a very low likelihood of stability problems following road construction or logging are expected in Class II terrain. The TLSC is not expected to be influenced by Class IV or Class V terrain.

Near the Bell mine, the TLSC crosses partially reclaimed mine waste rock that was deposited during open-pit mine operations between 1972 and 1990. This anthropogenic material may be susceptible to further consolidation settlement.

The northern portion of the TLSC crosses sections of moderately stable and moderately steep Class III terrain where the likelihood of landslide initiation following road construction or logging is considered to be low, and minor slumping may be expected along road cuts locally. Construction of the transmission line and/or access road should be feasible on the moderately steep terrain based on carefully designed cut and fill slopes and installation of suitably designed and constructed ditches and culverts for surface water control. The poorly-drained and saturated soils in this area are likely to provide poor foundation conditions.

The MFA is a predominantly stable, gently to moderately sloping terrain with local areas of moderately to marginally stable and moderately steep terrain. The east side of the mine site is on the moderately to marginally stable and moderately steep slopes of Hearne Hill. The mid- to lower slope of Hearne Hill is dissected by creek channels with potentially unstable steep banks. A rotational slide has been identified in one creek gully on the valley slope east of Booker Lake.

7.14.5.2 Snow avalanche

An avalanche path and potential avalanche initiation zones have been identified on the lower slopes of Hearne Hill within influence of the MFA and uphill of the TLSC near the mine site.

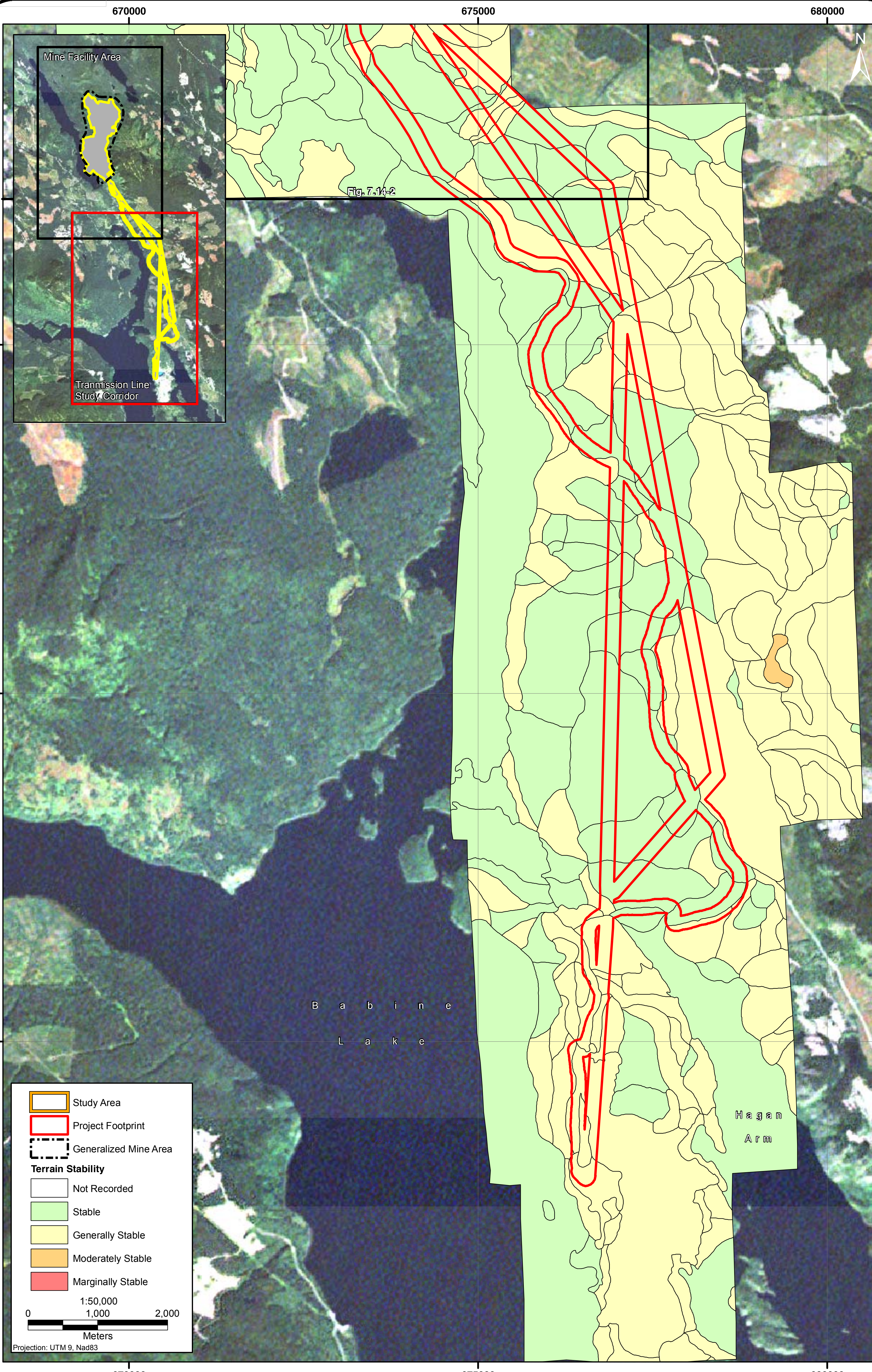


FIGURE 7.14-1

Morrison Copper/Gold Project - Terrain Stability

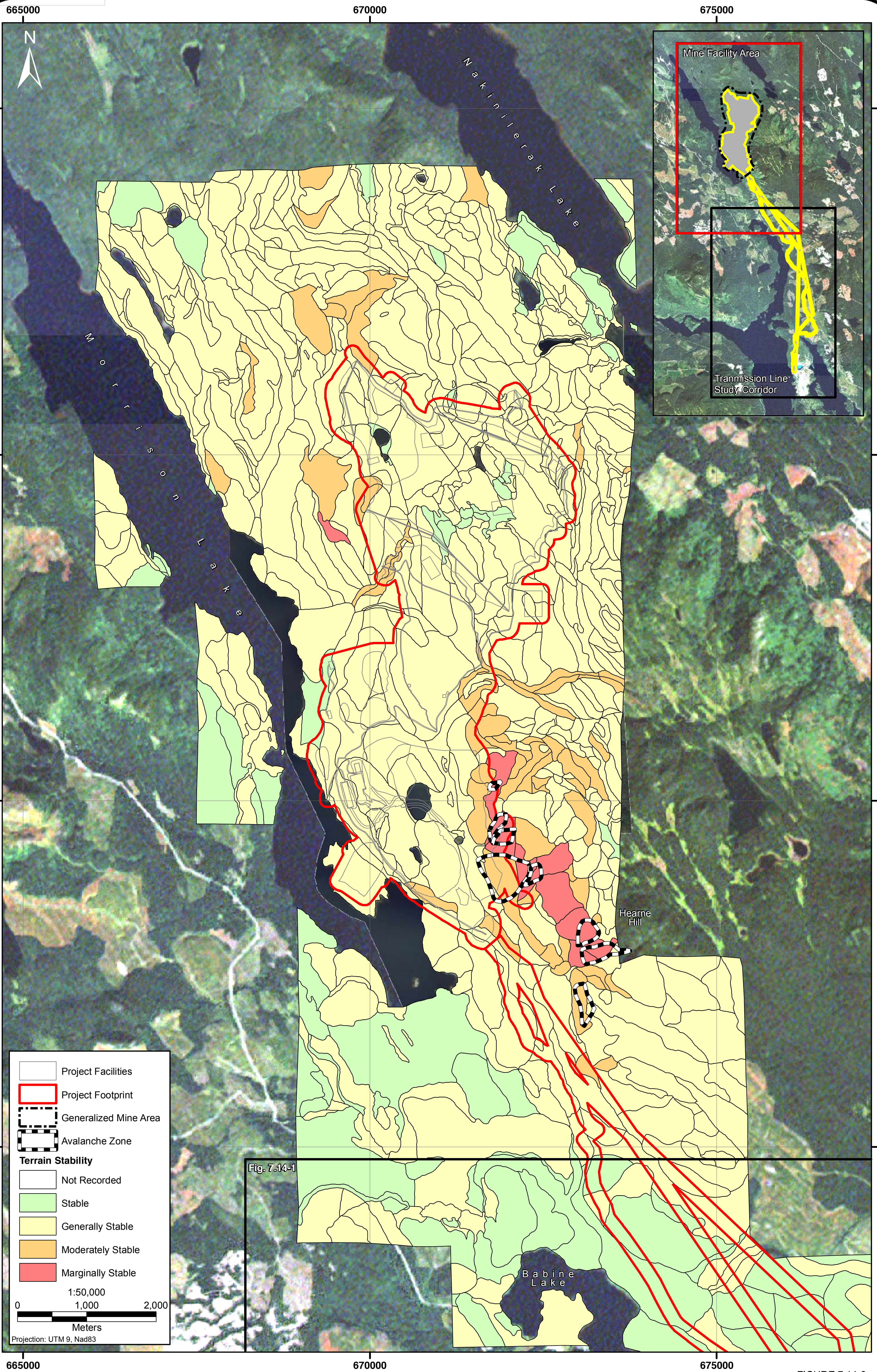


FIGURE 7.14-2

Morrison Copper/Gold Project - Terrain Stability

Based on the avalanche study, there is no evidence that run out from snow avalanches have damaged the forest at the toe of the slope. Small avalanches of size 2 or less could develop on Hearne Hill within a 30-year return period. A size 2 avalanche is unlikely to damage power line structures but could affect people on the ground in the avalanche starting zone. Size 3 avalanches are unlikely within a 30-year return period. Avalanches of this size could damage an unprotected transmission tower or threaten vehicles or mine facilities. Avalanches larger than Size 3 are possible but unlikely in the longer term (more than 100 years) because of the lack of snow supply.

The snow avalanche path and potential avalanche initiation zones are on moderately stable and moderately steep to steep slopes uphill of the MFA and TLSC. The design of Project infrastructure including roads, waste dumps, ditches, and the transmission line should consider the potential effects of avalanches. A 100-m buffer has been recommended at the toe of the slope of Hearne Hill below the potential avalanche areas. Access to this area when snow is present or construction of occupied facilities within this area should not be permitted unless the area is first assessed by an expert trained in avalanche safety, and evacuation plans or avalanche control plans have been developed. There is a hazard to worker safety within the avalanche initiation zones when snow is present; therefore, access should be controlled.

Construction of a waste rock storage facility is planned within the area of an identified avalanche path and within a creek gully affected by potential avalanche activity. During dump construction the avalanche hazard could affect worker safety; therefore, an avalanche safety program will be required along with an avalanche control plan. The snow avalanche study also identified a potential for avalanche formation on steep slopes associated with open pit and WRD development. Workers and equipment could be exposed to avalanche hazard and large blasts during open pit development could trigger avalanche activity.

7.14.5.3 Seismicity

The seismic hazard is low in the proposed MFA and TLSC areas. Four magnitude (M) 2 to 3 M earthquakes have been recorded within 100 km of the baseline study area since 1985, and the maximum recorded earthquake within 200 km of the study area was 3.2 M. These earthquakes are minor and unlikely to initiate landslides or rockfalls.

Because of the consequence of failure of major structures on the mine site, such as the tailings dams and waste rock storage facilities, earthquake return events based on probabilistic and deterministic values are considered in the seismic design of the structures.

7.14.5.4 Volcanic Activity

The Stikine Volcanic Belt is the closest area of active volcanic activity. The Project area is approximately 160 km east of the Tseax Cone, the remnants of a volcano that erupted 233 years ago. It is considered unlikely that the Project area would be directly affected by a volcanic eruption.

7.14.5.5 Soil Liquefaction

Glacial moraine (till) is the dominant soil type within the Project area. Till is generally dense and not susceptible to liquefaction. Recent alluvial deposits of silt, sand, or gravel are generally loosely consolidated. Alluvial deposits of incalated fine sand, silt and clay may be susceptible to liquefaction if they are located in low lying, poorly drained areas.

7.15 Ecosystems and Vegetation

The terrestrial plant communities (ecosystems) and vegetation within and surrounding the Project area were characterized using a combination of TEM, predictive ecosystem mapping (PEM), and field surveys. Descriptions of general landscape patterns, ecosystems, and plant species are provided. Ecosystems and plant species are discussed generally and also in terms of the conservation interest associated with them. Ecosystems that are sensitive to disturbance and invasive plant species are also discussed. A list of abbreviations used to discuss vegetation and ecosystems is provided in Table 7.15-1.

Table 7.15-1
Biogeoclimatic Ecosystem Classification Units

Abbreviation	Definition
ESSF	Engelmann Spruce Subalpine Fir zone
ESSFmc	Engelmann Spruce Subalpine Fir moist cold subzone
ESSFmv3	Engelmann Spruce Subalpine Fir moist very cold variant
SBS	Sub-boreal Spruce zone
SBSmc2	Sub-boreal Spruce moist cold variant
SBSmc2 81	Saskatoon/slender wheatgrass
SBSmc2 82	Sandberg's bluegrass/slender wheatgrass
SBSwk3	Sub-boreal Spruce wet cool variant
SBSwk3 02	Lodgepole pine/black huckleberry/reindeer lichens
SBSwk3 03	Douglas-fir – hybrid white spruce/thimbleberry

7.15.1 Methodology Overview

The following section provides a brief overview of the methods and data used for the characterization of ecosystems and vegetation in the Project area.

7.15.1.1 Ecosystem Mapping

Ecosystem mapping integrates variables such as climate, terrain, surficial materials, soils, and vegetation to stratify an area into meaningful ecological units (RIC 1998). Ecosystem mapping for the Project followed provincial guidelines and methodologies (Howes and Kenk 1997; RIC 1998).

Mapping was conducted in two ways and encompassed three study areas (Figure 7.15-1):

1. TEM was used for the footprint area (3,005 ha), which encompasses the MFA and TLSC, and the local study area (LSA; 18,860 ha), which is delineated as a buffer extending approximately 2 km beyond the footprint area.

2. PEM was used for the regional study area (RSA; 108,015 ha), which extends approximately 10 km around the footprint area.

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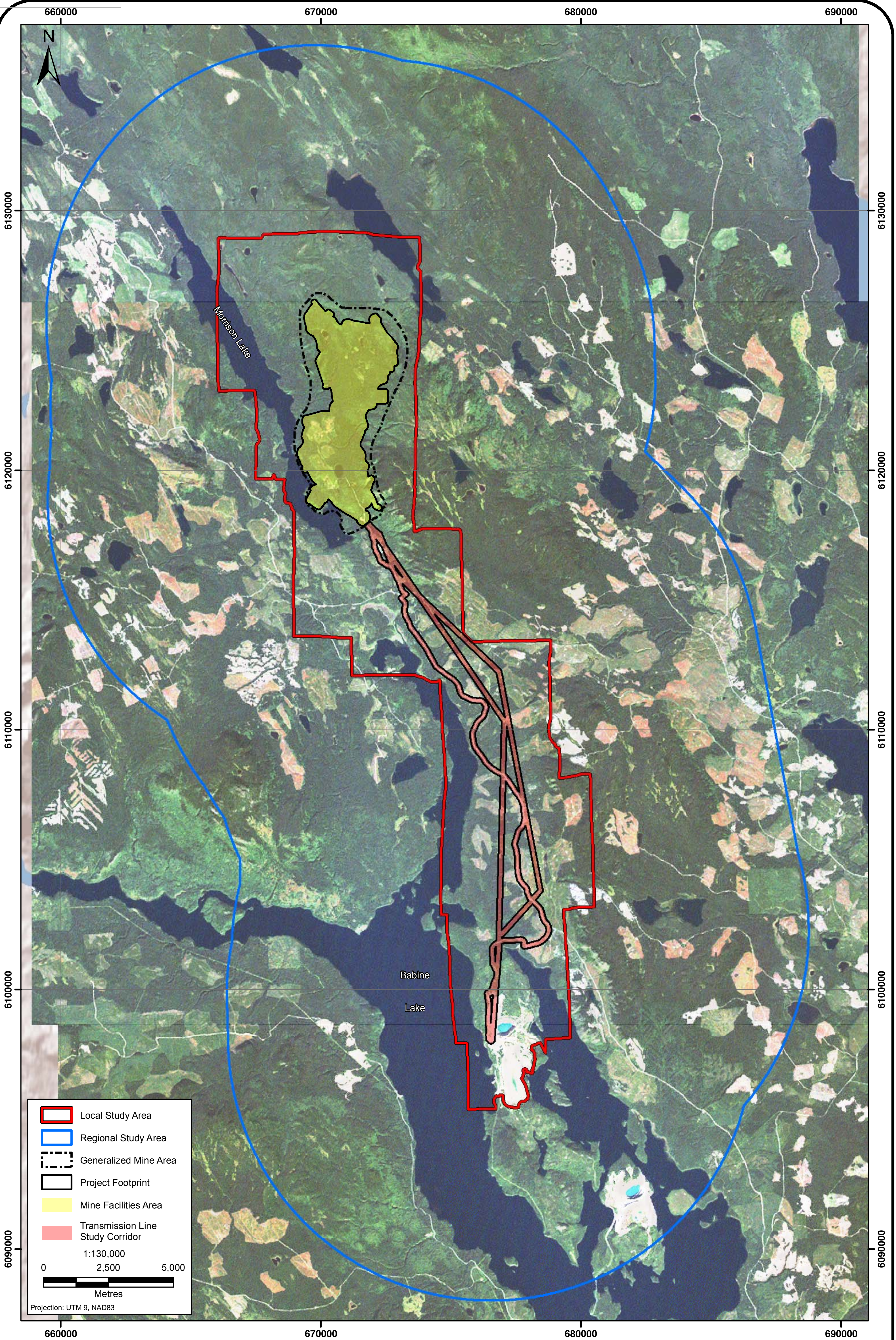


Morrison Copper/Gold Project Ecosystem and Vegetation Study Area Boundaries

FIGURE 7.15-1

For TEM, map units are delineated through air photo interpretation and verified by data collected in the field. Polygon mapping is generally a two-stage process: first, terrain polygons (representing “permanent” landform features) are delineated, and second, up to three ecosystem units within each terrain polygon are identified. Full details of the TEM process used for the Project are provided in Appendix 35.

PEM is a model-based approach to ecosystem mapping that uses existing data such as terrain and biogeoclimatic unit maps, as well as forest inventory data. The PEM data used for this project was acquired in several segments from the BC MOE, completed by the BC Ministry of Sustainable Resource Management (BC MSRM), and by Timberline Natural Resources Group Ltd. (Timberline) between 2001 and 2008 (BC MSRM 2001; Timberline 2007, 2008). Timberline created the PEM products for the Lakes timber supply area (TSA) and the Prince George and Fort St. James forest districts, while the Morice forest district PEM was supplied by the BC MSRM. The majority of the RSA is covered by the Lakes TSA PEM product supplied by Timberline.

Both TEM and PEM ecosystem units are derived from BC’s BEC system. This system is hierarchical, ranging from regional-level units (BEC units) based largely on climate to site-level units (site series) based on differences in soils and climax plant communities. For simplification, the site-level ecosystems identified through the TEM and PEM processes were categorized into general ecosystem types (e.g., wetter forest, drier shrub) according to their vegetation type and relative moisture status. These general ecosystem types are described in Appendix 35.

Vegetation Structural Stage

The existing developmental stage of the vegetation within an area can be described by its structural stage. Vegetation structural information is an important attribute commonly used to describe the habitat characteristics of vegetated ecosystems (RIC 1998). Structural stages range from un-vegetated units to old forest. A numeric code is provided for each stage, the details of which are provided in the TEM standards (RIC 1998).

The vegetation structural stage information for the footprint and LSA was completed concurrently with TEM. For the RSA, vegetation structural stage data were acquired from the BC MOE and modelled as a layer separate from the PEM. In some cases, structural stage could not be assigned to PEM polygons because of missing data or differences in spatial resolution and polygon extents. More information on structural stages used in this report is provided in Appendix 35.

7.15.1.2 TEM/PEM Quality Assurance/Quality Control

Quality Assurance

TEM and PEM followed provincial standards and guidelines with respect to classification, field methodology, and digital data capture (Howes and Kenk 1997; RIC 1998, 2000). Descriptions of the forested ecosystems potentially occurring in the study area were provided by the field guide for the Prince Rupert Forest Region (Banner et al. 1993). Baseline field survey data collected in 2006 and 2008 by Rescan personnel were used to refine the TEM.

Following completion, the data underwent a suite of checks to ensure the implementation of these standards, and to eliminate any errors in the data set. Specifically,

- polygons with missing data were highlighted and filled if possible (by looking at classification of surrounding polygons).
- deciles were summed for each polygon to ensure they added to 10.
- logical errors in structural stage/ecosystem unit combinations were rectified (e.g., water cannot be structural stage 7).

Accuracy Assessment

Ecosystem mapping products are used throughout the province for many different reasons. Assessing the thematic accuracy of each individual TEM or PEM project is a key component in the determination of the appropriate interpretative uses of the data (BC MOE 2006a). Any TEM or PEM project intended for use as a timber yield analysis must meet a minimum map accuracy standard of 65% overall (Meidinger 2003). Although not required, this map accuracy standard is recommended for all other interpretative uses (BC MOE 2006a).

Methods to assess the accuracy of ecosystem maps are outlined in “Protocol for Map Accuracy Assessment of Ecosystem Maps” (Meidinger 2003). The protocol provides a methodology for determining the average predictive accuracy of map polygons by comparing the results of field sampling to those indicated in the map. The results may be reported in one or more of the following ways:

- percent dominant correct: for each polygon, does the dominant entity from the map correspond to the dominant entity from the field sampling? Each polygon is rated as either yes or no, and an overall summary statistic is reported.
- percent overlap correct: for each polygon, are the proportions of each ecosystem mapped in the field the same as those predicted on the map? An overall summary statistic is reported.

Further, “correct” may be defined as either an exact match, or a match with a very similar ecosystem type (typically those adjacent on an edatophic grid, as presented in Banner et al. 1993). This latter approach is often referred to as “lumping,” and results in higher accuracies.

The methodology described in Meidinger (2003) was followed by Timberline in an internal accuracy assessment of their PEM products (Timberline 2007, 2008). Their reports should be consulted for further information regarding this methodology and for information regarding the quality of the input data. A report of map accuracy was not publicly available for the BC MSRM PEM data.

Rescan conducted an assessment of the TEM and PEM data for the Project area specifically, using field data collected for baseline studies in the summers of 2006 and 2008. All 80 ground-inspection sites were compared to the PEM results at those locations, with the ground-inspection sites assumed correct. Visual sites were not included in the assessment as they did not undergo the full level of rigour required to determine ecosystem type. The assessment was based on a comparison of the field data to the dominant ecosystem class within a complex PEM polygon and is equivalent to the "percent dominant correct" statistic identified above. Three PEM polygons that were not assigned site series, but rather were assigned a general category such as rock or meadow, were ignored during the calculation. The following site series were considered equivalent (i.e., were "lumped") for the purposes of this accuracy assessment:

- SBSmc2 05 and SBSmc2 06
- SBSmc2 01 and SBSmc2 05/06 (except SBSmc2 01c which is submesic and closer to SBSmc2 02 than SBSmc2 05)
- any of SBSmc2 01a, b, and c were considered a match with SBSmc2 01
- SBSmc2 09 and SBSmc2 10

All but three field plots fell within Timberline's Lakes TSA PEM; the remaining three fell within the PEM supplied by the BC MSRM. Because of the latter's limited sample size, the datasets were combined and overall accuracy statistics are reported, rather than for each individual PEM dataset.

An accuracy assessment will not be completed for the TEM data because the baseline field data were already used in the creation and refinement of the TEM, and cannot be used again to test the resulting product. Because the Morrison TEM is not to be used for timber analysis, the expense is unwarranted.

Accuracy Assessment Results

Timberline's final internal map accuracy for the Lakes TSA PEM (the largest of the three PEM datasets) was 70.9% and 63.7% respectively for percent dominant correct and percent overlap correct, without considering site series lumping. With lumping, the accuracy increased to 77.0% and 68.2% respectively for the percent dominant correct and the percent overlap correct. Map accuracy for Timberline's PEM of the Prince George and Fort St. James forest districts was 61% for percent dominant correct and 54% for percent overlap correct.

Rescan's independent accuracy assessment of the PEM in the Project area resulted in a percent dominant correct score of 62% (48 matches out of 77 samples).

7.15.1.3 Field Surveys

Field surveys provide a site-level evaluation of the ecosystems and plant species present throughout the Project area. This information is used to refine the ecosystem map, both in terms of boundaries and identified map units. Field surveys also provide presence/absence information about invasive species, rare species, and ecosystems as well as information regarding the site conditions in which these elements were found.

Field surveys were undertaken during the summers of 2006 and 2008 and followed provincial Resources Inventory Standards Committee (RISC) standards (BC MELP and BC MOF 1998) with regional forest guides used for reference (Mackinnon, DeLong, and Meidinger 1990; Banner et al. 1993). Sampling efforts focused on the footprint area encompassing both the MFA and TLSC as these areas are likely to be most disturbed during mine development and operation.

7.15.1.4 Ecosystems of Interest

Certain ecosystems were given special attention because of their conservation status and/or sensitivity to development. These ecosystems were collectively called “ecosystems of interest.” Two types of ecosystems of interest were identified in the Project area: listed ecological communities (rare ecosystems) and sensitive ecosystems.

Listed Ecosystems

The BC CDC maintains a list of rare ecological communities (ecosystems) in BC (BC MOE 2008a). These listed ecosystems can be linked to ecosystems mapped by TEM and PEM. A master list of potentially occurring rare (red- and blue-listed) ecosystems in the study areas was compiled (A5 in Appendix 35).

Sensitive Ecosystems

Sensitive ecosystems as defined by the BC MOE Sensitive Ecosystems Inventory (SEI) are ecosystems that are fragile and/or rare (BC MOE 2007d). For this section, sensitive ecosystems refer to fragile ecosystems only, as rare ecosystems are addressed separately. Ecosystem fragility refers to how sensitive an ecosystem is with respect to disturbance (McPhee et al. 2000). For this Project, sensitive ecosystems include riparian, wetland, and wetland transitional areas.

Riparian Ecosystems

Riparian ecosystems are adjacent to streams, lakes, ponds, and wetlands and differ from the uplands because of their high levels of soil moisture and soil nutrients, frequent flooding, and unique assemblage of plant and animal communities (Banner and MacKenzie 1998). All streams, lakes, and wetlands (as delineated on the provincial TRIM data) in the footprint area, the LSA, and the RSA were buffered by 40 m on all sides to delineate riparian areas. The chosen width was based on provincial standards (BC MOFR 2004; BC MOE 2007c) as well as knowledge of the local waterbodies’ characteristics.

Riparian areas are not considered separate ecosystems in the area calculations. The ecosystems that were mapped within the riparian buffers are included in the total area summaries for ecosystem types and the riparian area is a separate calculation that should not be added to the ecosystem type summaries.

Wetland and Transitional Ecosystems

Wetland and transitional ecosystems include true wetlands as well as ecosystems that exhibit characteristics of both wetland and upland ecosystems (e.g., vegetation structure similar to a wetland but merely moist soils and few wetland indicator species; MacKenzie and Moran 1998). These transitional ecosystems include wet meadows, shrub-carrs, and floodplain ecosystems. Forested swamps and fens are discussed separately from other wetter forests because they are different. Spatial data (TEM, PEM, and TRIM) were used to identify wetland and transitional ecosystems within the LSA and RSA.

7.15.1.5 Plant Species of Interest

Plant species of interest include those tracked provincially by the BC CDC and federally by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the federal *Species at Risk Act* (SARA; 2002). Plant species currently used by the local community for nutritional or medicinal purposes and those that are listed by the BC *Weed Control Act* (1985) are also considered.

Listed Plant Species

Plant species identified during the field surveys were cross-referenced against rare plant species listed by the BC CDC and in the Species at Risk registry (BC MOE 2008a; Environment Canada 2008). The resulting list of potentially occurring listed plants (A4 in Appendix 35) was used in a presence/not-detected level of inventory to document any such plants within the Project area.

Country Food Plants

Plant species used by local communities were identified during the country foods baseline studies (Appendix 43) and termed country food plants. These plants were cross-referenced with plant species lists developed during ecosystem mapping and vegetation field surveys.

Invasive Species

Invasive species generally refer to species (native or non-native) that, when introduced into a new setting, have the ability to compete with and replace native species, thereby changing the composition of the plant community (Haber 1997). A review of invasive plants and nuisance weeds as defined by the BC *Weed Control Act* (1985; Cranston, Ralph, and Wikeem 2002) was compiled before commencing fieldwork and compared with 2006 and 2008 baseline field results. A presence/not-detected level of inventory was then used to document invasive plants.

7.15.1.6 Metal Concentrations in Plant Tissue

Plant tissue samples were collected at various locations throughout the Project area to establish baseline metal concentrations. This information provides context for future monitoring throughout operations and after mine closure and reclamation. Plant species targeted for collection included those commonly found throughout the study area and likely to be a food source for wildlife or people. To assess spatial differences in metal concentrations, plant tissue concentrations were separated based on sampling locations between the proposed MFA and TLSC.

7.15.2 Results

7.15.2.1 Biogeoclimatic Ecosystem Classification Units

Four BEC units are present within the RSA. Low- to mid-elevations are either the Sub-boreal Spruce moist cold – Babine variant (SBSmc2) or the Sub-boreal Spruce wet cool – Takla variant (SBSwk3). Higher elevations above the SBS zone are either the Engelmann Spruce Subalpine Fir moist very cold – Omineca variant (ESSFmv3) or the Engelmann Spruce Subalpine Fir moist cold (ESSFmc) variant. The footprint area and LSA are primarily within the SBSmc2 BEC unit, with small sections within the ESSFmv3 BEC unit.

The ESSF BEC units are generally drier and colder than the SBS BEC units. Major tree species in the ESSF are subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*), as well as mountain hemlock (*Tsuga mertensiana*), and lodgepole pine (*Pinus contorta*). Major tree species in the SBS are hybrid white spruce (*Picea glauca* x *engelmannii*), subalpine fir, lodgepole pine, and black spruce (Picea mariana; Banner et al. 1993). Further details of each BEC unit in the Project area can be found in Appendix 35.

7.15.2.2 General Ecosystem Types and Structural Stages

Following vegetation mapping and classification of vegetation polygons into BEC units and structural stages, polygons are grouped together based on moisture and vegetation structural characteristics into general ecosystem types. This grouping allows for easier comparison among areas and later assessment of vegetation communities.

Mesic (moderately moist) forest is the dominant general ecosystem type at each level of study (i.e., within the footprint, LSA, and RSA; Figure 7.15-2). Mesic forests cover approximately 90% of the MFA and 76% of the TLSC (Appendix 35). Wetter forests are the second most dominant vegetated ecosystem type within each study area.

The footprint area consists predominately of mature forests (65%), followed by shrub communities (20%; Figure 7.15-3). Old forests are scarce in the footprint area (<1%; absent from the TLSC) compared to the LSA and RSA (Appendix 35). The majority of the LSA consists of mature forest (54%) followed by shrub (20%). The RSA is dominated by mature forests (32%), while the second most dominant structural stage is old/mature (27%).

The spatial distributions of general ecosystem types and vegetation structural stages in the RSA are shown in figures 7.15-4 and 7.15-5. Similar maps for the footprint area and LSA are provided in Appendix 35.

7.15.2.3 Listed Ecosystems

The BC CDC currently tracks 35 ecological communities within the Nadina Forest District; 27 of these communities are blue-listed and 8 are red-listed. Twelve of these ecosystems (including six wetland ecosystems) have the potential to occur within the RSA based on the BEC units present (Appendix 35).

Field studies identified one red-listed ecosystem: Saskatoon/slender wheatgrass (SBSmc2 81; *Amelanchier alnifolia*/*Elymus trachycaulus*) in the footprint area (Figure 7.15-6; Plate 7.15-1). The PEM identified this dry shrub/herb ecosystem, as well as another red-listed dry shrub/herb ecosystem: bluegrass/slender wheatgrass (SBSmc2 82; *Poa secunda* ssp. *secunda – Elymus trachycaulus*), in scattered locations throughout the LSA and RSA. According to the PEM, SBSmc2 81 covers 18 ha and 75 ha in the LSA and RSA, respectively, while SBSmc2 82 covers 216 ha and 1,493 ha. The PEM labelled all dry grassland/scrubland ecosystems in the region, regardless of BEC unit, as SBSmc2 81 or 82.

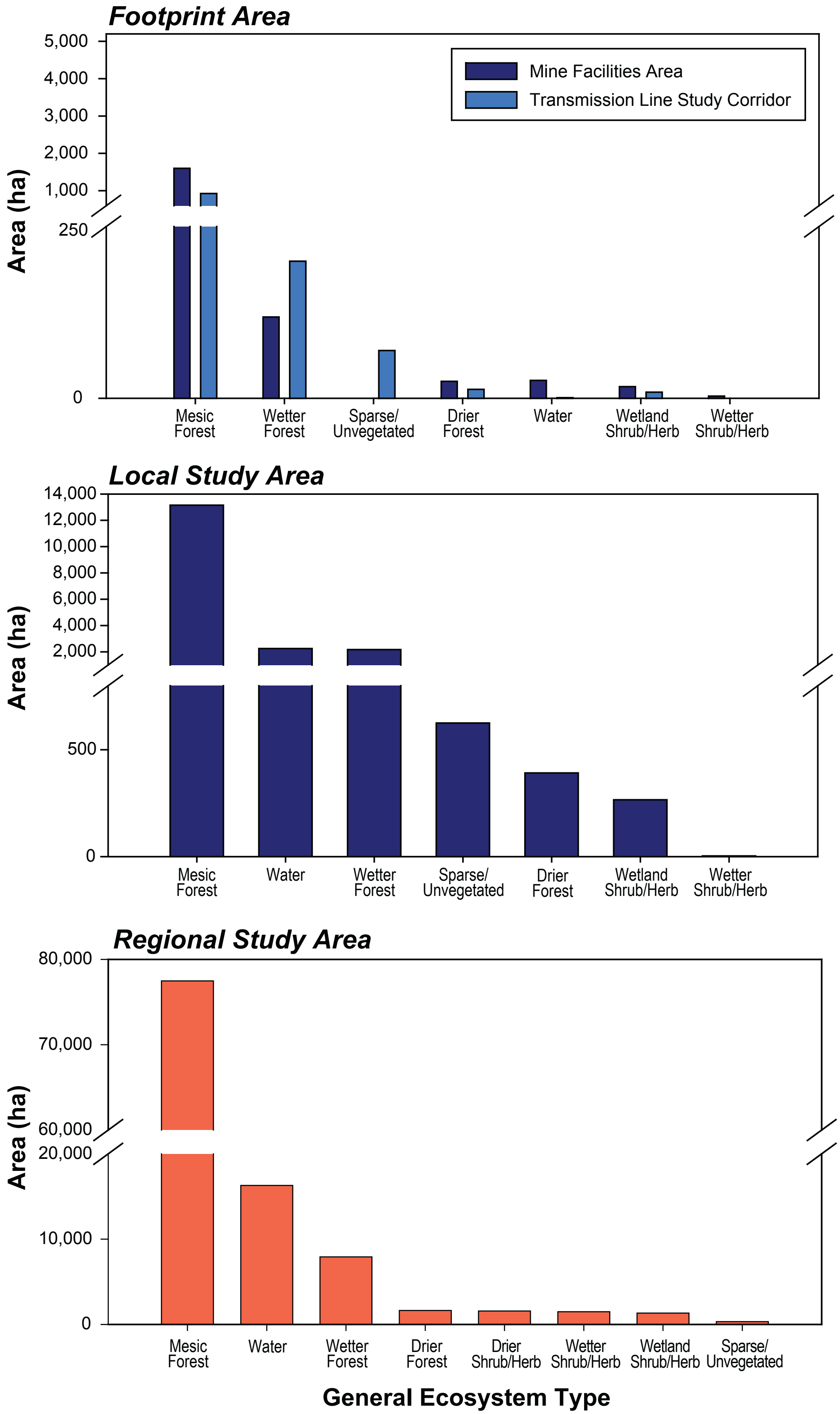


FIGURE 7.15-2

Morrison Copper/Gold Project Distribution of General Ecosystem Types

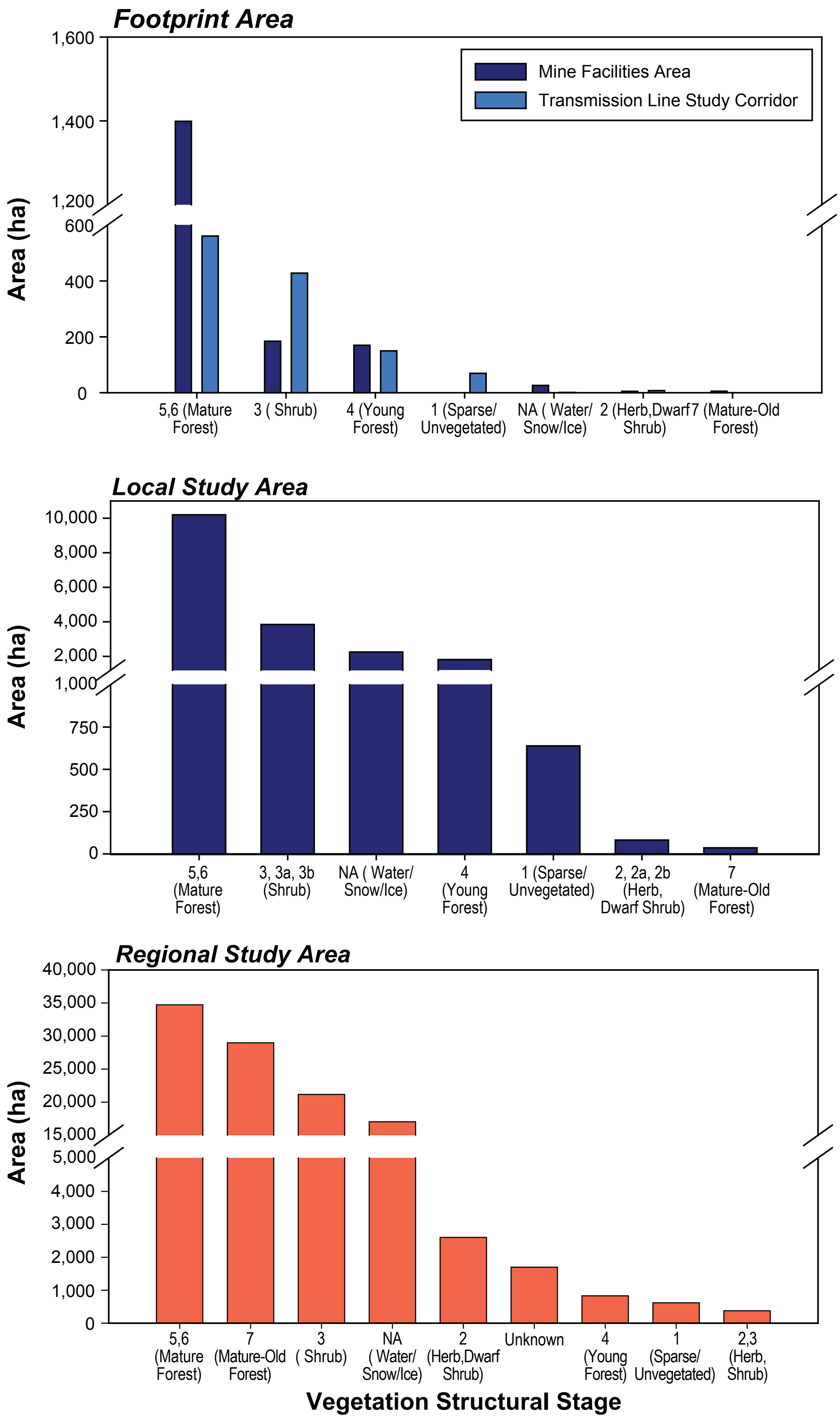
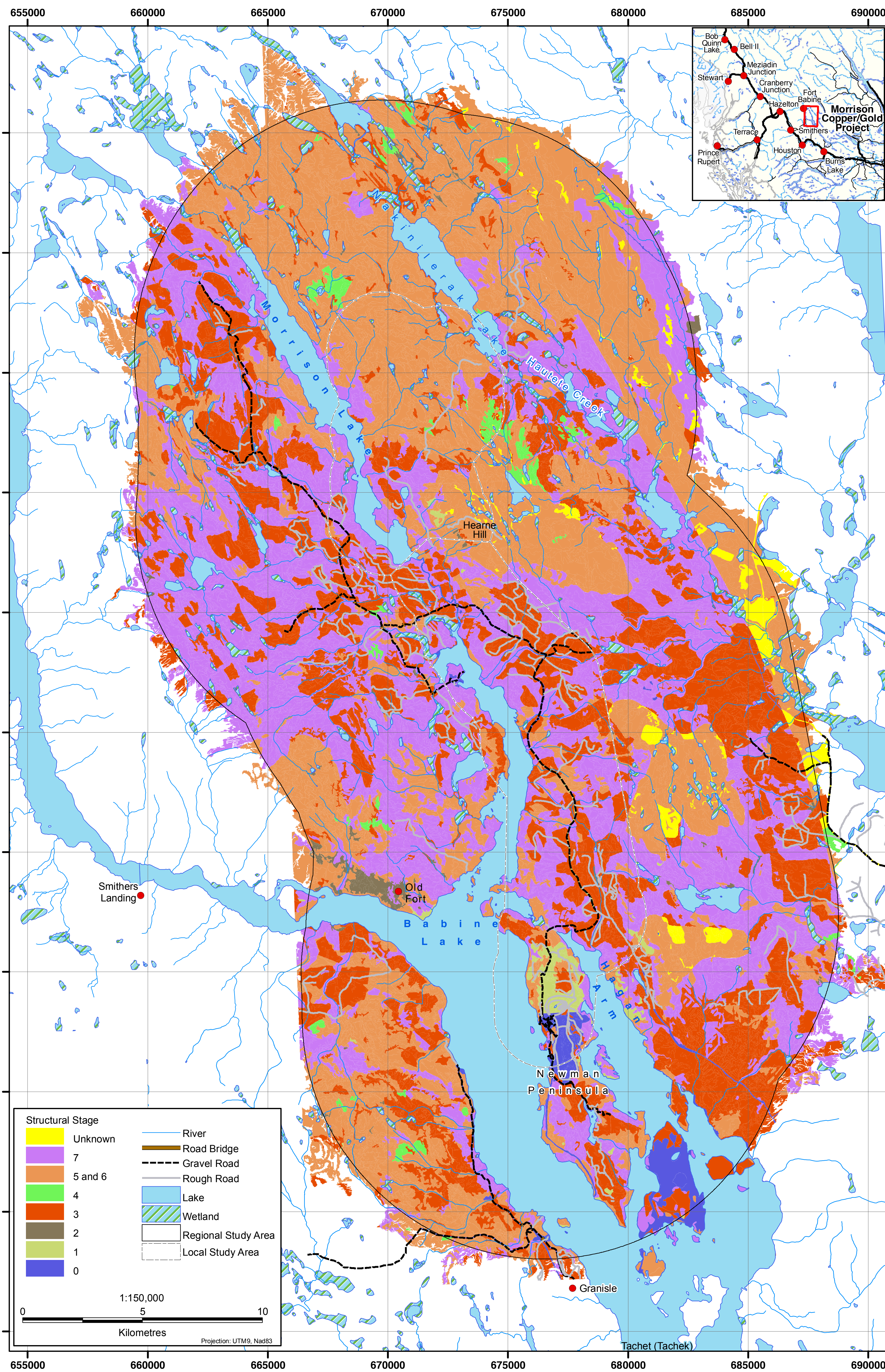


FIGURE 7.15-3

Morrison Copper/Gold Project
Distribution of Vegetation Structural Stages

FIGURE 7.15-4

Morrison Copper/Gold Project General Ecosystem Types Regional Study Area



Morrison Copper/Gold Project Vegetation Structural Stages Regional Study Area

FIGURE 7.15-5

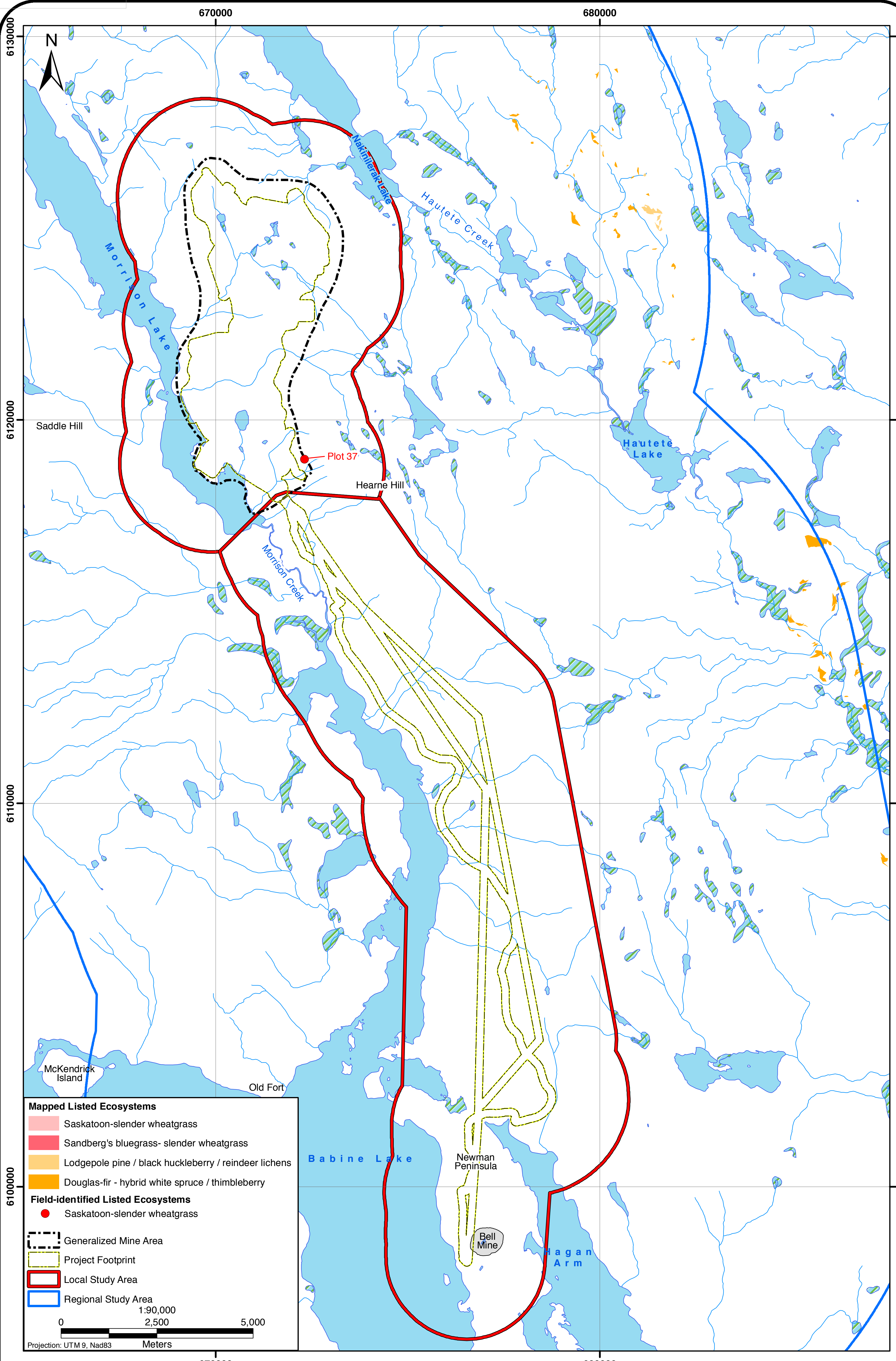


FIGURE 7.15-6

Morrison Copper/Gold Project Listed Ecosystem Locations

Plate 7.15-1. Saskatoon/slender wheatgrass ecosystem (SBSmc2 81).

Two other listed ecosystems were identified by the PEM within the RSA: lodgepole pine/black huckleberry/reindeer lichens (SBSwk3 02; *Pinus contorta*/*Vaccinium membranaceum*/*Cladina* spp.; Plate 7.15-2) and Douglas-fir–hybrid white spruce/thimbleberry (SBSwk3 03; *Pseudotsuga menziesii*/*Picea engelmannii* x *glauca*/*Rubus parviflorus*; no photo available). Together, these drier forest ecosystems account for 96 ha (<1%) of the RSA (Table 7.15-2).

Plate 7.15-2. Lodgepole pine/black huckleberry/reindeer lichens ecosystem (SBSwk3 02).

Table 7.15-2
Listed Ecosystems

Ecosystem	Provincial Status	LSA and Footprint Area (ha) TEM	LSA Area (ha) PEM	RSA Area (ha) PEM
Saskatoon/slender wheatgrass (SBSmc2 81)	Red-listed	0	18	75
Sandberg's bluegrass/slender wheatgrass (SBSmc2 82)	Red-listed	0	216	1,493
Lodgepole pine/black huckleberry/reindeer lichens (SBSwk3 02)	Blue-listed	0	0	32
Douglas-fir – hybrid white spruce/thimbleberry (SBSwk3 03)	Blue-listed	0	0	64

The TEM does not show any red- or blue-listed ecosystems in the footprint or LSA. The discrepancy is caused by methodological differences between the mapping techniques. The ecosystems identified by PEM rather than TEM are assumed to be true because neither mapping methodology is completely accurate, and because the potential presence of these listed ecosystems should not be ignored.

Riparian Ecosystems

There are 339 ha of riparian ecosystems within the footprint area, 2,248 ha within the LSA, and 12,833 ha within the RSA (Figure 7.15-7).

Wetland and Transitional Ecosystems

The extent of wetland and transitional ecosystems in the footprint, LSA, and RSA is shown in Table 7.15-3. Wetland and transitional ecosystems cover a total of 68 ha of the footprint area, 457 ha in the LSA, and 4,595 ha in the RSA. Forested swamps and non-treed bogs/marshes are the most common of these ecosystems. Other wetland and transitional ecosystems are relatively rare, the majority of which are only present within the RSA. More detailed information on wetlands in the Project area is provided in Appendix 31.

7.15.2.4 Plant Species of Interest

Plant Species Overview

A total of 188 plant species (including those identified to genus level only), belonging to 49 different families, were identified within the proposed Project area. Forbs were the most species-rich plant type and accounted for 69 of the 188 plant species. Deciduous shrubs were the second most common plant type and accounted for 33 species. The complete list of species and plant types is summarized in A14 of Appendix 35.

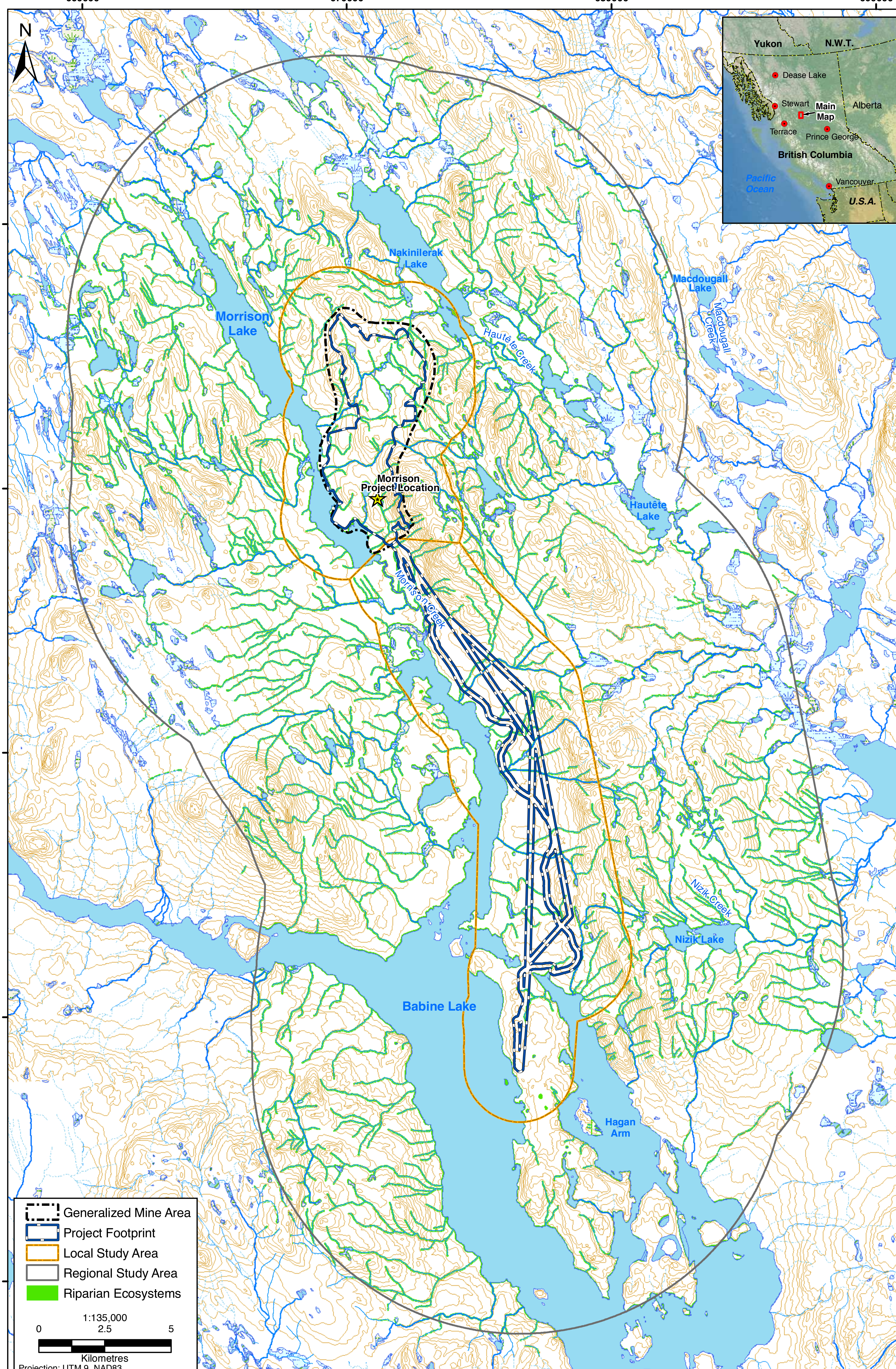


FIGURE 7.15-7

Morrison Copper/Gold Project Riparian Ecosystems in the Regional Study Area

Table 7.15-3
Extent of Wetland and Transitional Ecosystems

Ecosystem	General Ecosystem Type	Footprint Area (ha)	Local Study Area (ha)	Regional Study Area (ha)
Alpine wetland	Wetland Shrub/Herb	0	0	19
Cow-parsnip meadow	Wetter Shrub/Herb	0	0	22
Riparian shrub	Wetter Shrub/Herb	0	0	2
Non-treed bog/marsh	Wetland Shrub/Herb	26	259	1,277
Organic sedge fen	Wetland Shrub/Herb	0	6	13
Organic treed fen	Wetter Forest	0	0	121
Organic shrub fen	Wetland Shrub/Herb	00	0	14
Swamp forest	Wetter Forest	39	182	1,661
Shrub-carr	Wetter Shrub/Herb	0	0	159
Low bench floodplain	Wetter Shrub/Herb	3	3	17
Wet meadow	Wetter Shrub/Herb	0	0	1,252
Total		**68**	**457**	**4,595**

Listed Plant Species

The BC CDC lists two plant species that could occur in the ecosystems in the Project area: whitebark pine (*Pinus albicaulis*) and western Jacob's-ladder (*Polemonium occidentale* ssp. *occidentale*). Neither species was identified during the field surveys in 2006 and 2008.

Invasive Plant Species

Field surveys identified two invasive plant species (Appendix 35). Western water-hemlock (*Cicuta douglasii*) was documented at one site and common horsetail (*Equisetum arvense*) at 12 sites within the Project area. Neither species is regulated by the BC *Weed Control Act*.

Country Food Plants

Local community members identified the following five plant species as having cultural importance:

1. Blueberry (*Vaccinium* spp.)

2. Highbush-cranberry (*Viburnum edule*)

3. Black huckleberry (Vaccinium membranaceum)

4. Raspberry (*Rubus* spp.)

5. Soapberry (Shepherdia canadensis)

The most common country food plants in the Project area are black huckleberry and highbush-cranberry. The distribution of the country food plants identified during field studies is detailed in Appendix 35.

7.15.2.5 Metal Concentrations in Plant Tissues

Plant tissue samples were collected from 49 sites for metals analysis. Plant leaves were collected from red osier dogwood (*Cornus stolonifera*), black twinberry (*Lonicera involucrata*), willow (S*alix* spp.), and highbush-cranberry. Additionally, stems and/or berries from black huckleberry, raspberry, and wild rhubarb were collected and analyzed and are discussed in greater detail in Appendix 43.

Metal concentrations in the majority of plant samples were above detection limits for half of the metals tested. Metal concentrations varied by species and tissue type. Total and average metal concentrations between the proposed MFA and the TLSC were similar among all three sampling years. Detailed results are presented in Appendix 35.

7.16 Wildlife and Wildlife Habitat

7.16.1 Ecological Overview

7.16.1.1 Local Study Area

The LSA covers 18,519 ha, delineated by a 2-km buffer surrounding the Project footprint area. The Project footprint is composed of two distinct areas: the MFA (1,789 ha) and the TLSC (1,216 ha), covering a total area of 3,005 ha. The MFA principally includes the open pit, plant site, waste rock storage facility, TSF, and haul routes/pipelines that connect the facilities. The TLSC extends from the Bell Mine substation to the south end of the MFA.

All of the proposed mining development areas (main mine site, tailings area, and corridor between sites) are within the Sub-boreal Spruce moist cold biogeoclimatic subzone (SBSmc2; Banner et al. 1993). The SBS subzone is dominated by lodgepole pine and hybrid spruce forests and has a continental climate characterized by significant seasonal temperature extremes, with cold, snowy winters and warm, moist, and short summers. Annual precipitation is 440 to 650 mm (Banner et al. 1993). Prominent wildlife species associated with the SBS zone that can occur in high abundance include grizzly bear, moose, mule deer, wolf, fisher, American marten, and waterfowl such as Barrow's goldeneye (Meidinger and Pojar 1991). Higher elevation portions of Hearne Hill, which is on the ridge east of the Project footprint, are within the Engelmann Spruce/Subalpine Fir moist very cold biogeoclimatic subzone (ESSFmv3). The ESSF zone has a relatively cold, moist, and snowy continental climate. Growing seasons are cool and short and winters are long and cold. This subzone tends to occur in mountainous terrain that is steep and rugged. ESSF are dominant climax tree species. Prominent wildlife species within the ESSF zone include the grizzly bear, black bear, and moose (near wetlands). Other ungulates using the ESSF subzone include mountain goat, caribou, and mule deer. However, the deep snow conditions that occur in the ESSF subzone can limit or impede moose and mule deer movement, often forcing these animals to relocate during the winter. Amphibians (i.e., western toad and Columbia spotted frog) can be found in suitable waterbodies within the Project area. American marten, red squirrel, fisher, and wolverine are also found in the conifer forests associated with the Project's LSA (Meidinger and Pojar 1991).

7.16.1.2 Regional Study Area

The RSA is defined by a 10-km radius around the proposed development, covering approximately 100,255 ha and including the Morrison Lake LRMP Resource Management Zone. The 10-km perimeter identified for the RSA was selected to put the LSA into a regional ecological context. The 10-km RSA includes most BEC types that supply habitat for the species in the LSA. Therefore, it is possible to determine the abundance of habitat within the Project footprint and LSA relative to the general habitat attributes available in the greater eco-region within which the Project is situated.

Within the expanded RSA there are an additional two BEC units included for consideration of wildlife (SBSwk3 and ESSFmc; the other two are SBSmc2 and ESSFmv3, as mentioned in Section 7.16.1.2). There are also two BC CDC blue-listed forested ecosystems in the expanded RSA: lodgepole pine/black huckleberry/reindeer lichens (SBSwk3 02) and Douglas-fir/hybrid white spruce/thimbleberry (SBSwk3 03). Both of these rare ecosystems fall within the SBSwk3 BEC unit. The Douglas-fir/hybrid white spruce/thimbleberry (SBSwk3 03) ecosystem represents the northern extent of Douglas-fir.

7.16.2 Baseline Conditions

7.16.2.1 Overview

Baseline studies were undertaken during a series of site visits between August, 2004, and July, 2008, to characterize the terrestrial wildlife community and identify important wildlife habitats within the Project footprint and the surrounding areas (appendices 36, 37, 38, 39). Studies included bird surveys (point counts for forest birds, nest surveys for raptors, and boat-based and shoreline surveys for waterfowl) and amphibian surveys; incidental observations of wildlife were also recorded during each site visit. In addition, vegetation and habitat suitability modelling was completed for the entire RSA for five mammals: grizzly bear, moose, mule deer, American marten, and fisher.

7.16.2.2 Methodology

Characterization of the wildlife community included field-based investigations and a literature review to compile existing biological information. Discussions with knowledgeable individuals were also used to determine species that could be present in the area, including species that could have a conservation status or be declining, and other relevant biological information.

Wildlife studies focused on the direct footprint of the proposed development (Figure 7.16-1). The proposed footprint included:

- the main open pit mine site of approximately 1,200 m × 2,000 m on the eastern side of the south end of Morrison Lake at the foot of Hearne Hill;
- the tailings storage area 2,100 m north of the main mine area spanning approximately 3,000 m × 3,300 m;
- the overburden and low grade ore stockpiles;
- the WRD;
- the proposed tailings pipeline and road corridor joining the mine plant to the TSF;

- the road and transmission line coming from the Bell mine substation site on Babine Lake.

A road-based wildlife survey was conducted in November, 2004, to document all species that use the road, road verge, and habitats near the road. An aerial survey was conducted in March, 2005, to assess moose winter habitat value within 5 km of the proposed mine site, which included Morrison Creek and part of the western slope leading to Morrison Lake (Appendix 39). Habitat suitability mapping was conducted for the entire RSA using a combination of TEM (appendices 35 and 37) and PEM (Appendix 35) for five mammal species (grizzly bear, moose, mule deer, American marten, and fisher).

The results of these wildlife surveys indicated the presence or potential presence of 223 vertebrate species in the LSA. Of these 223 species, 27 species were deemed unlikely, 51 possible, 50 likely, and 96 confirmed. For definitions of probability of occurrence categories refer to Appendix 37. Table 7.16-1 provides a summary list of these species. Of the species confirmed as present, 3 were amphibians, 75 were birds, 8 were rodents and other small mammals, 8 were carnivores, and 2 were ungulates. Some of these species only have the potential to exist transiently in the area (i.e., during migration). Most of the birds found in the LSA depend on forest habitat (57 species), while the remainder are wetland-breeding species (18 species).

Table 7.16-1
Species Presence in the Morrison Copper/Gold Project Area

Species	Scientific Name	Presence: Confirmed (C), Likely (L), Possible (P) or Unlikely (U)
Amphibians		
Salamanders		
Long-toed Salamander	*Ambystoma macrodactylum*	P
Rough-skinned Newt	*Taricha granulosa*	P
Frogs and Toads		
Western Toad	*Bufo boreas*	C
Columbia Spotted Frog	*Rana luteiventris*	C
Northern Wood Frog	*Rana sylvatica*	C
Reptiles		
Western Garter Snake	*Thamnophis elegans*	P
Common Garter Snake	*Thamnophis sirtalis*	P
Birds		
Common Loon	*Gavia immer*	C
Red-necked Grebe	*Podiceps grisegena*	L
Horned Grebe	*Podiceps auritus*	C
Pied-billed Grebe	*Podilymbus podiceps*	P
American Bittern	*American Bittern*	P
Great Blue Heron	*Ardea herodias*	P
Sandhill Crane	*Grus canadensis*	P

(continued)

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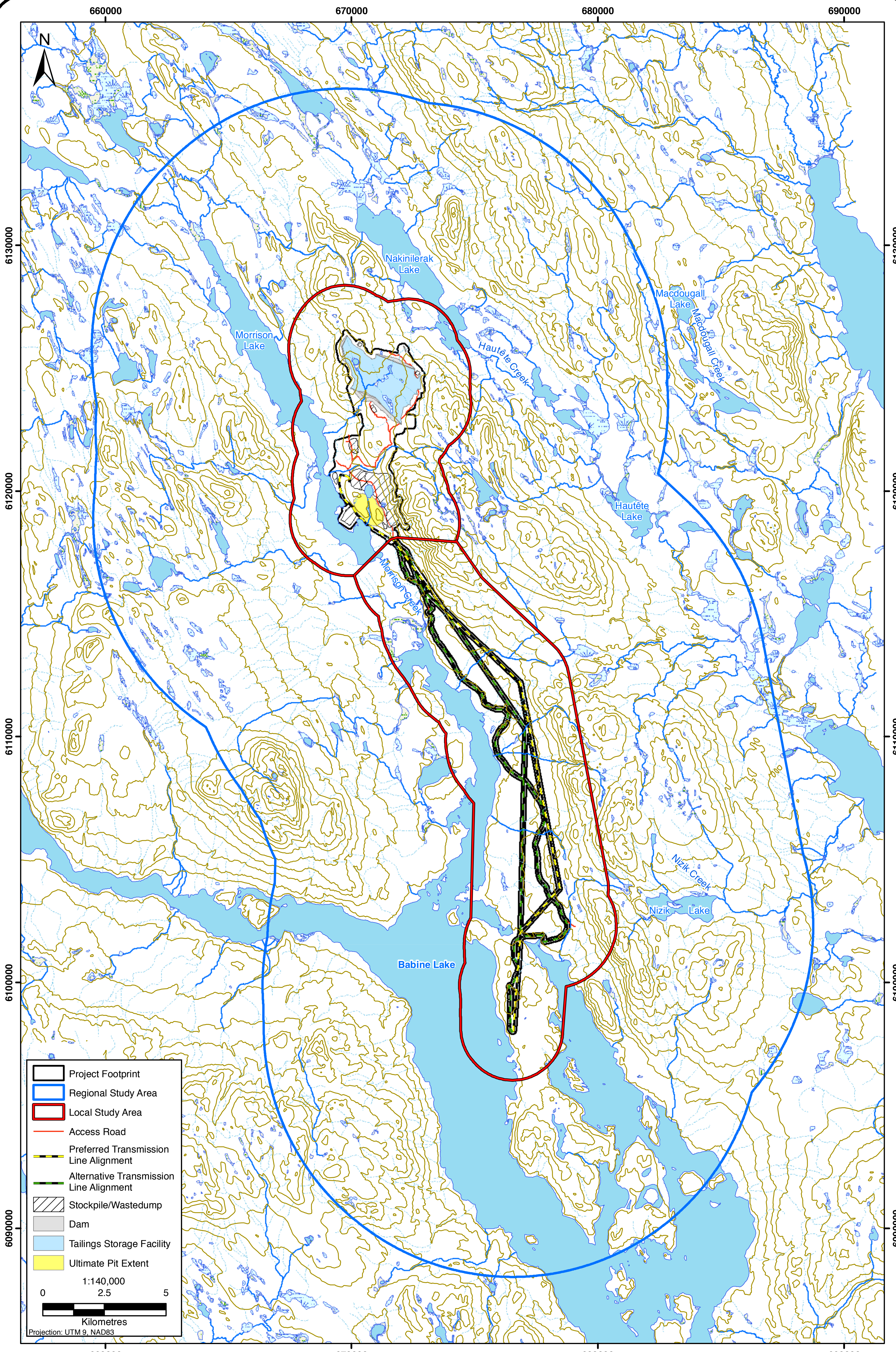

FIGURE 7.16-1

Morrison Copper/Gold Project Local and Regional Study Areas for Wildlife

Table 7.16-1
Species Presence in the Morrison Copper/Gold Project Area (continued)

Species	Scientific Name	Presence: Confirmed (C), Likely (L), Possible (P) or Unlikely (U)
Trumpeter Swan	*Cygnus buccinator*	C
Canada Goose	*Branta canadensis*	C
Mallard	*Anas platyrhynchos*	C
Gadwall	*Anas strepera*	L
Green-winged Teal	*Anas crecca*	C
Blue-winged Teal	*Anas discors*	L
American Wigeon	*Anas americana*	L
Northern Pintail	*Anas acuta*	L
Northern Shoveler	*Anas clypeata*	L
Canvasback	*Aythya valisineria*	P
Redhead	*Aythya americana*	U
Ring-necked Duck	*Aythya collaris*	C
Greater Scaup	*Aythya marila*	U
Lesser Scaup	*Aythya affinis*	L
White-winged Scoter	*Melanitta fusca*	L
Surf Scoter	*Melanitta perspicillata*	U
Harlequin Duck	*Histrionicus histrionicus*	L
Barrow's Goldeneye	*Bucephala islandica*	C
Common Goldeneye	*Bucephala clangula*	C
Bufflehead	*Bucephala albeola*	C
Common Merganser	*Mergus merganser*	C
Red-breasted Merganser	*Mergus serrator*	U
Hooded Merganser	*Lophodytes cucullatus*	C
Ruddy Duck	*Oxyura jamaicensis*	P
Osprey	*Pandion haliaetus*	C
Bald Eagle	*Haliaeetus leucocephalus*	C
Northern Harrier	*Circus cyaneus*	L
Sharp-shinned hawk	*Accipiter striatus*	L
Cooper's Hawk	*Accipiter cooperii*	U
Northern Goshawk	*Accipiter gentilis*	L
Red-tailed Hawk	*Buteo jamaicensis*	L
Swainson's Hawk	*Buteo swainsoni*	U
American Kestrel	*Falco sparverius*	P
Merlin	*Falco columbarius*	L
Ruffed Grouse	*Bonasa umbellus*	C
Spruce Grouse	*Falcipennis canadensis*	L
Willow Ptarmigan	*Lagopus lagopus*	U

(continued)

Table 7.16-1
Species Presence in the Morrison Copper/Gold Project Area (continued)

Species	Scientific Name	Presence: Confirmed (C), Likely (L), Possible (P) or Unlikely (U)
White-tailed Ptarmigan	*Lagopus leucura*	U
Sharp-tailed Grouse	*Tympanuchus phasianellus*	U
Rock Ptarmigan	*Lagopus muta*	U
Blue Grouse	*Dendragapus obscurus*	L
Sora	*Porzana carolina*	P
American Coot	*Fulica americana*	L
Killdeer	*Charadrius vociferus*	L
Greater Yellowlegs	*Tringa melanoleuca*	L
Lesser Yellowlegs	*Tringa flavipes*	C
Solitary Sandpiper	*Tringa solitaria*	C
Spotted Sandpiper	*Actitis macularia*	C
Wilson's Snipe	*Gallinago gallinago*	C
Wilson's Phalarope	*Phalaropus tricolor*	U
Bonaparte's Gull	*Larus philadelphia*	L
Mew Gull	*Larus canus*	P
Herring Gull	*Larus argentatus*	L
Black Tern	*Chlidonias niger*	P
Short-eared Owl	*Asio flammeus*	L
Great Horned Owl	*Bubo virginianus*	L
Northern Pygmy-Owl	*Glaucidium gnoma*	L
Barred Owl	*Strix varia*	C
Great Gray Owl	*Strix nebulosa*	L
Long-eared Owl	*Asio otus*	U
Boreal Owl	*Aegolius funereus*	L
Northern Hawk Owl	*Surnia ulula*	P
Northern Saw-whet owl	*Aegolius acadicus*	L
Common Nighthawk	*Chordeiles minor*	P
Black Swift	*Cypseloides niger*	P
Vaux's Swift	*Chaetura vauxi*	P
Calliope Hummingbird	*Stellula calliope*	U
Rufous Hummingbird	*Selasphorus rufus*	C
Belted Kingfisher	*Ceryle alcyon*	C
Red-breasted Sapsucker	*Sphyrapicus ruber*	C
Yellow-breasted Sapsucker	*Sphyrapicus varius*	U
Downy Woodpecker	*Picoides pubescens*	L
Hairy Woodpecker	*Picoides villosus*	C

(continued)

Table 7.16-1
Species Presence in the Morrison Copper/Gold Project Area (continued)

Species	Scientific Name	Presence: Confirmed (C), Likely (L), Possible (P) or Unlikely (U)
American Three-toed Woodpecker	*Picoides dorsalis*	C
Black-backed Woodpecker	*Picoides arcticus*	L
Northern Flicker	*Colaptes auratus*	C
Pileated Woodpecker	*Dryocopus pileatus*	C
Olive-sided Flycatcher	*Contopus cooperi*	C
Western Wood-pewee	*Contopus sordidulus*	C
Alder Fycatcher	*Empidonax alnorum*	C
Least Flycatcher	*Empidonax minimus*	C
Hammond's Flycatcher	*Empidonax hammondii*	C
Dusky Flycatcher	*Empidonax oberholseri*	C
Pacific-slope Flycatcher	*Empidonax difficilis*	P
Say's Phoebe	*Sayornis saya*	L
Cassin's Vireo	*Vireo cassinii*	C
Warbling Vireo	*Vireo gilvus*	C
Red-eyed Vireo	*Vireo olivaceus*	P
Steller's Jay	*Cyanocitta stelleri*	C
Gray Jay	*Perisoreus canadensis*	C
Clark's Nutcracker	*Nucifraga columbiana*	U
Black-billed Magpie	*Pica hudsonia*	U
American Crow	*Corvus brachyrhynchos*	L
Common Raven	*Corvus corax*	C
Horned Lark	*Eremophila alpestris*	U
Tree Swallow	*Tachycineta bicolor*	C
Violet-green Swallow	*Tachycineta thalassina*	C
Bank Swallow	*Riparia riparia*	P
Rough-winged Swallow	*Stelgidopteryx serripennis*	P
Barn Swallow	*Hirundo rustica*	L
Cliff Swallow	*Petrochelidon pyrrhonota*	P
Black-capped Chickadee	*Poecile atricapilla*	C
Chestnut-backed Chickadee	*Poecile rufescens*	P
Boreal Chickadee	*Poecile hudsonica*	C
Red-breasted Nuthatch	*Sitta canadensis*	C
Brown Creeper	*Certhia americana*	C
Winter Wren	*Troglodytes troglodytes*	C
American Dipper	*Cinclus mexicanus*	P
Golden-crowned Kinglet	*Regulus satrapa*	C

(continued)

Table 7.16-1
Species Presence in the Morrison Copper/Gold Project Area (continued)

Species	Scientific Name	Presence: Confirmed (C), Likely (L), Possible (P) or Unlikely (U)
Ruby-crowned Kinglet	*Regulus calendula*	C
Mountain Bluebird	*Oenanthe oenanthe*	L
Townsend's Solitaire	*Myadestes townsendi*	P
Swainson's Thrush	*Catharus ustulatus*	C
Hermit Thrush	*Catharus guttatus*	C
American Robin	*Turdus migratorius*	C
Varied Thrush	*Ixoreus naevius*	C
European Starling	*Sturnus vulgaris*	P
American Pipit	*Anthus rubescens*	U
Bohemian Waxwing	*Bombycilla garrulus*	L
Cedar Waxwing	*Bombycilla cedrorum*	P
Tenessee Warbler	*Vermivora peregrina*	C
Orange-crowned Warbler	*Vermivora celata*	C
Yellow Warbler	*Dendroica petechia*	C
Magnolia Warbler	*Dendroica magnolia*	C
Townsend's Warbler	*Dendroica townsendi*	C
Blackpoll Warbler	*Dendroica striata*	C
Yellow-rumped Warbler	*Dendroica coronata*	C
American Redstart	*Setophaga ruticilla*	C
Northern Waterthrush	*Seiurus noveboracensis*	C
MacGillivray's Warbler	*Oporornis tolmiei*	C
Common Yellowthroat	*Geothlypis trichas*	C
Wilson's Warbler	*Wilsonia pusilla*	C
Western Tanager	*Piranga ludoviciana*	C
Chipping Sparrow	*Spizella passerina*	C
Savannah Sparrow	*Passerculus sandwichensis*	P
Fox Sparrow	*Passerella iliaca*	C
Song Sparrow	*Melospiza melodia*	C
Lincoln's Sparrow	*Melospiza lincolnii*	C
White-throated Sparrow	*Zonotrichia albicollis*	P
Golden-crowned Sparrow	*Zonotrichia atricapilla*	U
White-crowned Sparrow	*Zonotrichia leucophrys*	L
Dark-eyed Junco	*Junco hyemalis*	C
Blue Grosbeak	*Passerina caerulea*	U
Red-winged Blackbird	*Agelaius phoeniceus*	C
Rusty Blackbird	*Euphagus carolinus*	C
Brewer's Blackbird	*Euphagus cyanocephalus*	L

(continued)

Table 7.16-1
Species Presence in the Morrison Copper/Gold Project Area (continued)

Species	Scientific Name	Presence: Confirmed (C), Likely (L), Possible (P) or Unlikely (U)
Brown-headed Cowbird	*Molothrus ater*	L
Pine Grosbeak	*Pinicola enucleator*	C
Purple Finch	*Carpodacus purpureus*	C
Cassin's Finch	*Carpodacus cassinii*	U
House Finch	*Carpodacus mexicanus*	U
Red Crossbill	*Loxia curvirostra*	L
White-winged Crossbill	*Loxia leucoptera*	C
Pine Siskin	*Carduelis pinus*	C
Evening Grosbeak	*Coccothraustes vespertinus*	P
House Sparrow	*Passer domesticus*	U
Mammals		
Insectivores		
Common Shrew	*Sorex cinereus*	L
Pgymy Shrew	*Sorex hoyi*	L
Dusky Shrew	*Sorex monticolus*	L
Water Shrew	*Sorex palustris*	P
Bats		
Big Brown Bat	*Eptesicus fuscus*	P
Silver-haired Bat	*Lasionycteris noctivagans*	L
California Myotis	*Myotis californicus*	P
Western Long-eared Myotis	*Myotis evotis*	L
Northern Long-eared Myotis	*Myotis septentrionalis*	P
Keen's Long-eared Myotis	*Myotis keenii*	P
Little Brown Myotis	*Myotis lucifugus*	L
Long-legged Myotis	*Myotis volans*	P
Yuma Myotis	*Myotis yumanensis*	U
Lagomorphs		
Snowshoe Hare	*Lepus americanus*	C
Rodents		
Southern Red-backed Vole	*Clethrionomys gapperi*	C
Brown Lemming	*Lemmus sibiricus*	P
Long-tailed Vole	*Microtus longicaudus*	L
Meadow Vole	*Microtus pennsylvanicus*	U
Muskrat	*Ondatra zibethicus*	P
Heather Vole	*Phencomys intermedius*	P
Northern Bog Lemming	*Synaptomys borealis*	L
Bushy-tailed Woodrat	*Neotoma cinerea*	P

(continued)

Table 7.16-1
Species Presence in the Morrison Copper/Gold Project Area (completed)

Species	Scientific Name	Presence: Confirmed (C), Likely (L), Possible (P) or Unlikely (U)
Deer Mouse	*Peromyscus maniculatus*	C
Porcupine	*Erethizon dorsatum*	C
House Mouse	*Mus musculus*	U
Northern Flying Squirrel	*Glaucomys sabrinus*	L
Hoary Marmot	*Marmota caligata*	P
Woodchuck	*Marmota monax*	L
Least Chipmunk	*Tamias minimus*	P
Red Squirrel	*Tamiasciurus hudsonicus*	C
Meadow Jumping Mouse	*Zapus hudsonius*	C
Western Jumping Mouse	*Zapus princeps*	C
American Beaver	*Castor canadensis*	C
Carnivores		
Coyote	*Canis latrans*	C
Gray Wolf	*Canis lupus*	C
Red Fox	*Vulpes vulpes*	P
Cougar	*Felis concolor*	P
Lynx	*Lynx lynx*	C
River Otter	*Lutra canadensis*	C
American Marten	*Martes americana*	C
Fisher	*Martes pennanti*	C
Striped Skunk	*Mephitis mephitis*	P
Ermine (Short-tailed Weasel)	*Mustela erminea*	L
Long-tailed Weasel	*Mustela frenata*	P
Least Weasel	*Mustela nivalis*	P
Mink	*Mustela vison*	P
Black Bear	*Ursus americanus*	C
Grizzly Bear	*Ursus arctos horribilus*	C
Ungulates		
Mountain Goat	*Oreamnos americanus*	U
Moose	*Alces alces*	C
Mule Deer	*Odocoileus hemionus*	C
White-tailed Deer	*Odocoileus virginianus*	P
Caribou	*Rangifer tarandus*	P
		96

7.16.2.3 Species of Conservation Concern

Within the RSA, three species of conservation concern were confirmed as occurring through direct observation of the animal or observation of a reliable sign of the species:

- western toad (*Anaxyrus* (formerly *Bufo*) *boreas*)
- grizzly bear (*Ursus arctos horribilus*)
- fisher (*Martes pennanti*)

Western toads were observed in adult and tadpole stages (indicative of active breeding populations) at two locations in the proposed main mine site (Booker Lake and W1; Appendix 38). The western toad is a large toad species, ranging from 5 to 13 cm long. Its current distribution in BC is unknown, although the central and northern regions of the province likely represent a stronghold for the species (Davis 2002). Western toads require a variety of terrestrial and aquatic habitats to complete different stages of their life cycle (spring breeding, summer foraging, and winter hibernation); they are also capable of moving over 5 km to breeding sites (Davis 2002). The western toad is a species of special concern on Schedule 1 of Canada's *Species at Risk Act* (2002), meaning that it requires monitoring under Section 79(2) of SARA; it is also the only globally red-listed amphibian that is found in Canada (Hammerson, Santos-Barrera, and Muths 2004). The International Union for Conservation of Nature (IUCN) listing for western toad is "EN A1ce," meaning that it is considered endangered with a high risk of extinction in the wild because of population reductions of 50% in the last 10 years as a result of declines in area of occupancy (COSEWIC 2002b). The western toad is yellow-listed within BC, which means that it is considered "secure but with conservation concern" (BC CDC 2008a), and protected under the *British Columbia Wildlife Act* (1996).

Grizzly bear tracks were found on the shoreline of Morrison Lake near the mouth of Morrison Creek (Appendix 39). The grizzly bear is a large subspecies of the brown bear that lives in the uplands of western North America. It is normally solitary in nature, although it can congregate in large numbers around creeks and rivers during salmon spawning. The grizzly bear is listed as a species of special concern by the COSEWIC (2002a), and is blue-listed in BC (BC CDC 2008b).

7.16.2.4 Wildlife Habitat

Wetland habitat assessment, forest bird habitat assessment, and habitat suitability mapping were conducted to identify important wildlife habitats within the Project area.

Wetland Habitat Assessment

Wetland habitats were assessed through a combination of field studies and digital wetland TRIM data analysis, which identified a total of 17 wetlands in the Project area (Appendix 31; Section 7.12). All five federally recognized wetland classes (bog, fen, marsh, swamp, and shallow open water) were found in the study areas, encompassing eight provincial wetland ecosystem associations and covering a total area of 66.75 ha. The most common wetland class was bog, which covered 33.15 ha of land. The most common wetland ecosystem association was spruce–creeping-snowberry–peat-moss (Wb01; 31.1 ha), which is a provincially blue-listed ecosystem. Several wetlands were surveyed for their value as habitat for amphibians and other wildlife such as moose and waterbirds. These surveys revealed the existence of breeding habitat for amphibians (western toad and Columbia spotted frog), waterfowl (Barrow's goldeneye, common goldeneye, bufflehead), beaver, and moose (Table 7.16-2) (Figure 7.16-2). Amphibian surveys were not conducted in the three wetlands that were mapped along the proposed transmission line (WL 001 A, WL 001b, and WL 003; Appendix 31), but a visual inspection of site photos revealed an absence of muddy shallow areas that allow western toads to move between the wetlands and upland. Therefore, these wetlands were deemed unlikely to support western toad breeding (L. Bol, pers. comm.).

Forest Bird Habitat Assessment

Songbird populations were surveyed during June, 2006, using standardized protocols, outlined in *Inventory Methods for Forest and Grassland Songbirds* (RIC 1999b; Appendix 36). Forest bird surveys included broadcasting recordings of northern goshawk, which is provincially red-listed in BC. If a call was returned in response to the recorded broadcast call, the presence of northern goshawk was confirmed.

There are nine broadly defined ecosystem types in the RSA, eight of which also occur in the LSA. The dominant ecosystem type in both the LSA and the RSA is mesic (moderately moist) forest. Water (including some ice and snow) covers the second largest area within the LSA and the RSA, followed by wetter forest. The spatial distributions of general habitat and ecosystem types in the RSA are shown in Figure 7.16-3. A similar map and further details, including descriptions of the general ecosystem types, are provided in Appendix 35.

Forest bird surveys were conducted in eight habitat types, five of which were forested (mature coniferous forest, young coniferous forest, young to mature mixed forest, regenerating pine clear-cuts, and riparian/wetland sites). The sites within mature coniferous forest and young to mature mixed forest had the highest avian richness and abundance. The amount of suitable goshawk nesting habitat in the Project area was similar to or somewhat lower than areas with comparable elevation ranges in the surrounding landscape. No goshawks or goshawk nests were found, although detection probability was thought to be low (Appendix 36).

Habitat Suitability Mapping

Wildlife habitat suitability mapping was completed to assess wildlife habitat for five focal mammalian species: grizzly bear, moose, mule deer, American marten, and fisher. The mapping of the RSA—defined by a 10-km radius around the proposed development—encompassed an area of approximately 100,255 ha. TEM and PEM were both used to develop the habitat suitability models. TEM was used to map the LSA near the Project footprint, while PEM results were extended to the RSA.

Habitat suitability ratings were developed for the following species, seasons, and life requisites:

- grizzly bear: spring, summer, fall (feeding)
- moose: winter (living)
- mule deer: winter (living)
- American marten: winter (living)
- fisher: winter denning (living)

Table 7.16-2
Lake, Pond, and Wetland Habitat Use by Wildlife in the Local Study Area

Site Name	Wetland Plot	Proposed development	Amphibian Observation	Bird Observation	Mammal Observation	Years	Reference	Wetland Class
Morrison Lake	–	N/A	–	Common loon Osprey Bald eagle (2 nests) Mallard Belted kingfisher Common merganser Lesser yellowlegs	Beaver Grizzly bear (tracks)	Aug 2004, November 2004, June 2006	1,2	Lake
W4 (Ore Pond)	MW01	Open Pit	Wood frog Columbia spotted frog	Barrow's goldeneye Common goldeneye Hooded merganser Belted kingfisher	Beaver dam	June 2006, July 2008	2	Swamp
W5 (Pond W)	–	Open Pit		Common goldeneye		July 2008	4	–
Booker Lake	–	Open Pit	Western toad Columbia spotted frog	Barrow's goldeneye Hooded merganser Bufflehead Bald eagle	Beaver dam	Nov 2004, June 2006, July 2008	1,2,4	Lake
W2 (TSF)	MW10	Tailings Storage Facility	Columbia spotted frog	Barrow's goldeneye Lesser yellowlegs Bufflehead Wilson's snipe Red-winged blackbird Green-winged teal Common yellowthroat Ring-necked duck	Beaver lodge	June 2006, July 2008	2,4	Marsh
–	MW07	Tailings Storage Facility	–	–	Beaver dam	July 2006 and July 2007	3	Marsh
–	MW06	Tailings Storage Facility	Frog	–	–	July 2006 and July 2007	3	Swamp

(continued)

Table 7.16-2
Lake, Pond, and Wetland Habitat Use by Wildlife in the Local Study Area (completed)

Site Name	Wetland Plot	Proposed development	Amphibian Observation	Bird Observation	Mammal Observation	Years	Reference	Wetland Class
W3 (TSF)	MW04, MW05	Tailings Storage Facility	Wood frog Columbia spotted frog	Ring-necked duck Green-winged teal Bufflehead Wilson's snipe Solitary sandpiper Horned grebe Lesser yellowlegs Common goldeneye	Beaver dam Moose	June 2006, July 2007, July 2008	2,3,4	Bog/Marsh
–	MW03	Tailings Storage Facility	–	Wildlife Trees	–	July 2006 and July 2007	3	Shrub-Carr
W1 (Pond X)	MW13, WL002	Waste Rock Dump	Western toad	Barrow's goldeneye Lesser yellowlegs Bufflehead	–	June 2006, July 2008	2,4	Bog/Fen

GIS No. MOR-23-029 Job No. 0793-001-01 April 8, 2009

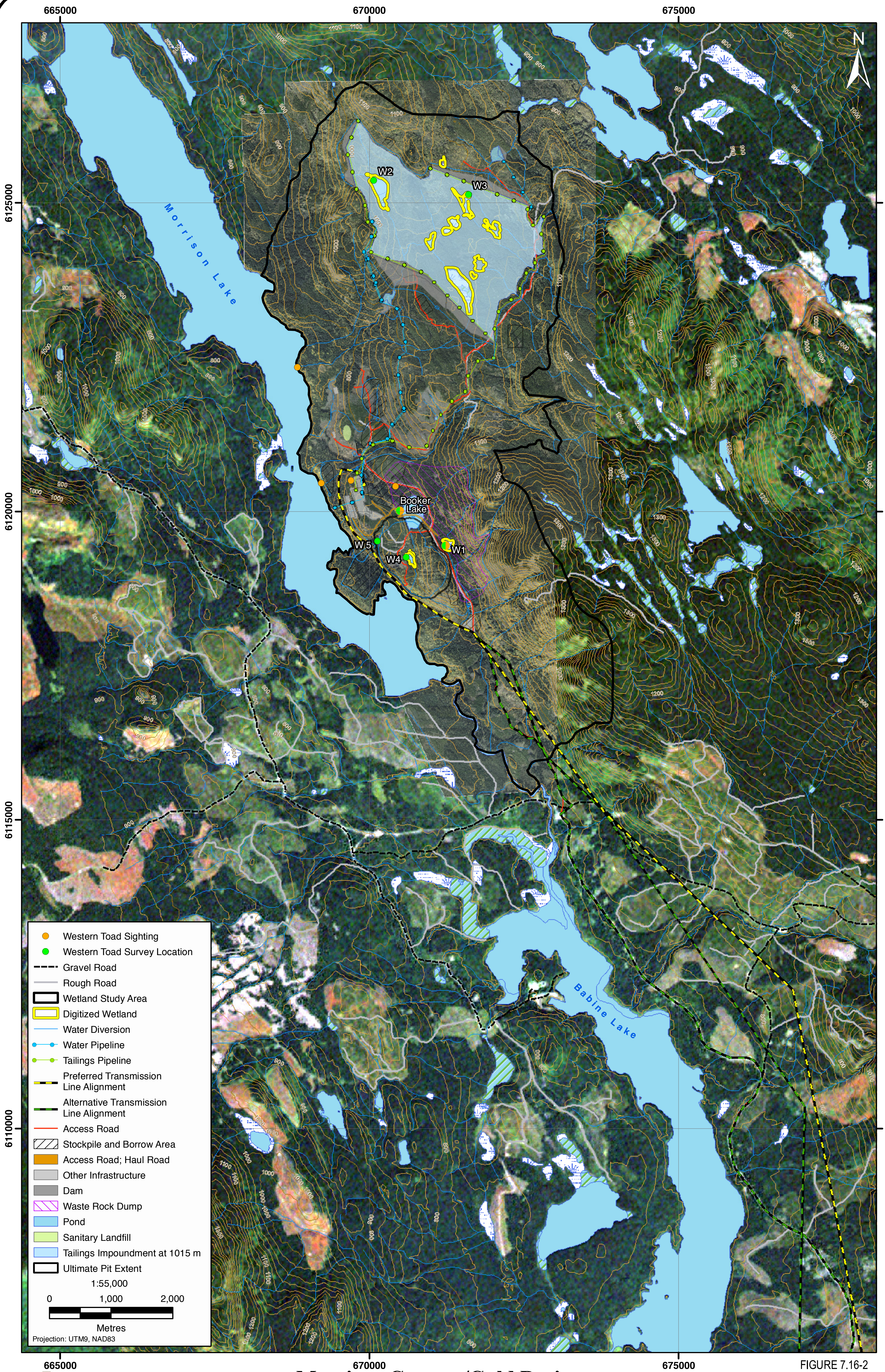

FIGURE 7.16-2

Morrison Copper /Gold Project
Location of Amphibian Surveys and Western Toad Observations, 2008

FIGURE 7.16-2

Habitat Types in the Morrison Copper/Gold Project Area

The following sections provide an overview of the habitat requirements, based on the species accounts and the habitat suitability maps, and a discussion of the use of the mapped habitats for each focal species. The species accounts, mapping methods, modelling assumptions, and suitability maps are described in detail in Appendix 37.

A summary of the wildlife habitat suitability in the LSA and RSA is outlined in Table 7.16-3 for each species. Suitable habitat includes areas with a ranking of "high," "moderately high," or "moderate" for each of the five wildlife species in the season(s) rated.

Table 7.16-3
Habitat Suitability Mapping Results

Suitable Habitat in LSA (ha)	Percent of LSA	Suitable Habitat in RSA (ha)	Percent of RSA
Grizzly Bear Spring			
12,636.03	81.74	67,834.94	79.95
Grizzly Bear Summer			
12,965.66	83.87	67,602.85	79.68
Grizzly Bear Fall			
13,343.85	86.32	71,729.42	84.54
Moose Winter			
10,871.73	70.32	55,725.90	65.68
Mule Deer Winter			
0.00	0.00	0.00	0.00
American Marten Winter			
10,313.19	66.72	59,731.64	70.4
Fisher Denning			
9,946.93	64.35	57,086.29	67.28

Suitable habitat is defined as all habitat rated moderate or better.

Grizzly Bear

Grizzly bears are a blue-listed species in BC and are federally listed as a species of special concern (COSEWIC 2002a). Grizzly bears have been identified by government regulators and stakeholders as a species requiring conservation consideration. Because of their important ecosystem function and conservation status, grizzly bears were selected as a focal species for wildlife habitat suitability studies for the Project.

The grizzly bear habitat suitability is primarily driven by the quality of available vegetative forage. Wildlife habitat ratings developed for grizzly bears considered the value of habitat during the spring, summer, and fall. Suitable grizzly bear habitat can cover large areas and broad elevation ranges; therefore, seasons were characterized both chronologically by date and by the succession of vegetation green-up (i.e., vegetation phenology) of forage species, which is often more biologically relevant than calendar date because of inter-annual weather variability.

Grizzly Bear Spring Habitat Requirements

Upon emerging from the den, grizzly bears predominantly feed on new emergent vegetation; they may also feed opportunistically on winter-killed or weakened ungulates. Grizzly bears typically descend in elevation from their high elevation den sites to lower elevation areas of early green-up. Habitats that tend to have the earliest green-up include low elevation south-facing slopes, riparian forests, and wetlands. These habitats/areas also generally overlap with ungulate late-winter/spring habitat. In the Project area, grizzly bears predominantly seek out cow parsnip meadows, low elevation alder-fern sites, riparian forest ecosystems, wet and rich forested stands (such as the spruce-horsetail and spruce-devil's club sites), and various wetland complexes (Appendix 37).

Grizzly Bear Summer Habitat Requirements

During the summer forage season, grizzly bears are observed to feed on the most diverse types of forage relative to other seasons. Some bears follow the green-up as it moves up in elevation and continue to feed on the same plant species as in the spring. In the Project area, berry species that are eaten by grizzly bears include black huckleberry (*Vaccinium membranaceum*), oval-leaved blueberry (*Vaccinium ovalifolium*), devil's club (*Oplopanax horridus*), red elderberry (*Sambucus racemosa*), high-bush cranberry (*Viburnum edule*), red raspberry (*Rubus idaeus*), black twinberry (*Lonicera involucrata*), and soopolallie (*Sheperdia canadensis*), among others. When available, salmon is also a staple of the late summer diets of grizzly bears. Chinook and Coho salmon are both present during late-summer in Morrison Creek. Because Morrison Creek is quite shallow and provides good access to spawning salmon, it is a suitable fishing area for bears.

Grizzly Bear Fall Habitat Requirements

Depending on availability, berries and salmon are the staple foods for grizzly bears throughout the fall. These food items are supplemented with ants and other insects until the first hard frost (Ciarniello 2006). Ciarniello (2006) found that grizzly bears most often ate black huckleberry compared to other berry-producing shrub species in the SBS and ESSF. These berries were most abundant in forest openings and old burn sites. Grizzly bears within the Project area likely share this preference. However, while old forestry cutblocks can support a suitable amount of berry production, most of the cutblocks within the Project area are on drier zonal sites that do not support as much berry production. Grizzly bears may also use alpine areas extensively in the fall to obtain berries and marmots as food items.

Sockeye salmon are also plentiful in Morrison Creek in September and early October. Consuming salmon during this period helps grizzly bears to rapidly increase their fat reserves in preparation for winter hibernation. Abundant signs (tracks and faeces) were found above and below the fish counting weir on Morrison Creek (Appendix 39).

Habitat Suitability Model

Habitat suitability modelling for grizzly bear focused on spring, summer, and fall seasons. Within the LSA and RSA, respectively, 12,636.03 ha (81.74%) and 67,834.94 ha (79.95%) of suitable spring habitat, 12,965.66 ha (83.87%) and 67,602.85 ha (79.68%) of suitable summer habitat, and 13,343.85 ha (86.32%) and 71,729.42 ha (84.54%) of suitable fall habitat were identified (Table 7.16-3; tables 3.2-1, 3.2-2, 3.2-3 in Appendix 37). In spring, suitable grizzly bear habitats were associated with wetlands and areas of high-quality late-winter moose habitat because of the abundance of forage and prey (i.e., winter-weakened or killed ungulates). High to moderately high value spring feeding habitats were limited (4% in LSA, 6% in RSA) within the study areas. In the summer and fall, high- and moderately high-quality habitats for grizzly bear were abundant in the study areas (69% [LSA in summer], 60% [RSA in summer] 67% [LSA in fall], and 58% [RSA in fall]), providing berries and salmon for grizzly bear diets. Further information and detailed maps are available in Appendix 37.

Moose

Moose have a high economic and social importance within the region associated with Morrison Lake. Moose are important for both subsistence and recreational hunters of the Lake Babine Nation, BC residents, and non-resident hunters (Appendix 42).

Winter Habitat Requirements

The moose habitat suitability ratings were developed to predict the suitability of winter habitat. While other habitats are also important, winter habitat is generally the limiting factor in the carrying capacity of the land base for moose because of increased energy demands associated with moving through the snowpack and the reduced nutritional quality of forage. Winter may also last as long as six months in the sub-boreal interior ecoprovince (RIC 1999a), adding to the limiting nature of this season. The most extreme winter conditions (i.e., when snowpack is most limiting to habitat use) were considered for the model. Accordingly, these ratings may more appropriately be considered late-winter habitat ratings.

Moose generally prefer forested habitats that are semi-open and have abundant browse (Pierce and Peek 1984; Stevens and Lofts 1988), and they are often associated with young forests, riparian forests, and wetlands (Stevens 1995). Ideal habitat for moose consists of a mosaic of shrubby plants (including burn patches and cutblocks), and mature forest that enhances the diversity of plant species and creates various seral stages (young, intermediate, and mature forests) (Stevens and Lofts 1988). A study by Pierce and Peek (1984) highlights that mature stands are used throughout the year (50% in summer, 50% in winter) and old growth forest stands were shown to be used more than expected based on availability during fall, winter, and spring.

Moose habitat suitability for living during the winter season was derived from habitat ratings that were based on a combination of feeding and security/thermal requirements. Feeding habitat requirements were met in ecosystems likely to produce suitable forage species such as willow (*Salix* sp.) and other shrub species. Security/thermal habitat was mainly based on the ability of a location to provide shelter from the snow (e.g., relatively closed canopy forests).

Moose Feeding Habitat Requirements

Plant species consumed by moose vary with geographic location (Peek 1974); however, twigs of shrubs and trees (i.e., browse) are the primary food eaten by moose in the winter (Stevens and Lofts 1988). The main species consumed by moose in early winter are willow, red-osier dogwood, and paper birch. The main species eaten by moose in late winter are willow, paper birch, subalpine fir (Eastman 1977), and aspen bark (Stevens and Lofts 1988). Moose in north-central BC are also known to eat falsebox (Peek 1974), high bush cranberry, Saskatoon berry, trembling aspen, and mountain ash (Westworth et al. 1989; Poole and Stuart-Smith 2005). A study by Poole and Stuart-Smith (2005) suggests that shrub cover (willow cover in particular) is a main factor influencing moose winter foraging areas. High densities of willow coverage are found in riparian valley bottoms and early seral cutblocks; they are also found in mesic areas within mid-seral to older pine and fir stands (Poole and Stuart-Smith 2005).

Moose Security/Thermal Habitat Requirements

Winter security and thermal habitats for moose include closed canopy coniferous forests that provide shelter from snow and wind (Coady 1974; Eastman 1974; Peek, Urich, and Mackie 1976). In BC, moose use forests with high canopy closure when snow depths are greater than 90 cm (Schwab 1985). Dense stands with more than 60% conifer species that are greater than 10 m in height provide moose with the best thermal protection and reduced snow depth (Allen, Jordan, and Terrell 1987).

Habitat Suitability Model

Habitat suitability modelling for moose focused on the winter season. Within the LSA and RSA, respectively, 10,871.73 ha (70.32%) and 55,725.90 ha (65.68%) of suitable winter habitat was identified (Table 7.16-3, Table 3.3-1 in Appendix 37). In general, these habitats were associated with low-elevation mesic forests, wetter shrub/herb, and drier shrub/herb ecosystems in the SBS BEC zones. High-value winter moose habitat is limited within the study areas (<1% in LSA and 1% in RSA); the majority is of moderate or moderately high quality. In addition, moose habitat quality was evaluated during aerial surveys in March, 2005, which determined that the west face of Hearne Hill and the area between the proposed open pit site and Morrison Lake are areas of high-value forage. Further information and detailed maps are available in Appendix 37.

Mule deer

Mule deer are an economic and social resource within the region associated with Morrison Lake. This species is important for both subsistence and recreational hunting by the Lake Babine Nation, BC residents, and non-resident hunters (Appendix 42).

The mule deer habitat suitability ratings were developed to predict the suitability of winter habitat. Similar to moose, winter habitat is the limiting factor in the carrying capacity of the land base for deer because of increased energy demands associated with moving through the snowpack and the reduced nutritional quality of forage during this long season (Armleder, Dawson, and Thomson 1986). The most extreme winter conditions (i.e., when the snowpack limits habitat use the most) were considered for the model. Therefore, these ratings may more appropriately be considered late-winter habitat ratings.

Winter Habitat Requirements

Winter habitat requirements for mule deer combine feeding, security, and thermal life requisites. Deer adapt to winter conditions by selecting areas with a shallow snowpack, adequate food, and sufficient shelter that offers security cover and favourable thermal environments (Armleder, Dawson, and Thomson 1986; Kirchhoff and Schoen 1987). As winter progresses, deer generally move from areas of deeper snow to areas with south-facing aspects, windswept ridges, and lower elevations where snowpacks are shallower (Martinka 1968; P. F. Gilbert, Wallmo, and Gill 1970; Armleder et al. 1994). Aspect, topography, slope, and micro-habitat also influence winter habitat use by mule deer (Armleder, Dawson, and Thomson 1986). Northeastern-facing aspects often host forest stands with a high crown cover, which intercepts snow and decreases the snow depth on the forest floor. Sloped ground on south-facing aspects is also warmer; thus, the snowpack is reduced quickly in such areas. Topography is important as it influences snow characteristics, site temperature, and stand development. Slope is important because larger slopes have larger surface areas over which snow can be distributed; consequently, they are associated with reduced snow depth. As snow depth increases, slope and aspect become increasingly important considerations for habitat suitability. In areas of high snow depth, slopes of 35 to 55% and southeastern to western aspects are most important to mule deer.

Winter Feeding Habitat Requirements

Mule deer typically select mature forest stands because they offer more available (i.e., less buried) forage and facilitate ease of travel through a reduced snowpack (Harestad 1979). In the BC interior, deer have been shown to primarily use mature Douglas-fir dominated forest types and their use of these stands increases significantly when snow depth exceeds 25 cm (Armleder et al. 1994). Within this region, mule deer used regenerated stands (1 to 40 years) significantly less often when they contained deep snow as compared to lower snow depths ranging from 0 to 25 cm. They also used open range habitat less than expected at all snow depths (Armleder et al. 1994). Douglas fir is an important winter food for mule deer in the BC interior (R. J. Dawson, Armleder, and Waterhouse 1990; Waterhouse, Armleder, and Dawson 1994), making up 60 to 95% of winter mule deer diets (R. J. Dawson, Armleder, and Waterhouse 1990). To a lesser extent, Saskatoon berry, soopalallie, and willow are present in mule deer diets throughout the BC interior. Oregon grape, subalpine fir and red-osier dogwood are abundant in the diet of mule deer in SBS biogeoclimatic zones of this region (R. J. Dawson, Armleder, and Waterhouse 1990; Waterhouse, Armleder, and Dawson 1994).

Winter Security/Thermal Habitat Requirements

Shelter is provided to mule deer through security cover, thermal cover, and snow interception (Armleder et al. 1998). A multi-layered structure provides mule deer with visual cover and favourable thermal conditions, as it reduces air movement and decreases outward radiation (Armleder, Dawson, and Thomson 1986). Shrubs and trees also provide bedding sites (Stevens and Lofts 1988). Deer use mature stands for their thermal attributes and the snow interception that the layered structure and high crown cover of mature trees provide (Kirchhoff and Schoen 1987). Crown closure is important for mule deer because it ensures a high degree of snow interception (Kirchhoff and Schoen 1987).

Habitat Suitability Model

Habitat suitability modelling for mule deer focused on the winter season. Because of the deep snowpack in the study areas, mule deer are not anticipated to be able to make use of the habitat.

Therefore, the majority of the habitat was identified as very low quality for the SBS and nil for the ESSF BEC zones. No suitable (neither moderate, moderately high, nor high) habitat was identified within the LSA or RSA (Table 7.16-3, Table 3.4-1 in Appendix 37). Although only a small amount of low-quality habitat was identified in the RSA (<0.5%), mule deer may be able to use additional areas within the RSA that were not identified by the modelling. Further information and detailed maps are available in Appendix 37.

American Marten

American marten are economically important within the region and are currently harvested in the area (Appendix 42). Given the limited criteria for winter habitat suitability and the higher energy demands for thermoregulation and travel through the snow, winter is considered to be the critical (limiting) season for American marten. The American marten winter habitat suitability model relied on the ecosystem mapping products, and was based on a four-class rating scheme: high, moderate, low, and nil.

Winter Habitat Requirements

Winter habitat was assessed for its potential to provide food and shelter for American marten. Optimal American marten winter habitats include mesic to hygric mature and old growth coniferous forests with an abundance of coarse woody debris (CWD), 20 to 60% canopy closure with low deciduous canopy, and low to intermediate shrub cover (Koehler and Hornocker 1977). In winter, American marten avoid open meadows and burn sites, and were observed to pass through, but not hunt in, openings less than 100 m in width (Koehler and Hornocker 1977).

Winter Feeding Habitat Requirements

CWD is important in American marten winter feeding habitat because it provides habitat for prey as well as access points for marten into to subnivean areas to hunt for those prey (Corn and Raphael 1992; Buskirk and Ruggiero 1994). American marten typically feed on small mammals whose winter distributions often correspond directly with winter forage habitat value (Buskirk and Ruggiero 1994). American marten were observed to forage less in younger successional stage forests than in older aged forest stands (Koehler, Blakesley, and Koehler 1990). The selection of older versus younger successional stands is likely linked to the selection of habitat that hosts their preferred primary winter prey species. Red-backed voles were found in highest densities in forested habitats (Buskirk and Macdonald 1984), closely associated with large diameter logs (Hayes and Cross 1987) and plant cover (Nordyke and Buskirk 1991).

Cover may have an important influence on marten prey abundance (Coffin et al. 1997). Red squirrels (*Tamiasciurus hudsonicus*) require cones produced by late successional conifer stands (Flyger and Gates 1982), and snowshoe hare *(Lepus americanus*) prefer dense mature conifer stands (Bookhout 1965). Overall, mesic habitats supported the greatest rodent populations and understorey plants, whereas xeric (drier) sites were only suitable for deer mice (Koehler and Hornocker 1977). American marten also benefit from overhead canopy cover that minimizes excessively deep snow, as snow depths greater than 30 cm may limit access of American marten to subnivean prey (Boyd 1977; Koehler and Hornocker 1977).

Winter Security/Thermal Habitat Requirements

Spruce- and fir-dominated habitat tends to provide the best cover for American marten in winter, as it provides security from predators and thermal shelter. Security and thermal shelter are provided by an abundance of CWD, high shrub and low shrub closure, canopy closure, and the presence of trees and snags (Lofroth 1993). CWD, decayed stumps, and large diameter trees provide American marten with access to well-insulated subnivean rest areas typically in cavities of decayed logs, snags, stumps, and squirrel middens (Steventon and Major 1982; Buskirk 1984; Buskirk et al. 1989). High and low shrub cover and canopy closure is important for American marten, as it reduces predation risk (Buskirk and Ruggiero 1994), and likely influences foraging opportunities (Lofroth 1993; Buskirk and Powell 1994; Krohn, Zielinski, and Boone 1997). Early and late successional stages provide cover through shrubby vegetation and lower tree branches, respectively. Studies have suggested that canopy closures of more than 50% are optimal for American marten; however, canopy closures between 30 and 50% are also acceptable (Koehler and Hornocker 1977; Spencer, Barrett, and Zielinski 1983; Strickland and Douglas 1987; Lofroth and Steventon 1990).

Habitat Suitability Model

Habitat suitability modelling for American marten focused on the winter season. Within the LSA and RSA, respectively, 10,313.19 ha (66.72%) and 59,731.64 ha (70.40%) of suitable winter habitat was identified (Table 7.16-3, Table 3.5-1 in Appendix 37). In general, high-quality habitat occurs in older, mesic forests with an abundance of CWD in the RSA. Within the LSA, most of the mine footprint area is high-quality habitat, while habitat along the transmission line is divided almost equally between high- and low-quality habitat. Further information and detailed maps are available in Appendix 37.

Fisher

The fisher is an economic resource within the region and its pelts are highly valued in the fur trapping industry. However, habitat loss due to forest harvesting and other practices is reducing fisher habitat, and likely population numbers, across the province. The fisher winter/denning habitat suitability model relied on the ecosystem mapping products developed for the Project, and was based on a four-class rating scheme: high, moderate, low, and nil.

Winter Habitat Requirements

Winter habitat requirements for fisher focused on feeding and denning conditions, as the winter season is the limiting factor for fisher. Clear patterns of denning habitat use during the winter have been demonstrated in other studies (Raine 1983; J. H. Gilbert et al. 1997). Snow depth and the amount of CWD in an area are the main limiting habitat attributes for fisher winter habitat (Raine 1983; Arthur, Krohn, and Gilbert 1989).

Winter Feeding Habitat Requirements

Banci (1989) found that the winter diets of fisher tend to consist of snowshoe hare and red squirrel. Typical feeding habitats include mature coniferous stands with high levels of CWD that support healthy prey populations and provide a high degree of canopy closure for snow interception. Fisher also forage in riparian areas for small mammals and in shrubby habitats that support snowshoe hare populations. Fisher rarely use open habitats that lack any form of overhead shrub or tree cover for foraging (Raine 1981; Weir 1995), and when crossing these habitats, they usually move quickly (Powell 1981). Sufficient overhead cover can consist of trees or shrubs.

Winter Security/Thermal/Denning Habitat Requirements

Fishers use many different structures for security and thermal regulation in the winter season. These structures include subnivean burrows, snow dens, hollow logs, tree cavities, large branches, and witch's brooms (diseases or deformities in a woody plant) for resting dens (Powell 1977; Weir 1999). In BC, Weir (2003) recorded fishers using branch rest structures most frequently (57.0%), followed by cavity (19.8%), CWD (18.6%), and ground rest structures (4.6%). Fishers typically den in old growth, conifer-dominant forests with some deciduous vegetation to provide the required structure for resting den sites, particularly CWD. Weir (2003) found that fishers moved to subnivean spaces within or beneath CWD exclusively when temperatures were below -15°C. In the absence of restrictive thermoregulatory demands, fisher probably select arboreal resting sites because of the increased protection from predators provided by an elevated vantage point, with the additional advantage of improved detection of prey (Raphael and Jones 1997).

Habitat Suitability Model

Habitat suitability modelling for fisher focused on the winter denning season. Within the LSA and RSA, respectively, 9,946.93 ha (64.35%) and 57,086.29 ha (67.28%) of suitable denning habitat was identified overall (Table 7.16-3, Table 3.6-1 in Appendix 37). In general, high-quality habitat occurs in older, mesic forests and along low elevation riparian areas in the study areas. Within the LSA, most of the mine footprint area is high-quality habitat, while habitat along the transmission line is divided almost equally between high- and low-quality habitats. Further information and detailed maps are available in Appendix 37.

7.17 Archaeology and Heritage Resources

7.17.1 Introduction

This section describes the environmental setting for archaeology and heritage resources for the Project (Figure 7.1-1). The archaeological and heritage resources study focused exclusively on the physical remains of cultural heritage and those sites protected under the *Heritage Conservation Act*, R.S.B.C. 1996, c. 187 (HCA; see Appendix 41). Separate studies for the Project were conducted for Aboriginal traditional knowledge and current land use (see Chapter 6 and Appendix 42). The archaeology and heritage study consisted of background research, an archaeological overview assessment (AOA), and an archaeological impact assessment (AIA). Background research was undertaken to establish the context in which archaeological and heritage resources are found within the region. This consisted of a review of the natural setting (paleo-environmental conditions and biogeoclimatic setting), ethnographic background, historical background (including past mining and logging activities), and known archaeological resources. The AOA, which included preliminary field reconnaissance (PFR), assessed the archaeological potential for the Project area and determined that an AIA would be required.

The study was conducted under HCA Heritage Inspection Permit 2006-309, issued by the Archaeology Branch, BC Ministry of Tourism, Culture and the Arts. The AOA was conducted in 2006 and 2007. The AIA was undertaken during the 2008 and 2009 field seasons and involved a field examination of the Project footprint to identify and record possible archaeological sites.

7.17.2 Methodology

7.17.2.1 Background Research

Background information was reviewed for the Project footprint and the surrounding region. This included ethnographic and historical studies, traditional use and ecological knowledge studies, previous archaeological investigations, previously recorded archaeological sites, and topographic and orthophotographic maps. Reports on past archaeological studies were obtained from the Archaeology Branch, BC Ministry of Tourism, Culture and the Arts and archaeological site forms were obtained through a database search of the Remote Access to Archaeological Data, held by the Archaeology Branch. Published information available from the Simon Fraser University library, University of British Columbia library, and Vancouver Public Library was also reviewed.

TU/TEK information was collected for the area in and around the Morrison Project from 2007 to 2008 in collaboration with Lake Babine Nation leadership and community members. Lake Babine Nation review of and approval for the release of the TU/TEK information gathered and reported is still pending.

7.17.2.2 Field Methods

A copy of the HCA permit application for the Project was sent for review to the Lake Babine Nation by the Archaeology Branch on July 24, 2006. On August 28, 2006, a copy of the HCA permit was sent to the Lake Babine Nation. In December, 2006, a slow, low-level helicopter reconnaissance flight was conducted by Verna Power (Old Fort Councillor, Lake Babine Nation), Alex Michell (Old Fort Hereditary Chief, Lake Babine Nation), and Kathryn Scott (Traditional Use Specialist, Rescan) and Lisa Seip (Senior Archaeologist, Rescan). The objectives were: to identify areas of traditional use, observe the terrain to assess the archaeological resource potential of the Project area, and to identify the need and scope of further field studies. On June 6, 2007, a PFR was conducted that involved examination of ground surface exposures and a visual assessment of the terrain. The fieldwork for the AIA (Appendix 41) was conducted from June 3 to 12, November 12 to 16, 2008 and June 30 to July 3, 2009. Members of the Lake Babine Nation participated in the PFR in June, 2007, and in the AIA field assessment in 2008 and 2009. The field methods employed for this study were consistent with those outlined in HCA Heritage Inspection Permit 2006-309.

For further information on the design, methodology, scope of work, results, and involvement of the Lake Babine Nation in the archaeological field work (AOA and AIA) refer to Appendix 41 Morrison Copper/Gold Project Archaeological Impact Assessment Interim Report.

7.17.3 Natural Setting

7.17.3.1 Paleoenvironment

The Project is on the Nechako Plateau within the Intermountain Belt of central BC. The area is characterized by a northern interior continental climate of moist and cold conditions. During the Pleistocene, the area was covered by glacial ice and was not habitable until approximately 10,000 to 13,000 years ago, when the ice receded (Cannings and Cannings 2004). While post glacial climatic and environmental conditions are not well known in the area, it is likely that re-vegetation of the area immediately followed deglaciation and may have provided a suitable environment for human habitation between 10,300 years ago (Dixon 1999) to 9,500 years ago (Ryder and Clague 1989). The Hypsithermal Interval, which occurred between approximately 10,000 and 7,000 years ago, was characterized by warmer temperatures and periods of drought (Clague and MacDonald 1989). This was followed by a period between 7,500 and 4,500 years ago of increased precipitation, warm, but cooler temperatures than previously and the expansion of forested areas. Between 4,500 and 3,000 years ago the climate was moister and cooler than present. By 3,000 years ago the climatic conditions stabilized to those similar to today with a few periods of cooler temperatures.

7.17.3.2 Biogeoclimatic Zones

Regionally, the landscape is characterized by rolling uplands with low ridges and numerous lakes and is within two biogeoclimatic zones: the Sub Boreal Spruce Moist Cold-Babine Variant and the Engelmann Spruce Sub-Alpine Fir Moist Very Cold-Omineca Variation. Within these two biogeoclimatic zones, elevation ranges from valley bottoms to mountain peaks from 900 to 1,700 m. Coniferous forest cover is dominant in the region, with subalpine parklands found at higher elevations (for more information see Appendix 35; Meidinger and Pojar 1991).

7.17.4 Cultural Setting

The Project is within the asserted traditional territory of the Lake Babine Nation who speak a dialect of the Babine-Witsuwit'en language, part of the Athabaskan-Eyak-Tlingit language family (Kari 1975; Story 1984; Yinka Dene Language Institute 2006). In early ethnographic records, they have been described as a division of the Carrier tribe (Jenness 1943; Tobey 1981).

The Lake Babine people traditionally managed the land through the potlatch system, including the rights to hunt and fish in certain areas. They followed a seasonal round, following the plants and animals in the region, which provided food sources throughout the year. Though members of the Lake Babine Nation now live primarily in four locations and use Old Fort seasonally, they traditionally lived in small settlements scattered along the shores of Babine Lake (Jenness 1943; Fiske, Marucci, and Power 2000). Trade was important for the Lake Babine people, as they were situated in a fortuitous location for the movement of goods from east to west. Many well-established "grease" trails used in the transportation of eulachon oil and other trade items in the region attest to the importance of trade in the area. To the north of the Project area the Babine Lake Grease Trail connected Takla Lake to Fort Babine and then continued to the Gardner Canal on the Pacific coast (G. Dawson 1881; MacDonald and Cove 1987). Late summer and early fall were an important time for the annual salmon runs. Following the salmon runs the Lake Babine people continued to fish for other freshwater species. They hunted large game, trapped smaller fur-bearing animals, and harvested plants for food and medicine. In addition to hunting around Babine Lake, they made annual trips up to the mountain tops to hunt mountain goats and sheep (Jenness 1943; Fiske, Marucci, and Power 2000).

The following ethnographic sources were reviewed and considered: Brown (1823; 1826), Duff (1964), Fiske et al. (2000), Fiske and Patrick (2000), Furniss (1993a; 1993b), Hackler (1958), Hall (1992), Hargus (1991), Harmon (1905), Jenness (1934; 1943), Kew (1956), Kobrinksy (1973), Morice (1889; 1892; 1893; 1904; 1910), Ogden (1842), Tobey (1981), Turnbull (1966), and Whitehead (1988). Additional traditional use and knowledge for the general area can also be found in Budhwa (2007), Fiske et al. (2000), and Fiske and Patrick (2000). For information specific to current land use in the Project area, refer to Appendix 42.

7.17.5 Historic Setting

7.17.5.1 Trade

Prehistorically and historically, trade has played an important role in the region. Trails were used by both Aboriginal communities and European fur traders and connected inland areas with the resource-rich Pacific coast. Many of these trails were originally established by Aboriginal communities as trade corridors and by the time the first European traders arrived in the Babine area in the late 1700s, well-established trade networks were already present (Figure 7.17-1). A permanent trading post, Fort Kilmaurs (also known as Fort Babine and later Old Fort) was established in 1822 by the Hudson's Bay Company (HBC) and a native settlement quickly established itself near the Fort (Plate 7.17-1). The Fort was built near the point between the two northern arms of Babine Lake. The HBC chose this location because of its favourable position near a large salmon fishery (which allowed for the procurement of salmon to supply Fort St. James to the south, the trade headquarters and storehouse for trade goods for the trading district of New Caledonia) and the potential to tap into the active trade network that was already established in the region. However, by 1836, with the Fort in considerable need of repair, the salmon fishery farther away than was practical (over 56 km to the north), and the lack of success tapping into the fur trade in the region, it was decided that the Fort would be moved to the end of the northwestern arm of Babine Lake, only 11 km from the salmon fishery (Morice 1910). Although materials to build the new Fort Babine were ready by the autumn of 1838 difficult relations with the local inhabitants in the area delayed construction by 50 years (Morice 1904).

7.17.5.2 Gold Rush

The Omineca Gold Rush also played a part in the history of the region and saw a temporary increase in the use of local trail networks. In 1869, when the gold rush in the region began, prospectors travelled up the Skeena River and along a rough trail from Hazelton (Gitenmax) to Babine Lake and on to the Omineca (Large 1957; Fiske and Patrick 2000). Traffic through the Babine region began to subside with the improvement of transportation to the Omineca region from the Fraser River and the gold rush eventually ended in 1873 with news that gold had been discovered in the Cassiar District (Taylor 1978).

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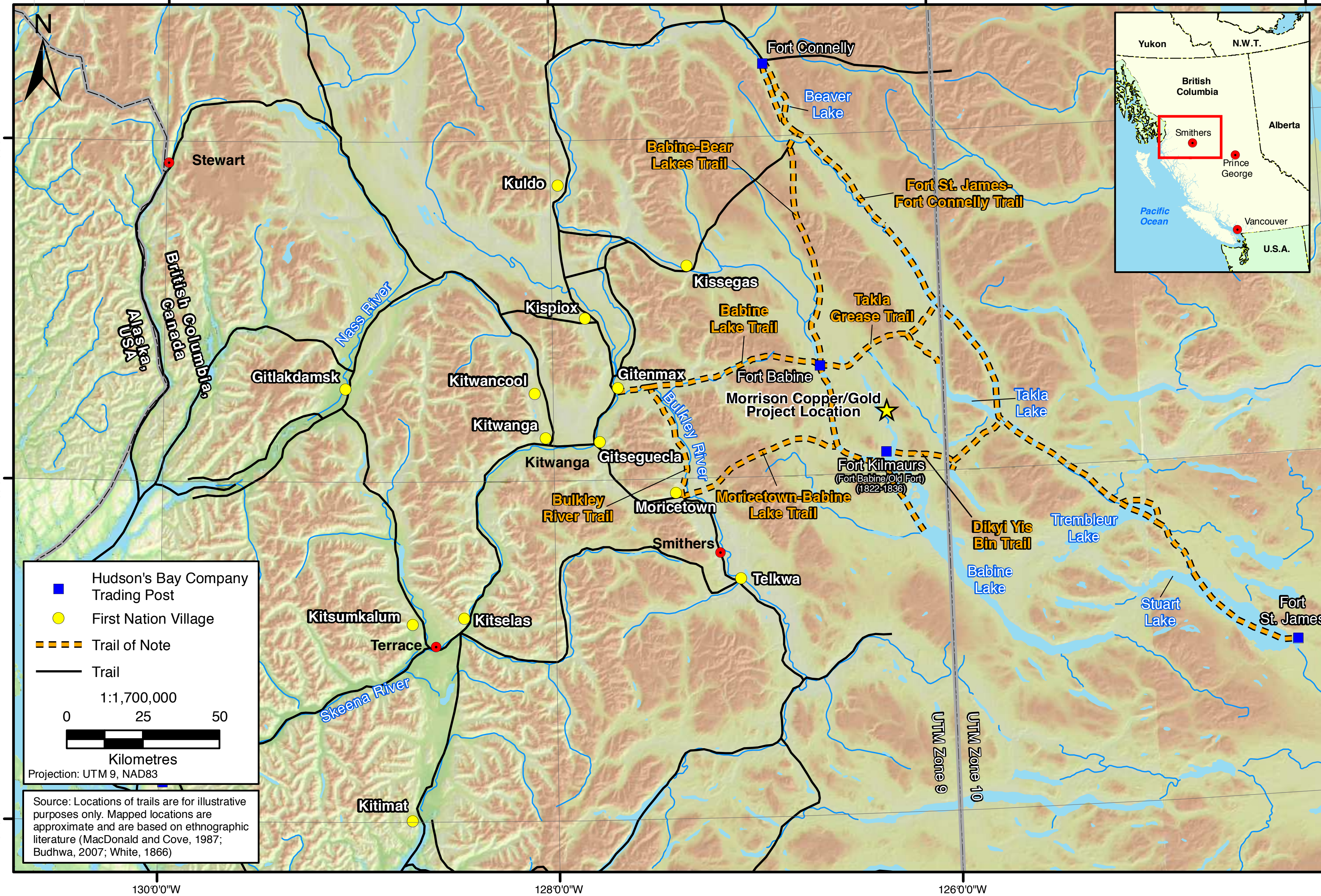
August 6, 2009



Morrison Copper / Gold Project
Trails, Trade Routes and Historic Sites

FIGURE 7.17-1

pbm

Rescan™

Plate 7.17-1. Seasonal settlement of Old Fort, December 2006.

7.17.5.3 Recent Mining

The Project is near two former copper/gold projects: the Bell Mine operated from 1972 to 1992 and is 22 km to the south of the Project, and the Granisle Mine operated from 1966 to 1969 and is 29 km to the south. The Morrison deposit was discovered in 1962 by Noranda Exploration, which continued with exploration activities until 1973. They completed six drilling programs consisting of a total of 95 holes. Further exploration was done from 1998 to 2002 by PBM, which undertook a comprehensive drilling program on the property. Drilling activities involved the clearing of land and levelling the ground surface for equipment and has resulted in some isolated areas of land surface disturbance throughout the property (Plate 7.17-2).

7.17.5.4 Recent Logging

Logging and associated forestry activities have occurred in the region since the 1970s (Drushka 1998) and have had a significant effect on the landscape (Plate 7.17-3). The area is within the forest management area of Canfor and selected timber harvesting areas have been logged. Additionally portions of the Project area were subject to a forest fire in the early 1900s.

Plate 7.17-2. Ground disturbance at an old drilling site in the open pit area.

Plate 7.17-3. Effect of logging activities in the Project area.

7.17.6 Archaeological Setting

7.17.6.1 Previous Archaeological Investigations

The Babine Lake region is known to have a rich cultural heritage that includes both pre-contact/prehistoric sites, important post-contact sites, and numerous trails used both prehistorically and historically. AIAs have been conducted for a number of timber harvesting areas in the immediate Project vicinity within Canfor's forest management area (Norcan 1999, 2001, 2002, 2003). Archaeological shoreline investigations have also been conducted along the

Morrison Arm of Babine Lake (G. Mohs 1974, 1975; A. Mohs and Mohs 1976). Additional archaeological studies in the region include: Arcas (1997; 1999; 2001), Carlson (1997; 1998), I.R. Wilson (1998), Irvine (1980), Simonsen (1984), and Traces (1999). Many of these archaeological assessments were conducted for the forestry industry and have largely focused on defined and localized cut block units.

In general, the predominately recorded archaeological site types in the region include habitation sites, cultural depression and cache pit sites, CMT sites, trails, and historic sites. The majority of recorded sites in the area tend to cluster along the shorelines of lakes.

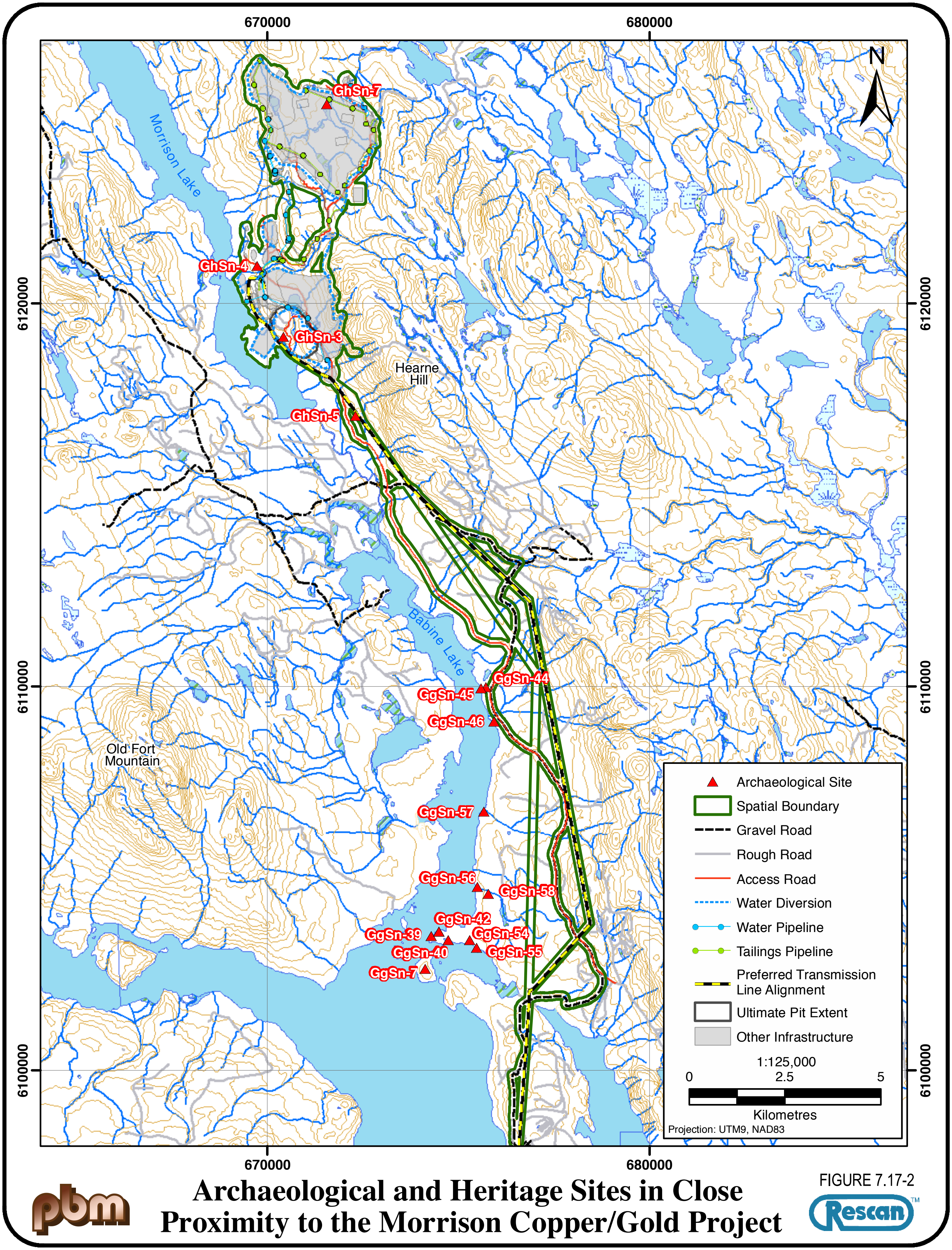
7.17.6.2 AIA Results for the Project

Four archaeological sites have been recorded in the Project footprint: GhSn-3, GhSn-4, GhSn-5, and GhSn-7 (Table 7.17-1 and Figure 7.17-2). GhSn-3 is within the open pit boundaries, GhSn-4 is to the northwest of the WRD in association with other infrastructure, GhSn-5 is approximately 100 m from options A and B of the TLSC, to the southeast of the MFA, and GhSn-7 is in the TSF area. GhSn-3, GhSn-4, and GhSn-5 are all CMT sites that postdate 1846 AD and are in harvested cut blocks. These sites are in poor condition with few CMTs remaining. As a management strategy, some of the CMTs in these areas were stumped above the scars in an effort to preserve them during logging activities. CMTs remaining in these areas are generally in poor condition and in various states of decay. Additionally, these sites are not protected by the HCA. GhSn-7 is a pre-contact period (prehistoric) site, with an overall moderate significance, characterized by lithic materials made of sedimentary rock (Plate 7.17-4) and is protected by the HCA (see Appendix 41 for additional information).

Table 7.17-1
Archaeological Sites within Project Footprint

Site Borden #	Project Component	Site Type	Comments	Source
GhSn-3	Open Pit	CMT site	Site is not protected by the HCA and has been heavily affected by logging.	Norcan (2001)
GhSn-4	Other Infrastructure	CMT site	Site is not protected by the HCA and has been heavily affected by logging.	Norcan (2001)
GhSn-5	Transmission Line Study Corridor – Options A and B	CMT site	Site is not protected by the HCA and has been heavily affected by logging.	Norcan (2001)
GhSn-7	Tailings Storage Facility	Lithic scatter site	Site is protected under the HCA	Appendix 41

A total of 12 other archaeological sites are within 2.5 km of the Project footprint (Table 7.17-2 and Figure 7.17-2). These sites include cultural depressions, CMTs, and trails. Although they fall outside of the Project footprint, they add to the understanding of the archaeological setting for the region. In addition, numerous historic blazed trees were found in the MFA and along the TLSC. While recently blazed trees (10 to 50 years old) were noted during the 2008 field assessment, they will not be discussed further as none predate 1846 AD and therefore are not protected by the HCA.



Archaeological and Heritage Sites in Close Proximity to the Morrison Copper/Gold Project

FIGURE 7.17-2

Plate 7.17-4. Core fragment (left) and flakes (right) found at site GhSn-7.

Table 7.17-2
Archaeological Sites Near the Transmission Line Study Corridor

Borden Number	Site Type	Associated Land Formation	Distance from TLSC	Source
GgSn-7	10 Cultural depressions/cache pits	N side of island	2.5 km west of Option A	Mohs (1974)
GgSn-39	1 Cultural depression/cache pit	W tip of peninsula on Morrison Arm, Babine Lake	2.5 km west of Option A	Mohs and Mohs (1976)
GgSn-40	1 Cultural depression/cache pit	S side of peninsula on Morrison Arm, Babine Lake	2.1 km west of Option A	Mohs and Mohs (1976)
GgSn-42	1 Cultural depression/cache pit	NW side of peninsula on Morrison Arm, Babine Lake	2.4 km west of Option A	Mohs and Mohs (1976)
GgSn-44	CMT site (1915-1946 AD)	S of small marsh	163 m west of Option C	Norcan (2001)
GgSn-45	CMT site (1865-1932 AD)	E shore of Babine Lake	270 m west of Option C	Norcan (2001)
GgSn-46	CMT site (1846-1930 AD)	S of small unnamed creek	154 m west of Option C	Norcan (2001)

(continued)

Table 7.17-2
Archaeological Sites Near the Transmission Line Study Corridor

Borden Number	Site Type	Associated Land Formation	Distance from TLSC	Source
GgSn-54	1 Cultural depression	S side of peninsula on Morrison Arm, Babine Lake	1.4 km west of Option A	Norcan (2002)
GgSn-55	1 Cultural depression/cache pit	S side of peninsula on Morrison Arm, Babine Lake	1.6 km west of Option A	Norcan (2002)
GgSn-56	4 Cultural depressions	S of small unnamed creek	1.4 km west of Option A	Norcan (2002)
GgSn-57	1 Cultural depression	S of small unnamed creek	1.3 km west of Option A	Norcan (2002)
GgSn-58	Trail (length ~600 m)	S of small creek	1.0 km west of Option A	Norcan (2002)

7.18 Land and Resource Use

7.18.1 Introduction

This land and resource use environmental setting provides an overview of the land tenures and uses near the Project area. The Project is on Crown land within the asserted territory of the Lake Babine Nation and the Morice Land and Resource Management Plan (LRMP). Various tenure holders operate within the study area, including guide outfitters, trappers, anglers, and mineral and placer title holders. Furthermore, there are non-tenured land use activities that overlap with the proposed mine and haul route, such as hunting, fishing, snowmobiling, and backcountry tourism.

Complete details of the land and resource use in the Project area are provided in Appendix 42.

7.18.2 Approach and Methods

Land and resource use information for the environmental setting was collected using a combination of desk-based and field research as part of baseline data collection efforts. The information was collected for both a primary and secondary study area. The former is an area defined as encompassing key mine infrastructure (including the open pit, tailings facility, access road, and transmission line) and a buffer delineated by natural barriers. The latter is an area beyond the mine footprint intended to capture regional-level land and resource uses. The main focus of the effects assessment will be on the primary study area, dependent on the scope and extent of use area of each land user and/or interest group. The effects assessment attempts to make direct links between mine infrastructure and/or processes and land uses. As such, for each land user group, the effects assessment focuses on a specific area within the primary study area.

Desk-based research entailed gathering and compiling existing literature and databases, area management plans, and local, regional, and provincial government publications, such as Official Community Plans (OCPs). Land uses and tenures in and around the Project area were identified through various methods, including consulting publicly available databases and reports such as: the provincial Integrated Land and Resource Registry, the BC MOE's Fish and Wildlife Branch (e.g., harvest data), the BC Ministry of Forests and Range (BC MOFR), BC Parks, BC Mineral Titles Online, the Guide Outfitters Association of BC (GOABC), the Morice LRMP, and the BC Ministry of Energy, Mines and Petroleum Resources' (BC MEMPR) website publications.

Field research entailed interviewing local community members, leaders, business owners, government agencies, tenure holders, and First Nations. The objectives of field interviews were to further clarify and confirm desk-based information; collect detailed, up-to-date, quantitative, and qualitative information directly from the land users; determine the extent and intensity of land use; and identify potential Project-related effects and mitigation strategies.

7.18.3 Land Management

7.18.3.1 Morice Land and Resource Management Plan

The Project is within the Morice LRMP, which was developed over 18 months, starting in October, 2002, and signed in July, 2007. The LRMP addresses the combined and sometimes competing concerns and interests of the public, the government, and the five First Nations with traditional territories within the LRMP, including the Lake Babine Nation. The lengthy, substantive process of multi-party negotiations and consensus building that inform LRMPs make it worthy of consideration, even if they are not legally binding. The LRMP deals with and provides management direction for a variety of socio-economic and land use issues. These include community resiliency, cultural heritage, hunting and fishing, settlement, visual resources, recreation, tourism, access, agriculture, botanical forest products, guide outfitting, minerals, timber, and trapping. Tables 7.18-1 and 7.18-2 summarize the objectives of the general management directions for community and economic values, respectively.

Table 7.18-1
Community Values: Summary of Objectives

Community Value	Objectives
Community Resiliency	• Support a diversity of economic activities • Support local employment, including the number, diversity, and quality of jobs • Optimize long-term local investment through land use certainty • Provide for local economic benefits • Preserve and enhance the quality of life and social values of communities (e.g., noise, viewscapes)
Cultural Heritage	• Identify, record, and report First Nations cultural heritage resources when encountered, particularly those that provide evidence or demonstration of use and occupancy, or are archaeological sites • Conserve First Nations cultural heritage resources • Preserve in an untouched state archaeological sites and sites indicating traditional use and occupancy

(continued)

Table 7.18-1
Community Values: Summary of Objectives (completed)

Community Value	Objectives
	• Conserve the composition, structure, and function of areas where traditional use sites or trails are concentrated or numerous • Maintain or restore traditional First Nations access to cultural heritage resources and traditional use areas • Minimize effects to First Nations cultural heritage resources and traditional use areas when managing forest health or catastrophic events • Recognize and respect First Nations traditional use areas and activities • Recognize and respect First Nations traditional ecological knowledge and wisdom
Hunting and Fishing	• Maintain access opportunities to fulfill a range of activities associated with recreational hunting and fishing • Maintain or increase the range of opportunities to hunt across the LRMP area by maintaining sustainable wildlife populations • Maintain or increase the range of opportunities to fish across the LRMP area by maintaining sustainable fish populations

Settlement	• Concentrate settlement expansion in areas meeting the following expansion criteria:
	  • consistent with existing or planned main road access and existing or planned electrical service, or
	  • where allowed in OCPs
	• Provide opportunities for isolated, single parcel settlement across the LRMP area
	• Recognize and protect known historical settlement areas
	• Manage areas adjacent to settlement areas to avoid adverse effects to safety, health, and the quality of life within the settlement area

Visual Resources	• Complete a visual landscape inventory within scenic areas • Avoid effects to visual resources in the interim prior to establishment of visual quality objectives • Establish visual quality objectives for scenic areas • Manage the visual resource in scenic areas in accordance with established visual quality objectives • Apply forest practices that maintain visual quality at the landscape level across the plan area
Recreation	• Maintain or improve the integrity and functionality of recreational features and facilities • Maintain or improve the integrity and functionality of trails, respecting traditional First Nations trail networks • Maintain opportunities for motorized and non-motorized terrestrial recreation • Maintain opportunities for a non-motorized recreational experience on lakes

Source: (BC MAL and BC ILMB 2007).

Table 7.18-2
Economic Values: Summary of Objectives

Economic Value	Objectives
Tourism	• Maintain or improve the integrity and functionality of features, facilities, and trails • Encourage growth in the tourism industry
Access	• Minimize and, where necessary, mitigate both immediate and cumulative access-related effects to environmental values • Encourage access development to support social and economic values and address associated issues
Agriculture and Range	• Maintain or expand agriculture activities on arable land within the agricultural expansion area • Maintain or expand Crown domestic livestock range (as described in the *Range Act*; i.e., horses, cattle, sheep) • Manage for long-term range productivity on Crown rangeland • Maintain access to water resources for domestic livestock on Crown range tenures
Agriculture and Range (continued)	• Maintain access to water resources for agricultural purposes outside of Crown range tenures (e.g., as livestock watering and irrigation purposes)
Botanical Forest Products	• Maintain or enhance the distribution and abundance of culturally important botanical species over time • Maintain or enhance access to areas with cultural important botanical species • Minimize effects to culturally important botanical species and the ecosystems that support them • Maintain or enhance the distribution and abundance of organically certifiable botanical species • Maintain, conserve, or enhance pine mushroom habitat
Guide Outfitting	• Maintain sustainable populations of game species • Maintain guide outfitting opportunities across the LRMP area • Maintain physical access to guide territories
Minerals and Energy	• Promote mineral, aggregate, and energy projects that provide a variety of economic opportunities for their full life cycles • Maintain the legal right of access for mineral exploration • Allow for access for aggregate and energy exploration and development outside of protected areas • Minimize environmental effects over the full life cycle of mineral, aggregate, and energy projects • Encourage opportunities to develop mineral and energy resources
Timber	• Maintain or increase timber production and harvesting across the available land base • Maintain the health of the timber resources • Minimize alienation of the available productive forest land base as a result of development activities • Reduce non-recoverable losses over time • Maintain a forest land base to support small, area-based forest tenures

(continued)

Table 7.18-2
Economic Values: Summary of Objectives (completed)

Economic Value	Objectives
Trapping	• Provide trapping opportunities across the land base • Provide trapping opportunities within each registered trapline area • Maintain or enhance access to registered traplines • Manage the effects of land use activities on the integrity of traplines and access trails used to maintain traplines

Source: (BC MAL and BC ILMB 2007).

The Morice LRMP also addresses herbicides and pesticides by identifying issues and providing general guidelines and goals related to their use. Table 7.18-3 gives an overview of the issues and goals.

Table 7.18-3
Pesticide Use: Issues and Goals

Pesticide Use Issues	Pesticide Use Goals
Conflicting views over pesticide use	Elimination of aquatic and terrestrial invasive, non-native organisms
Risk to natural ecosystem communities, components, and species due to invasive, non-native organisms.	Limit the spread of invasive native organisms
Effects associated with the use of fertilizers	Clean water and soils
Effects of pollution on environment and health values	Clean water and soils

Source: (BC MAL and BC ILMB 2007).

Beyond General Management Directions (GMDs), the LRMP also contains specific guidance for areas of particular importance, identified as Resource Management Zones (RMZs). The land use baseline study (Appendix 42) identifies six RMZs (out of a total of 20 for the entire LRMP) that either directly overlap with or are near the Project. The relevant RMZs are:

- Friday/Nakinilerak/Hautete Lakes
- Morrison Lake
- Le Talh Giz/Old Fort Mountain
- Granisle Community Recreation Area
- Mahtzehtzel/Nex Lake

Figure 7.18-1 depicts the locations of the six RMZs in relation to the Project. While GMDs apply to all RMZ areas, there are additional, specific objectives for RMZs, of which the ones relevant to the Project are summarized in Table 7.18-4. The objectives are related to mostly ecological considerations and management of forestry practices, while allowing and supporting mining activities.

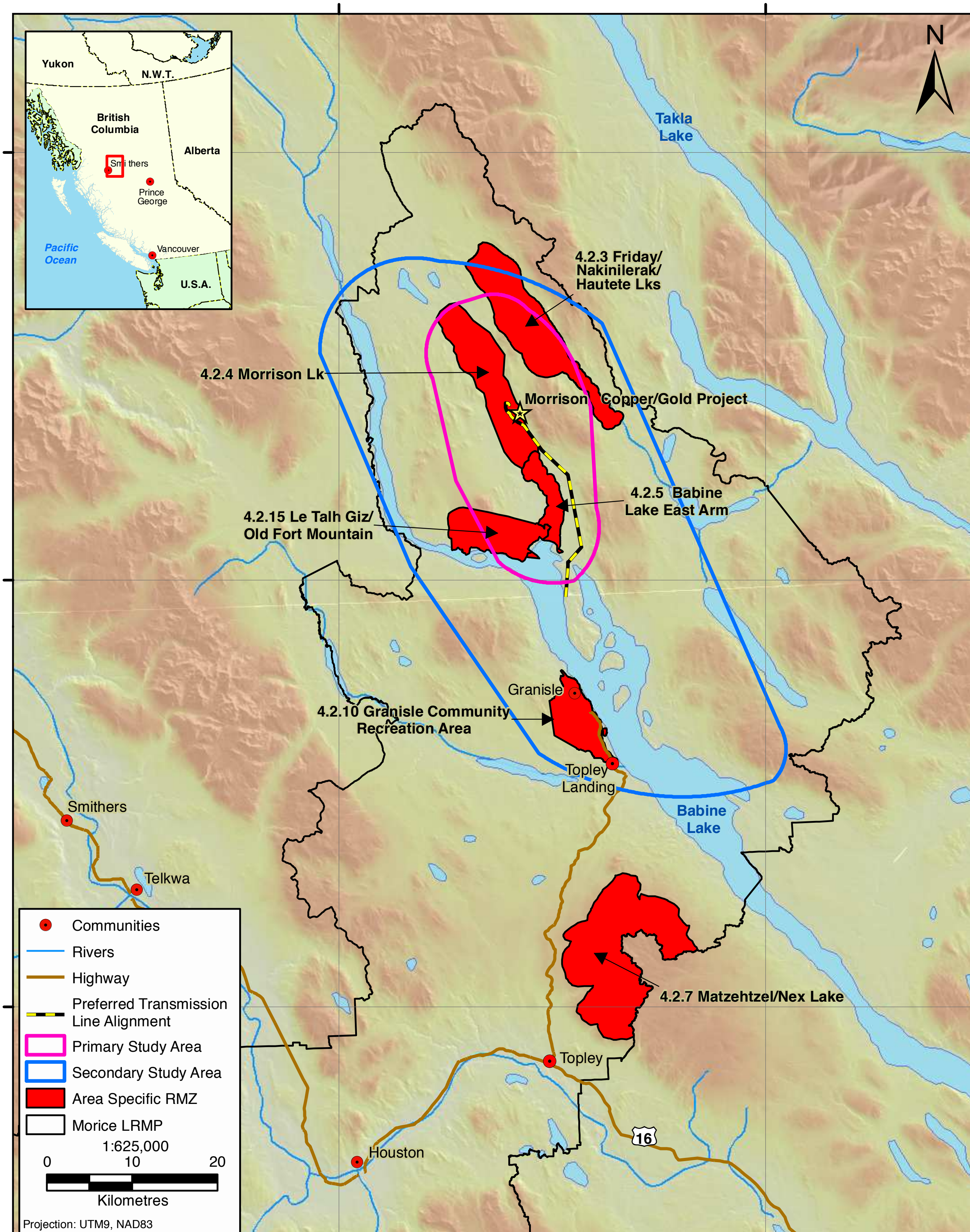


FIGURE 7.18-1

Morice LRMP Resource Management Zones near Morrison Copper / Gold Project

Table 7.18-4
Resource Management Zones: Summary of Objectives

Resource Management Zone	Objectives
Friday/Nakinilerak/Hautete Lakes	• Maintain ecological structure and function • Minimize human effect on and around Friday Lake • Maintain access to Hautete Lake at existing levels
Morrison Lake	• Maintain riparian function and integrity • Maintain the structure and function of forested ecosystems
Le Talh Giz/Old Fort Mountain	• Manage forest resources in a manner that is respectful of cultural and ecological values • Maintain cultural heritage features and values
Granisle Community Recreation Area	• Maintain the quality of the recreational experience
Babine Lake East Arm	• Maintain riparian function and integrity
Matzehtzel/Nex Lake	• Avoid effects to wetland complexes resulting from human use

Source: (BC MAL and BC ILMB 2007).

7.18.3.2 Lake Babine Nation Land Use Planning

The Lake Babine Nation is currently involved in land use planning endeavours that are linked to the treaty process, but does not have a completed plan. Accordingly, Lake Babine Nation leadership has engaged its membership to gather information about land use activities. This information will be used to identify the values of the Lake Babine Nation and to make decisions about how these may apply to and/or govern proposed and reoccurring land-based activities on their traditional territory. Given the involvement of the Lake Babine Nation in the process of developing the Morice LRMP, it can be reasonably expected that some of the Lake Babine Nation's values are captured within this document.

7.18.3.3 Provincial Parks and Protected Areas

There are several provincial parks and conservancies in and around the Project area. The conservancies were designated as part of the Morice LRMP process because of their natural, recreational, and/or cultural importance. The provincial parks predate the LRMP process. Table 7.18-5 provides a summary of the primary and secondary parks and conservancies within the study area.

Three protected areas (Sanctuary Bay, Long Island, and Wilkinson-Wright Bay conservancies) and two parks (Topley and Red Bluff) are considered in the land use study because of their proximity to the Project's proposed haul route, transmission line corridor, and mine site. The provincial designation of conservancy differs from a Class A park in that conservancies explicitly recognize the significance of the protected area to First Nations, and provide for a wider range of small-scale, low-impact economic activities while prohibiting large-scale projects. Visitor attendance numbers are not available for any of the protected areas and parks, except Red Bluff Park whose statistics are pending. Accordingly, the level of use of the conservancies and parks is unknown. The major functions and features of the protected areas and parks are summarized in Table 7.18-6.

Table 7.18-5
Summary of Provincial Parks and Protected Areas and their Distance from the Project

Park or Protected Area	Distance from Project (from the haul route)
Primary Parks and Protected Areas	
Sanctuary Bay Conservancy	17 km
Secondary Parks and Protected Areas	
Babine Lake Marine Park	20 km
Mount Blanchet Park	23 km
Rainbow Alley Park	26 km
Bear Island Conservancy	29 km
Long Island Conservancy	36 km (4 km)
Red Bluff Park	39 km
Topley Landing Park	44 km
Wilkinson-Wright Conservancy	48 km

Source: (BC MAL and BC ILMB 2007).

Table 7.18-6
Summary of Major Functions and Features of the Protected Areas and Parks

Protected Area or Park	Established	Size (ha)	Geographic Features and Purpose
Sanctuary Bay Conservancy	2008	820	• Protects several islands, scenic lakeshore viewscapes and bays • Offers an area for boat anchorages • Culturally important to Lake Babine Nation because of hunting and trapping
Long Island Conservancy	2008	850	• Protects several islands, scenic lakeshore viewscapes, and beaches • Boat access only
Wilkinson-Wright Bay Conservancy	2008	2,196	• Recreational boating, wilderness camping, and safe anchorages • Protects several islands and undisturbed lake shoreline • Significant to First Nations • Boat access only
Red Bluff Park	1978	148	• Key activities include swimming, angling, and salmon enhancement projects at Fulton River and Pinkut Creek • Has a beach and is adjacent to the Fulton River spawning area • Backcountry camping is permitted, but no facilities are provided Contains 27 standard vehicle-accessible campsites • Hunting and trapping are prohibited, but fishing is permitted
Topley Landing Park	1964	12	• Opportunities for canoeing or kayaking exist on Babine Lake. Motorboat use is permitted, and there is a boat launch site available • Backcountry camping is permitted, but no facilities are provided • Off road access for snowmobiling is not permitted • Hunting, fishing, and trapping are permitted

Source: (BC MOE 2008b).

7.18.4 Lake Babine Nation Land Uses

7.18.4.1 Background

The Project is on Crown land within the asserted traditional territory of the Lake Babine Nation. In general, First Nations have constitutionally supported rights and freedoms within their traditional territories, which are defined by the treaty process and/or case law. Members of First Nations have the right to land use and occupancy, including hunting, fishing, and land and/or self-governance rights. Legal and constitutional precedent protects First Nation land and resource use within the Project area with more specific definitions and parameters determined by land use planning and treaty negotiations.

7.18.4.2 Land Use Activities

The Lake Babine Nation has past and current use in the primary study area. This is reflected in the ecological knowledge that the members of the Lake Babine Nation hold about the primary study area. Year-round land use activities by members of the Lake Babine Nation include trapping, hunting, gathering, and fishing. The majority of Lake Babine Nation land users come from Fort Babine (24 km northwest of the Project) and the seasonal village of Old Fort (18 km southwest of the Project). Although there is no direct forest service road access from these communities to the Project site, Lake Babine Nation members use a combination of boat, trail, and vehicular methods to access the area in and around the Project. Fewer Lake Babine Nation land users are from Tachet and Woyenne (Burns Lake). There is a high degree of intercommunity mobility among members of the Lake Babine Nation, which results in Woyenne community members accessing their territory along Lake Babine to fish and gather. Access to the site from Fort Babine is through a series of trails on ATV or skidoo. Access to Old Fort is through motorized boats and trails.

Sockeye salmon fishing on upper Babine Lake, and as far north as Morrison Creek, is especially prevalent among seasonal residents of the Old Fort village. Lake Babine Nation land users number in the dozens and fish, process, and smoke hundreds of salmon daily between August and September. To a lesser degree, rainbow trout, cutthroat trout, and lake char are also harvested. Lake Babine Nation land users are only able to access Old Fort by boat, launching 14 km north of Granisle along the Granisle Connector Road.

Year round residents of Fort Babine and seasonal residents of Old Fort also trap and hunt in the Project study area. Trapline activity has declined since the late 1980s because of decreasing pelt prices and the rising cost of gas. The most popular species trapped in the Project study area is marten. The use of Lake Babine Nation traplines has severely declined in recent years. Lake Babine Nation members also engage in moose hunting. Prime moose habitat for hunting has been identified by members of Lake Babine Nation as being north of Old Fort along the shores of Morrison Lake.

The Lake Babine Nation also holds a forestry tenure approximately 14 km south of the Project area, just off the forestry road and proposed haul route on the east side of Babine Lake. The active tenure is 16 ha. The Lake Babine Nation's forest tenure is discussed in more detail in Section 7.18.5.4

7.18.5 Land Tenures

7.18.5.1 Mineral

Provincially, the rise in metal prices driven by the Asian market demand has caused mineral exploration to proliferate in recent years. Province-wide expenditures on mineral exploration increased fourfold from 2000 to 2006. In 2007, eight mining projects were proposed for permitting through the EA process. In terms of operations, there were four new mines in development in 2007. However, the recent recession has caused many proposed projects and mining operations to be put on hold or abandoned entirely.

Mining operations and mineral exploration in and around the Project area have occurred consistently from as early as the 1960s. The area is located in the Babine Porphyry Copper Belt of BC, which hosts a number of economically significant occurrences of porphyry copper, molybdenum, gold, and silver mineralization. Historically, the Granisle and Bell mines (about 22 km from the Project) were responsible for large-scale, industrial land use within the study area. Granisle Mine operated on Copper Island from 1966 to 1982, while the Bell Mine operated on Newman Peninsula from 1970 to 1992. Both mines are currently in reclamation, which includes an extensive water quality monitoring and re-vegetation program around the tailings pond.

In 1997, PBM acquired the Morrison mineral claim block from Noranda, who initially discovered the copper/gold deposit in 1963. To date, the deposit has undergone two periods of intense exploration in the late 1980s and 1990s. Noranda Inc. conducted a mapping and drill program from 1963 to 1973. Preliminary pit design and operating studies were conducted in 1988 to 1990. In 1997, PBM entered into an agreement with Noranda Inc. to obtain 50% interest in the Morrison property. In 1998, PBM commenced with a drill program and studies to develop the Morrison deposit. In 2004, PBM purchased 100% interest in the Morrison property from Falconbridge Ltd. (formerly Noranda Inc.).

There are 2 companies and 13 individuals who hold claims in the area in and around the Project other than PBM. The northern parts of the Babine and Morrison lakes hold the highest concentration of mineral tenures. Most of the non-PBM mineral claims are on the west side of the Morrison Lake. Two of the mineral claims, including the claim held by PBM, are "legacy claims," which means that they existed prior to the *Mineral Tenure Act* of 1996. The claim closest to the Project is held by Ronald Hugh McMillan and is 3 km northwest. The claim owners are summarized in Table 7.18-7 and the claim locations in relation to the Project are depicted in Figures 7.18-2 and 7.18-3.

7.18.5.2 Guide Outfitters

Out-of-province and foreign hunters in pursuit of big game are required to hunt with the assistance of a guide outfitter, who holds tenure over areas defined and regulated by the province. The Project's land use study area overlaps with two guide outfitting territories, which are owned by Dave Hooper (Tukii Lodge) and Stewart Berg (Double Eagle Guide and Outfitters). Table 7.18-8 provides an overview of the level, intensity, and seasonality of their tenure use. Figure 7.18-4 depicts the boundaries of the guide outfitting territories in relation to the Project area.

Table 7.18-7
Current Mineral Claims and Tenure Holders near Morrison Copper/Gold Project

Claim or Tenure Owner Name	Owner Number	Number of Claims *
Mineral Claims		
Pacific Booker Minerals Inc.	102758	93
Johnson, Timothy Arthur	113391	3
Kreft, John Bernard	114661	1
Maclaren Forest Products Inc.	116382	4
McMillan, Ronald Hugh	132841	6
Menard, Rolland Joseph	118167	8
Morris, James Hay	118932	3
Morris, Keith P.	118937	2
Woolverton, Roy Wilkins	129456	2
Billingsley, Richard John	139085	4
Copper Ridge Explorations Inc.	146162	1
Funk, Kelly Brent	146571	4
Galambos, Kenneth D.	109109	11
Keefe, Ralph Raymond	113794	6
Kress, Dwayne Edward	146911	4
Walker, Douglas Frederick	146695	1

*** Owners may have additional claims beyond scope of Project study area.**
Source: (Government of BC 2008).

David Hooper offers guided hunting concentrated in the northern reaches of his 727,972 ha outfitting territory (#608G003) to non-resident hunters with 50% of clients hunting along southeast shoreline of Morrison Lake. Hooper's territory is 12% contained within the secondary study area. The order of species preference among clients is as follows: moose, black bear, mountain goat, grizzly bear, wolf, and mule deer. Moose are the most-harvested species. They are generally killed 1 km north of the proposed mine site. The Morrison Lake portion of Hooper's guiding territory is considered ideal because of the level of wildlife availability and fewer resident and First Nations land use conflicts (which are more prevalent in other parts of his territory). Hooper's clients are predominantly from the US with 15% from Germany, and a few from Poland, Slovenia, and Belgium. Guiding is Hooper's sole source of income and he employs five other staff on a seasonal basis. The guiding activities are supported by two main facilities, including Tukii Lodge at Smithers Landing and Tukii Hunting Camp on the southeast shore of Morrison Lake. The former consists of eight cabins of various sizes with full amenities and the latter consists of two bunk houses, one cook house with sleeping facilities, a shower house, storage, woodshed, and a meat house. Table 7.18-9 summarizes the 2008 rates at Tukii Lodge related to the guiding services.

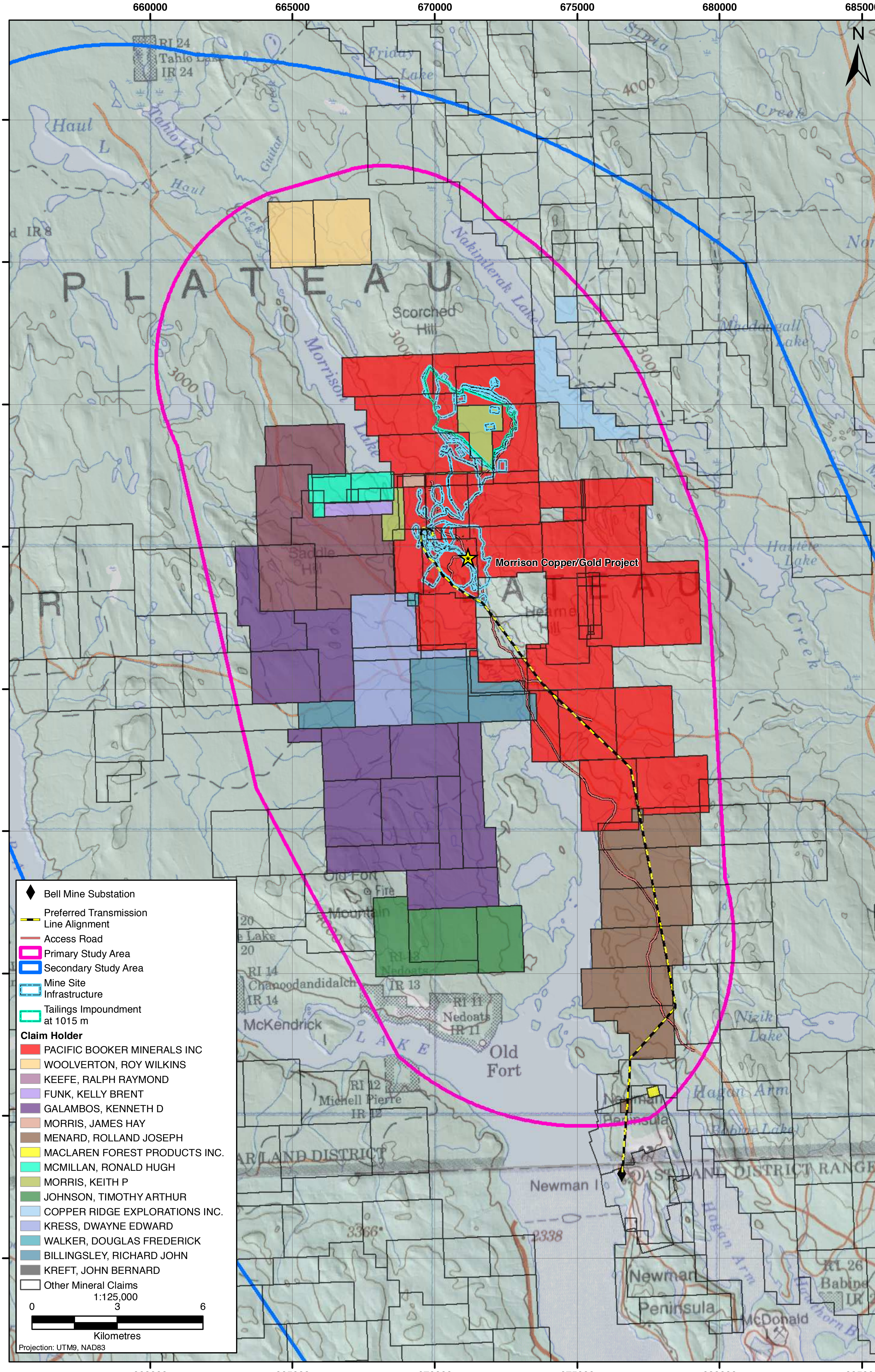


FIGURE 7.18-2

Morrison Copper/Gold Project Mineral Claims: 2008

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gis no. MOR-16-031 Job No. 0793-001-05 February 17, 2009

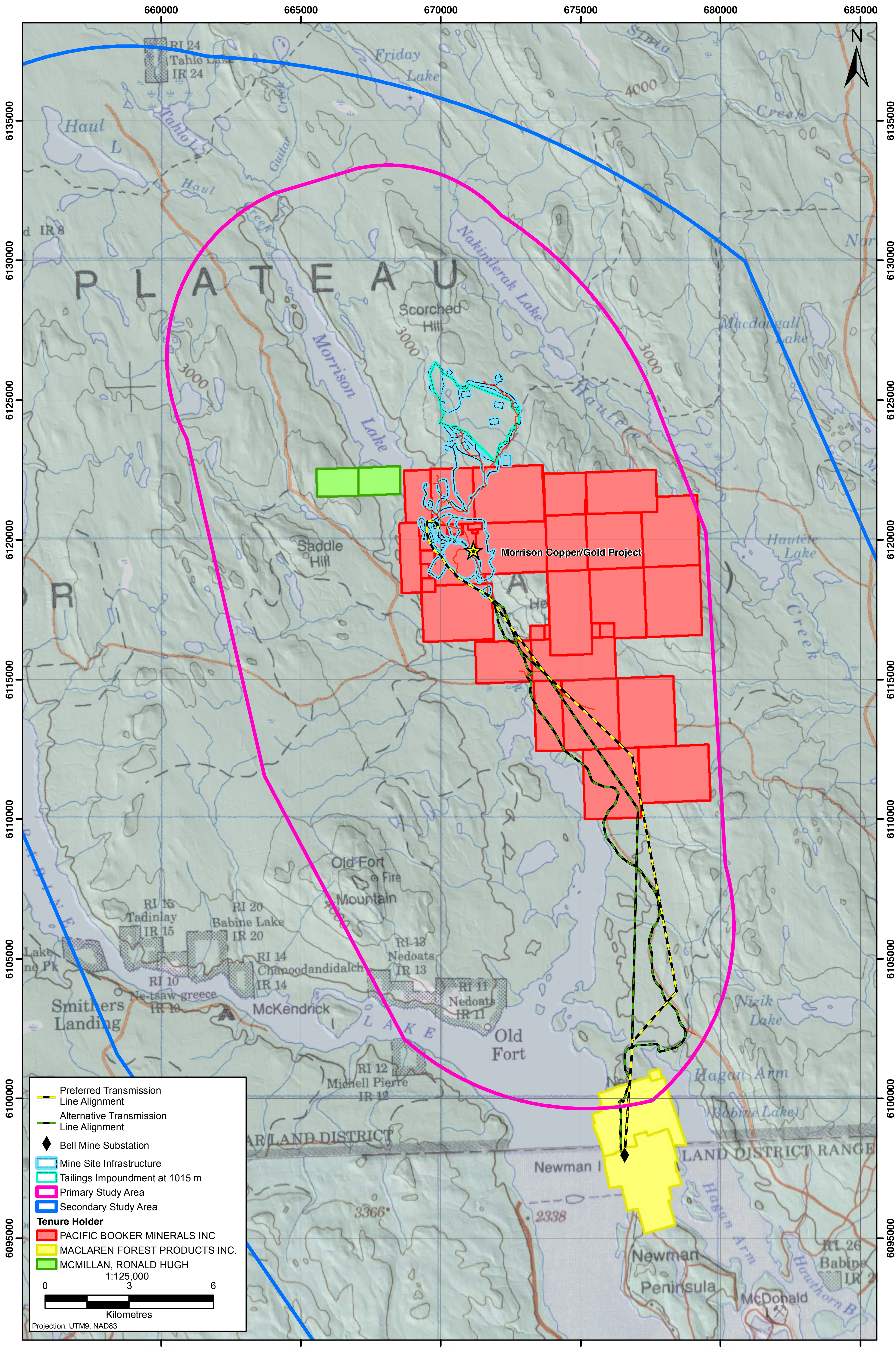


FIGURE 7.18-3

Mineral Legacy Claims Near Morrison Copper/Gold Project: 2008

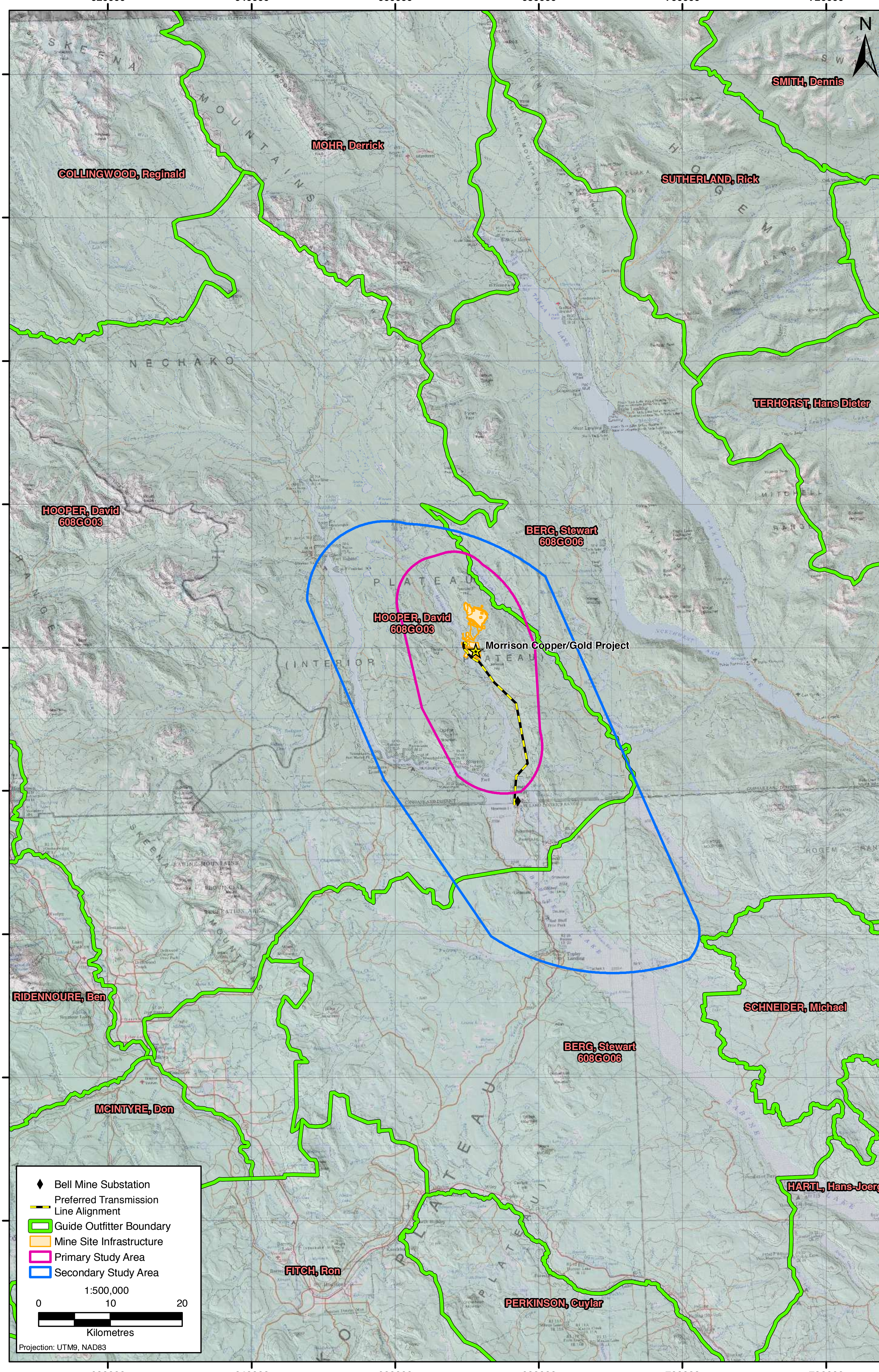


FIGURE 7.18-4

Guide Outfitters Relative to Morrison Copper/Gold Project

Table 7.18-8
Summary of Guide Outfitting Tenure Details

Name	Months	Species	Transportation Mode(s)	Camp/Lodge Location	# of Clients and Trips
Dave Hooper	May to Nov; Feb. to Mar. (wolf only)	Moose, black bear, mountain goat, grizzly bear, wolf, mule deer	Boat and ATV	Hunting camp on the eastern shore of Morrison Lake and a lodge at Smithers Landing	65 to 75 (guiding) and 20 (angling); 6 trips of 12 clients each
Stewart Berg		Black bear, grizzly bear, moose, lynx, deer, goat, wolf	Vehicles, boats, and horse	Main hunting camp 40 km northeast of Morrison Lake; camp at Nakinilerak Lake 7 km northeast (closest to Morrison site); camp at Natowite Lake 25 km southeast	N/A

Table 7.18-9
Tukii Lodge Products and Rates (2008)

Product	Rate
Guided fishing trips: Including accommodation and meals, gear and transportation	
Party of 2 or more	$525/day per person
Non-guided fishing trips and use of facilities	
Outpost camps	$245/day
Transportation to and from outpost camps	$500/day
Boat rentals	$155/day
Cabins	$90 to $145
Boats	$100 to $185/ day + fuel
Meals	$65/day per person
Day guide and equipment	$750/day
Hunts	
Moose, 10 day, 2 on 1	$6,300
Moose, 10 day, 1 on 1	$8,300
Mule deer, 6 day, 2 on 1	$3,780
Hunts	
Mule deer, 6 day, 1 on 1	$4,980
Spring Black Bear, 6 day, 2 on 1	$3,780
Spring Black Bear, 6 day, 1 on 1	$4,980
Mountain Goat, 10 day, 1 on 1	$8,500
Grizzly, 10 day, 1 on 1	$17,000
Wolf, 8 day, 2 on 1	$5,040
Wolf, 8 day, 1 on 1	$6,640
Trophy fees	
Mule deer	$1,100
Mountain Goat	$4,000
Coyote	$250
Grizzly	$10,000
Moose	$4,000
Black Bear	$1,200
Wolf	$700

The western most boundary of Stewart Berg's 727,972 ha guiding territory (# 608G006) is 7 km northeast of the Project. Berg's territory is 8% contained within the secondary study area. Berg's clients consist of Americans and Europeans. To support guiding efforts, Berg maintains 13 horses at several camps and cabins within his territory. Berg employs 14 staff seasonally and guiding is his main source of income. The closest camp is along the southeast shore of Nakinilerak Lake.

Provincially collected big game harvest data confirm that moose is the most commonly harvested species in the Wildlife Management Unit (WMU) 6-08, which overlaps with 20% of the Project study area. Levels of moose harvest have increased from 1976 to 2005, with an average of 39 moose killed annually by non-resident hunters. The highest number of kills occurred in 2000 (84 kills) and 2004 (86 kills). Black bear is the second most commonly harvested species in WMU 6-08, with an average of 21 kills a year.

7.18.5.3 Traplines

Trapping has been a culturally and economically significant land use activity throughout the province since the late 1800s. In 1926, the provincial government divided the province into trapline territories and began to require registration of individuals and families within these territories as a means of regulating wildlife harvest. Over the years, trapline activities were profitable until the fur industry crash in the early 1990s. Since then, a combination of high gas costs and low fur prices have acted as a deterrent to trapping activities. Currently, tenure holders need to register a harvest of 50 pelts or $200 in pelts to maintain an active trapline status,, although written permission can be requested for an extension if this is not achievable (Wildlife Act; 2007). People continue to trap (albeit at low levels) for a variety of economic, social, and cultural reasons.

There are two trapline territories that overlap the Project components (Figure 7.18-5). There are no current trapline activities within the Project area. However, trapping is considered culturally significant and relevant to the trapline holders who are members of the Lake Babine Nation. Trapline tenures are cultural important because they delineate boundaries between Lake Babine Nation clans and afford clan members exclusivity of hunting and fishing rights within trapline borders. Table 7.18-10 provides an overview of the trapline information and activities.

Table 7.18-10
Summary of Trapline Details

Name	Trapline #	Most Commonly Trapped Species	Year of Highest Revenue (Amount)	Year of Lowest Revenue (Amount)
Alex Michell and Peter Alex	TR0608T023	marten, squirrel	1996 ($5,195)	2001 ($218)
Leonard, Joyce and Ryan Williams	TR0608T049	marten, weasel, mink	2000 ($718)	1997 ($39)

gis no. MOR-16-034 Job No. 793-5 February 23, 2009

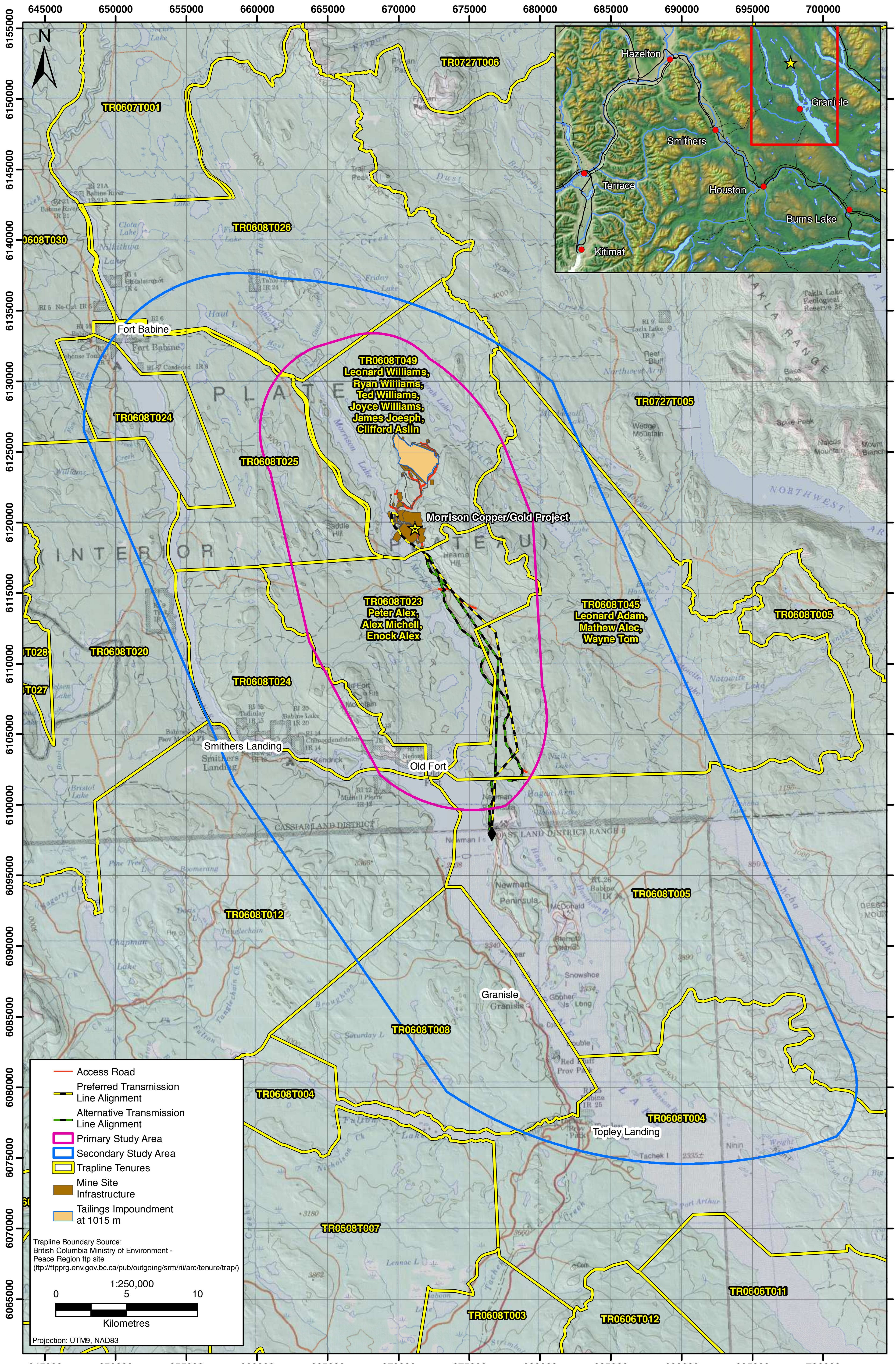


FIGURE 7.18-5

Trapline Tenures Near Morrison Copper/Gold Project

Mr. Michell (TR0608T023) has concentrated his trapline harvest in the southern end of Morrison Lake. Before the drop in fur prices and the rise in gas prices, Mr. Michell trapped his territory regularly for economic gain; however, he has not trapped the area since 1997. According to provincial kill data, the highest number of species harvested in T023 between 1987 and 2005 was marten, followed by squirrel (BC MOE 2007b). Table 7.18-11 lists the harvest data and estimated revenues for the TR0608T023 trapline. The provincial record of registered kills depicts sporadic use of the trapline with no kills registered for 10 years out of 18 years from 1987 to 2005. The total estimated revenue generated on the trapline, as calculated from the provincial data set, amounts to $2,553. As noted in Section 7.18.2, these data reflect only the kills that were registered; therefore, the data may not capture the actual total harvest on the trapline.

Table 7.18-11
Trapline Harvest Data for TO23 (1987 to 2005)

Year	Species	Total	Avg. Price	Total Estimated Revenues	Royalty	Total Royalties
1987	Fox	1	$35.76	$35.76	$1.56	$1.56
1987	Marten	2	$95.13	$190.26	$1.42	$2.84
1987	Squirrel	3	$0.87	$2.61	$0.03	$0.09
Annual Total		**6**		**$228.63**		**$4.49**
1989	Marten	6	$65.00	$390.00	$1.79	$10.74
1989	Squirrel	17	$0.90	$15.30	$0.03	$0.51
Annual Total		**23**		**$405.30**		**$11.25**
1991	Marten	4	$55.77	$223.08	$1.89	$7.56
Annual Total		**4**		**$223.08**		**$7.56**
1992	Marten	5	$38.00	$190.00	$1.75	$8.75
1992	Squirrel	1	$1.60	$1.60	$0.03	$0.03
Annual Total		**6**		**$191.60**		**$8.78**
1993	Squirrel	1	$1.35	$1.35	$0.03	$0.03
Annual Total		**1**		**$1.35**		**$0.03**
1994	Fisher	1	$44.60	$44.60	$1.28	$1.28
1994	Marten	15	$43.74	$656.10	$1.46	$21.90
1994	Squirrel	4	$1.39	$5.56	$0.04	$0.16
Annual Total		**20**		**$706.26**		**$23.34**
1995	Mink	1	$28.00	$28.00	$0.92	$0.92
1995	Weasel	2	$5.75	$11.50	$0.14	$0.28
Annual Total		**3**		**$39.50**		**$1.20**
1997	Marten	1	$38.82	$38.82	$1.53	$1.53
Annual Total		**1**		**$38.82**		**$1.53**
2000	Marten	17	$41.31	$702.27	$1.28	$21.76
2000	Mink	1	$16.29	$16.29	$0.56	$0.56
Annual Total		**18**		**$718.56**		**$22.32**
GRAND TOTAL		***82***		***$2,553.10***		***$80.50***

Source: (BC MOE 2007b)

The proposed Project is within the boundary of trapline TR0608T049, which is registered to Leonard Williams and his children, Joyce and Ryan Williams. James Joseph originally owned the line, followed by Leonard Williams' brother Ted Williams and Clifford Aslin Sr. These individuals are deceased, yet their names remain as trapline registrants. Clifford Aslin Sr. used the trapline on a regular basis before he passed away in the fall of 2006. He caught mostly marten with his son, Clifford Aslin Jr. The trapline has not been used since Clifford Aslin Sr.'s death. Currently, none of the registrants use the trapline territory due to a lack of time and interest. According to the provincial data represented in Table 7.18-12, the most commonly harvested species in T049 between 1987 and 2005 was marten, followed by weasel and mink. According to provincial data (1987 to 2005), the trapline was consistently used with the exception of five years, including 1990, 1999, 2001, 2002, 2003, and 2004. Based on registered kills, the total estimated revenue over 18 years is $25,650.

Table 7.18-12
Trapline Harvest Data for TO49 (1987 to 2005)

Year	Species	Total	Avg. Price	Total Revenue	Royalty	Total Royalties
1987	MART	10	$95.13	$951.30	$1.42	$14.20
1987	MINK	1	$48.57	$48.57	$0.89	$0.89
1987	SQUI	14	$0.87	$12.18	$0.03	$0.42
1987	WEAS	3	$3.77	$11.31	$0.06	$0.18
1987	WOLV	1	$182.84	$182.84	$6.32	$6.32
Annual Total	**29**		**$1,206.20**		**$22.01**	
1988	FISH	1	$66.12	$66.12	$5.37	$5.37
1988	MART	67	$73.92	$4,952.64	$1.79	$119.93
1988	WEAS	1	$1.60	$1.60	$0.07	$0.07
Annual Total	**69**		**$5,020.36**		**$125.37**	
1989	MART	3	$65.00	$195.00	$1.79	$5.37
Annual Total	**3**		**$195.00**		**$5.37**	
1991	MART	23	$55.77	$1,282.71	$1.89	$43.47
Annual Total	**23**		**$1,282.71**		**$43.47**	
1992	MART	49	$38.00	$1,862.00	$1.75	$85.75
1992	MINK	1	$25.00	$25.00	$0.92	$0.92
Annual Total	**50**		**$1,887.00**		**$86.67**	
1993	FISH	3	$41.55	$124.65	$1.39	$4.17
1993	MART	20	$56.77	$1,135.40	$1.48	$29.60
1993	OTTE	1	$104.71	$104.71	$1.40	$1.40
Annual Total	**24**		**$1,364.76**		**$35.17**	
1994	FISH	6	$44.60	$267.60	$1.28	$7.68
1994	MART	57	$43.74	$2,493.18	$1.46	$83.22
1994	MINK	2	$18.79	$37.58	$0.95	$1.90
1994	WEAS	12	$4.00	$48.00	$0.13	$1.56
Annual Total	**77**		**$2,846.36**		**$94.36**	
1995	FISH	1	$55.00	$55.00	$1.25	$1.25
1995	MART	15	$52.00	$780.00	$1.50	$22.50

(continued)

Table 7.18-12
Trapline Harvest Data for TO49 (1987 to 2005) (completed)

Year	Species	Total	Avg. Price	Total Revenue	Royalty	Total Royalties
Annual Total	**16**		**$835.00**		**$23.75**	
1996	FISH	1	$55.08	$55.08	$1.21	$1.21
1996	MART	93	$55.04	$5,118.72	$1.39	$129.27
1996	MINK	1	$20.88	$20.88	$0.70	$0.70
Annual Total	**95**		**$5,194.68**		**$131.18**	
1997	FISH	1	$44.64	$44.64	$1.41	$1.41
1997	MART	15	$38.82	$582.30	$1.53	$22.95
Annual Total	**16**		**$626.94**		**$24.36**	
1998	MART	13	$34.56	$449.28	$1.51	$19.63
Annual Total	**13**		**$449.28**		**$19.63**	
2000	FISH	1	$38.94	$38.94	$1.32	$1.32
2000	MART	92	$41.31	$3,800.52	$1.28	$117.76
2000	MINK	3	$16.29	$48.87	$0.56	$1.68
2000	WEAS	1	$6.53	$6.53	$0.15	$0.15
Annual Total	**97**		**$3,894.86**		**$120.91**	
2001	MART	5	$45.72	$228.60	$1.15	$5.75
2001	MINK	2	$16.76	$33.52	$0.52	$1.04
Annual Total	**7**		**$262.12**		**$6.79**	
2001	OTTE	2	$108.78	$217.56	$2.77	$5.54
Annual Total	**2**		**$217.56**		**$5.54**	
2005	MART	7	$80.31	$562.17	$1.45	$10.15
Annual Total	**7**		**$562.17**		**$10.15**	
Grand Total	***525***		***$25,650.00***		***$749.36***	

Source: (BC MOE 2004).

7.18.5.4 Forestry

Introduction

There are four forest tenure holders in and around the Project area, namely Canfor, West Fraser Mills (operated by Houston Forest Products), and the Lake Babine Nation within the primary study area. PBM holds a wood lot licence, which permits small scale and localized timber removal for the purposes of clearing the areas in and around testpits and drill holes. The Houston Forest Products forest tenures are concentrated on the west side of Morrison Lake.

These tenures are within the Nadina Forest District, which is a jurisdiction that was formed in 2003 from the joining of the Lake Forest District with the Morice Forest District. Figure 7.18-6 represents the various forest tenures, the companies and organizations that hold them, and their status as of the writing of this report.

Forestry activities are supported by two camps, of which one lies in the primary study area (i.e., Houston Forestry Products Camp) and the other is contained in the secondary study area (i.e., Babine Camp). The former is a 60-person camp on the northern end on Babine Lake close to the mouth of Morrison Creek. It is accessible by air, water, and forest service roads. Babine Camp is a 120-person camp on the east side of Babine Lake (7 km along the Jinx FSR).

For the purposes of the effects assessment, only the Canfor and Lake Babine Nation tenures will be described in the following sections.

Canadian Forest Products

Canfor owns the tenures and licences to harvest and operate in the area to the east of Babine Lake. Canfor purchased Northwood Forest Products, which previously purchased the Bulkley Valley Forest Products Company. The area has been actively harvested for approximately 30 years. Canfor anticipates that additional harvesting will occur in the area in two years, depending on the spread of the mountain pine beetle (MPB) and economic conditions. Canfor expects to harvest between 300,000 m^3 and 400,000 m^3 per year, which is equivalent to 30% of the volume capacity of Canfor's sawmill. The area to the east of Babine Lake is considered to have a good supply of timber, including good growing sites and replacement rates. The last harvest in this area was in 2007. Canfor engages in reforestation efforts that usually occur one or two years following forestry activities. The work is contracted out to reforestation companies.

The approximate area covered by the strategic blocks is 90,000 m^3 over three years, which would result in traffic volumes of 10 truck loads per day for 150 days per year. Associated pick-up and low-bed traffic would be estimated at another 10 vehicles per day for 180 days. Canfor's operating areas along the Hagan Forest Service Road are on the "town side" of the mine site and harvesting of this area would last two years.

Lake Babine Nation

Lake Babine Nation holds a 16 ha non-replaceable forest licence (#A82283) along the transmission line alignment and Forest Service Road used to access the Project. It was issued in March, 2008, with a 5-year term, expiring in February, 2013. No timber has been harvested to date under this tenure, which has an annual allowable cut (AAC) of 81,397 m^3 per year. The tenure falls in both the salvage and containment zones defined by the Emergency Bark Beetle Management Area (EBBMA).

Mountain Pine Beetle Epidemic

The MPB epidemic has had a devastating economic effect on the forest industry in BC by damaging lodgepole pine in Western Canada. In response to this epidemic, the province has temporarily increased the AAC to allow forest companies to maximize the value gained from affected timber. Accordingly, the AAC has been increased provincially by 15 million m^3 from a level of 90 Mm^3 in 2005 to 2006. The MPB epidemic has already affected an area of 530 Mm^3 (40% of total marketable pine volume) and is predicted to last until 2018, with a projected affected area of 78% of pine volume.

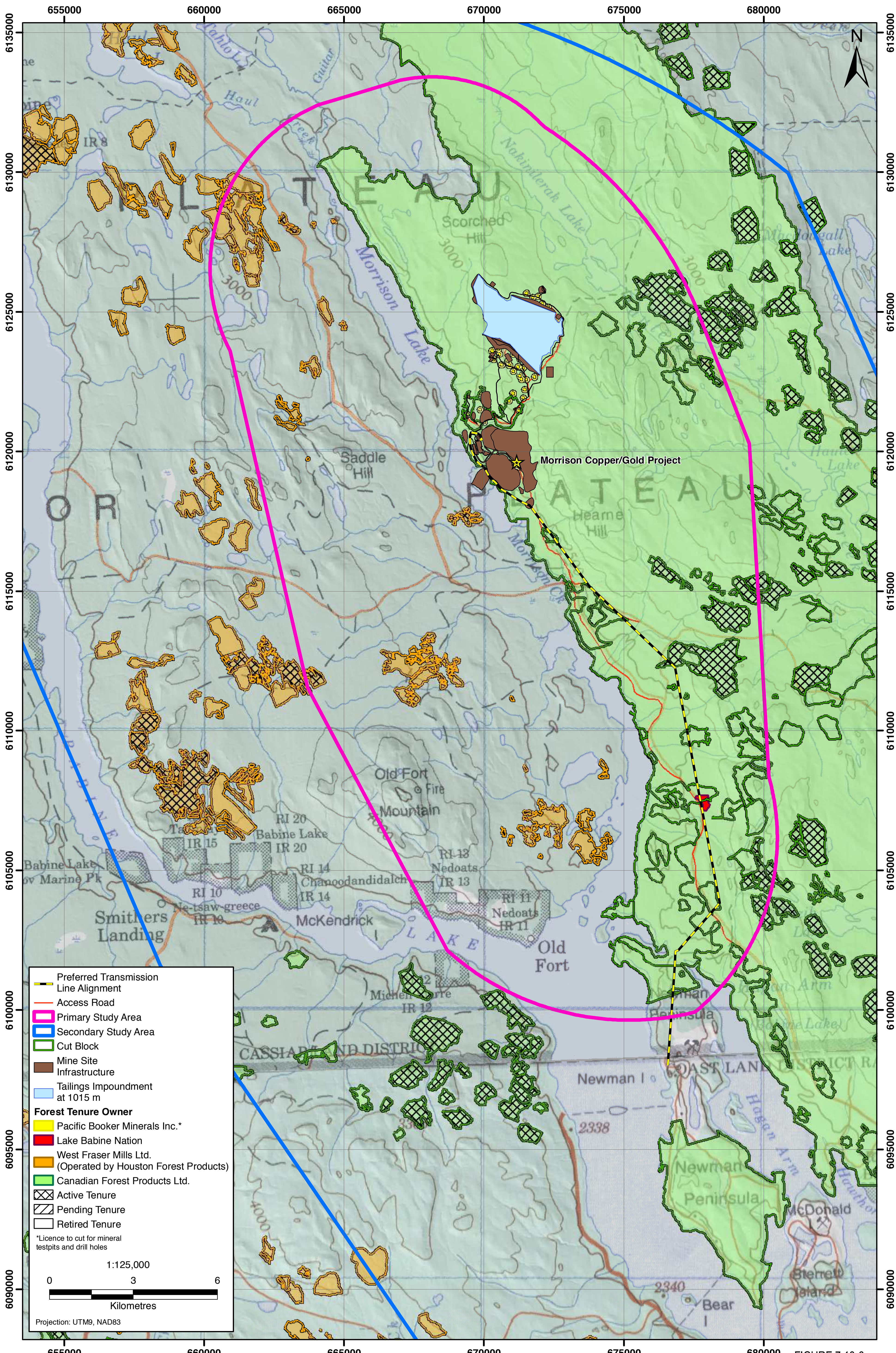


FIGURE 7.18-6

Forestry Tenures Relative to Morrison Copper/Gold Project

The Morice TSA, which overlaps with the Project, has been and will continue to be affected by the MPB. An estimated 24% of the total pine timber is infected (12.7 Mm^3). The cumulative pine kill is projected to be 73% of the total mature pine volume in the Morice TSA. The province has raised the AAC in the Morice TSA by 204,000 m^3 to 2.16 Mm^3.

7.18.5.5 Private Property

Ookpik Lodge is advertized as a remote wilderness accommodation specializing in wildlife viewing (e.g., black bear, moose, loon, grizzly bear, eagles, and trumpeter swans). The lodge is on the northeastern shore of Babine Lake, 9 km from the Project. Float plane and boat provide the main means of accessing the lodge. The proposed concentrate haul route via an existing Forest Service Road is approximately 1 km inland from the lodge. The lodge attracts clients from the US, Europe, and elsewhere, who visit the lodge to experience the wilderness values in the area. Limited boat traffic and resulting reduced noise levels at the north end of Babine Lake along Morrison Arm contribute to this atmosphere. The current owners are Carol and Helmut Hofmeister who have managed the lodge since 1993; however, the lodge has been around since the 1930s.

7.18.5.6 Angling

There are two confirmed angling interests in and around the Project study area held by Dave Hooper (Tukii Lodge) and Pierce Clegg (Babine Norlakes Management Ltd). The species of interest for these anglers are mainly rainbow trout, steelhead, and salmon. The typical cost of a seven-day angling trip is $3,675 in 2008. Table 7.18-13 summarizes details about the angling guides and their companies.

Table 7.18-13
Angling Guides Near the Morrison Copper/Gold Project

Angling Guide	Company	Species	River and Lakes near the Project
Dave Hooper	Tukii Lodge		Babine Lake; Morrison Lake
Pierce Clegg	Babine Norlakes Management Ltd.	Rainbow trout and steelhead	Babine Lake

Source: (BC MOE 2008b).

7.18.6 Land Uses

Besides land tenure holders, there are also non-tenured land uses that occur in the primary study area (e.g., Lake Babine Nation, resident hunters, fishing, tourism, and snowmobiling). These are either protected by the Charter of Rights as with First Nations or supported for cultural and/or economic reasons.

7.18.6.1 Resident Hunters

Resident hunters also use the Project area; they are required to have Canadian citizenship or permanent status and reside in BC for more than six months a year. To hunt anywhere in the province, resident hunters must obtain hunting licences and tags for specific species. These range in cost depending on the species; grizzly bear tags are the most expensive. According to provincial kill data collected by the BC MOE, there is resident hunting activity within and around the primary study area. Kill data are gathered by WMUs and the Project falls within WMU 6-08. The primary and secondary land use study areas make up 5% and 20% of the WMU, respectively. The primary study area represents a small percentage within the WMU. Hunters are not required to specify precisely where within WMUs they harvested wildlife. As such, it is not possible to determine the exact levels of resident hunting within the primary study area. Figure 7.18-7 depicts the number of annual kills in WMU 6-08 from 1987 to 2005 for the most commonly hunted species.

Resident hunters within WMU 6-08 target mostly moose, mule deer, and black bear (in order of most kills). Following a sharp increase in 1988, moose hunting trends over the last 28 years have generally declined. The highest number of registered kills was in 1988 with 361 moose harvested. The lowest harvest levels occurred during the early 1980s and late 1990s when approximately 150 moose were killed. According to the kill data, mule deer and black bear hunting have remained steady in WMU 6-08 over the last 28 years with an average of 55 and 35 harvested, respectively.

7.18.6.2 Backcountry Recreation

Fishing

Aside from angling guides (Section 7.18.5.6), locals and tourists also make use of Lake Babine as a popular fishing destination. In and around the Project area, there are several prime destinations for fishing rainbow trout, salmon, and burbot. The southern end of Nilkitkwa Lake, called “rainbow alley,” is a high value rainbow trout area and the Fulton River Fish Hatchery maintains stocks of sockeye salmon in Babine Lake and ensures a 90% return rate to the Skeena River.

Snowmobiling

Snowmobiling is a significant recreational activity in northern communities in BC. The closest active snowmobiling clubs are the Houston and Burns Lake Snowmobile Clubs, which are members of the BC Snowmobile Federation. Most club activities are concentrated in and around Smithers and Fort Babine. However, there may be a low level of club coordinated snowmobile use in the Project study area, according to interviews with representatives from both clubs.

The Houston Snowmobiling Club was established 30 years ago and operates in a 100-km area in and around Houston. The three most commonly used areas include Equity Meadows (20 km south of Houston), the Telkwa Range (near Smithers), and to the south near Huckleberry mine. The snowmobile area closest to Highway 118 towards Granisle is the “Onion,” a mountain between Smithers and Granisle. Access to the Onion is only possible a few times a year because of the lack of trails and dependency on favourable weather conditions. The Houston Snowmobiling Club has 50 registered members and approximately 25 to 30 snowmobiles owned by Houston community members. The club maintains, grooms, and brushes three routes close to Houston. Membership costs are $85 for a single person, $130 for a couple, and $135 for a family. The snowmobile members ride weekly, mostly on Saturdays and Sundays.

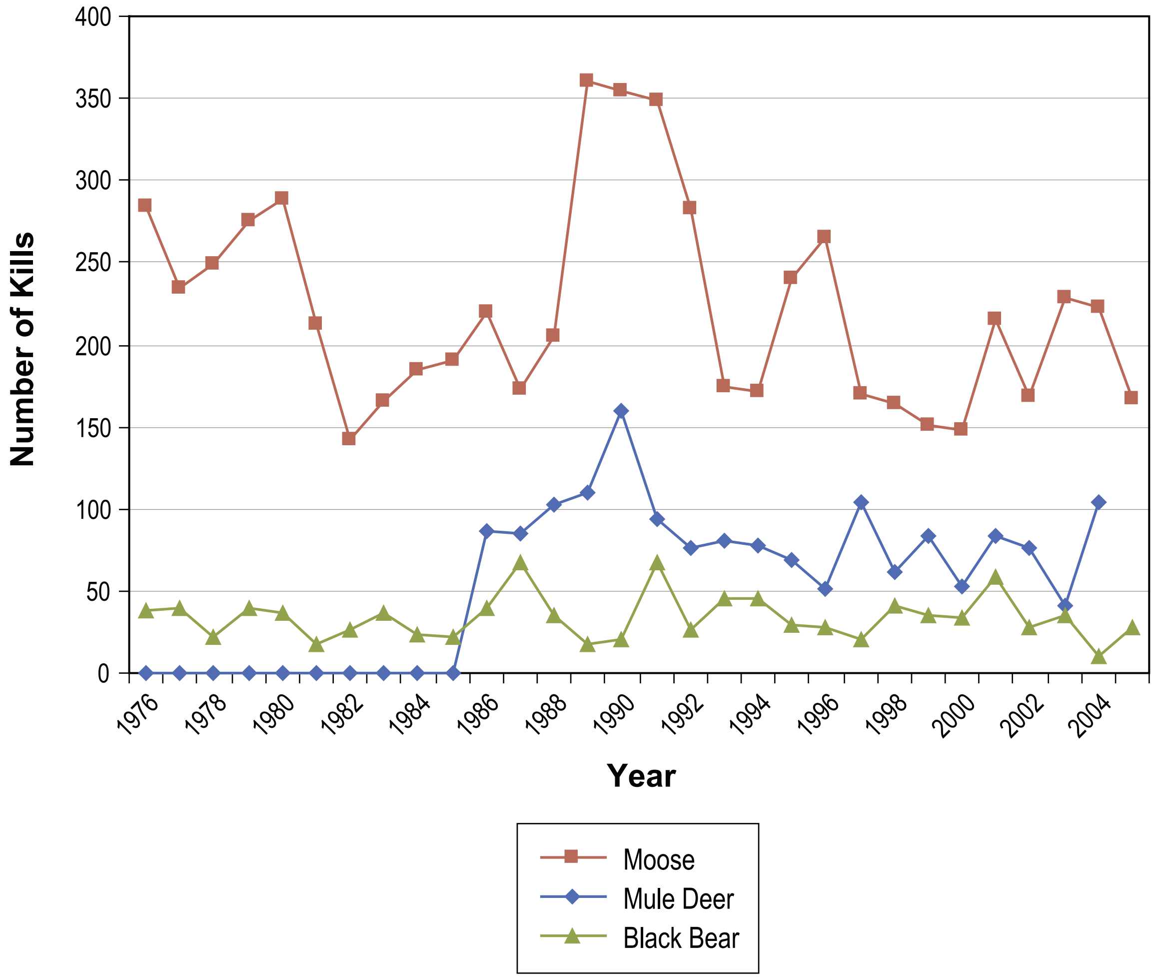


FIGURE 7.18-7

Morrison Copper/Gold Project: Total Resident Kills

The Burns Lake Snowmobiling Club is in cooperation with the Burns Lake club, sharing trails and offering discounts to those who ride on groomed trails. Members of either club pay $5 for use of the trails, while the public fee is $15. There has not been much increase in the number of new members over the past five years, but there has been an increase in young riders who neither pay the fees nor obey the rules.

Tourism

The Lake Babine area is a popular tourist destination. The Granisle Tourism Information Centre, which collects data on visitor numbers, reported between 800 and 1,000 tourists visited the centre in 2007. The visitors consist mainly of locals from Houston, Burns Lake, and Smithers, with some tourists from Europe, including Germany and Holland, but few from the US. Foreign and local visitors are drawn to the area for its wilderness and recreational value with a particular emphasis on fishing, hiking, and scenic viewing. Boating is also a favourite activity, supported by several marinas along the shores of Babine Lake, including one in Granisle. There is also camping at provincial parks. In the winter season, cross-country skiing and snowmobiling are the dominant activities in the area around Granisle.

7.18.6.3 Access and Roads

The Project access and concentrate haul route follows existing FSRs, including Jinx and Hagan FSRs, makes use of a barge to cross Lake Babine, and continues on Highway 118. This section describes the current level of road use, capacity, and other pertinent details.

Lake Babine Barge

Canfor has operated the Babine Lake barge for nearly 20 years to facilitate access to its tenures on the east side of Babine Lake. Craig McCarthur and Bill Wilson currently run the barge. Many different industry groups use the barge on a yearly or seasonal basis, including guide outfitters, mining exploration and forestry. There is varying levels of public use of the barge by hunters and recreationists concentrated in the summer and fall, but this is limited by the priority given to industry transport needs. The barge runs on a weekly basis from Michelle Bay (near Tachet) to Nose Bay on the east side of Lake Babine. At full capacity the barge has and could run 3,400 barge trips per year; however, Canfor has budgeted for 115 in 2009 given the recent downturn in logging activities on the east side of Lake Babine. The barge is running at a lower capacity than previous years, because logging activities have declined. The barge is able to transport eight concentrate B-Trains with trucks at a time without modification and can operate on a schedule of 24 hours a day, 7 days a week, and 365 days a year.

However transportation studies done for PBM assume that the barge will operate 14 hours a day, 7 days a week, for 365 days of the year during Project operations. The barge is adequately sized to move all (11) B-Trains, without trucks, in a single trip. The barge can make approximately 1 (return) trip per hour (Appendix 12). PBM requires approximately 2 return trips per day during operations.

Forest Service Roads

A well-developed FSR system supports logging activities in the area on the east side of Babine and Morrison lakes. The 2-km stretch of FSR beginning at the barge landing is called the Nose, the next 7 km section is called Jinx Road, and the remaining segment, which is approximately 38 km long, is referred to as Hagan Road and Morrison East.

The current level of use of these FSRs is low because of ongoing reforestation efforts, but has been higher in the past. Canfor anticipates that forestry activities in and around the Project study area will increase as early as two years from now. This would result in a renewed influx of logging truck traffic along these FSRs, up to an estimated 10 logging trucks per day as well as an additional 10 service and support vehicles.

Highway 118

The traffic levels on Highway 118 are currently low and amount to approximately 100 or more cars per day. The BC MOFR is seeking to repave Highway 118 in the near future, subject to funding and other pressures for access across the province. A substantial increase in traffic on Highway 118 is expected in the next four to five years resulting from an increase in timber harvest because of the MPB epidemic. A traffic flow rate of 20 trucks every hour is predicted.

7.19 Socio-economic Environment

7.19.1 Introduction

The existing socio-economic conditions of communities identified as susceptible to being affected by the Project have been summarized to provide contextual information on the human dimension of the Project. The socio-economic environment of the study communities is characterized by social, economic, health, cultural, and community components and considerations. The following overview of the socio-economic environment is drawn from the *Socio-economic Baseline Study Report* (Appendix 45), which provides comprehensive details of the socio-economic conditions of the study communities.

This environmental setting reports on past and current socio-economic conditions, as well as dynamics and trends that have been observed in the provincial, regional, and local study communities to date. This baseline information, which profiles the socio-economic conditions in communities before the Project's existence, provides a basis for predictions of potential Project-related change, in addition to providing benchmarks from which projected changes can be measured and monitored. In particular, this information supports the effects assessment (Section 8.19), including the identification and assessment of potential effects and the development of mitigation, enhancement measures, and management planning.

The following section outlines the study boundaries, general methodology, and a summary of the socio-economic conditions of the study communities. The focus of baseline information varies slightly between communities, with emphasis given to the specific socio-economic components of the different communities that are most likely to be influenced by the Project. Accordingly, the most diverse and detailed level of information is provided on the primary communities, which are those communities nearest the Project that are expected to encounter the most significant and varied effects. In contrast, relatively less information is provided on the wider provincial community, given that the Project's effects are likely to be diluted and essentially limited to being economic in nature.

7.19.2 Study Boundaries

The Project could affect multiple subsets of communities, ranging from the provincial community to communities in local villages and towns. The Project is in northwestern BC within the Bulkley-Nechako Regional District (BNRD). Additionally, it falls within the asserted traditional territory of the Lake Babine Nation. To capture large-scale trends, socio-economic information is profiled at a broad level starting with a provincial, regional, and First Nations overview before the focus is narrowed to more localized community levels.

The area directly surrounding the Project contains a number of local level Aboriginal and non-Aboriginal communities that are likely to experience the widest range of socio-economic effects. Depending on the Project's proximity to these communities and the nature in which they are anticipated to be affected, individual communities have been classified as either primary or secondary, with primary communities anticipated to be the most significantly affected communities.

The socio-economic baseline conditions are reported for the following study communities and discussed within these general categories:

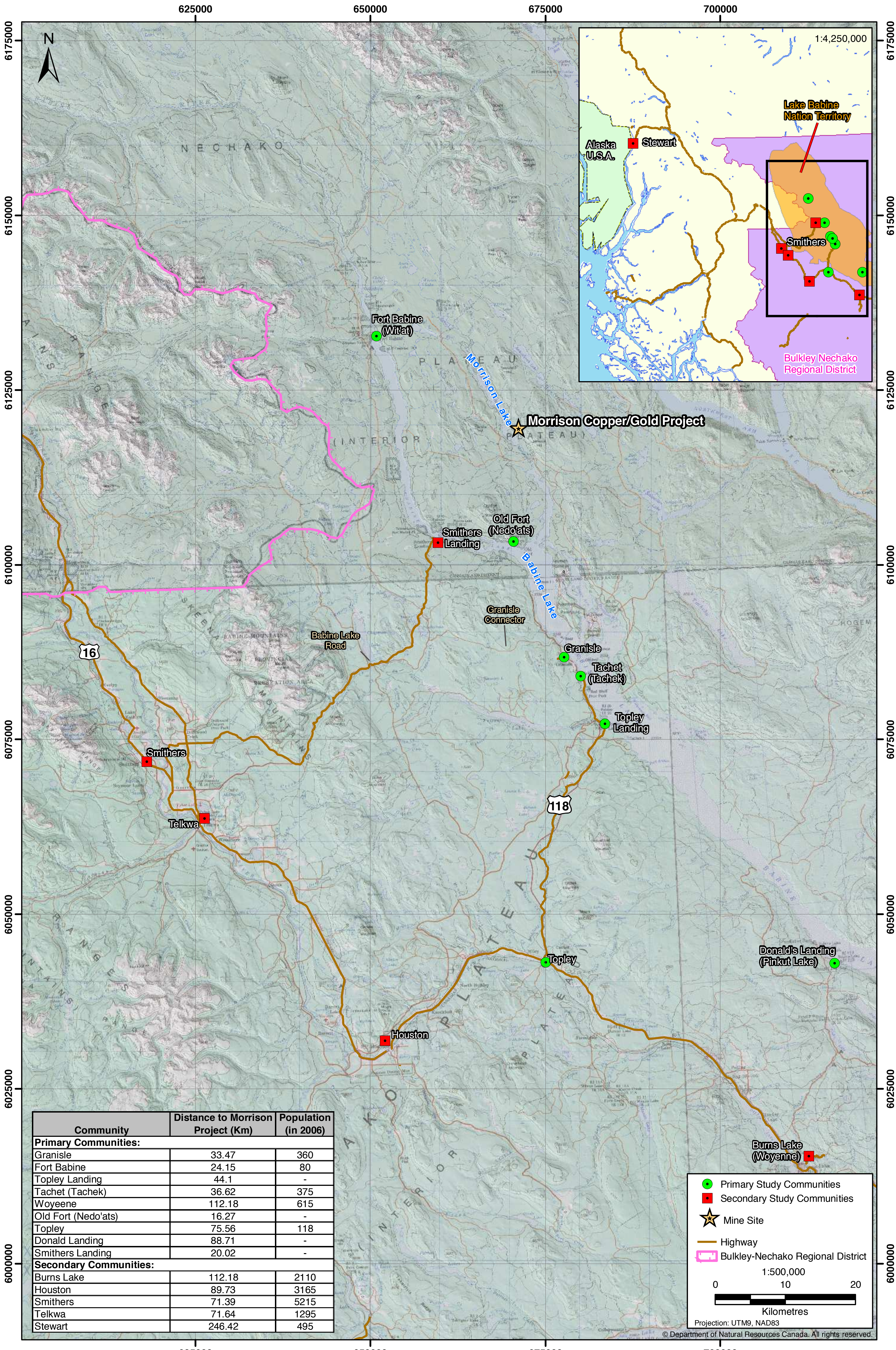
- the province of BC;
- the regions of northwestern BC and the BNRD;
- the Lake Babine Nation;
- the primary study communities, which include the Lake Babine Nation communities of Fort Babine, Old Fort, Tachet, Donald's Landing, and Woyenne in addition to the Village of Granisle, Topley, Topley Landing, and Smithers Landing; and
- the secondary study communities of Burns Lake, Houston, Telkwa, Smithers, and Stewart.

Figure 7.19-1 illustrates the regional study area, as well as primary and secondary study communities.

7.19.3 Methods

Socio-economic information on the study communities has been compiled from the results of thorough desk- and field-based research. Quantitative data were extracted from existing and available statistics, and other data from provincial, regional, and local sources. Key sources included Statistics Canada Census data and BC Statistics (BC Stats).

Qualitative primary research was conducted to verify, contextualize, and fill in gaps in the quantitative information and data collected. This consisted of telephone and face-to-face interviews with key information holders and service providers in the communities, including community leadership, health care providers, social workers, teachers, and major employers. These interviews provided supplementary information that helped to consolidate existing research.



Community	Distance to Morrison Project (Km)	Population (in 2006)
Primary Communities:		
Granisle	33.47	360
Fort Babine	24.15	80
Topley Landing	44.1	-
Tachet (Tachek)	36.62	375
Woyeene	112.18	615
Old Fort (Nedo'ats)	16.27	-
Topley	75.56	118
Donald Landing	88.71	-
Smithers Landing	20.02	-
Secondary Communities:		
Burns Lake	112.18	2110
Houston	89.73	3165
Smithers	71.39	5215
Telkwa	71.64	1295
Stewart	246.42	495

FIGURE 7.19-1

Morrison Copper/Gold Project
Socio-economic Study Communities

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Rescan

Qualitative and quantitative socio-economic indicators were used to gauge the status of the population, education, social services and issues, health services and issues, and cultural and economic conditions in the different communities. The availability and reliability of data had a considerable bearing on the selection of indicators. Appendix 45 provides details of the indicators available for this report.

7.19.3.1 Limitations

Quantitative

The cross-checking of quantitative data was difficult as the root source was primarily Statistics Canada Census data. Detailed socio-economic information was only available at the Local Health Area level, which often encompasses more than one community. For some communities and reserves, no data are available beyond those for the wider region.

Furthermore, because of the small size of most study communities and confidentiality concerns, much of the available Statistics Canada data have been rounded, aggregated, and/or masked. Outdated information is yet another concern, as the BC economy has changed significantly over the past five to ten years. During this period, the state of the economy has fluctuated, with economic growth shifting from slumped to resurgent and strong before more recently reversing course, as the economy has entered a recession in response to the global economic crisis. Furthermore, there are data inconsistencies with respect to information from Census subdivisions and other regional zones in the province, as the borders of these areas rarely coincide with one another, and have often changed significantly over time.

Qualitative

To address data gaps and limitations, this study has followed a mixed-method approach, supplementing statistical data with information gained from community interviews with key professionals, leadership, service providers, and local residents in study area communities. Endeavours were made to thoroughly cross-reference information obtained from interviews for validity and reliability with quantitative data and the results of other interviews, although this was not always possible. Available quantitative information would ideally be verified and complemented using qualitative data derived from community-based collaborative research efforts involving local members of the Lake Babine Nation communities. Socio-economic community interviews were suspended at the Lake Babine Nation's request in August, 2007, and have not resumed since that date to respect appropriate communication protocol.

7.19.4 Provincial Economy

7.19.4.1 Overview

The modern BC economy, which began with the fur trade and gold rush in the mid-1800s, has strong ties to the natural resource sector, with the mining and forestry industries having played a central role in early economic development. The economy has diversified significantly since this time, and BC's population has increased rapidly. BC currently has the third-largest population in Canada, representing 13% of the country's residents and 12% of the national gross domestic product (GDP; BC Stats 2006b).

The BC economy has gained strength over the past several years, although it has recently begun to contract. Economic growth in the province slowed to 3.1% in 2007, yet still managed to outpace the national growth rate (2.7%) for the sixth consecutive year (Statistics Canada 2007b). As of May, 2008 (at which time there was minimal awareness of the imminent economic downturn) estimates of the provincial economic growth rate for 2008 ranged between 2.2% and 2.9%, while growth rates for 2009 had been forecast to average between 2.7% and 2.9% (Province of British Columbia 2008). Nominal[1] economic growth in 2008 was reported at 3.5%, while real[2] economic growth was reported at -0.3%, with further economic retraction expected in 2009 (BC Stats 2009). In early 2007, the unemployment rate fell to a 31-year low of 3.9%, although since March 2009, it has escalated to 7.4% (BC Stats 2007d). The previously high rates of employment and economic growth were accompanied by high inflation rates, which surpassed their target range of between 1% and 3% in September, 2008. Inflation rates have since fallen as oil prices have dropped and economic growth has slowed.

In the latter part of 2007, economic growth was restrained by a strong Canadian dollar and weakened US markets. The manufacturing sector in particular was adversely affected by these economic conditions. The Canadian dollar lost some of its strength in the latter part of 2008, which encouraged export sales. At the same time, demand for Canadian imports decreased due to the declining growth of the global economy. Despite these circumstances, BC businesses have maintained higher levels of optimism than businesses in most other provinces in the country (CFIB 2008). In the first quarter of 2008, 858 major capital investments were noted to be on the horizon. Some of these projects include the Port of Vancouver, the Vancouver Convention Centre, the 2010 Winter Olympics, and the Sea to Sky Highway redevelopment (BC Stats 2008a). However, the stock market's tumbling value and weakening of the global economy in the latter half of 2008 have raised questions over the BC economy's ability to achieve predicted growth levels.

Overall, the provincial economy has become increasingly diverse over time, which is illustrated by its declining dependence on natural resource industries. Focus has shifted from mining and forestry to value-added manufacturing and service sectors. Employment in the natural resource sector has fallen from 13% of the provincial labour force in 1990 to only 9% in 2005 (BC Stats 2006a). While dependence on natural resource industries is declining for the province overall, much of this trend is based in the heavily populated regions of the Lower Mainland and Vancouver Island. In contrast, many of the smaller communities outside these regions still exhibit a strong reliance on the primary goods industries, including mining, forestry, agriculture, and fishing (BC Stats 2006b). These industries, which are subsectors of the goods sector, are more sensitive to economic fluctuations than the service sector, and their employees are more likely to experience periods of unemployment during economic downturns.

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[1] Nominal indicators are in current prices.

[2] Real indicators have been adjusted to remove inflationary distortions over time, by weighting all values to the dollars from one year (e.g., $2002).

Mining

In recent years, the province's northern regions have experienced an upsurge in exploration and mining activities, driven by high global demand (particularly in Asia), and more directly by surging mineral prices. While mining activities are localized by nature and often found clustered in mineral-rich regions, the economic implications can be seen at the provincial scale.

A recent review of the mining industry, which included the participation of 40 companies across BC, highlighted the exceptionally strong growth in the mining sector in recent years, yet noted some weakening in 2007 (PricewaterhouseCoopers 2008). Key findings included:

- Expenditures on exploration and development grew from $129 million in 2006 to $158 million in 2007.
- In 2007, gross mining revenues fell to $6.9 billion from a high of $8.1 billion in 2006, yet remained above 2004 and 2005 levels. Net revenues for the mining industry were also down in 2007, estimated at $5.56 billion. After strong growth in recent years, these revenue declines were speculated to be caused by falling coal prices.
- Net income for the industry decreased from $2.3 billion in 2006 to $1.2 billion in 2007.[3] However, the industry still generated operating cash flows of approximately $2 billion.
- The average number of people employed by BC mining increased from 7,071 in 2005 to 7,415 in 2007.
- The return on shareholder investment decreased from 64.8% in 2006 to 41.6% in 2007, but remained high in relative to other industries.
- In 2007, the mining industry contributed a total of $463 million in government payments, which was significantly lower than the $799 million paid in 2006, but higher than 2004 levels.

Coal and copper are the most important exports from BC's mining industry. In 2007, the provincial mining industry was hit by falling coal prices; however, precious metals and base metals experienced dramatic price increases during 2007. The price of lead doubled while gold prices jumped by $US93/oz. to US$697/oz. in 2007. The price of copper weakened slightly in 2007, yet remained higher than historical levels caused by an 83% price increase in 2005. Copper accounted for approximately 30% of the net revenue received by the industry, and gold for 4%.

The mineral industry is particularly vulnerable to volatility in global markets and boom-bust cycles because of the high export rate of mining products and because most mineral prices are set internationally. In past years, demand outstripped the available supply of many minerals because of strong growth in industrializing Asian countries, which resulted in increases in the values of many minerals on world markets. In the latter half of 2008, weakening global demand coupled

[3] Net income grew strongly in 2004, 2005, and 2006, respectively reported at $871 million, $1.8 billion and $2.3 billion (PricewaterhouseCoopers 2005; 2006; 2007).

with the international stock market crisis has led to much fluctuation in mining industry markets and increased uncertainty.

During 2007, there were 20 mines operating in BC. Two of these were new mines and one was re-opened. There were 11 metal, 10 coal, and 36 major industrial mines, as well as numerous quarries (BC MEMPR 2008). There were also significant numbers of placer mines and over 1,100 aggregate pits in operation. One mine was in its construction phase, while more than 20 proposals for new mines and quarries have been submitted for government review.

Mining, oil, and gas industries (including support activities) employed approximately 13,800 people across the province in 2005 (90.5% male), accounting for 3.2% of the provincial GDP (BC Stats 2006a). The majority of jobs were unique to primary industries in the area of trades and equipment operation. Mining workers earned among the highest wages of any industry, averaging $25.67 per hour (BC Stats 2006b). Average annual salaries and benefits increased from $99,900 in 2006 to $101,900 in 2007 (PricewaterhouseCoopers 2008). High salaries and benefits reflect the recent shortage of skilled and experienced workers.

Forestry

With approximately two-thirds of BC's land covered in forests, the forest industry is significant to both past and contemporary economic development, and has historically accounted for more than half of provincial exports. However, export prices have remained relatively constant since the mid-1990s and have not experienced the increases seen in most other commodity markets. In 2005, forest products represented only 39% of total export value, down from more than 60% in the 1980s (BC Stats 2006b).

The forestry industry employed 21,600 people in 2005, with an average wage of $23.60 per hour (which is 20% higher than the provincial average). The industry is a major employer throughout northwestern BC, and employs mostly men, who make up 80% of the workforce (BC Stats 2006b). Employment in forestry and logging is expected to grow over the next few years, at approximately the same rate as the growth of the economy. However, the overall contribution of this industry to the provincial GDP is expected to decline slightly, from 2.9% in 2005 to 2.5% by 2014 (BC Stats 2006b).

The provincial forest industry is presently dealing with an MPB epidemic, which is detrimentally affecting an estimated 9.2 million hectares across the province. AACs for many TSAs have been temporarily increased so that the maximum value may be gained from the affected timber. Harvest activity will be cut back in the future to allow forests to recover and regenerate (BC MOFR 2007a).

Other Industries

Aside from forestry and mining, other resource-based industries in BC include agriculture, fishing, tourism, and guide outfitting.

7.19.5 Regional Overview

7.19.5.1 Northwestern BC

Overview

Northwestern BC is a large and relatively undeveloped area, encompassing the Nechako and North Coast development regions. Despite increases in the overall population of BC, this region's population has been falling for the last decade, with the rate of decline easing in more recent years.

The region is further characterized by its remoteness, with communities generally isolated from one another, the major population, and governance centres in the southern districts of the province. Transportation and communication options are limited, and reaching service centres, such as Smithers, often requires travelling long distances.

Northwestern BC exhibits a larger dependence on primary resource industries such as mining, forestry, and fishing than much of the rest of the province. While forestry accounts for a significant amount of regional employment, tourism, administration, and mining are also recognized as major driving forces of northwestern BC's economy. The port of Prince Rupert has provided a number of jobs and has helped to stimulate the local economy because of the increased rail traffic through the region.

As communities in this region rely on the predominantly resource-based economy, they are susceptible to fluctuations in global commodity markets. The unemployment level in northwestern BC tended to track the provincial average closely in the early 1990s, but as the recession affected the region in the late 1990s, unemployment rose more significantly in northwestern BC because of its heavy reliance on natural resources. The discrepancy between the unemployment rates of the region and the province narrowed in 2002, but widened again in 2007. Unemployment in the region was estimated at 7.7% in 2008, down from 12.6% in 2002, although is likely to rise in 2009 to mirror provincial increases (Statistics Canada 2007a).

Key barriers to employment include a structural mismatch of skills and employment opportunities. Without further training, employee transferability between industries has been limited, particularly among low-skilled, older workers who were forced to leave the declining forestry industry. Other barriers to employment in the region include limited public transportation, access to education, and variance in motivational levels (J. Botti, 2008, pers. comm.).

Real wage growth in the region was the lowest in the province between 2002 and 2005, with nominal wages barely keeping pace with provincial inflation and threatening to cause a decline in purchasing power[4] (BC Check-Up 2008). However, since this time, wages are believed to have gradually risen in the region as they have across the province, while inflation is believed to

[4] Real wages are adjusted into constant dollars to remove inflationary bias, whereas nominal wages are based on unadjusted current dollar figures.

have receded as it did in BC in late 2008 in response to falling oil prices in combination with an overall weakening of the economy.

Mining

The regional mining industry currently constitutes a significant source of employment for the region. Data from 2004 indicate that the mining sector directly accounted for about 207 jobs in the Bulkley Valley, and upwards of 600 jobs in the wider region (BC Stats 2004; Table 7.20-1). At present, three mines are operating in the area: Eskay Creek, Huckleberry, and Kemess South; however, these mines are all expected to close within the next few years (operations scheduled to end in 2008, 2010, and 2009, respectively). As indicated by Table 7.19-1, this is expected to result in the loss of a significant source of employment.

Table 7.19-1
Predicted Mine Closures and Employment Losses by Community, by 2010

Community	Jobs Lost
Primary Effect Area	
Smithers	173
Telkwa	30
Houston	79
Prince Rupert	5
Terrace	52
Hazelton	16
Total – Eskay Creek	368
Total – Huckleberry	283
Total – Highway 37/37A Corridor	138
Total – Northwestern BC (incl. Kemess)	629

Source: (Bridges and Robinson 2005; NovaGold Resources Inc. 2006).

To create local employment opportunities, future mineral development has been supported by local and regional management plans which, combined with the recent high prices of minerals, have helped to facilitate significant growth in mineral exploration in the region (BC ILMB 2000; BC MSRM 2004). Mineral exploration in the area is said to employ 1,330 people on a seasonal basis (BC MEMPR 2006). Proposed developments in the area include: Galore Creek[5] (permitted), Red Chris (permitted), Mount Klappan (pre-application), Kutcho Creek (pre-

[5] The Galore Creek mine began construction activities in 2007, with an expected start date in 2012. However, on November 26, 2007, the project operators announced an indefinite suspension in construction activities, due to higher capital costs and construction delays.

application), Schaft Creek (pre-application), and the Davidson Project (application under review). The Kemess North mine expansion EA application underwent a joint panel review that resulted in a recommendation to the government that the project not be permitted. In the spring of 2008, the federal and provincial governments announced that they accepted this recommendation, which confirmed that the proposed Kemess North project will not be permitted in its current form (DFO 2008).

Although northwestern BC has in recent years past experienced an increase in mineral exploration and development activity, it is important to note that mineral development is both cyclical and finite by nature. Mining activitiy is also highly sensitive to mineral price changes. Throughout northwestern BC, there are numerous examples of projects that have been suspended or closed and subsequently restarted in response to market fluctuations (e.g., the Granduc, Premier, Cassiar, Bell, and Kitsault mines). Employment opportunities at a single mine may have significant longevity, extending over several decades, however they are ultimately confined to a finite period, and while a large workforce may be hired for the first few years of construction, the size of the workforce during operations will usually be somewhat reduced. Forthcoming mine closures over the next couple of years in combination with a weakening economy are expected to result in substantial job losses which will be strongly felt in many of the remote communities in this region.

Forestry

The key communities in which forestry is most prominent include the Town of Houston, which is home to large modern mills, along with Ft. St. James and Smithers where forest manufacturing is significant.

The northwestern BC forestry industry continues to face the difficult challenges of high operating costs, recently unfavourable exchange rates,[6] a low-value timber profile, and MPB epidemics in some areas. About 70% of the timber in the Lakes District is pine, almost all of which is said to be infested with MPBs (BC Check-Up 2007). The MPB-affected Lakes District region has been almost entirely harvested to prevent further spreading and to set the stage for long-term reforestation and replenishment.

Within northwestern BC is the Nadina Forest District, which includes the Morice TSA and the Lakes TSA. The Project is within the Morice TSA, which covers approximately 1.5 million hectares of forest and is administered from Burns Lake (BC MOFR 2007a). The major forestry companies operating in the area surrounding Babine Lake and the Project include Canfor and Houston Forest Products. The Lake Babine First Nation also owns a much smaller sized tenure parcel on the east side of Babine Lake.

The Morice TSA contains more species and higher diversity than most TSAs in the Northern Interior Region, but "pine still represents 54 million cubic metres or 43% of the total volume with the timber harvesting land base," (BC MOFR 2007a). By 2010, the MPB will have

[6] Forestry industry exports have been adversely affected by the high Canadian dollar, given that a higher dollar translates to higher prices for importers.

cumulatively affected an estimated 73% of the total mature pine volume in the area (BC MOFR 2007a). Effective February 1, 2008, the Morice TSA's new AAC was raised from the original 1.96 million cubic metres to 2.16 million cubic metres to respond to the growing MPB infestation (BC MOFR 2007b).

Tourism

Tourism in northwestern BC has increased over the past decade, with a notable expansion in ecotourism taking place in and around the 16 provincial parks in the region (WelcomeBC 2007). An increasing number of people now visit the area to participate in an array of outdoor recreational activities, such as fishing, hunting, hiking, camping, boating, and skiing. In addition to these activities, angling and guide outfitting services contribute to the local tourism industry. Strong growth in revenue derived from tourist accommodation in the northwestern region relative to others indicates that the regional tourism industry performed well in 2007 (Province of British Columbia 2008).

Public Sector

The public sector is another key source of employment in northwestern BC. The majority of government services are concentrated within the town of Smithers. Major employers within the public sector include the education, health, environment, and resources.

Infrastructure

The housing market in BC has started to lose momentum compared to previous years, which is exemplified by the lower housing starts in the second quarter of 2008 compared to 2007 (CMHC 2008). Northwestern BC in particular was one of the first regions to experience a housing market slowdown. Major infrastructure projects in northwestern BC are anticipated to stimulate the economy over the next five years. These projects include: the development of a major 600,000 unit container port at the port of Prince Rupert; the proposed Enbridge Gateway Pipeline Project linking Strathcona, Alberta, to Kitimat, BC; the hydro corridor project to interconnect Coast Mountain Power Corporation's Forrest Kerr hydroelectric project to the BC Hydro lines; and the construction of liquid natural gas (LNG) terminals in Kitimat.

The Project's concentrate haul route will travel south along Hagan Road, which is a gravel logging road down the eastern shore of Babine Lake. At Nose Bay, the trucks cross the lake by barge to Michelle Bay near Granisle. From there, the haul route follows the paved Highway 118 from Granisle to Topley, continues north along Highway 16, then north and northwest along Highways 37 and 37A to the port of Stewart.

The area surrounding the Project is not expected to be harvested for the next 4 to 6 years. Once harvesting commences, the road is expected to experience a multi-directional increase in traffic with a maximum of approximately 10 loaded forestry trucks travelling on the road per hour in addition to an increase in the frequency of barge trips across Babine Lake (R. Phillips, 2008, pers. comm.).

The concentration of traffic activity in the local region is highest around the communities of Granisle, Tachet, and Topley Landing, where the majority of services are located (G.

Archambault, 2008, pers. comm.). The main road users in the immediate area are the residents of Granisle and Topley Landing, visiting recreationalists, and forestry trucks.

The low level of forestry activity in the immediate area has also resulted in fewer logging trucks on Highway 118, on the east side of the lake (G. Archambault, 2008, pers. comm.). The traffic level on Highway 118 from Granisle to Topley Landing and into Topley has been estimated at approximately 100 vehicles per day, with seasonal variations (F. Seychuk, 2008, pers. comm.). The BC Ministry of Transportation (BC MOT) claims that repaving and general upgrading is scheduled to occur in 2009, pending confirmation of provincial funding.

7.19.5.2 Bulkley-Nechako Regional District

The BNRD is a large sparsely populated sub-region of northwestern BC that encompasses the primary and secondary study communities. Comprehensive data were collected on the BNRD to confirm socio-economic trends in the region and, in particular, to help supplement information gaps in smaller communities in which information was unavailable.

Historical Economic Context

The BNRD's modern economy began with the construction of the Collin's Overland Telegraph Line that passed through the regional district to link Alaska with the Lower 48 states in the United States, and was further developed with the construction of the Grand Trunk Railway. These developments brought an influx of settlers attracted by inexpensive homesteads in the area. Soon after, a resource-based economy emerged in the region.

Governance

The BNRD is established as the "local government," providing political representation for rural residents and unincorporated areas.[7] The regional district, headquartered in Burns Lake, encompasses various government operations, which are spread throughout the seven electoral areas in the regional district's jurisdiction.

Population

In 2006, BC Stats reported the BNRD's population to be 38,243, representing less than 1% of the total provincial population. Approximately 48% of the population resides within the boundaries of the eight major communities in the region, while the remaining majority are reported to live in unincorporated areas. While the population of the province as a whole increased by 5.3% between 2001 and 2006, the population of the BNRD declined by 6.4% (BC Stats 2007a). The population is also characterized by a lower median age than the province. Migration to the BNRD has been tied to the economic activity of the forest industry, and accordingly experienced a decline during the industry downturn between 1998 and 2004.

[7] The BNRD fully supports the local population living in rural centres and provides support for 50% of the population living in unincorporated areas.

Education, Skills and Training

The region's population was reported to contain a higher proportion of people without a high school certificate than the province as a whole (31% versus 20%) and a much lower proportion of people with post-secondary educational achievements (Statistics Canada 2007a). A relatively high proportion of BNRD residents compared to BC residents have skills in trades (13% versus 11%), reflecting the nature of many employment opportunities in natural resource industries.

Education services are provided by the Bulkley Valley School District 54 and Nechako Lakes School District 91. These two districts serve a combined 8,200 students across 39 educational sites throughout the region. Northwest Community College (NWCC) operates in Smithers and Houston, and includes a new School of Mineral Exploration and Mining, which provides specific training and skills associated with the regional mining industry. The District is also home to the College of New Caledonia (CNC), which operates from Burns Lake.

Employment

In 2006, the BNRD had a labour force participation rate of 69.5%, which was higher than the provincial rate of 65.6%. Unemployment was estimated at 10.3%, which was also higher than the provincial rate of 6%, and was noted to be more significant for men than women.

Income and Earnings

The median earnings for all BNRD residents over the age of 15 years, including those with full-time employment, exceeded provincial medians in 2005, particularly for males. This is partially due to the nature of local employment opportunities, many of which are high wage positions in the primary resources sector that are traditionally held by men. Female median earnings and income levels were lower than median levels for BC. Overall, the median income level in the BNRD was slightly lower than the provincial median. Employment insurance (EI) and basic income assistance was reportedly obtained by 4.3% of the population as compared to 3.2% of the provincial population. On average, earnings and income levels for the BNRD as a whole were loosely comparable with non-First Nation primary communities and well above those for First Nation primary communities.

Economy and Business Environment

The forestry sector has typically provided a principal source of employment for the BNRD's local residents, along with resource-based industries and manufacturing. Men primarily relied on employment in resource-based industries, manufacturing, and business services, while women were more dependent on education, health and social services, and retail trade. This is a trend observed across communities in the region. Occupations most common to the community included those related to trades, transport, and equipment operation, and sales and service.

BC Stats reported a total of 3,597 businesses operating in the BNRD in 2006, representing about 1% of all businesses in the province. While total new business incorporations increased steadily in recent years from 78 in 2002 (to 135 in the BNRD in 2006), the overall number of businesses dropped 5.5% between 2003 and 2006 (BC Stats 2007c). The number of small businesses declined most significantly. The majority of businesses were related to primary resources, followed by retail and wholesale trade, tourism, the public sector, construction and transportation, and other service-related businesses.

Health and Social Characteristics

Health services are provided by the Northern Health Authority, which offers six health facilities, including four hospitals. The major regional health facility is the Bulkley Valley District Hospital in Smithers. There are also hospitals in Burns Lake, Ft. St. James, and Vanderhoof providing acute care, emergency and diagnostic services, and there is an additional diagnostic treatment centre in Fraser Lake. The region provides high standards of home and community care services but has experienced limited resources to address certain public and mental health issues. Major renovations to enhance emergency care and diagnostic imaging facilities, valued at $2.5 million, were completed in 2005.

Reports indicate that residents within the BNRD jurisdiction have significantly poorer health than BC residents as a whole (Northern Health 2005; BC Stats 2007c). In 2006, the BNRD was ranked 7th worst out of 26 regional districts in terms of health, with an Index of Health Problems of 0.48 (BC Stats 2007c). The Northern Health Authority believes that most health and social problems are caused by factors such as alcohol and tobacco consumption, diet, personal fitness, injury risk, and air quality factors, and are not endemic to the region. Furthermore, resource-based employment is known to increase the risk of accidents and injury. Residents of primary study communities have lower life expectancies, and a much higher statistical likelihood of experiencing premature death caused by an accident than those from elsewhere in the province. Other key social concerns identified include a prevalence of high school incompletion, teen pregnancies, and juvenile crime, which may also be reflected in the primary study communities (BC Stats 2007b).

Crime

Crime rates vary significantly across the region. Some communities, such as Telkwa and Houston, face relatively low crime rates, while other communities, such as Smithers and Burns Lake, face rates that are significantly higher than the provincial average.

From 2004 to 2006, spousal abuse and serious drug offences were more prevalent in the BNRD than in the province. Juvenile crime in the regional district was also more common than in the province; this was particularly true for property crime (e.g., theft) and the total amount of serious crimes (BC Ministry of Public Safety and Solicitor General 2008).

Infrastructure

The BNRD hosts a wide range of well-developed infrastructure.for the community, including highways, air, and rail services. Yellowhead Highway 16 connects most of the communities of the BNRD, running east to west and linking Prince George with Prince Rupert. The Smithers airport and CN Rail provide alternative means of transportation within the region and beyond.

In terms of housing, there were 14,550 occupied private dwellings in 2006 in the BNRD, with single-detached family homes making up 80% of the housing stock. Occupied dwellings in the BNRD were predominately owned (76.1%) rather than rented, which exceeded the provincial average (66%). Property values in the BNRD in 2006 averaged $165,796, having risen from previous years. The BNRD's housing stock is relatively new, reflecting the post-war growth in the regional economy. Between 2001 and 2006, much less housing was constructed (565 dwellings) compared to previous years (Statistics Canada 2007a).

Municipal public and private utilities are available to virtually all areas of the regional district. Natural gas is supplied by Pacific Northern Gas, water is provided by the various municipalities and private wells, and electricity is generated and distributed by BC Hydro.

Improved technology and telecommunication capabilities have allowed industries and residents throughout the BNRD to operate globally efficient businesses in the region.

7.19.6 First Nations

7.19.6.1 Lake Babine Nation

The Project is on Crown land within the asserted traditional territory of the Lake Babine Nation, which includes four relatively isolated communities. A fifth community is located outside the boundaries of the territory, near Burns Lake. Babine Lake is geographically and culturally central to the Lake Babine Nation's traditional territory and identity.

Cultural Revitalization and Sustainability

First Nations in BC, as in other parts of Canada, are making efforts to revitalize and sustain their culture. Aboriginal education and government funding programs support common initiatives to foster cultural and social self-reliance among numerous First Nations communities. Central to all initiatives are language, ties to traditional ways of being and living, and learning from the community's Elders. Examples of such program components include: language and culture camps, school immersion programs, apprenticeship programs, certification of language and culture authorities, Aboriginal higher (post-secondary) education programs, student bursaries, and course curriculum review and design (Province of British Columbia 2007).

Lake Babine Nation Culture and Society

The Lake Babine Nation follows a matrilineal social organization and includes four clans: Bear, Frog, Caribou, and Beaver, each led by its respective hereditary chief. Hereditary names and titles are socially ranked and this is reflected in ways of address as well as during seating arrangements at the *balhats*, which are multipurpose traditional ceremonies (Fiske and Patrick 2000).

Also known as potlatches, balhats are a ceremonial custom and are central to the legal order, economics, politics, and cultural identity of the Lake Babine Nation. Commonly lasting up to 12 to 14 hours, a wide range of business is conducted during the balhats. Hereditary Chiefs play a key role during the ceremonies as traditional ways of exercising legal authority are carried out. "Community harmony, ways of maintaining security, justice and culture are founded at the heart of the balhats" (Fiske and Patrick 2000).

Lake Babine Nation community members have long partaken in activities that contribute to their subsistence economy, including hunting and trapping, fishing, and plant and berry harvesting.

There are five Lake Babine Nation communities and associated member bands: Fort Babine, Old Fort, Tachet, Donald's Landing, and Woyenne. Fort Babine (Wit'at) is the oldest and most isolated settlement, to the northwest of the Project. The population centre of the Lake Babine Nation is now much farther south, based out of Woyenne, which has become the "core village" and administrative centre for the Lake Babine Nation because of its size and facilities (Fiske and Patrick 2000).

Governance and Treaty Negotiations

In 1957, the government at the time merged the Fort Babine and Old Fort bands and declared the united groups the "Lake Babine Band." The purpose of this amalgamation was to streamline administration and delivery of services and to eventually expand reserve land. "This government imposed decision was not appreciated nor accepted by the two groups, who, in the past made decisions independently" (Fiske and Patrick 2000).

The Lake Babine Band Council, whose members are elected tri–annually, represents all members of the Lake Babine Nation and manages inter-governmental relations, funding and budgets, and the provision of social and health services. Additional responsibilities related to land and resource issues, treaty negotiations, and language and cultural programs belong to the Office of the Hereditary Chiefs, whose Elders' Council plays an advisory role to the elected Chief of the Band Council.

Currently, the Lake Babine Nation is in Stage 4 (Negotiation of an Agreement in Principle) of the 6-stage BC treaty process, whereby negotiations take place to define the rights and obligations of the topics outlined in the treaty agreement framework established in Stage 3. Treaty negotiation components include: existing and future interests in land, sea, and resources; structures and authorities of government; relationship of laws; regulatory processes; amending processes; dispute resolutions; financial components; and fiscal relations (BC Treaty Commission 2007).

Social and Health Context

First Nations peoples have holistic concepts of health and well-being that extend beyond individual physical and mental well-being to include emotional, spiritual, and social well-being. Their health system is sustained by a healthy environment, functioning social relationships within families and the community, and a strong sense of cultural identity. From this holistic perspective, traditional indigenous knowledge, healing practices, and ceremonies are key components of the healing process.

Community health programs and services are run by a health director out of the general band office and delivered by health representatives in each community. To meet the distinct health care needs of the community, programs and services offered include: immunization programs, nursing and home care, drug and alcohol programs, community support services, administration of health and medical benefits, as well as health education programs. Social services offered include: family support, financial assistance, education, and counselling (Lake Babine Nation 2008a).

Indian and Northern Affairs Canada's (INAC's) Research and Analysis Directorate calculated a community well-being (CWB) index, which combines income, education, labour force activity, and housing conditions considerations into one index. The CWB index for the Lake Babine Nation was estimated at 57 out of 100 in 2001, which placed the Lake Babine Nation 13 points below the First Nations' average in BC, and 28 points below the non-Aboriginal CWB provincial index.

Access to clean and safe drinking water is a critical issue of concern for Lake Babine Nation leadership. INAC has placed Lake Babine First Nation on a priority list as a community with high-risk drinking water systems and drinking water advisories in effect (INAC 2006). Water quality is of particular concern for residents of Fort Babine and Tachet.

Over the past thirty years, the Lake Babine Nation, like other Aboriginal communities in the country, has experienced a decline in traditional activities, authority, and its economy, together with a breakdown of family organization and social cohesion. One by-product of these circumstances is the increase in social issues pertaining to crime.

Presently, many Lake Babine Nation members live outside their territories. In past years, migration to non-Aboriginal communities was encouraged, yet has not resulted in the positive effects that were hoped for, such as educational and employment success. The closures of the two copper mines that were once operating on Lake Babine have resulted in high rates of unemployment in the village of Tachet.

The band office administers numerous services for different purposes such as recreation, employment and training, housing, and legal services. The Lake Babine Nation owns and operates a number of businesses and services in addition to holding forestry tenureship on the east side of Babine Lake. Details are described in the Appendix 42.

7.19.7 Primary Study Communities

7.19.7.1 Characteristics of the Primary Study Communities

Overview

A number of trends and attributes are common to the majority of the primary communities. In general, these communities tend to be:

- small in size, isolated, and composed of many Aboriginal reserves;
- growing populations in First Nation communities and in Granisle, yet declining in unincorporated areas;
- slightly male-dominant populations, in contrast to the province which is female-dominant;
- relatively young in age, as compared to the province except for Granisle, which is a retirement community;

- characterized by relatively low levels of education and skills development in comparison to the BC provincial average, with high rates of high school incompletion (with Granisle being the exception);
- limited in educational options within the northwest;
- affected by high unemployment as well as low labour force participation rates;
- varied in the degree to which they are affected by adverse conditions (e.g., First Nations communities tend to experience higher unemployment levels and lower incomes than non-Aboriginal communities);
- relatively low income areas with median earnings below provincial levels in the majority of communities, and with males consistently earning more in full-time earnings than females; and
- underpinned by resource-based industries (e.g., fishing and forestry), manufacturing, education, and other services.

These issues characterize the socio-economic environment of the primary communities as a group, and are also relevant for many individual communities.

7.19.7.2 Fort Babine [8]

Fort Babine's traditional name "Wit'ane Keh" is roughly translated to mean "place of making dry fish." The community is approximately 100 km north of Smithers, on the northwest arm of Babine Lake. This small Lake Babine Nation community was originally established by the Hudson's Bay Company in 1840 and is now a popular location for fishing and boating.

Fort Babine's population has remained relatively stable in recent years, according to Census data. The population increased by 7% (5 people) between 2001 and 2006, to a total of 80 people, with equal numbers of males and females (Statistics Canada 2007a). The population was relatively young compared to the province, with no one reported to be over the age of 64 years in the community. The median age for men was 37 years and 35 years for females.

In 2006, it was reported that 73% of Fort Babine's population over the age of 15 years had not completed high school, while the remainder had obtained either a trade or college certificate. At the same time, the community's participation rate accounted for a mere 31%, while 20 people were reported to be without a job, bringing unemployment to 75%. This was approximately 12-times higher than the provincial unemployment rate of 6% (Statistics Canada 2007a). No income data were available for the community, because of its small size.

Fort Babine's local economy is largely resource-based, with a number of silviculture, forestry, and fishery businesses operating within the community, providing a range of seasonal as well as full-

[8] The Statistics Canada data incorporated into this section of the report for Fort Babine have been derived from Census data collected for the Indian Reserve Babine 6, which is the community's geographical classification employed by Canadian statistical agencies.

time employment opportunities. The community is home to the Babine Salmon Project and Fort Babine Fish Hatchery. There is also work available at the Lake Babine Nation's band office.

Fort Babine experiences unique challenges because of its isolation from both main service centres and other Lake Babine Nation communities and the services they offer. For example, a wide variety of off-reserve services are provided by The Indian Friendship Centre in Smithers; however, the Centre is virtually inaccessible to Fort Babine community members. Various social and health programs are administered by the band office and involve both in-house and external visiting professionals.

Fort Babine is accessed from the Babine Lake Rd, which is a gravel road off Highway 16. There are 29 houses in Fort Babine. The band office serves as a meeting space in addition to the local school's gym. Similar to Tachet, there is a water treatment plant; however, the facility is not in full operation and water is hauled in from Smithers on a bi-weekly basis (C. Williams 2007 pers. comm.). There are currently no stores or gas stations in Fort Babine (Lake Babine Nation 2008b; D. Patrick, 2007, pers. comm.). Most residents have phones and the band office also has an internet connection.

7.19.7.3 Old Fort

Old Fort, which was once a trading post, is at the division of two arms of the Babine Lake and is recognized as a truly historic and rustic community. The 21 houses in Old Fort are only accessible by boat. There is also a church, community hall, and 5 smoke houses. Approximately 16 new smoke houses are needed for families' cabins to accommodate the high level of salmon processing that takes place in August.

Because of the community's small size, there are no 2006 Census data available specifically for Old Fort. Experts from BC Stats indicate that data for the community have been aggregated at the level of the Bulkley Nechako Regional District Electoral Area G (BNRDG), which incorporates a large rural area surrounding Granisle and Houston, including Old Fort, Topley, Topley Landing, Smithers Landing, and Fort Babine (E. Panzenboeck 2008 pers. comm.). Refer to Section 7.19.7.8 for further socio-economic information on the larger district, which includes Old Fort.

7.19.7.4 Tachet [9]

Tachet is a community on the Fulton River, near its junction with Babine Lake. Every year thousands of spawning salmon migrate to the area, attracting tourists to view the natural spectacle. Tachet is accessed from Highway 118, followed by a gravel road near Topley Landing that continues to the reserve.

According to the 2006 Census statistics, Tachet's population was estimated to total 375 people. The community contained a larger number of men than women, with approximately 54% of the

[9] The Statistics Canada data incorporated into this section of the report on Tachet have been derived from Census data collected for the Indian Reserve Tache 1, which is the geographical classification given to the community by Canadian statistical agencies. Notably, no 2001 data was available.

population composed of males in 2006. In the community, the median age was 26.2 years for males and 28.5 years for females.

The 2006 Census data reveal that 81% of Tachet's population had not completed high school. The entire population aged between 35 and 64 years were without a high school certificate. The limited educational attainments of the community contrast starkly with the higher average education levels in BC.

The community had a low labour participation rate of 35% in 2006, which was significantly lower than the provincial rate of 66%. At this time, 40 people were estimated to be unemployed, corresponding to a 42.1% unemployment rate (Statistics Canada 2007a).

Tachet reported the lowest earnings among the primary communities. In 2005, median earnings for the working population over the age of 15 years totalled $8,567, compared to $25,722 in BC, while those working full-time earned a median of $22,848 compared to $42,230 in BC. Median income after tax was also reported to be well below the median for the province in 2005, estimated at $7,824 in Tachet versus $22,785 in BC. In contrast with many other communities as well as the BC as a whole, women reported higher annual median earnings than men and also higher incomes. However, men earned slightly more than women in full-time earnings, although the salary disparities were relatively slim. Approximately 32% of the community's aggregated income was derived from government sources, which was much higher than average in BC (11%).

The dominant industries in Tachet that employed the most people according to the 2006 Census included: resource-based industries, manufacturing, health care and social services, education, business, and other services.

There are some home care services offered out of the Tachet Band office, as well as other programs involving visits from social and health professionals (P. Malcolm 2007 pers. comm.). The band office is central to the 40 houses that compose the community. There is a community hall, a water treatment plant, a child care facility, a sports field, a convenience store, and a gas station in Tachet (Lake Babine Nation 2008b; D. Patrick, 2007, pers. comm.).

7.19.7.5 Donald's Landing

Donald's Landing, which is sometimes associated with "Pinkut Lake," currently does not have any permanent residents. Similar to Old Fort, it is a place where Lake Babine Nation members go to harvest and process fish on a seasonal basis. Some Lake Babine Nation members currently residing in Burns Lake have expressed desires to move back to their traditional village and revitalize the community. There are currently internal Lake Babine Nation initiatives in progress for a development plan that would incorporate Donald's Landing with Pinkut Lake and Pendelton Bay (M. Joseph 2007 pers. comm.).

There are no 2006 Census data available specifically for Donald's Landing because of the community's small size. Data have been aggregated at the level of the Bulkley Nechako Regional District Electoral Area B (BNRDB), which is a large rural area surrounding Burns Lake, and including: Donald's Landing, Palling, Decker Lake, Sheraton, and Babine Lake. The socio-economic statistics that follow are for the BNRDB and are indicative of the larger district, which contains Donald's Landing.

The population of the BNRDB stood at 2,155 people in 2006, having fallen 5.3% since 2001, when it was recorded at 2,275 people. The community contained slightly more males (52%) than females (48%) and was relatively young compared to the provincial population, with the median ages of males and females in the BNRDB estimated at 37.6 years and 39.2 years, respectively.

The BNRDB's population has obtained assorted levels of education, skills, and training. In 2006, approximately 29% of the population over the age of 15 years were without a high school certificate, while 30% reported completing high school to be their highest educational achievement. The remaining population held various trades, college certificates, and university degrees.

The BNRDB's participation rate rose marginally from 71.6% in 2001 to 74.8% in 2006. There were 110 unemployed people in the BNRDB (Statistics Canada 2007a). The unemployment rate for the community stood at 8.9%, having declined significantly since 2001 when unemployment was estimated at 21.2%.

Notably, these data are for the wider BNRDB, and may not accurately reflect the incomes and earnings received by residents of Donald's Landing. Earnings in the BNRDB were estimated at $28,677 in 2005, which was slightly higher than median earnings in BC. This was caused by the influence of male earnings, which were approximately three times higher than female earnings. Men also earned more than women for full-time employment, although the margins were smaller. Overall, earnings received by full-time employees of both genders were estimated at $54,253. Estimates of median income after tax in the BNRDB were estimated at $25,885, which again exceed the provincial median ($22,785) because of the male population's influence. Relatively more of the community's aggregated income was derived from employment than was typical in BC.

The division of labour between the different industries was diverse. The industries in the BNRDB that employed the most labour in 2006 included: resource industries, manufacturing, education services, business services, and other services.

7.19.7.6 Woyenne [10]

The population of Woyenne was reported to have risen 3.4% between 2001 and 2006, from 595 to 615 people. Population growth was more significant among males, who in 2006 represented slightly more than 51% of the population. The median age of the population, estimated at slightly over 26 years for both genders, was well below the provincial median in 2006.

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[10] The Statistics Canada data incorporated into this section of the report for Woyenne have been derived from Census data collected for the Indian Reserve Woyenne 27, which is the geographical classification for the community employed by Canadian statistical agencies.

Census data from 2006 reveal that 65% of Woyenne's population over the age of 15 years were without any certified education. The majority of those who lacked a high school certificate were aged between 35 and 64 years. In 2006, approximately 21% of the population over 15 years reported completing high school to be their highest academic achievement, while 10% were reported to have acquired a trade certificate.

The overall participation rate of Woyenne increased from 41% in 2001 to 49% in 2006, but remained well below the comparable 2006 rate for BC (65.6%). There were 70 unemployed people in Woyenne in 2006, which corresponded to an unemployment rate of 28.6% (Statistics Canada 2007a). Unlike many other communities, the unemployment rate in 2006 had increased since 2001, when it stood at 23.5%.

In 2005, the median earnings among the Woyenne population over the age of 15 years totalled $23,503, compared to $25,722 for the province (Statistics Canada 2007a). However, full-time employees reported median earnings of $45,621, which exceeded the $42,230 estimated for BC. Notably, males earned $45,654 while the female population reported no earnings from full-time employment, which appears to have skewed the full-time median earnings for the total population. Income after tax in the community was estimated at $11,142 in 2005, which was also substantially lower than the comparable level for the province ($22,785). A significantly higher proportion of the community's aggregated income was derived from government sources compared to BC (21% versus 11%).

In 2006, the industries in Woyenne employing the most labour included manufacturing and other services. Other industries employing smaller proportions of people included resource-based industries, construction, and retail trade. The manufacturing industry was observed to be entirely male dominant. The narrow spectrum of industries operating in the community indicates a lack of economic diversity.

There are 151 houses in Woyenne (D. Patrick 2007 pers. comm). Access is by paved road. Most amenities are offered through the Band office. Unlike the other Lake Babine Nation communities, most households in Woyenne have communications including telephone and internet services.

7.19.7.7 Village of Granisle

Once a wilderness settlement, Granisle has grown from a population of 300 people in the 1960s, at around the time the Granisle mine commenced operating, to approximately 2,000 people in the early 1970s when the Bell mine was also fully operational. Officially incorporated on June 28, 1971, Granisle was once termed BC's newest town. Low copper prices forced the mines to close in the early eighties, causing the population to fall to fewer than 500 people as former employees moved to other communities seeking employment (Noranda Minerals Inc. 1993). Now considered a retirement village, residents enjoy the amenities available and actively participate in various organizations and activities (L. McGuire 2007 pers. comm.).

Following the final closure of the Bell and Granisle mines in the 1990s, the village of Granisle's population continued to decline as employees and their families moved to other communities.

The village's population has since stabilized over the years into a relatively small population in comparison to its peak during the 1970s and late 1980s. According to Census data, the population totalled 365 people in 2006, having increased 4.2% from 350 people in 2001. The population was reported to contain slightly more males than females. The median age of the community was estimated to be 59.1 years for males and 58.8 years for females.

Granisle's population holds a wide range of different educational qualifications and skills. Only 17% of the population over the age of 15 years were reported to have no certified education, while at the other end of the spectrum, 15% had some kind of university qualifications. Completing high school was the most significant educational achievement for approximately 32% of population, while 9% had completed a trade certificate and 27% had a college certificate. The community is home to Babine Elementary and Secondary School, built to accommodate 500 students, but currently only has 46 registered students (G. Wood 2007 pers. comm.).

Granisle's participation rate decreased between 2001 and 2006 from 50.8% of 40.9%. Of the population participating in the labour market, a total of 35 people were unemployed in 2006, corresponding to a 25% unemployment rate (Statistics Canada 2007a). Unemployment levels were even higher in 2001, estimated at 30.3%, when the region was in the midst of an economic downturn.

The population of 15 years of age and over in Granisle reported median earnings of $14,313 in 2005, which was well below provincial levels ($25,722). Median earnings for women were higher than for men. The income reported for full-time employees according to Census data was $60,679 in 2005, which seems counterintuitive, given that women made $0 in median full-time earnings while men reported $35,691 in median full-time earnings. The median income after tax for Granisle was reported at $22,102 which was essentially on par with the province ($22,785). Slightly more than half of the community's collective income was derived from employment, with 20% derived from government transfers and another 26% from other money sources.

Granisle's economy revolved around mining from the late 1960s and early 1970s through to the early 1990s. Primarily copper miners and their families resided in the community until 1992. In response to the dramatic drop in the population size following the mine closures, a comprehensive socio-economic survey was commissioned as part of a community social and economic development strategy designed to provide input into the 1994 OCP. As mining declined in the mid-1990s, this strategy highlighted potential opportunities in tourism, retirement, recreation, health care, and forestry as areas to focus future development. The economy has since changed and is now classified largely as a retirement and recreational community. According to Census data, the industries that provide the most employment to the community include resource-based industries, education, business, and other services.

Granisle is home to numerous businesses associated with construction and contracting, retail, accommodation, and food services. Services and amenities in Granisle are currently limited to a small general store, two hotels, a café, a post office, an RCMP station, a library, an ice rink, a health centre, a seniors' hall, a school, and the village of Granisle office. However, the community does not have a grocery store or any other general hardware or supply store, and locals are obliged to shop in either Houston or Burns Lake for many supplies. The community is also home to the Mammoth Lodge, which is in need of renovation work, but has the potential to serve the rising number of tourists and people from the mineral exploration and development industry (Getawaybc.com 2006).

The Granisle Health Centre (GHC) offers service primarily to the Granisle community, as well as Topley Landing, Tachet, residents along Babine Lake, RV/camping parks, and visitors to the area. Apart from the GHC, the next closest health services are in Houston, 10 km away, providing general medical services, physiotherapy, chiropractors, lab services, and pharmacies. The majority of the clientele are retirees.

The village of Granisle contained 250 dwellings in 2006, 81.1% of which were single-detached structures. Approximately 73% of homes were owned rather than rented. Compared to the provincial average of $418,703, the average cost of an owned dwelling in Granisle was $67,909 (Statistics Canada 2007a).

The community has the infrastructural capacity to accommodate population growth of up to 5,000 people. The village of Granisle's OCP has a land use map outlining various zoning designations, including: low to high density residential, mobile residential, commercial, and industrial activity.

7.19.7.8 Topley, Topley Landing, and Smithers Landing (Bulkley Nechako District Electoral Division G)

There are limited or no 2006 Census data available for certain study communities, because of their small size. The population of Topley was reported at 118 people in 2006, having changed marginally since 2001, while the populations of Topley Landing and Smithers Landing were so small they have not been officially reported by Statistics Canada (BC Stats 2008b). Data on these communities have been aggregated at the level of the BNRDG, which is the unincorporated rural area surrounding the study communities of Granisle and Houston. The BNRDG also incorporates the off-reserve areas of Fort Babine and Old Fort. The following section will draw upon data for the BNRDG as best estimate data to gauge the socio-economic conditions of these communities.

Between 2001 and 2006, the BNRDG population fell 3.2% from 1,095 people to 1,060 people, with males accounted for most of this decline. Approximately 53% of the population in 2006 were reported to be male. The 44.5 year median age of the male population exceeded the provincial median for males (40), while the female median age in the community of 40.4 years was slightly below the BC median for females (41.5).

In 2006, a significant proportion of the population over the age of 15 years was reported to have no certified education (30%) or only basic high school certification (33%). Almost 16% of the population had completed a trade certificate, 17% had a college certificate, and 5% had university qualifications (5%).

The BNRDG's labour participation rate rose from 66.2% in 2001 to 69.4% in 2006. A total of 85 people were estimated to be unemployed in the BNRDG in 2006, bringing the unemployment rate to 14.2% (Statistics Canada 2007a).

Notable, these data are for the wider BNRDG, and may not accurately reflect the income and earnings received by residents of Topley, Topley's Landing or Smithers Landing. In the BNRDG, median earnings were reported at $29,521 in 2005. Median earnings for both men and women exceeded comparable levels in the province, as did overall median earnings. Full-time overall median earnings were estimated at $53,170, which were also higher than provincial levels. This was also the case for males but not for females. In 2005, both genders in the BNRDG were reported to have greater median incomes after tax than comparable levels for BC, receiving an overall median income of $24,136. Employment generated the majority of income received by the community, accounting for 85% of the aggregated total income in 2005, with a relatively low amount of income derived from government and other sources.

The industries in the BNRDG with the most significant labour forces in 2006 included resource-based industries, manufacturing, and business services. These industries were male dominant in 2006, employing 85% of the community's male workforce. The female workforce was much more evenly distributed across industries, including: construction, retail, health care and social services, and education industries. This helped to diversify the overall composition of industry in the BNRDG.

These communities offer a range of services and amenities. Services in Topley include: a general store, a gas bar, two restaurants, the Topley Elementary School (which has 33 students enrolled in kindergarten through to grade 7), a community hall, a post office, and a volunteer fire department with first responders. The main business in Topley Landing is the Babine Lodge, on the shores of Babine Lake. It offers accommodations, a dining lounge, beer and alcohol sales, laundry facilities for guests, licensed fishing and hunting trips, and a small gift shop. The lodge also has a gas station available for boats. The sole business in Smithers Landing is Tukii Lodge, which is a family operated business, providing eight accommodation units as well as an on-site restaurant, marina, and outfitting services, which have attracted international visitors (BC Lodging & Campgrounds Association 2008).

7.19.8 Secondary Communities

Burns Lake, Houston, Telkwa, and Smithers have been identified as secondary study communities because of their roles as regional service centres. They represent potential sources of employment, and goods and services for the Project. These communities serve as regional service centres for education, health, and economic programs and community facilities, as well as air and highway transportation. Additionally, government services for the region are centred in Smithers. Stewart has also been included because of its important role as the proposed terminus of hauling activities.

The secondary communities have significantly larger populations than most of the primary study communities, with 2006 populations estimated at 2,110 in Burns Lake, 3,165 in Houston, 1,295 in Telkwa, 5,215 in Smithers, and 495 in Stewart. With the exception of Burns Lake, which increased by almost 9%, the populations of these communities have all been declining in recent years. Stewart's population experienced the most dramatic decline, falling 25% between 2001 and 2006.

The secondary communities' local economies are largely supported by forestry, mining, and tourism; however, they are significantly more diverse than the primary communities. The populations of Houston and Telkwa in particular have slightly above average earnings levels, with many residents working in the resource sector. In 2006, unemployment in each of the secondary communities exceeded the 6% average for BC. Unemployment was estimated at 11.4% in Burns Lake, 10.5% in Houston, 9.5% in Telkwa, 8.5% in Smithers, and 8.2% in Stewart.

Rates of high school completion in the secondary communities were below average levels for the province, yet much higher than in the primary communities, with the exception of Granisle. Secondary communities also host a greater range of educational opportunities. The NWCC has campuses in Smithers and Houston, while the CNC has a campus in Burns Lake. Both of these institutions provide specific training and skills associated with the regional mining industry. These communities attract residents from across northwestern BC (including primary study communities) who wish to pursue post-secondary education and training programs.

The Lakes District Hospital in Burns Lake and the Bulkley Valley District Hospital in Smithers are the receiving hospitals for patients from most primary study communities. Additionally, there are health centres in each of the other secondary communities. These facilities and their associated programs meet the needs of both the secondary and primary communities by addressing a diverse range of social and health issues.

7.20 Visual Resources and Aesthetics

7.20.1 Introduction

The visual resources and aesthetics environmental setting discusses the relevance of the visual quality in and around the Project area. The Project falls within the Morice LRMP and is on Crown land in the asserted traditional territory of the Lake Babine Nation.

Complete details of the visual resources and aesthetics in the Project area are provided in Appendix 46.

7.20.2 Methodology

The study area was delineated by determining areas from which the open pit, waste rock piles, and TSF could be visible. This was done using the viewshed analysis tool in ArcView 9.3 Spatial Analyst. A viewshed identifies the areas in a landscape that can be seen from one or more observation points. The analysis was based on a Shuttle Radar Topographic Mission (SRTM) seamless digital elevation model (created in 2004) that had an approximate resolution of 90 m (CIAT 2004).

During the summer of 2008, several Rescan field crews photographically recorded the current visual quality at various locations. General directions and descriptions accompany these photos in Appendix 46.

The Morice LRMP identifies visual quality management strategies for forestry-related industries operating in the area. Although the Project does not fall within this category, the strategy objectives have been considered.

7.20.3 Morice Land and Resource Management Plan

The Morice LRMP addresses and provides management directions for a variety of socio-economic and land use issues. In summary, the general management directions for community value objectives regarding visual resources are (BC MAL and BC ILMB 2007):

- Complete a visual landscape inventory within scenic areas.
- Avoid effects to visual resources in the interim prior to establishment of visual quality objectives.
- Establish visual quality objectives for scenic areas.
- Manage the visual resource in scenic areas in accordance with established visual quality objectives.
- Apply forest practices that maintain visual quality at the landscape level across the plan area.

These objectives should be applied within scenic areas, which are those landscapes that are visible from communities, public use areas, and land and water-based travel corridors. The relevant scenic areas within this study are listed together with the associated management considerations from the Morice LRMP in Table 7.20-1. The management considerations listed are only required by law for forestry-related activities, but they will be used to guide a visual quality assessment for non-forestry related development. The main focus for the identification of scenic areas is tourism and recreational facilities and features. Figure 7.20-1 shows these locations in relation to the scenic areas listed in Table 7.20-1.

Table 7.20-1
Management Consideration for Identifying Scenic Areas

Scenic Area	Management Consideration
Friday/Nakinilerak/Hautete Lakes	Highly likely the public will be concerned if the landscape is visually altered
	No apparent visual change in the natural viewscape allowed
Morrison Lake	Highly likely the public will be concerned if the landscape is visually altered
	No apparent visual change in the natural viewscape allowed
Babine Lake	Highly likely the public will be concerned if the landscape is visually altered
	Visual change is allowed; emphasis placed on minimizing effects from development

Source: (BC MAL and BC ILMB 2007).

The LRMP also contains specific guidance for areas of particular importance, identified as RMZs. The visual resources and aesthetics baseline (Appendix 46) identifies four RMZs that intersect or are near the Project. The relevant RMZs are:

- Le Talh Giz/Old Fort Mountain

- Babine Lake East Arm
- Morrison Lake
- Friday Lake / Nakinilerak Lake / Hautete Lake

The objectives for these RMZs are summarized in Table 7.20-2.

Table 7.20-2
Other Area Specific Management Zones: Summary of Objectives

Other Area Specific Resource Management Zones	Objectives
Le Talh Giz/Old Fort Mountain	Manage forest resources in a manner that is respectful of cultural and ecological values
	Maintain cultural heritage features and values
Babine Lake East Arm	Maintain riparian function and integrity
Morrison Lake	Maintain riparian function and integrity
	Maintain the structure and function of forested ecosystems
Friday/Nakinilerak/Hautete Lakes	Maintain ecological structure and function
	Minimize human effect on and around Friday Lake
	Maintain access to Hautete Lake at existing levels

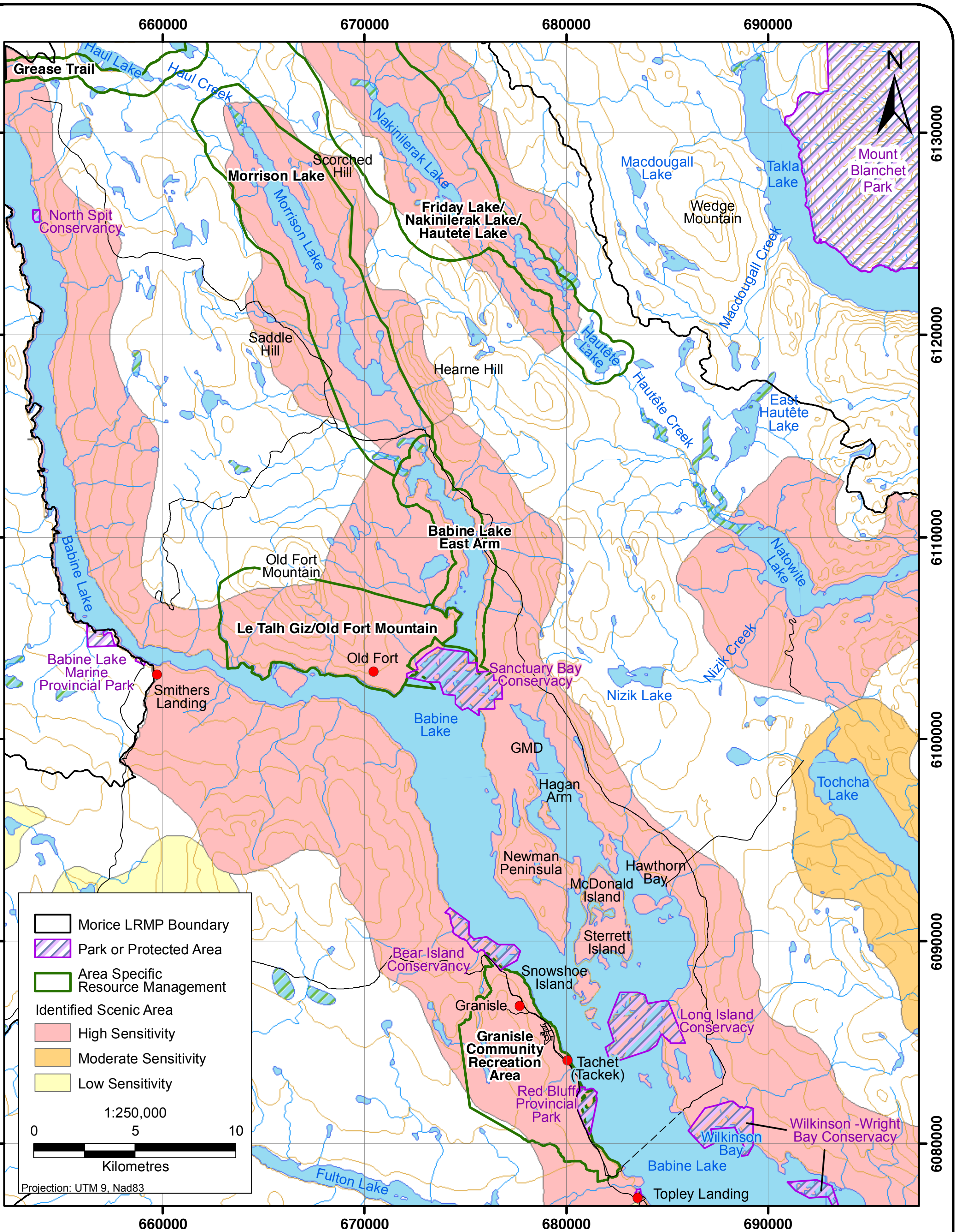
Source: (BC MAL and BC ILMB 2007).

The scenic areas and the specific RMZs are shown on Figure 7.20-1. This figure also shows the Sanctuary Bay Conservancy, which is considered in this study because of its proximity to the Project's transmission line corridor. Conservancies explicitly recognize the significance of the protected area to First Nations, and provide for a wider range of small-scale, low-impact economic activities while prohibiting large-scale projects. The Sanctuary Bay Conservancy was established in 2008, it is 820 ha in size, and it (BC MAL and BC ILMB 2007):

- Protects several islands, scenic lakeshore viewscapes, and bays.
- Offers an area for boat anchorages.
- Holds high cultural importance to the Lake Babine Nation because of its hunting and trapping areas.

7.20.4 Results and Discussion

Prior to fieldwork, a viewshed analysis was performed to delineate the areas from which the open pit, waste rock piles, and TSF could be visible. The viewshed identified areas in the landscape that could be seen from one or more observation points.



Scenic Areas and Resource Management Zones near Morrison Copper / Gold Project

FIGURE 7.20-1

The area's topography obstructs views of the Project developments from the east and west, while the atmospheric conditions limit visibility from farther than 30 km to the north and south. For more detail, please see Appendix 46.

Because of these physical limitations and the requirements listed in the Morice LRMP, the focal areas for this study were the Resource Management Areas, Sanctuary Bay Conservancy, and tourist facilities.

The study area comprised the following locations:

- the Sanctuary Bay Conservancy;
- four Resource Management Zones (Le Talh Giz/Old Fort Mountain, Babine Lake East Arm, Morrison Lake, and Friday Lake/Nakinilerak Lake/Hautete Lake);
- tourist features and facilities outside these areas.

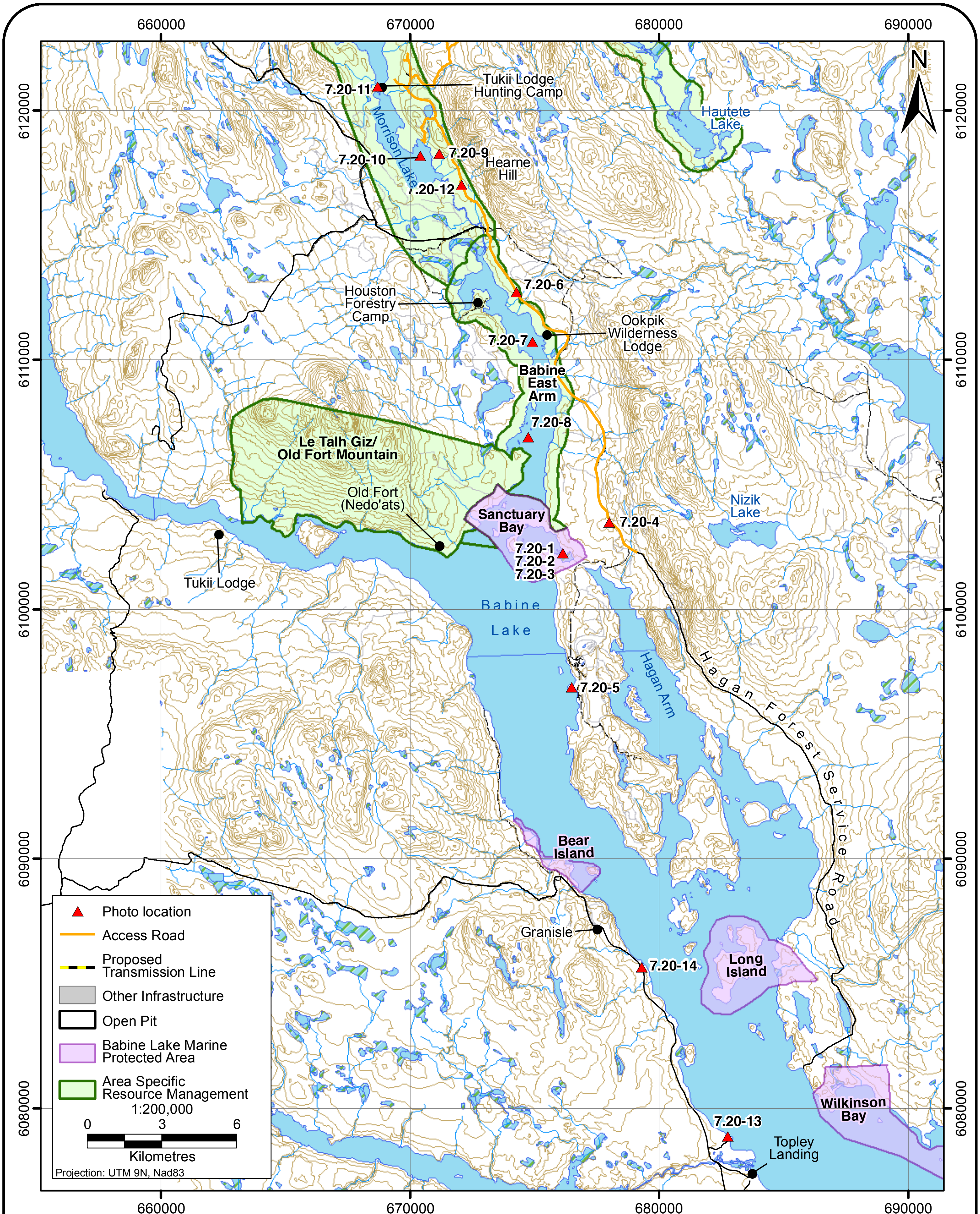
These locations are shown on Figure 7.20-2 and discussed below.

7.20.4.1 Sanctuary Bay Conservancy

The Sanctuary Bay area is part of Babine Lake, just south of its eastern arm and north of Newman Peninsula. It is a small bay with a wetland that was examined in the *Morrison Copper/Gold Project Wetlands Baseline Studies Report, 2007 to 2008* (Appendix 18). This protected area has a cabin on the northern shore, an anchorage for recreational use, and a historical site on the southern shore. The Nedo'ats Hereditary Chiefs have indicated the historical site as culturally highly valuable (BC MAL and BC ILMB 2007). Plates 7.20-1 to 7.20-3 show views taken from the wetland area within the bay looking in the direction of the TLSC. The plates show a forested background where the transmission line will be constructed.

Plate 7.20-1. Looking east-northeast from the Sanctuary Bay marine protected areas.

Plate 7.20-2. Looking southeast from the Sanctuary Bay marine protected area.



Morrison Copper / Gold Project
Visual Quality Reference Locations

FIGURE 7.20-2

Plate 7.20-3. Looking eastward from the Sanctuary Bay Marine Protected area.

7.20.4.2 Le Talh Giz/Old Fort Mountain

Old Fort Mountain or Le Talh Giz is the area around Old Fort at the northern junction of the eastern and western arms of Babine Lake. This area includes the top of Old Fort Mountain, which the LRMP describes as providing a good view of Babine Lake and its surroundings. The Nedo'ats Hereditary Chiefs have also labelled this area as culturally highly important (BC MAL and BC ILMB 2007). The area is not intersected by any of the Project features, but the transmission line could be visible from the lookout point. A photograph could not be obtained at this location, but the EA discusses this area. Plate 7.20-4 shows the view towards Old Fort Mountain, uphill from where the transmission line will be constructed. Plate 7.20-5 shows the view towards the north from the former Bell mine WRD, showing Le Talh Giz/Old Fort Mountain and Old Fort (Nedo'ats).

Plate 7.20-4. Looking westward over Babine Lake East Arm towards Le Talh Giz/Old Fort Mountain. The transmission line will be in the foreground.

Plate 7.20-5. Looking northward from the former Bell mine waste rock dump towards Le Talh Giz/Old Fort Mountain.

7.20.4.3 Babine Lake East Arm

The eastern arm of Babine Lake has been identified as a high-value cultural and fisheries area (BC MAL and BC ILMB 2007). This arm connects the south of Babine Lake to Morrison Creek, which is downstream from Morrison Lake. There are several cabins along the shore and Ookpik Lodge is on the eastern shore. Just north of this lodge on the western shore of the lake is an anchorage for recreational purposes and a hunting camp. Plate 7.20-6 shows an aerial view looking toward Morrison Creek and Morrison Lake to the north. In the distance, the peninsula where an overburden stockpile may be constructed is visible. Plate 7.20-7 is an aerial view of Ookpik Lodge from Babine Lake East Arm, showing the lodge with its marina and the landscape behind it where the transmission line will be constructed. Plate 7.20-8 shows the area directly south of the anchorage along the western shore of the lake looking toward Sanctuary Bay and Babine Lake.

Plate 7.20-6. Aerial overview in northern direction from the anchorage on Babine Lake East Arm. Morrison Lake is visible in the background.

Plate 7.20-7. Aerial view of Ookpik Lodge and the landscape behind it where the transmission line will be constructed.

Plate 7.20-8. Aerial view from the hunting camp on the western shore of Babine Lake East Arm looking in a southern direction along the shoreline towards Sanctuary Bay and Babine Lake.

7.20.4.4 Morrison Lake

Morrison Lake is north of the eastern arm of Babine Lake, connected to Babine Lake by Morrison Creek; this lake can only be reached by the Hagan Forest Service Road because the creek is shallow. The LRMP describes the area as providing an excellent fishing and boating experience and having high cultural value to the Nedo'ats Hereditary Chiefs (BC MAL and BC ILMB 2007). Plates 7.20-9 and 7.20-12 show the surrounding area from the road leading to the lake in an easterly direction towards Hearne Hill. The transmission line would be in the foregrounds of these pictures. Plate 7.20-10 shows the eastern shore of Morrison Lake looking toward the proposed mine site. In the background, the northern foot slope of Hearne Hill is visible. The plate provides an overview of where the proposed ultimate pit and WRD will be constructed. Along the shore, the proposed access road and transmission line will be constructed. Plate 7.20-11 shows the hunting cabin belonging to the Tukii Lodge; the proposed Morrison mine plant site would be 1 km to the southeast and the proposed ultimate pit would be 1.5 km southeast of this area. The nearest Project component will be the proposed organic bearing stockpile approximately 500 m away, which will be used for reclamation of the proposed WRD.

Plate 7.20-9. Looking eastward from Hagan Forest Service Road towards Hearne Hill.

Plate 7.20-10. Looking northeast from Morrison Lake at the northern foot slope of Hearne Hill in the direction of the proposed overburden stockpile and waste rock dump and projected transmission line along the access road.

Plate 7.20-11. Looking eastward from Morrison Lake towards Tukii Lodge Hunting Camp.

Plate 7.20-12. Looking eastward from Hagan Forest Service Road. The transmission line will be in the foreground.

7.20.4.5 Friday Lake / Nakinilerak Lake / Hautete Lake

Nakinilerak Lake is part of the Area Specific Resource Management Zone that is described in the Morice LRMP as Friday Lake/Nakinilerak Lake/Hautete Lake. It is northeast of the proposed TSF. The area is difficult to reach over land and will most likely remain without developed access. At the northern end of the lake, the LRMP indicates the existence of a cabin that can only be reached by trail or floatplane. Recreational opportunities in this area include canoeing, angling, hunting, and backcountry activities. Photographs were not taken of this site because of there is limited accessibility to the area.

7.20.4.6 Touristic Features and Facilities

The Babine Lake area is one of the most touristic areas of northern BC. Many tourists visit the towns and villages along its shore to enjoy the wilderness setting. The Morice LRMP recognizes this area as important to tourism and labelled it as highly scenic.

Field crews took photographs from several locations along Babine Lake and from the barge crossing the lake to the Hagan Forest Service Road. Plate 7.20-13 shows the northern and eastern views from the barge landing at Topley Landing on the eastern shore of Babine Lake. The distance from the barge to the nearest point of the transmission line corridor at the Bell mine substation is almost 20 km.

Plate 7.20-14 shows a compilation of photographs taken from a little marina at the end of the road leading north from Granisle along the western shoreline of Babine Lake. This site is approximately 4 km west of the Bell mine substation on the west side of Babine Lake. The transmission line will extend in a northern direction from the Bell mine substation along the eastern shore of Babine Lake.

Plate 7.20-13. Looking northward and eastward from the barge landing at Topley Landing.

Plate 7.20-14. Looking northward and eastward from a marina near Granisle.

7.21 Noise

This chapter describes the existing noise conditions in the Project area and the surrounding potential areas of influence.

The Project is approximately 65 km northeast of Smithers and within 30 km of two former mines, Bell and Granisle. The Project area is on the Nechako Plateau, an elevated inland plateau characterized by forested, rolling, relatively low-relief terrain, complex drainage, and large plentiful lakes.

Potential noise effects are an important concern to Project stakeholders, particularly when elevated noise can lead to increased annoyance or human health risks to local residents. Noise may also affect wildlife populations by causing them to avoid important habitats and/or key behaviours such as feeding, breeding, or watching for predators, which can ultimately lead to reduced productivity and/or increased mortality.

Desk-based research and field observations highlighted a number of local communities near the proposed mine site that may be sensitive receptors and contribute to background noise levels in the Project area including (Figure 7.21-1):

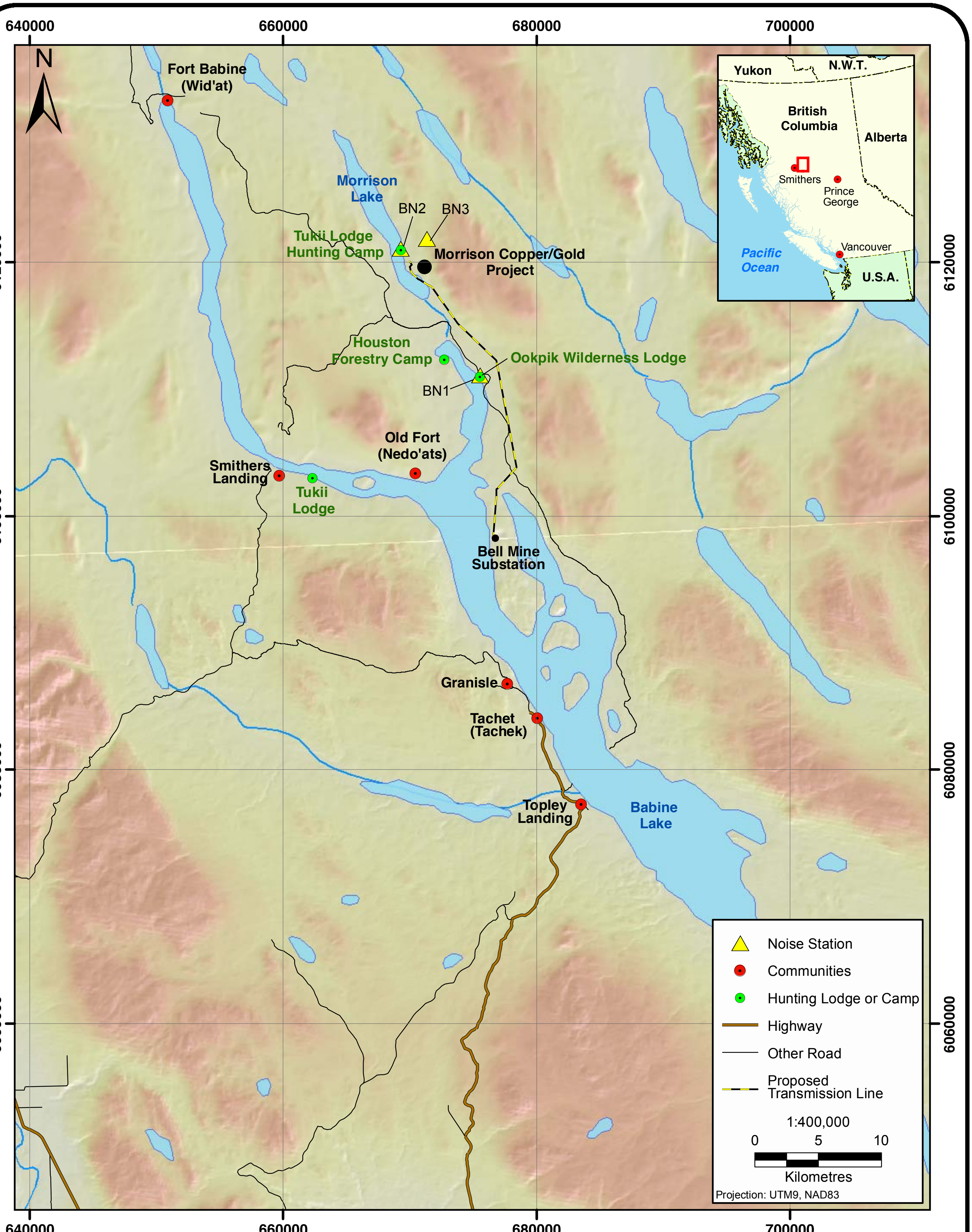


FIGURE 7.21-1

Morrison Copper/Gold Project
Noise Station Locations

- Old Fort (seasonal dwellings)
- Granisle
- Fort Babine
- Tachet

Three other human receptors (individual residences only), operating as hunting and wilderness camps, were observed near the Project site. Occupancy is seasonal.

7.21.1 Data Sources

Baseline noise was measured at three locations within or near the Project area in 2008 including:

- Ookpik Lodge (BN1)
- Tukii Lodge Hunting Camp (BN2)
- East of Morrison Lake in an open area (BN3)

These locations were selected to characterize the range of baseline conditions in the region, including a site close to a local resident, as well as sites near the proposed mine site and supporting infrastructure. The collection of noise data from the Project area occurred over an approximate 1-day period at each monitoring location (Table 7.21-1).

Table 7.21-1
Location of Noise Baseline Measurements

Location	Easting	Northing	Elevation (masl)	Duration of measurement
BN1	675,525	6,107,519	712	13:30 on September 3 2008 to 10:00 on September 4 (20.5 hours)
BN2	668,835	6,120,950	734	13:30 on September 4 2008 to 10:00 on September 5 (20.5 hours)
BN3	671,303	3,121,739	961	14:20 on September 4 2008 to 11:30 on September 5 (21 hours)

Baseline noise contributions were characterized for the Project area based on data gathered by a sound level meter at each monitoring location (Quest Model 2900). The sound level meters recorded the average sound level and peak sound levels in decibels adjusted (dBA). The noise measurements were recorded every minute and the sound meter was approximately 1.5 m above the ground level.

This baseline study uses the equivalent continuous sound level (L_{eq}) to evaluate noise levels of the Project area. The maximum and minimum sound levels reported over the study period are also reported (L_{max} and L_{min}).

7.21.2 Baseline Conditions

The noise levels recorded at all three stations were low and steady during the night and fluctuated, causing some peaks during the day. The L_{eq} for BN1, BN2, and BN3 were 31.7, 27.7, and 29.1 dBA, respectively. These L_{eq} values are lower than the permissible sound level defined in the Alberta EUB Noise Directive (2007) of 40 dBA L_{eq} during night conditions within 1.5 km of any new facility. Table 7.21-2 summarizes sound levels at the three monitoring stations.

BN1 had the maximum L_{eq} recorded during the study period and BN2 the lowest of the three stations. An increase of 3 dBA is just barely perceptible by the human ear; a difference of 5 dBA is noticeable and a change of 10 dBA is perceived as twice as loud. Differences in L_{eq} values between each monitoring location were barely perceptible to the human ear because the L_{eq} values were all within 4 dBA of each other.

Table 7.21-2
Sound Levels (dBA) at the Project Monitoring Locations

Location	L_{eq}	L_{max}	L_{min}
BN1	31.7	65.4	22.9
BN2	27.7	68.2	25.2
BN3	29.1	67.2	24.3

Worst-case conditions for the Project site were assumed as the baseline noise levels recorded at each monitoring station. Summer noise levels are often in excess of winter levels because of increased human activity. The baseline noise measurements were influenced by a number of external noise sources at each monitoring station including:

- BN1: pedestrian traffic at the beginning of the monitoring period;
- BN2: boat noise from Morrison Lake during the latter part of the monitoring period;
- BN3: all terrain vehicles and truck traffic.

These noise sources are attributed to common land uses that will contribute to the baseline noise emissions in the Project area year round.

There was no precipitation recorded at the Project station during the time of monitoring and wind speeds were generally low. Therefore, rain and wind did not bias the baseline noise measurements.

7.22 Human Health

The Project may affect environmental media such as air quality, noise levels, drinking water, and country foods. These effects, in turn, have the potential to affect the health of the people that frequent the area. This section presents a summary of the land users within the Project area, as well as the existing environmental media quality. The environmental setting for air and noise were previously presented in sections 7.3 and 7.21, respectively. This section provides a brief overview of these two sections as they relate to human health. This section also presents the environmental setting and baseline conditions for country foods and stream water that may be used for drinking.

7.22.1 Land Users

Current land uses in the Project area relate primarily to forestry activities; Canfor Corporation has tree farm licences and Houston Forest Products Ltd. operates to the west of Morrison Creek. Other activities include hunting, trapping, guide outfitting, backcountry wilderness tourism, and harvesting of country foods.

The Project location is presented in Figure 7.1-1. Land users were identified in Appendix 42. Permanent settlements surrounding the Project include: Smithers Landing (20 km southwest), Fort Babine (25 km northwest), village of Granisle (35 km south), Tachet (50 km southeast) and Burns Lake (100 km southeast). These surrounding permanent settlements have limited accessibility to the Project area. Direct road access from these settlements requires circumventing Babine Lake in a cargo barge at Topley Landing and driving 50 km north to the Project area. The Project area is also accessible seasonally by personal watercraft from Babine Lake by travelling northward through Morrison Creek and into Morrison Lake. In the winter the site can be accessed by snowmobile over the ice of Babine and Morrison Lakes.

Seasonal land use in the Project vicinity include: Old Fort (15 km south), Tukki Lodge Hunting Camp (1,500 m northwest of the proposed open pit), and Ookpik Wilderness Lodge (9 km southeast, off the access road, along the proposed transmission line route; Figure 7.22-1). Old Fort is seasonally occupied by First Nations during the summer and fall. There is no road access to Old Fort; it is only accessible by lake. Tukki Lodge Hunting Camp is used by guide outfitters, hunters, and recreational land users from spring through to the end of fall. The Tukki Lodge Hunting Camp owners reside at the Tukki Lodge in Smithers Landing. The Ookpik Wilderness Lodge is used by for recreational purposes.

7.22.2 Air Quality

Air quality is defined by the levels of gases and fine PM in the air. Carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), PM, and diesel emissions are the primary pollutants that may be associated with the Project development. $PM_{2.5}$ and PM_{10} denote particulate matter sizes of 2.5 and 10 micrometres (µm), respectively. Smaller particles pose a greater health risk because when inhaled they enter deeper into the lungs and are more difficult for the body to remove. Table 7.22-1 presents a brief description of the potential health effects associated with each air pollutant. The potential health effects listed do not represent an exhaustive list, but the most common direct health effects are listed to provide rationale for their evaluation in the health effects assessment. Indirect effects from air pollution generally include restricted activity days, lost school days, lost work days, etc. These indirect effects can be a result of air pollution-related illnesses.

Combustion sources of PM are of particular concern when examining air quality and human exposure. Epidemiological and toxicological studies have shown combustion-derived particles (i.e., incinerators, coal plants, and diesel engines) are more toxic than non-combustion derived particles (i.e., road dust).

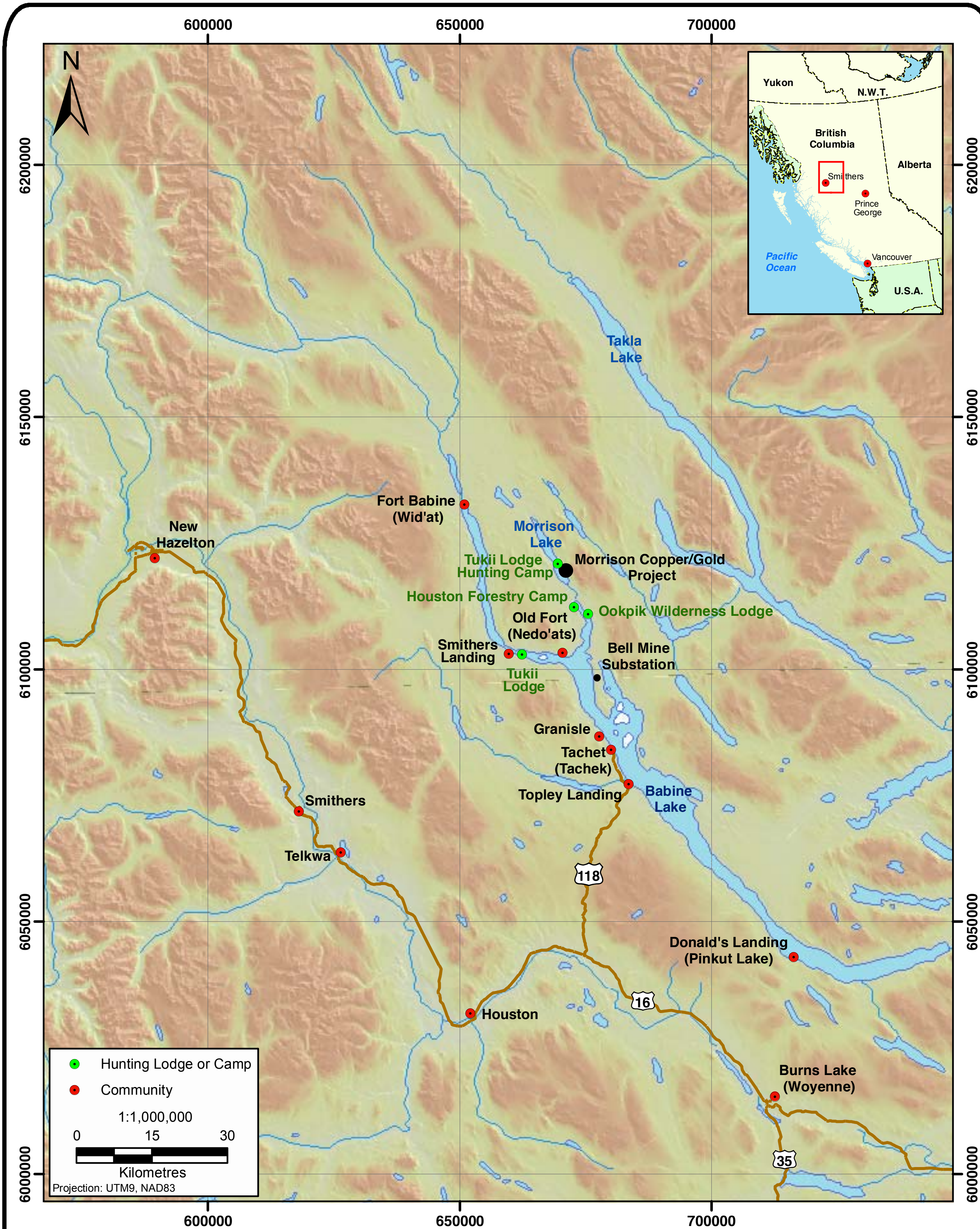


FIGURE 7.22-1

Morrison Copper/Gold Project Surrounding Communities and Land User Structures

Table 7.22-1
Air Pollutants and Associated Potential Health Effects

Air Pollutant	Associated Health Effect
CO	Flu-like symptoms: headache, fatigue, nausea, vomiting, increased heart rate, impaired mental and cognitive function.
SO_2	Increased breathing resistance, wheezing, shortness of breath, coughing, sore throat, aggravation of existing respiratory diseases such as asthma.
NO_2	Irritation of mucous membranes: eyes, nose, throat, and lungs. Coughing, shortness of breath.
PM_{10}	Shortness of breath, wheezing, coughing, aggravation of existing respiratory diseases such as asthma, significant reduction in life expectancy.
$PM_{2.5}$	Shortness of breath, wheezing, coughing, aggravation of existing respiratory diseases such as asthma, significant reduction in life expectancy, cardiovascular effects such as hardening arteries and plaque formation in blood vessels.

Some of the potential effects associated with inhalation of diesel particulates include:

- lung inflammation and increasing response to an inhaled allergen
- acute respiratory illnesses in children
- lung cancer

Because of the low levels of human activity along the road route and mine site, baseline air quality measurements for CO, SO_2, NO_2, $PM_{2.5}$, and PM_{10} were not considered necessary by the Project air quality specialists.

The only indicator of air quality measured within the Project area was dustfall. Dustfall was monitored at six locations within the study area (Section 7.3). Total dustfall, metals, nitrate, and sulphate were analyzed from the samples collected. All dustfall data were measured in $mg/dm^2/day$, which cannot be converted into realistic inhalable concentrations, subsequently further dustfall interpretation with respect to human health is not considered necessary.

7.22.3 Noise Levels

Noise is defined as any undesirable sound that may irritate people, disturb rest or sleep, cause loss of hearing or otherwise affect the quality of life of affected individuals. People encounter noise in their living and working environments daily. For the Project, sources of noise include: road vehicles, construction, mining equipment, mining operations, and electrical sounds from the proposed transmission line. The effects of noise can include: hearing impairment, interference with speech communication, disturbance of rest and sleep, psychological and physiological effects (i.e., stress), mental health effects, and effects on residential behaviour (WHO 1999).

Noise is measured in a non-linear scale known as decibels (dB); however, these measurements are filtered or weighted (A-weighted) to account for noise frequencies that are audible to humans. Measured noise levels that are A-weighted are reported as dBA. Table 7.22-2 presents a table of typical noise levels in terms of dBA. Since the dBA scale is logarithmic, multiple noises cannot be summed cumulatively. For example, the noise from a typical conversation (50 dBA) and a passenger car 10 m away (70 dBA) does not result in a total of 120 dBA, which would be equivalent to a jet taking off 100 m away. The cumulative noise level from multiple sounds is converted by the following formula:

$$L_{total} = 10\log_{10}(10^{\frac{L_1}{10}} + 10^{\frac{L_2}{10}})$$

where L_1 and L_2 are the noise levels to be added (in dB). The cumulative noise would be 70.04 dBA. Thus, the noise from a typical conversation would be less audible near a passenger car.

Table 7.22-2
Typical Sound Levels

Sound Range (dBA)	Source
0	Human hearing threshold
10	Rustling of leaves
20 to 40	Quiet room
40 to 60	Typical conversation
60 to 80	Passenger car, 10 m away
80 to 90	Busy road, 10 m away
100	Jackhammer, 1 m away
110 to 130	Takeoff of a jet, 100 m away
130	Human pain threshold

Baseline noise was measured at three locations within or near the Project area: BN1 (Ookpik Wilderness Lodge), BN2 (Tukii Lodge Hunting Camp), and BN3 (open area north east of the proposed open pit (Figure 7.22-2). Noise detected at BN1 was from activities at the Ookpik Wilderness Lodge. Noise detected at BN2 was primarily from boat traffic in Morrison Lake. Noise from the Tukii Lodge Hunting Camp activities was not detected as there was no one there at the time of monitoring. Noise detected at BN3 was from road vehicles and all terrain vehicles. All noise measurements were collected in September, 2008, for approximately 24 hours at each monitoring location. Wind noise was low and no precipitation occurred during the monitoring. No helicopters or aircraft were noted for the duration of the monitoring period.

Table 7.22-3 presents the summary of sound levels measured at the three monitoring locations. The equivalent continuous sound levels (L_{eq}) for the 24-hour monitoring period for BN1, BN2, and BN3 were 31.7, 27.7, and 29.1 dBA, respectively. These Leq values are lower than the permissible sound level defined in the Noise Directive (Alberta EUB 2007), which is 40 dBA L_{eq} during nighttime within 1.5 km of the new facility. Although this limit is a regulation for the energy industry in Alberta, it provides an understanding of reasonable sound level conditions in the environment and puts the monitoring results into context. The maximum values represent noise from camp activities (BN1), boat traffic (BN2), and vehicular traffic (BN3).

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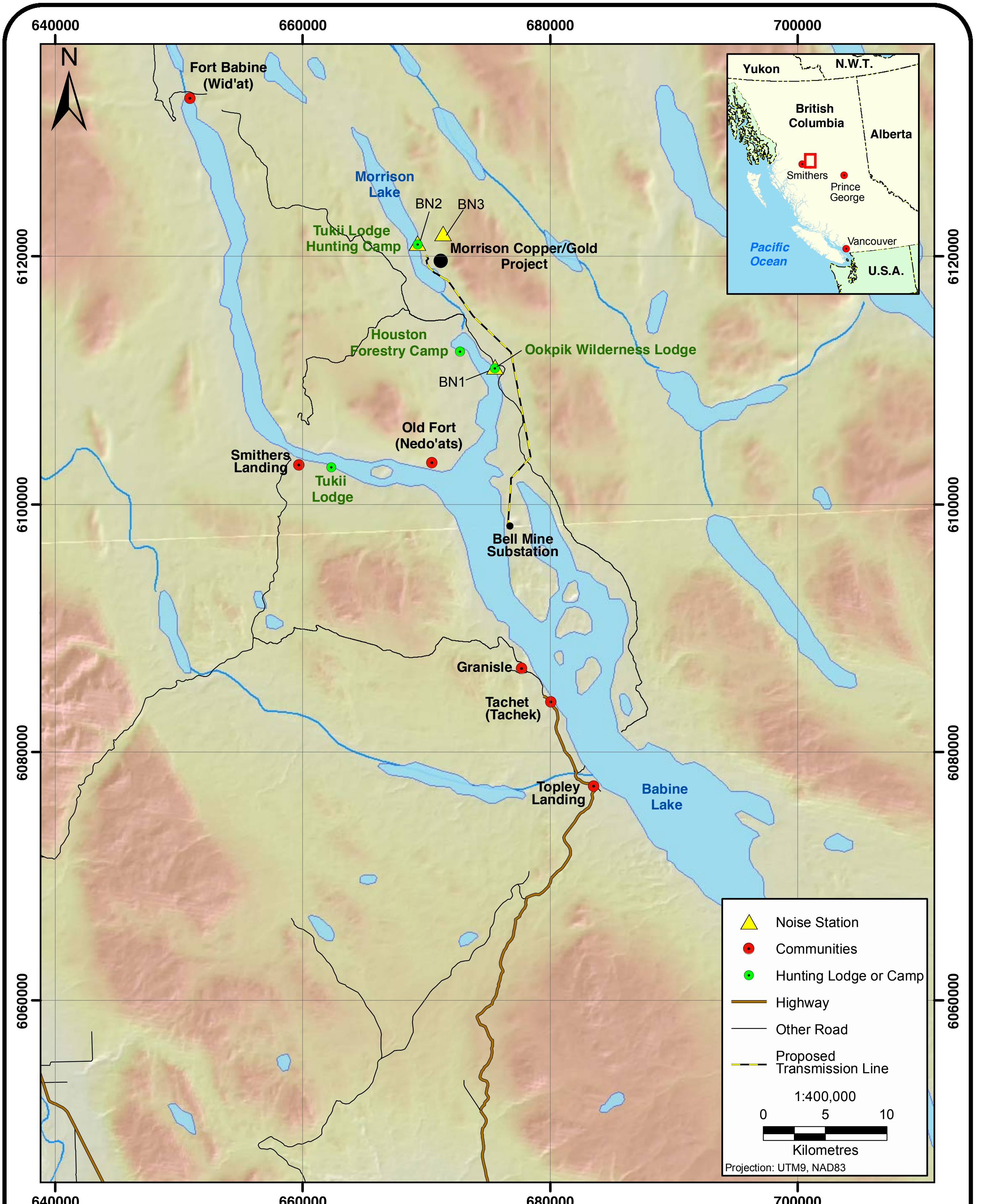


FIGURE 7.22-2

Morrison Copper/Gold Project
Noise Station Locations

Table 7.22-3
Sound Levels (dBA) at the Monitoring Locations

Location	L_{eq}	L_{max}	L_{min}
BN1	31.7	65.4	22.9
BN2	27.7	68.2	25.2
BN3	29.1	67.2	24.3

7.22.4 Drinking Water

The land use interviews conducted for the land use baseline indicated that no specific surface waterbody is used as a drinking water source in the Project area. However, information from other land use studies indicates that guide outfitters, hunters, and recreational users typically do consume untreated surface waters. In addition, the Terms of Reference for the Project Environment Assessment specify that health effects related to water quality must be assessed. The conceptual model for this assessment is presented in Figure 7.22-3, which describes how the chemicals of potential concern (COPCs) in the surface water end up being consumed by people.

Because no specific creeks were identified as drinking water sources, no waterbodies were sampled specifically for the baseline characterization of drinking water quality. However, there were three years of water quality data collected by Rescan for the aquatics baseline characterization. These data were summarized and used to determine the baseline drinking water quality.

Untreated water was collected from creeks and streams surrounding the mine footprint, proposed transmission line routes, and Morrison Creek. Figure 7.22-4 presents the creek sampling locations surrounding the Project area. The results of the stream water data from 2006 to 2007 (Appendix 26) and 2008 (Appendix 27) were summarized and compared to the BC Drinking Water Guidelines and Health Canada's Canadian Drinking Water Guidelines (BC MOE 2006b; Health Canada 2008). The data represent both physical (i.e., pH, turbidity), and chemical (i.e., total metals, nutrients) parameters. Notably, because the samples were not specifically collected for the determination of drinking water quality, no microbial or bacterial analyses were conducted.

Table 7.22-4 presents a summary of the mean and maximum concentrations from the drinking water analytical results. The only parameter that exceeded the health-based guideline was the maximum concentration of nitrate. Of the 287 samples collected and analyzed for nitrate, 1 sample was observed to exceed the guidelines.

The concentration in this sample was 38.7 mg/L, all other samples were below 0.30 mg/L. This outlier sample was likely cross-contaminated during sample collection, transport, or in the laboratory, and therefore it is not considered reflective of the actual surface water concentrations. Maximum concentrations of the following four metals exceeded their respective drinking water aesthetic objectives (i.e., taste or operational objectives): aluminum, iron, and manganese. Maximum and average values of true colour in the study area exceeded the drinking water aesthetic objectives.

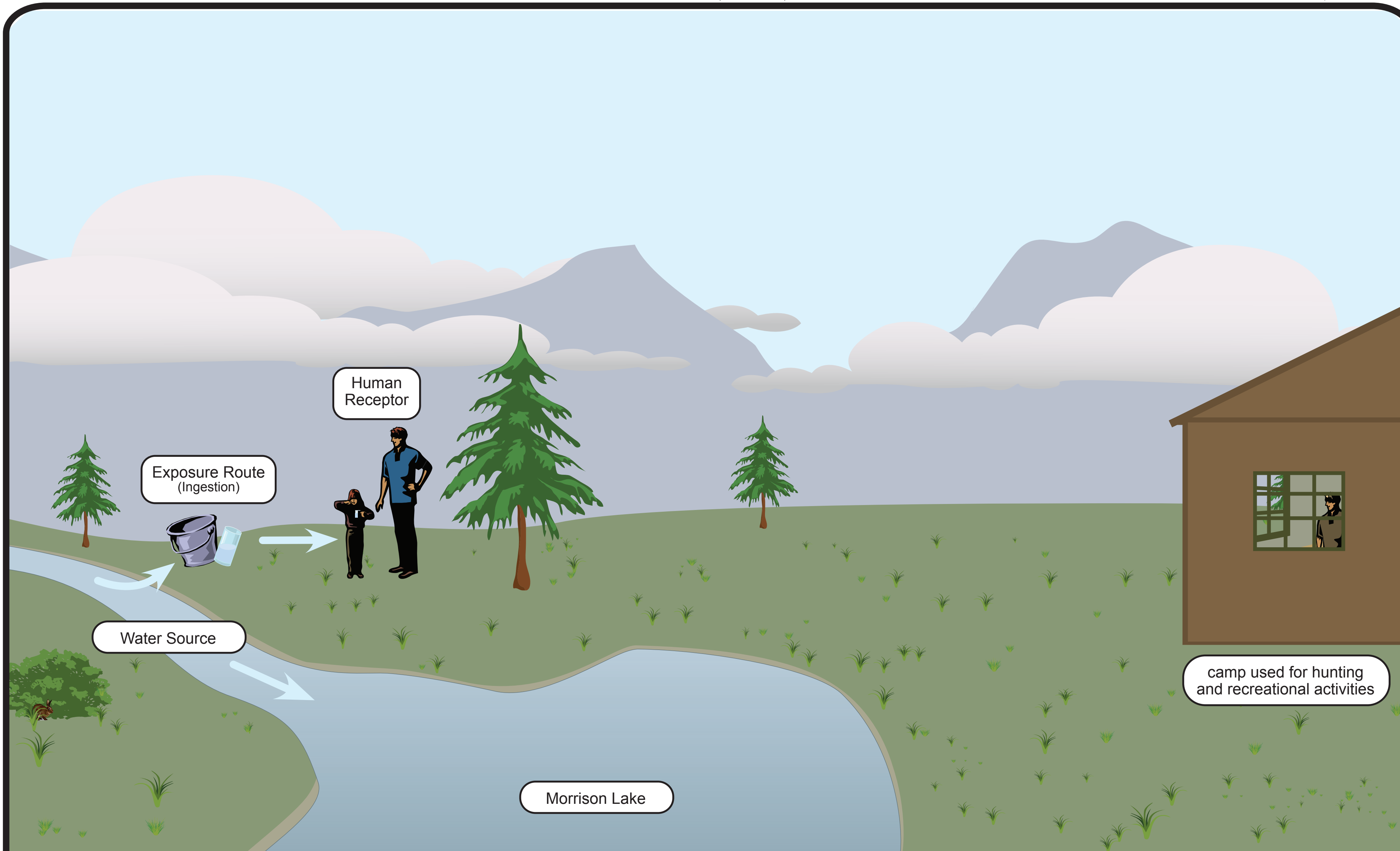
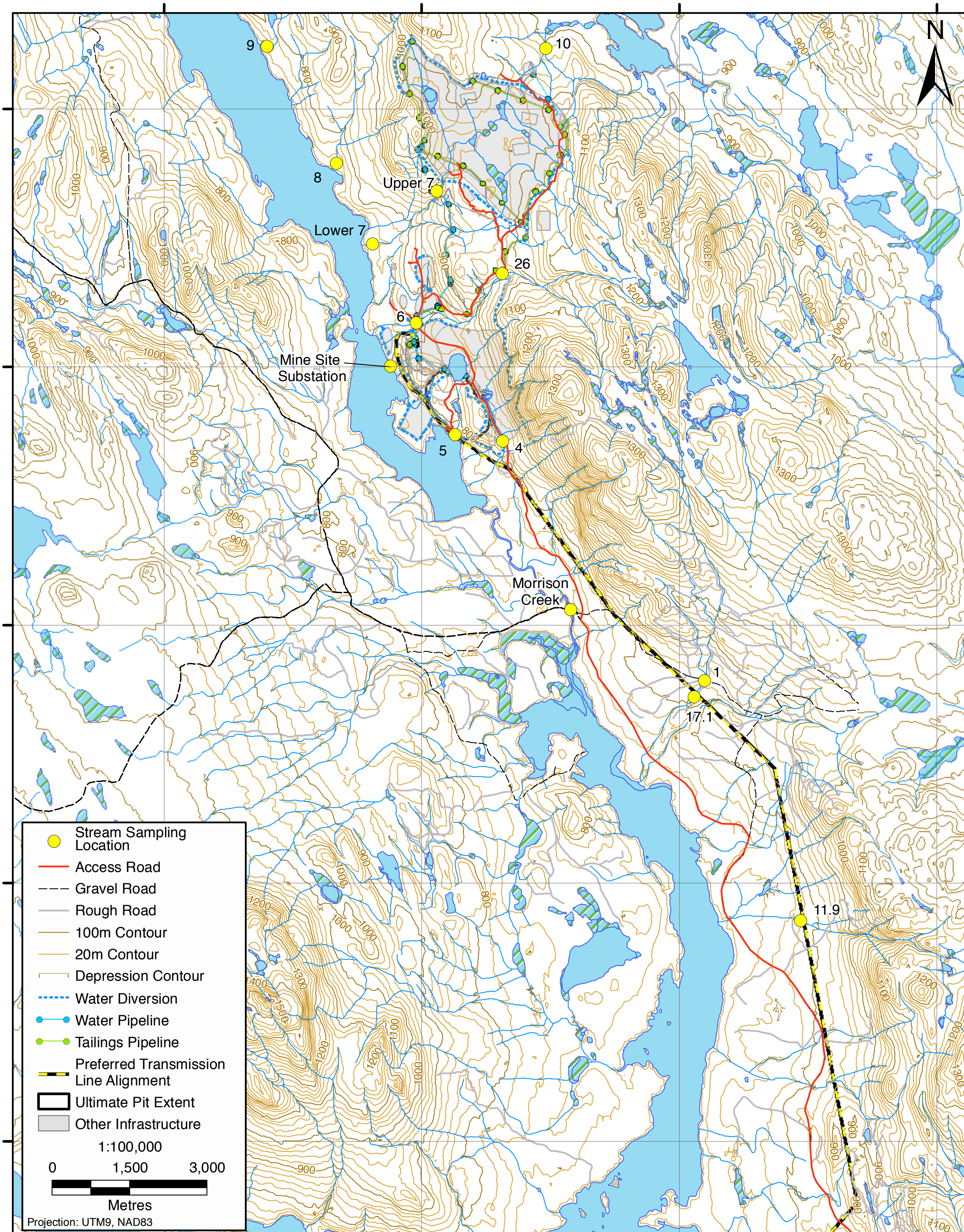


FIGURE 7.22-3

Morrison Copper/Gold Project Drinking Water Conceptual Model



Morrison Copper/Gold Project
Stream Water Sampling Locations

FIGURE 7.22-4

Table 7.22-4
Morrison Copper/Gold Project Surface Drinking Water Summary (mg/L)

	Number of Samples	Average	Max	Health Canada Drinking Water [a]	BC Drinking Water [b]
Physical Tests					
Hardness (as CaCO3)	288	68.4	206.0	ng	80 to 100 mg/L is acceptable, over 200 mg/L is poor but can be tolerated, over 500 mg/L is normally unacceptable
Colour, True (CU)	288	**23.1**	**71.4**	15[c]	15[c]
pH	288	7.8	8.3	6.5 to 8.5[c]	6.5 to 8.5[c]
Total Dissolved Solids	288	93.6	264.0	500[c]	500[c]
Turbidity (NTU)	287	1.3	11.6	3[c]	3
Anions and Nutrients					
Ammonia as N	193	0.007	0.202	ng	ng
Chloride (Cl)	193	0.26	1.25	250[c]	250[c]
Fluoride (F)	193	0.047	0.108	1.5	1.5
Sulfate (SO_4)	288	10.0	87.0	500[c]	500[c]
Nitrate (as N)	287	0.2	**38.7**	45	10
Nitrite (as N)	193	0.001	0.007	3.2	1
Cyanides					
Cyanide, Total	285	0.006	0.120	0.2	0.2
Total Metals					
Aluminum	288	0.07	**3.91**	0.10[c]	0.10[c]
Antimony	288	0.00012	0.00025	0.006	0.006
Arsenic	288	0.00054	0.00504	0.01	0.025
Barium	288	0.03	0.11	1	1
Boron	288	0.02	0.05	5	5
Cadmium	288	0.00003	0.00419	0.005	0.005
Chromium	288	0.0004	0.0053	0.05	0.05
Copper	288	0.0022	0.0182	1[c]	1[c]
Iron	256	0.14	**5.33**	0.3[c]	0.3[c]
Lead	288	0.0002	0.0021	0.01	0.01
Manganese	288	0.017	**0.591**	0.05[c]	0.05[c]
Mercury	193	0.00001	0.00030	0.001	0.001
Selenium	288	0.00036	0.00235	0.01	0.01
Sodium	288	2.2	13.6	200[c]	200[c]
Uranium	288	0.00004	0.00021	0.02	0.02
Zinc	288	0.002	0.021	5[c]	5[c]

[a] = http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/index-eng.php#tech_doc.
[b] = http://www.env.gov.bc.ca/wat/wq/BCguidelines/approv_wq_guide/approved.html#1.
[c] = based on aesthetic or operational guideline.
Bold indicates levels above guideline.
ng = no guideline.

7.22.5 Country Foods

Country foods are animals, plants, and fungi used by humans for nutritional or medicinal purposes that are harvested through hunting, fishing, and gathering of vegetation. The proposed Project may have effects on these foods; thus, a baseline evaluation on the quality of country foods near the Project area was conducted. The study area for the country foods assessment included the mine footprint and surrounding area, and a 1 km radius of either side of the three proposed transmission line routes (Figure 7.22-5).

The methodology for the country foods baseline assessment was based on Health Canada's guideline for assessing food issues in environmental impact assessments (Health Canada 2004).

Country foods interviews were conducted in Babine, Tachet, Smithers Landing, and Burns Lake. Interviewees included First Nation groups, one guide outfitter, trappers, and recreational users. These individuals provided information on what foods they harvest from the Project area as well as their consumption rates and frequencies of each food. The interviews indicated that there is limited use of the Project area, with the exception of the guide outfitter. However, because of the small number of interviewees compared to the general population of the area, the amount of harvesting from the Project area is relatively uncertain. For example, although only one guide outfitter was interviewed there is more than one guide outfitter in the area.

The country foods evaluated in this study were moose (*Alces alces*), grouse (*Phasianidae* sp.), lake trout (*Salvelinus namaycush*), black huckleberry (*Vaccinium membranaceum*) and raspberry (*Rubus* sp.). These species were selected based on the results of the country food interviews.

This assessment focused on metals because the Project is a base metals mine and base metals also occur in environmental media (i.e., soil, water, and plant and animal tissue). The following nine metals and one herbicide were selected as COPCs: aluminum, arsenic, barium, chromium, copper, iron, lead, selenium, vanadium and glyphosate. The selection of the COPCs was based on screening of the environmental media concentrations (i.e., soil and water) against the CCME guidelines. Glyphosate was selected as it is used in the area by forestry companies. COPCs exist in the surrounding soil and water, and are taken up by plants and animals and subsequently ingested by country food harvesters. Figure 7.22-6 presents the conceptual model for the country food assessment, which describes how COPCs in the environment move into the food chain and subsequently into humans through the diet.

The results of the assessment indicated no unacceptable risks to human receptors (toddlers or adults) from the consumption of moose, grouse, lake trout, black huckleberry, and raspberry. Based on the measured and predicted levels of metals in these foods, the amounts currently consumed by country foods harvesters are within the recommended maximum weekly intakes (RMWIs). Thus, people may safely continue to eat these foods.

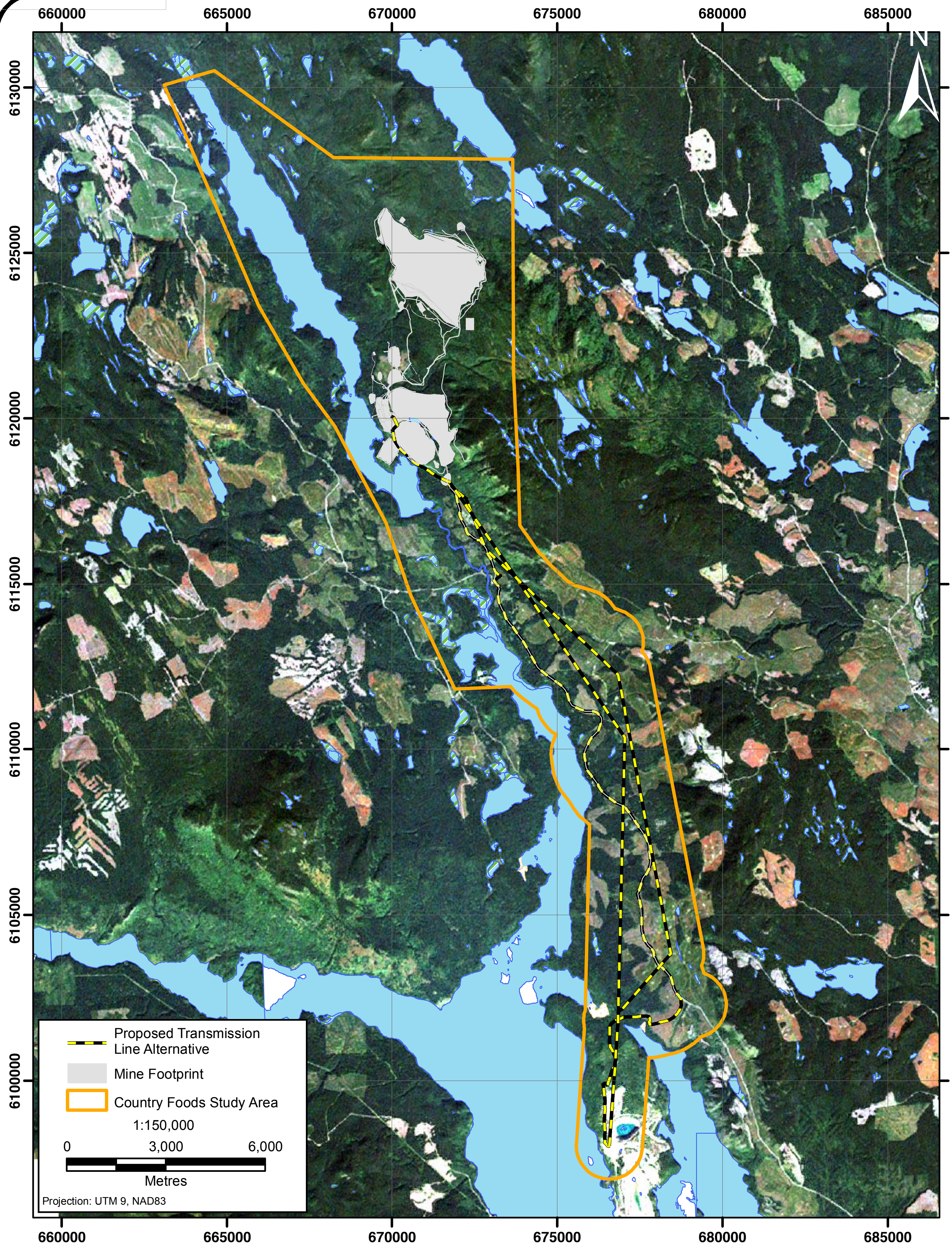


FIGURE 7.22-5

Morrison Copper/Gold Project
Country Foods Baseline Study Area

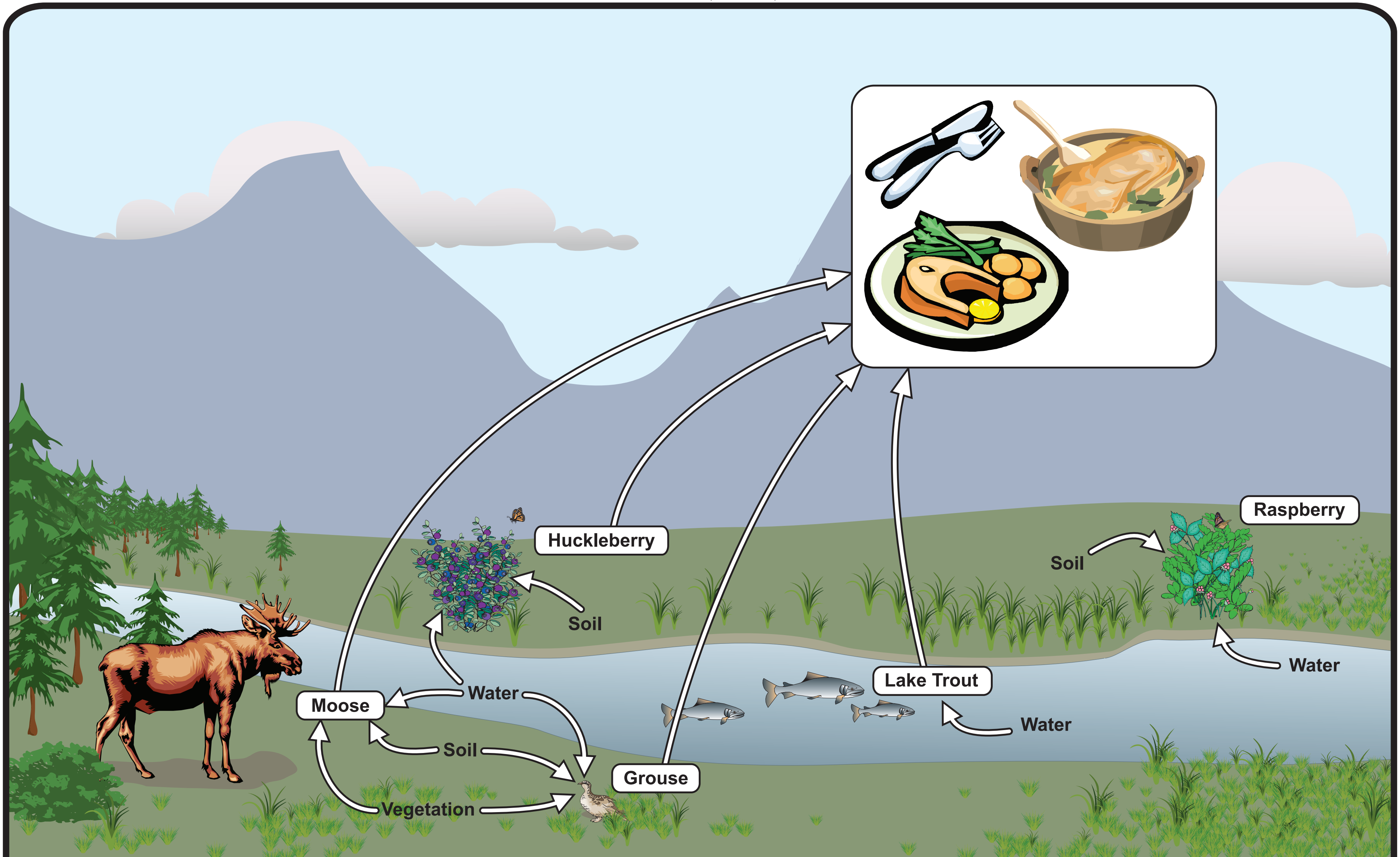


FIGURE 7.22-6

Morrison Copper/Gold Project Country Foods COPC Conceptual Model