5.0 ENVIRONMENTAL IMPACTS

5.1 Atmospheric Environment

5.1.1 Introduction

Activities associated with the Phase 1-Meliadine All-weather Access Road (AWAR) (the AWAR Project) have the potential to impact the atmospheric environment, which is comprised of the following 4 components:

- Air Quality;
- Noise;
- Meteorology and Climate; and
- Climate Change.

To assess these impacts, a semi-qualitative assessment of effects and associated impacts was completed.

Changes in air quality (i.e., changes in ground level concentrations) are linked closely with effects to other environmental disciplines such as surface water, soils, vegetation, wildlife, and people. Similarly, changes in noise levels from the AWAR Project can have local influences on people and wildlife. Subsequently, related assessments for effects from changes in air quality and noise are provided in the following sections:

- Surface Water Environment (Section 5.2);
- Cultural Environment (Section 6.2); and
- Socio-economic Environment (Section 6.3).

5.1.2 Existing Environment

5.1.2.1 General Setting

The AWAR Project is located north of Rankin Inlet in Nunavut and starts from the existing municipal road that provides access to Iqaluqaarjuup Nunanga Territorial Park to the Meliadine West Advanced Exploration site. The AWAR Project is located in the Maguse River Upland Ecoregion portion of the Southern Arctic Ecozone (Ecological Stratification Working Group 1995). The AWAR will span this environment with multiple water crossings.

To facilitate the assessment and interpretation of potential effects associated with the AWAR Project, it is necessary to define appropriate spatial boundaries. Spatial boundaries were developed with consideration of soil, vegetation, human, and wildlife components. The regional study area (RSA) was selected to capture any effects that may extend beyond the immediate AWAR Project area and subsequently to assess potential cumulative effects on terrain and soils, vegetation, and wildlife in the broader regional context. For the atmospheric assessment, this area was assumed to be consistent with the overall AWAR Project RSA. A local study area (LSA) also was defined for air quality and noise components to assess the immediate direct and indirect effects of the AWAR Project on the atmospheric environment. This was selected as bounding an area of 1.5 kilometres (km) either side of the AWAR.

5.1.2.2 Existing Air Quality

The air quality assessment focused on emissions and resulting concentrations of the following compounds:

- particulate matter, including total suspended particulate (TSP), particles nominally smaller than 10 µm in diameter (PM_{10}), and particles nominally smaller than 2.5 µm in diameter ($PM_{2.5}$);
- oxides of nitrogen (NO_X) and the resulting nitrogen dioxide (NO_2);
- sulphur dioxide (SO_2); and
- carbon monoxide (CO).

For each of the above compounds there are available objectives and criteria, which are listed in Table 5.1.2-1.

Table 5.1.2-1: Canadian Regulatory Air Quality Guidelines

Substance	Nunavut Air Quality Standards	NWT Air Quality Standards[a]	Canada-Wide Standards[b]	National Ambient Air Quality Objectives[c]		
				Desirable	Acceptable	Tolerable
SO_2 (µg/m³)						
1-Hour	450	450	—	450	900	—
24-Hour	150	150	—	150	300	800
Annual	30	30	—	30	60	—
NO_2 (µg/m³)						
1-Hour	—	400	—	—	400	1 000
24-Hour	—	200	—	—	200	300
Annual	—	60	—	60	100	—
CO (µg/m³)						
1-Hour	—	15 000	—	15 000	35 000	—
8-Hour	—	6 000	—	6 000	15 000	20 000
TSP (µg/m³)						
24-Hour	120	120	—	—	120	400
Annual	60	60	—	60	70	—
$PM_{2.5}$ (µg/m³)						
24-Hour	—	30[d]	30[d]	—	—	—
Annual	—	—	—	—	—	—

[a] GNWT (2011b).
[b] CCME (2000).
[c] Environment Canada (1981).
[d] Compliance with the GNWT standard is based on measured maximum value (Veale 2008), whereas compliance with the Canada Wide Standard is based on the 98th percentile of the annual monitored data averaged over 3 years of measurements.
— = No guideline available; µg/m³ = micrograms per cubic metre; SO_2 = sulphur dioxide; NO_2 = nitrogen dioxide; TSP = total suspended particulates; PM = particular matter; CO = carbon monoxide; NWT = Northwest Territories.

There is no local air quality monitoring station available for Rankin Inlet, Nunavut. The closest air quality monitoring stations in the National Air Pollution Surveillance Network to the AWAR are all approximately 1200 km away, with the most complete data set coming from the Northwest Territories (NWT). The background air quality of the NWT was chosen as a proxy for the AWAR Project area. Table 5.1.2-2 provides a listing of the available northern air quality data for the parameters used in the evaluation. It should be noted that no TSP data were available.

Table 5.1.2-2: Available Existing Air Quality Data

Pollutant	Usual Hourly NWT Readings[a]	
	[µg/m³]	ppb
Sulphur Dioxide	0 - 14	0 - 5
Nitrogen Oxides	0 - 31	0 - 15
Nitrogen Dioxide	0 - 21	0 - 10
Carbon Monoxide	0 - 250	0 - 200
Particulate Matter < 2.5 µm	0 - 10	—
Particulate Matter < 10 µm	0 - 15	—

[a] Air Quality in the NWT (2005). Retrieved 24 August 2011 from http://www.air.enr.gov.nt.ca/NWTAQ/nwtairquality.aspx
$\mu g/m^3$ = micrograms per cubic metre; ppb = parts per billion

As seen in the table, the readings are typically very low and well below the given air quality standards. The values shown include local community emission sources. It is expected that Rankin Inlet will have similar existing air quality; however, existing air quality along the AWAR would be expected to be lower than existing data from northern communities.

Higher particulate matter concentrations mainly occur in the spring when snow melt exposes the winter sand and gravel on roads to wind and vehicle disturbance. Wild fires, combustion products from vehicles, and heating and electricity generation can also account for increased levels of particulate matter.

5.1.2.3 Existing Noise Levels

5.1.2.3.1 Overview of Acoustic Environment

Based on Golder's review of available aerial photography for the study area, it is understood the AWAR Project site consists entirely of wilderness. Due to the remote nature of the AWAR Project site, the existing noise levels at sensitive points of reception, which could be affected by the AWAR Project works and activities, is expected to be consistent with that of a rural environment. Therefore, the existing conditions will be dominated by sounds of nature, with little influence from human activity (e.g., animal calls).

5.1.2.3.2 Measures for Evaluating Noise

To help understand the analysis and recommendations made in this report, the following is a brief discussion of technical noise terms.

Sound pressure level is expressed on a logarithmic scale in units of decibels (dB). Since the scale is logarithmic, a sound that is twice the sound pressure level as another will be 3 dB higher. However, it should be understood that the human ear also responds logarithmically to changes in sound pressure level. Therefore, a double of sound pressure (3 dB increase) subjectively is only a slightly perceptible change in level.

It is common practice to sum sound levels over the entire audible spectrum (i.e., 20 hertz to 20 kilohertz) to give an overall sound level. However, to approximate the hearing response of humans, the frequency spectrum must be weighted to account for how the human ear perceives sound. The resulting "A-weighted" sound level is often used as a criterion to indicate a maximum allowable sound level. In general, low frequencies are weighted higher, as human hearing is less sensitive to low frequency sound.

Environmental noise levels vary over time, and are described using an overall sound level as the L_{eq}, or energy averaged sound level. The L_{eq} is the equivalent continuous sound level, which in a stated time, and at a stated location, has the same energy as the time varying noise level. It is common practice to measure L_{eq} sound levels to obtain a representative average sound level.

Environmental noise is commonly evaluated on an hourly L_{eq} basis. For the assessment of the AWAR Project, the predictable worst hour, (i.e., the hour with activities which result in the highest L_{eq} noise emissions), will be evaluated against existing conditions. In this report, hourly L_{eq} noise levels will be referred to simply as "noise levels."

5.1.2.3.3 Relevant Criteria

Actual existing noise levels are expected to range between 30 to 55 dBA. Levels would be higher during periods of inclement weather and/or periods of localized active natural activity. The only location where the ambient environment surrounding the AWAR may be under the influence of existing road traffic is at the junction of the AWAR Project and the existing road that leads to Rankin Inlet. Beyond 1 km from this junction, away from Rankin Inlet, the existing noise levels are expected to be dominated by natural sounds and occasional ATV or snowmobile pass-bys. Once one approaches the northern area of the AWAR, existing noise levels may be influenced by exploration activities at the Meliadine West Advanced Exploration site.

Based on the qualitative analysis of the existing acoustic environment, a minimum noise level of 35 dBA is considered applicable as per Health Canada's *National Guidelines for Environmental Assessments: Health Impacts of Noise*. This is consistent with minimum noise levels in neighbouring provincial jurisdictions, such as Alberta.

In areas where the AWAR Project is predicted to generate a sound level contribution of 35 dBA or less, it will be considered to have a negligible effect on existing noise levels.

5.1.2.4 Existing Meteorological and Climate Conditions

The AWAR Project is located in the Maguse River Upland Ecoregion portion of the Southern Arctic Ecozone (Ecological Stratification Working Group 1995). This ecoregion is classified as having a low arctic ecoclimate, with long cold winters and short cool summers with prolonged periods of misty weather.

The Environment Canada station at Rankin Inlet was used to provide both the meteorological data and long-term climate information. Meteorology refers to the hourly observations of weather conditions. In contrast, climate refers to the long-term averages of observed meteorology. Climate is usually described using 30-year climate normals, the most recent of which covers the period from 1971 to 2000. The Environment Canada Rankin Inlet station used to characterize the existing meteorology and climate (Environment Canada 2000) is located at UTM 545005 Easting and 6965509 North (Zone 15) (NAD83 Datum).

Temperature

The long-term average daily temperature at Rankin Inlet is -11 degrees Celsius (°C). The warm season, which for the purpose of this study is classified as months having daily average temperatures above 0°C, occurs from June through September. This period is referred to as the "Unfrozen" period. During this period, the daily maximum temperature is below 15°C. The coldest months in the region are from November to April, where the daily maximum temperature is below -10°C. This period is referred to as the “Frozen” period. Figure 5.1.2-1 provides a summary of temperature normals, including extreme indices at Rankin Inlet.

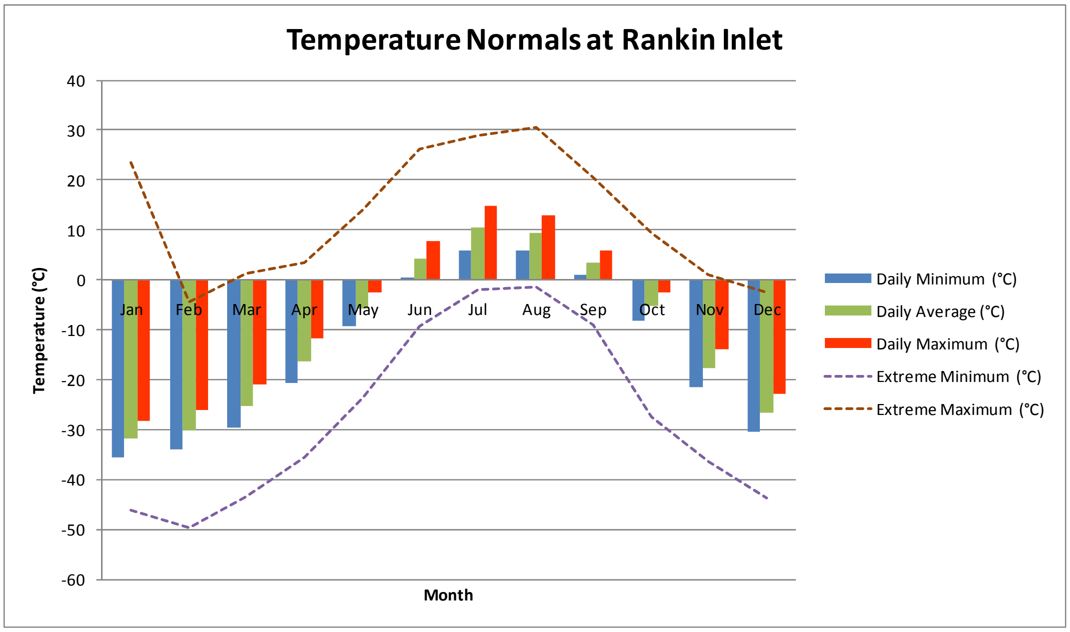

Figure 5.1.2-1: Temperature Normals at Rankin Inlet

Precipitation

On average, Rankin Inlet experiences 297.1 millimetres (mm) of total annual precipitation. The total average annual rainfall is 181.5 mm, with most rainfall occurring from May through October. The total average annual snowfall is 119.7 centimetres, with most snowfall occurring from November through April. During both of these periods, some months experience mixed precipitation. Figure 5.1.2-2 provides a summary of monthly and annual precipitation levels, including extreme indices.

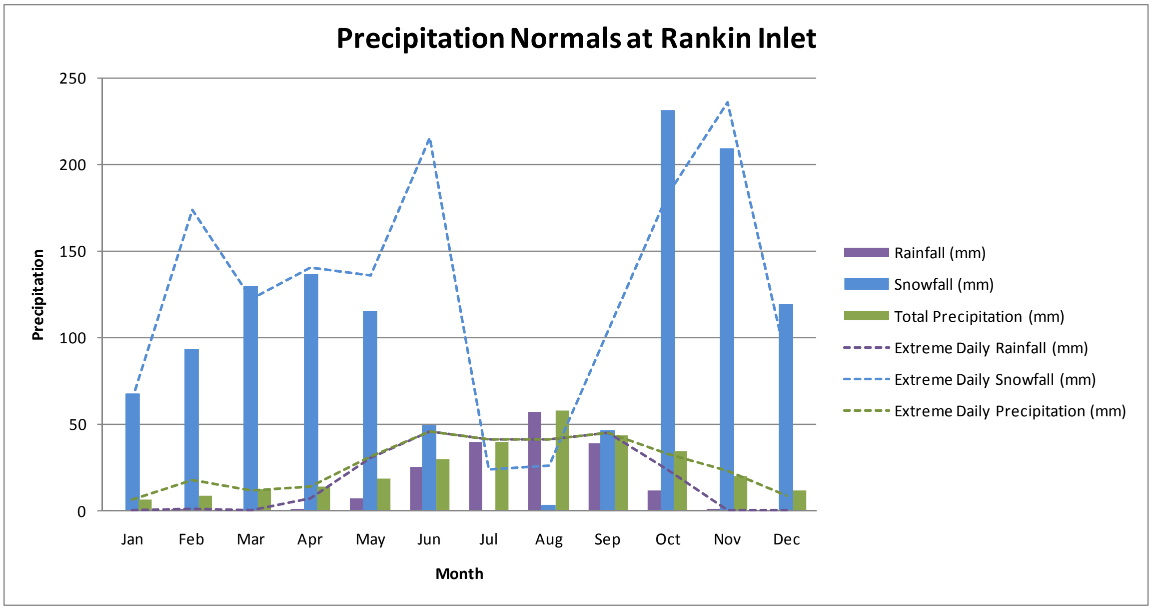

Figure 5.1.2-2: Precipitation Normals at Rankin Inlet

Wind

The prevailing wind direction at Rankin Inlet is from the northwest. This prevailing wind direction is consistent for all months of the year. The average wind speed is 23 kilometres per hour (km/h). Thus, the Rankin Inlet region seems to have its surface weather characteristics affected more by inland weather than coastal effects from its east to south border. Table 5.1.2-3 provides a summary of climate normals for wind at Rankin Inlet.

Table 5.1.2-3: Normal Surface Wind at Rankin Inlet

Period	Speed (km/h)	Most Frequent Direction	Maximum Hourly Speed (km/h)	Direction of Maximum Hourly Speed	Maximum Gust Speed (km/h)	Direction of Maximum Gust
Jan	23.9	NW	102	NW	132	NW
Feb	23.9	NW	93	NW	113	NE
Mar	23.4	NW	93	NW	111	NW
Apr	22.4	NW	93	NW	111	NW
May	22.1	NW	102	NW	117	NW
Jun	19.8	NW	74	E	111	E
Jul	19.2	NW	74	NW	106	NW
Aug	21.1	NW	93	NW	124	NW
Sep	24.2	NW	83	E	109	W
Oct	26.5	NW	93	W	137	W
Nov	25.3	NW	93	NW	124	N
Dec	24	NW	100	NW	124	NW
Year	23	NW		NW		W

km/h = kilometres per hour; E = east; N = north; NE = northeast; NW = northwest; W = west

A more useful way to view wind data is using a wind rose figure. A wind-rose figure is often used to illustrate the frequency of wind direction and the magnitude of the wind speed. The lengths of the bars on the wind-rose indicate the frequency and speed of the wind. The wind direction (blowing from) is illustrated by the orientation of the bar in one of 16 cardinal directions. Figure 5.1.2-3 presents a 5 year wind rose (2006 through 2010) for the meteorological records at Rankin Inlet. The windrose show noticeable frequent wind from east to south quadrant, which may indicate the coastal effects during daytime heating.

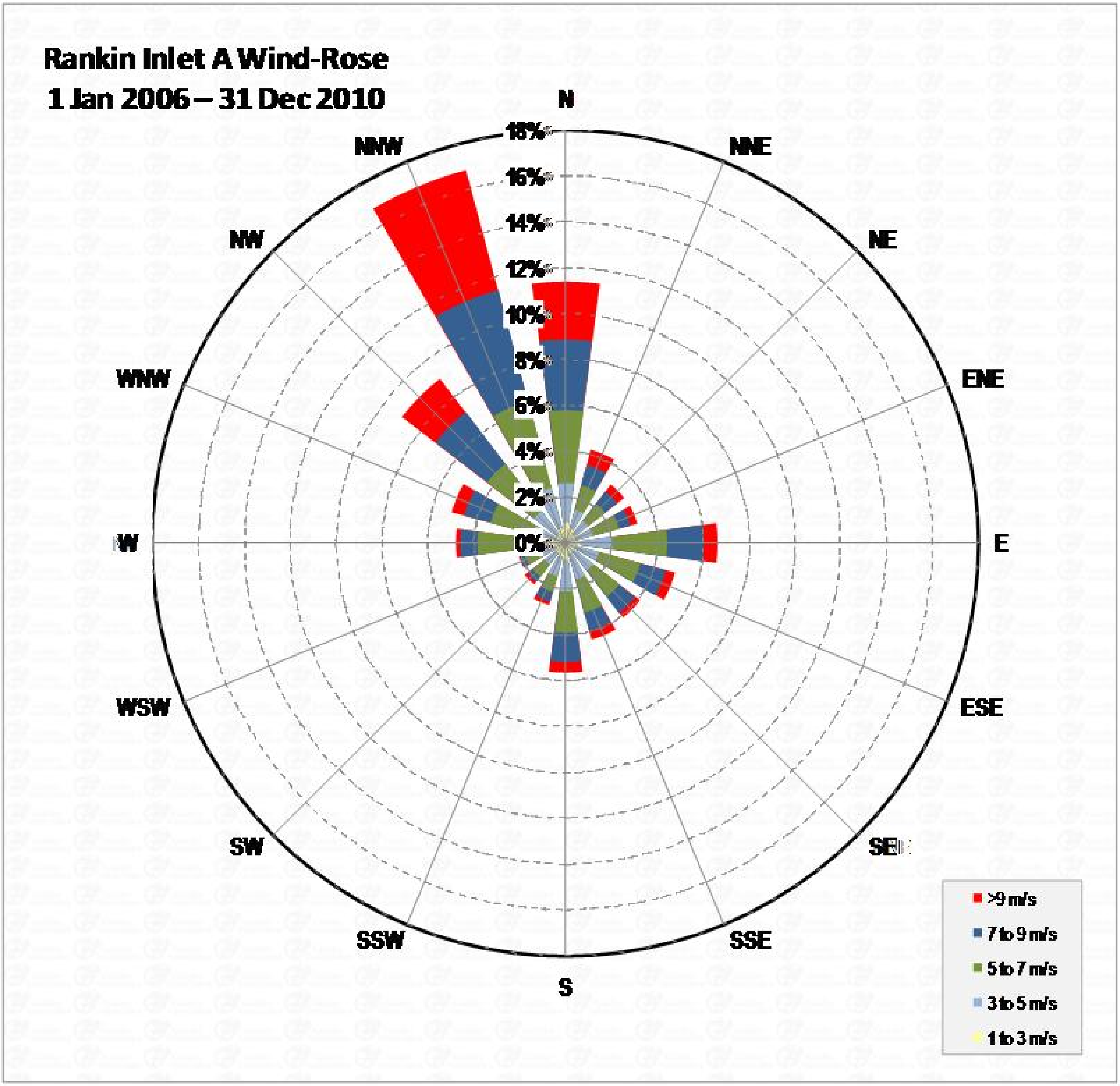

Figure 5.1.2-3: 2006 - 2010 Wind-Rose at Rankin Inlet Airport

5.1.2.5 *Existing Greenhouse Gas Emissions*

Greenhouse gas emissions (GHG) collectively referred to emissions of a series of compounds identified by the Intergovernmental Panel on Climate Change as contributing to the potential for changing the planet's climate. The most notable of these GHG emissions is carbon dioxide; however, a number of other compounds, such as methane and nitrous oxides, also are important GHGs. Table 5.1.2-4 lists the GHG emissions for the transportation sector, as well as for the territory as a whole. In a similar manner, Table 5.1.2-5 lists the Canadian transportation sector and overall GHG emissions. As GHG emissions are considered a global issue, the territorial and national GHG totals are the values to use when comparing emissions from the AWAR Project.

Table 5.1.2-4: Greenhouse Gas Emissions for Nunavut

Sector or Activity	Annual GHG Emissions (kt CO_2 equivalent)					
	1990	2004	2005	2006	2007	2008
Transportation Sector Total	**—**	**341**	**116**	**212**	**329**	**326**
Civil Aviation (Domestic Aviation)	—	39.0	31.0	35.0	35.0	34.0
Road Transportation	—	29.1	25.1	24.9	28.5	21.5
Light-Duty Gasoline Vehicles	—	4.67	3.71	3.4	3.84	3.82
Light-Duty Gasoline Trucks	—	13.6	11.3	10.4	11.8	11.8
Heavy-Duty Gasoline Vehicles	—	0.19	0.14	0.14	0.17	0.17
Motorcycles	—	0.04	0.03	0.03	0.03	0.03
Light-Duty Diesel Vehicles	—	0.05	0.04	0.04	0.04	0.04
Light-Duty Diesel Trucks	—	0.84	0.8	0.74	0.81	0.83
Heavy-Duty Diesel Vehicles	—	8.66	8.56	9.45	11	3.89
Propane & Natural Gas Vehicles	—	1	0.54	0.73	0.88	0.92
Railways	—	—	—	—	—	—
Navigation (Domestic Marine)	—	—	—	—	0.9	—
Other Transportation	—	270	59	150	260	270
Off-Road Gasoline	—	1	0	—	—	—
Off-Road Diesel	—	270	59	150	260	270
Pipelines	—	—	—	—	—	—
Territorial Total	—	**429**	**152**	**246**	**370**	**361**

GHG = greenhouse gas emissions; CO_2 = carbon dioxide

Table 5.1.2-5: Greenhouse Gas Emissions for Canada

Sector or Activity	Annual GHG Emissions (kt CO_2 equivalent)					
	1990	2004	2005	2006	2007	2008
Transportation Sector Total	**145 000**	**188 000**	**192 000**	**191 000**	**199 000**	**198 000**
Civil Aviation (Domestic Aviation)	6 400	7 800	7 900	7 700	8 800	8 500
Road Transportation	98 400	129 000	131 000	133 000	136 000	135 000
Light-Duty Gasoline Vehicles	45 800	41 100	39 900	39 900	41 000	40 600
Light-Duty Gasoline Trucks	20 700	42 000	43 100	43 600	44 800	44 800
Heavy-Duty Gasoline Vehicles	7 810	6 400	6 300	6 430	6 620	6 660
Motorcycles	146	245	252	256	264	264
Light-Duty Diesel Vehicles	355	431	432	435	448	446
Light-Duty Diesel Trucks	707	1 990	2 130	2 230	2 320	2 370
Heavy-Duty Diesel Vehicles	20 700	36 500	38 100	38 900	40 000	39 400
Propane & Natural Gas Vehicles	2 200	860	720	790	830	880
Railways	7 000	6 000	6 000	6 000	7 000	7 000
Navigation (Domestic Marine)	5 000	6 600	6 400	5 800	6 100	5 800
Other Transportation	29 000	38 000	41 000	39 000	41 000	41 000
Off-Road Gasoline	6 700	7 700	7 300	6 700	7 100	6 300
Off-Road Diesel	15 000	22 000	23 000	23 000	25 000	28 000
Pipelines	6 850	8 470	10 100	9 610	8 940	7 460
Canadian Totals	**592 000**	**741 000**	**731 000**	**718 000**	**750 000**	**734 000**

GHG = greenhouse gas emissions; CO_2 = carbon dioxide

5.1.3 Effects Analysis

The construction and operation of the AWAR Project have the potential to affect air quality, noise, meteorology and climate, and GHG emissions. The potential pathways through which the AWAR Project could affect these components of the environment are presented in Table 5.1.3-1.

Table 5.1.3-1: Potential Pathways for the Atmospheric and Acoustic Environment

Component	Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
Air Quality	Construction of the Phase 1 AWAR	Fugitive emissions and construction vehicle exhaust	The following environmental design and mitigation features will lessen the effects of Phase 1 AWAR construction on air quality: • Controlling fugitive dust from construction activities • Equipment and vehicles will comply with relevant non-road emission criteria at the time of purchase • Regular maintenance will be implemented for equipment and vehicles	Primary
	Traffic on the Phase 1 AWAR	Fugitive emissions (i.e., road dust) and vehicle exhaust	The following environmental design and mitigation features will lessen the effects of Phase 1 AWAR operations on air quality: • Watering of roads, in select areas, and enforcing speed limits to suppress dust production • The road surface will be maintained through grading and the addition of granular material Equipment and vehicles will comply with relevant non-road emission criteria at the time of purchase • Regular maintenance will be implemented for equipment and vehicles	Primary
Acoustic	Construction of the Phase 1 AWAR	Noise emissions from construction equipment and blasting at quarries	The following environmental design and mitigation features will lessen the effects of Phase 1 AWAR construction on noise: • Equipment and vehicles will be operated with manufacturers' supplied noise controls • Regular maintenance will be implemented for equipment and vehicles • Use of screen at the quarries or borrow areas	Primary

Table 5.1.3-1: Potential Pathways for the Atmospheric and Acoustic Environment (continued)

Component	Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
Acoustic (continued)	Traffic on the Phase 1 AWAR	Noise emissions from traffic	The following environmental design and mitigation features will lessen the effects of Phase 1 AWAR operations on noise: • All vehicles will adhere to the 50 km/h speed limit (enforced by AEM) • Phase 1 AWAR vehicles will be operated with manufacturers' supplied noise controls • Phase 1 AWAR will be maintained to minimize pot holes and ruts	Primary
Meteorology and Climate	None	None	None	None
Climate Change	Traffic and equipment exhaust on the Phase 1 AWAR during construction and operations	Greenhouse Gas Emissions from vehicle exhaust	The following environmental design and mitigation features will lessen the effects of Phase 1 AWAR operations on Greenhouse Gas emissions: • All vehicles will adhere to the 50 km/h speed limit (enforced by AEM). • Regular maintenance will be implemented for AEM equipment and vehicles	Primary

The following section discusses the potential pathways relevant to the atmospheric environment.

5.1.3.1 Pathways with No Linkage

There is no defined linkage that is considered valid between the AWAR Project and the meteorology and climate component. As described by the federal government *"…the contribution of an individual project to climate change cannot be measured*" (FTPCCCEA 2003). Therefore, the GHG emissions from the construction and operation of the AWAR will be too small to have any effect on climate or meteorology.

5.1.3.2 Secondary Pathways

There are no disciplines identified as having linkages to the atmospheric environment components. All of the anticipated pathways for the atmospheric environment are considered to be primary pathways.

5.1.3.3 Primary Pathways

The following pathways were verified to be primary for effects to the atmospheric environment, and will be carried through the effects assessment (Table 5.1.3-1).

- Air Quality: fugitive emissions and construction vehicle exhaust;
- Air Quality: fugitive emissions (i.e., road dust) and vehicle exhaust;
- Noise: noise emissions from construction equipment and blasting at quarry sites;
- Noise: noise emissions from traffic; and
- Climate Change: GHG emissions from vehicle exhaust.

5.1.4 Effects on Air Quality

5.1.4.1 Summary of Primary Pathways

Two primary pathways were identified for air quality:

- Air Quality: fugitive emissions and construction vehicle exhaust; and
- Air Quality: fugitive emissions (i.e., road dust) and vehicle exhaust.

5.1.4.2 Effects Assessment

Study Area

As previously described in Section 5.1.2, a local and regional study area have been defined for assessing the effects of the AWAR Project on air quality. The LSA was defined for air quality as the area where the immediate direct and indirect effects of the AWAR Project would occur. Specifically, the LSA was selected as an area enclosing the AWAR and 1.5 km on either side. Air quality used the common RSA for the terrestrial component.

Methods

The approach used to assess effects of the AWAR Project on air quality included the following steps:

- determine, qualitatively, whether the construction or operation during Phase 1 would result in the greatest effects on air quality;
- estimating the air emissions for Phase 1 of the AWAR Project with the greatest effects;

- use a dispersion model (AERMOD) with worst case screening meteorology to estimate the concentrations of the selected compounds as a function of distance from the roadway; and
- comparing the predicted concentrations to available criteria and standards.

Air emissions during construction and operations were calculated on the basis of available information regarding the AWAR Project and published emission factors. The emissions associated with construction were calculated using the general construction emission factor in the WRAP Fugitive Dust Handbook (Countess 2006). The emissions associated with the operation of the AWAR Project made use of fleet details for AWAR Project activities provided by AEM. The following were used for calculating the air emissions of TSP, PM_{10}, $PM_{2.5}$, NO_X, SO_2, and CO during operations:

- fugitive road dust (i.e., TSP, PM_{10}, $PM_{2.5}$) emissions were calculated using the emission factors presented in Sections 13.2.2 of AP-42 (U.S. EPA 2010a), and the vehicle activity levels identified for weekdays during the winter, weekends during the winter, weekdays during the summer, and weekends during the summer; and
- exhaust emissions were calculated using the U.S. EPA MOBILE6 emissions model and the vehicle activity levels identified for weekdays during the winter, weekends during the winter, weekdays during the summer, and weekends during the summer.

Concentrations with distance from the roadway were calculated using the AERMOD dispersion model with the SCREEN option. This mode of operation facilitates estimating worst-case 1-hour concentrations. The site-specific worst case meteorological data to support the AERMOD predictions was generated by MAKEMET (a component of the AERSCREEN model) (U.S. EPA 2011). Specific inputs included an assumption of rural, flat terrain, and single road segment 500 metres (m) in length, simulated using a series of adjacent volume sources. A line of receptors was placed at increasing distance from 25 to 1500 m from the centre point of the road.

Emission Inventory

Based on the information provided by AEM, the operations vehicle fleet will change depending on the season (i.e., frozen period and unfrozen period), as well as day of the week (i.e., weekday and weekend). A summary of the estimated AWAR Project fleet traffic is provided in Table 5.1.4-1. During periods of inclement weather, the road traffic would likely drop to zero.

Fugitive road dust emissions resulting from vehicular travel along the AWAR were derived using U.S. EPA, AP-42 Section 13.2.2 - Unpaved Roads (U.S. EPA 2010b), as modified by Environment Canada to account for half of the snow covered days. Inputs to the calculation included an assumed average silt and moisture contents outlined in Section 13.2.2 of AP-42 (10% silt content, 6.5% moisture content). In some areas, AEM has committed to apply active controls on the road surfaces to reduce dust. These controls could include actions such as applying chemical dust suppressants or using water. These controls are expected to achieve an average control efficiency of 70%. Although literature does not provide a control efficiency for regular maintenance of the road surfaces, the commitment by AEM to maintain the road surface is expected to have benefits with respect to the amount of dust generated. For the winter period, no controls were assumed.

Table 5.1.4-1: All-weather Access Road Project Related Fleet Traffic of Phase 1

Vehicle Type	Total Number of Trips per Day			
	Frozen Weekdays	Frozen Weekends	Unfrozen weekdays	Unfrozen Weekends
Pickup	10	4	14	8
Cube Van	2	1	3	1
Passenger Van	2	1	2	1
Fuel Truck	2	0	2	0
Transport Truck	1	1	1	1
Transport Trucks (only when barge arrivals occur and for one month after last barge)	10[a]	10[a]	10	10
Snow Plow	1	1	0	0

[a] Transport of barge off-loaded freight could extend for up to one month after the last barge arrival, so assumed to extend into the winter frozen period.

Table 5.1.4-2 provides a listing of the daily emissions on the day with the highest emissions (assuming dust mitigation during the unfrozen period). This corresponded a winter weekday, when additional traffic required due to transport of stockpiled barge off-loaded freight, was using the AWAR.

Table 5.1.4-2: Maximum Daily Air Emissions – Winter Weekday

Vehicle Type	Emission Rate (kg/day)					
	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO
Pickup	79.27	31.01	3.18	0.11	0.00	1.29
Cube Van	15.84	6.19	0.62	0.01	0.00	0.03
Passenger Van	15.83	6.18	0.62	0.00	0.00	2.66
Fuel Truck	15.84	6.19	0.62	0.01	0.00	0.07
Transport Truck	7.92	3.10	0.31	0.01	0.00	0.05
Barge Transport Trucks (only when barge arrivals occur and for one month after last barge)[a]	79.23	30.97	3.13	0.07	0.00	0.48
Snow Plow	7.92	3.09	0.31	0.01	0.00	0.03
Overall Values	**221.85**	**86.72**	**8.80**	**0.21**	**0.01**	**4.61**

[a] Transport of barge off-loaded freight could extend for up to one month after the last barge arrival, so assumed to extend into the winter frozen period.

kg/day = kilogram per day; TSP = total suspended particulate; PM_{10} = particles nominally smaller than 10 µm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 µm in diameter; NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; CO = carbon monoxide

On an annual basis, there will be a combination of winter weekdays, winter weekends, summer weekdays, summer weekends, days without barge traffic, and days when additional traffic required due to barge unloading and transport. Using the information provided by AEM, the annual emissions from the AWAR Project (assuming dust mitigation during the unfrozen period) were calculated and summarized in Table 5.1.4-3.

Table 5.1.4-3: Annual Air Emissions

Vehicle Type	Emission Rate (kg/year)					
	TSP	**PM_{10}**	**$PM_{2.5}$**	**NO_X**	**SO_2**	**CO**
Pickup	9817.4	3841.4	394.9	96.1	0.2	184.2
Cube Van	2001.8	781.9	78.5	17.8	0.1	4.6
Passenger Van	1753.0	684.4	68.3	10.7	0.1	284.4
Fuel Truck	1487.0	581.1	58.7	31.3	0.1	7.2
Transport Truck	1010.7	395.1	40.0	26.8	0.1	6.6
Barge Transport Trucks	2927.6	1144.6	116.1	84.5	0.2	20.9
Snow Plow	677.2	264.6	26.7	10.7	0.0	2.4
Overall Values	**19 674.7**	**7693.1**	**783.3**	**277.8**	**0.7**	**510.4**

kg/year = kilogram per year; TSP = total suspended particulate; PM_{10} = particles nominally smaller than 10 µm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 µm in diameter; NO_x = oxides of nitrogen; SO_2 = sulphur dioxide; CO = carbon monoxide

The air emissions of TSP during construction, assuming no controls, were calculated to be 79% of the predicted emissions during operations. The emissions of other compounds would represent a smaller fraction. Therefore, air emissions will be greatest during the operations of the AWAR, when traffic along the access road is at its peak (i.e., on days when additional traffic is required due to barge unloading and transport). Since air emissions will be lower during the construction activities than during operations, the dispersion modelling was only completed using for the operations air emissions.

Dispersion Modelling Results

Based on the calculations, the maximum emission rates are expected to occur during the winter period during weekdays. During the winter months, no emissions management activities have been assumed, which results in higher daily particulate emissions. This is a conservative approach, as AEM has a mitigation procedure to address road dust emissions.

Dust will be mitigated by maintaining posted speed limits (50 km/h). In areas or times identified by the AEM road supervisor as being prone to high dust levels or areas where safe road visibility is impaired, or in areas where dust deposition is impacting fish habitat and/or water quality, the road supervisor will arrange mitigation measures as appropriate. This could involve actions such as grading of the road surface, placement of new coarser topping, and/or watering of the road surface. Use of chemical dust suppressants will be used only as a last resort and only in accordance with the Environmental Guidance for Dust Suppression published by the Government of Nunavut Department of Environment (January 2002).

The predicted concentrations for the period with the highest emissions (winter weekday with barge traffic) are summarized in Table 5.1.4-4. Predicted concentrations are below the criteria for all parameters except 24-hour TSP at the closest receptor to the roadway. This value is likely conservative (i.e., over-estimation) given the conservative nature of the modelling and emissions used in the predictions.

Table 5.1.4-4: Dispersion Modelling Results (Winter Weekday no Mitigation)

Distance from Road	24-Hour TSP	24-Hour PM_{10}	24-Hour $PM_{2.5}$	1-Hour NO_2	24-Hour NO_2	1-Hour SO_2	24-Hour SO_2	1-Hour CO
25	121.78	47.61	4.83	4.68	1.92	0.011	0.004	6.16
50	116.18	45.42	4.61	4.47	1.84	0.010	0.004	5.88
75	110.05	43.02	4.36	4.23	1.74	0.010	0.004	5.57
100	103.92	40.62	4.12	4.00	1.64	0.009	0.004	5.26
200	82.89	32.40	3.29	3.19	1.31	0.007	0.003	4.20
300	67.79	26.50	2.69	2.61	1.07	0.006	0.002	3.43
500	48.68	19.03	1.93	1.87	0.77	0.004	0.002	2.46
700	37.30	14.58	1.48	1.43	0.59	0.003	0.001	1.89
1000	27.00	10.55	1.07	1.04	0.43	0.002	0.001	1.37
Criteria or Guideline	**120**	**50**	**30**	**400**	**200**	**450**	**150**	**15 000**

TSP = total suspended particulate; PM_{10} = particles nominally smaller than 10 µm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 µm in diameter; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide

The predicted concentrations for the summer period weekdays (assuming dust mitigation) are summarized in Table 5.1.4-5. Predicted concentrations are below the criteria for all parameters. This value is likely conservative given the conservative nature of the modelling and emissions used in the predictions.

Table 5.1.4-5: Dispersion Modelling Results (Summer Weekday with Mitigation)

Distance from Road	24-Hour TSP	24-Hour PM_{10}	24-Hour $PM_{2.5}$	1-Hour NO_2	24-Hour NO_2	1-Hour SO_2	24-Hour SO_2	1-Hour CO
25	106.49	41.65	4.25	4.68	1.92	0.011	0.005	5.77
50	101.59	39.73	4.06	4.47	1.84	0.011	0.004	5.51
75	96.22	37.63	3.84	4.23	1.74	0.010	0.004	5.21
100	90.86	35.54	3.63	4.00	1.64	0.010	0.004	4.92
200	72.48	28.35	2.89	3.19	1.31	0.008	0.003	3.93
300	59.27	23.18	2.37	2.61	1.07	0.006	0.003	3.21
500	42.56	16.65	1.70	1.87	0.77	0.004	0.002	2.31
700	32.62	12.76	1.30	1.43	0.59	0.003	0.001	1.77
1000	23.61	9.23	0.94	1.04	0.43	0.002	0.001	1.28
Criteria or Guideline	**120**	**50**	**30**	**400**	**200**	**450**	**150**	**15 000**

TSP = total suspended particulate; PM_{10} = particles nominally smaller than 10 µm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 µm in diameter; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide

The predicted concentrations for the summer period weekdays (assuming no dust mitigation) are summarized in Table 5.1.4-6. With the exception of 24-hour TSP and PM_{10}, the predicted concentrations are below the criteria for all parameters except at the closest receptor to the roadway. Without mitigation efforts the predicted 24-hour TSP and PM_{10} concentrations are greater than the standards out to a distance of 600 m. These predictions are likely conservative given the conservative nature of the modelling and emissions used in the predictions.

Table 5.1.4-6: Dispersion Modelling Results (Summer Weekday with no Dust Mitigation)

Distance from Road	24-Hour TSP	24-Hour PM_{10}	24-Hour $PM_{2.5}$	1-Hour NO_2	24-Hour NO_2	1-Hour SO_2	24-Hour SO_2	1-Hour CO
25	354.64	138.51	13.90	4.68	1.92	0.01	0.005	5.77
50	338.33	132.14	13.26	4.47	1.84	0.01	0.004	5.51
75	320.46	125.16	12.56	4.23	1.74	0.01	0.004	5.21
100	302.61	118.19	11.86	4.00	1.64	0.01	0.004	4.92
200	241.37	94.27	9.46	3.19	1.31	0.01	0.003	3.93
300	197.41	77.10	7.74	2.61	1.07	0.01	0.003	3.21
500	141.75	55.36	5.56	1.87	0.77	0.00	0.002	2.31
700	108.63	42.43	4.26	1.43	0.59	0.00	0.001	1.77
1000	78.62	30.71	3.08	1.04	0.43	0.00	0.001	1.28
Criteria or Guideline	**120**	**50**	**30**	**400**	**200**	**450**	**150**	**15 000**

TSP = total suspended particulate; PM_{10} = particles nominally smaller than 10 µm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 µm in diameter; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide

5.1.4.3 Effects Summary

In evaluating the effects of the AWAR Project on air quality, all AWAR Project design and mitigation measures were incorporated in the assessment. Therefore, the effects predicted above represent residual effects.

It is expected that only AWAR Project traffic will be permitted to travel along the AWAR during Phase 1 of the AWAR Project, with limited controlled access to Inuit beneficiaries that own the land and have the right to access it. These will be approved on a pass basis by Kivalliq Inuit Association (some pick-ups, but mostly ATVs and snowmobiles). General public/joyriders will not be permitted. Snowmobiles and ATVs are not expected to contribute much to the particulate emissions given the size and weight of the vehicles, as well as the speeds they typically travel. In addition, it is expected that there will only be a small incremental increase in the number of snowmobiles and ATV relative to the current activity levels along the AWAR route. On weekends, the number of public pickup trucks could increase the totals for this category to the levels of AWAR Project vehicles expected on weekdays. As a result, public vehicles will not have a measurable change to the air predictions that are based on the worst case weekday activities.

5.1.4.4 Uncertainty

As with all predictions, air quality predictions have a degree of uncertainty. To mitigate the uncertainty, conservative assumptions with respect to emissions and predictions have been used. For example, the emissions and predictions are based on a day when the barges are present and additional trucks are using the AWAR. During most of the year (greater than 75% of the days), traffic along the AWAR does not include barge related traffic. In addition, the modelling was conducted using worst case screening meteorology (e.g., a set of hourly meteorological conditions that cover the range of conditions possible) to verify the highest predictions are represented.

5.1.4.5 Monitoring and Follow-up

Dust will be monitored through regular inspections of the road dust conditions by the AEM road supervisor during both construction and operation. Dust will be mitigated partly by maintaining posted speed limits. In areas or times identified by the AEM road supervisor as being prone to high dust levels, or areas where safe road visibility is impaired, or in areas where dust deposition is impacting fish habitat and/or water quality, the road supervisor will arrange mitigation measures as appropriate. This could involve actions such as grading of the road surface, placement of new coarser topping, and/or watering of the road surface. Use of chemical dust suppressants will be only used as a last resort and only in accordance with the Environmental Guidance for Dust Suppression published by the Government of Nunavut Department of Environment (January 2002).

5.1.5 Effects on Noise

5.1.5.1 Summary of Primary Pathways

Two primary pathways were identified for noise:

- noise emissions from construction activities; and
- noise emissions from road traffic.

5.1.5.2 Effects Assessment

Study Area

For the purpose of acoustics, the study area includes the 1.5 km region on either side of the AWAR along its entire length.

Emission Inventory

During the construction of the road, it is anticipated that noise will be generated by the following sources:

- Graders:
  - diesel engine radiated;
  - diesel engine exhaust;
  - tires; and
  - contact forces between grade blade and road fill material.
- Dump Trucks:
  - diesel engine radiated;
  - diesel engine exhaust;
  - tire; and
  - material dumping.

The above sources are considered to include all valid pathways through which noise associated with the construction of the AWAR Project may enter the surrounding environment. Noise emissions from construction equipment were assumed to satisfy the specifications in Ontario Ministry of Environment document NPC-115 “Noise due to Construction Equipment”, and other applicable guidelines.

During the regular use of the road, depending on season, noise may be generated by pass-bys of the following vehicle types:

- ATVs;
- snowmobiles;
- pickup trucks;
- cube vans;
- passenger vans;
- fuel trucks;
- transport trucks (including those due to barge arrival); and
- snow plows.

Based on traffic information for both the advance surface and underground exploration operation and controlled use by the public, the worst-case noise impact will occur during the summer months with a peak daily traffic count of 60 vehicle pass-bys per day, with 20% of these pass-bys being transport and fuel trucks.

In terms of individual vehicle noise emissions, reference levels provided by the *Ontario Road Noise Analysis Method for Environment and Transportation* (ORNAMENT) were used.

Noise emissions for ATVs, snowmobiles, pickup trucks, cube vans, and passenger vans were assumed to have equivalent sound emission levels to ORNAMENT automobiles. Noise emissions for fuel trucks were assumed to have equivalent sound emission levels as ORNAMENT medium trucks, and noise emissions for transport trucks were assumed to have equivalent sound emission levels as ORNAMENT heavy trucks.

Methods

During construction, road construction noise effects were assessed based on the following assumptions:

- at any location, either a grader or a dump truck would be the dominant noise source;
- the equipment has an effective source height of 2 m;
- the equipment is in continuous operation;
- beyond the road construction area, the terrain consists of acoustically absorptive ground conditions; and
- the receptor source height is 1.5 m.

The noise levels generated by construction activities within the study area was predicted using the ISO 9631-2 standard entitled “Acoustics – Attenuation of Sound during Propagation Outdoors – Part 2: General Method of Calculation”.

During typical usage, road traffic noise effects were assessed based on the following assumptions:

- all vehicles will travel at 50 km/h;
- there will be no acoustic shielding benefit provided by natural features (i.e., ridges, etc.); and
- the assessed predictable worst case hour consists of 32 passenger vehicles, 2 fuel trucks, and 6 transport truck pass-bys, which is conservatively over 100% higher than is realistically expected.

The noise levels generated by road traffic within the study area were predicting using ORNAMENT.

Noise Assessment

Noise attenuates primarily due to geometric spreading, but also through absorption, both ground and air, and shielding, when present. The results show the predicted noise levels at key distances based on the modelling assumptions (Table 5.1.5-1).

Table 5.1.5-1: Predict Noise Levels

Distance from Room\Source (m)	Noise Level due to Construction (Hourly L_{eq}, dBA)	Noise Level due to Road Traffic (Hourly L_{eq}, dBA)
50	65	48
100	58	44
200	51	39
350	46	35
400	44	34
800	36	[a]
900	35	[a]
1000	34	[a]

[a] Road traffic results are limited to 500 m distance due to restrictions of the modelling software.

m = metre; L_{eq} = energy averaged sound level; dBA = A-weighted decibel

Blasting

Prediction of Air Vibration Levels

Air vibrations, or airblast, is a pressure wave travelling through the air produced by the direct action of the explosive on air or the indirect action of a confining material subjected to explosive loading. Air vibrations from surface blasting operations consist primarily of acoustic energy below 20 Hz, where human hearing is less acute (Siskind et al. 1980), while noise is that portion of the spectrum of the air vibration lying within the audible range from 20 to 20000 Hz. It is the lower frequency component (below 20 Hz) of air vibration, that which is less audible, that is of interest as it is often the source of secondary rattling and shaking within a structure. For the purposes of this report, air vibration is measured as decibels in the Linear or Unweighted mode (dBL).

Air vibrations attenuate from a blast site at a slower rate than with ground vibrations. The distribution of air vibration energy from a blast is also influenced by the current weather conditions during the blast. For example, wind can increase down-wind levels by 10 to 15 dBL above that which would otherwise be measured (Dowding 1985). Low cloud ceilings and temperature inversions also contribute to air vibrations propagating further than would typically be the case. Other factors influencing air vibration distribution from a blast include the length of collar and type of stemming material, differences in explosive types and variations in burden distance.

The rate at which air vibrations decay or attenuate from a blast site can be expressed by the Scaled Distance, which is defined as:

Scaled Distance (SD) = $D/\sqrt[3]{W}$

where D = distance (ft) between the blast and receptor
W = maximum weight of explosive (lbs) detonated per delay period

Prediction of maximum air vibrations was based on the following equation for quarry blasting from the International Society of Explosives Engineers (ISEE 2011):

$P = 20\log_{10}[1.317(SD)^{-0.966}] + 170.75$ (based on quarry blasting)

Where P = peak air pressure (dBL)
SD = Scaled Distance ($ft/lb^{0.33}$)

Table 5.1.5-2 summarizes the predicted peak air vibration levels that could be experienced at various receptor distances assuming maximum explosive weights of 45 kg per delay period during the AWAR Project.

Table 5.1.5-2: Predicted Peak Air Vibration Levels

Receptor Distance (m)	Peak Air Vibration During AWAR Project (dBL)
100	137
125	136
200	132
300	128
400	126
500	124
600	122
700	121
800	120
900	119
1000	118
1500	115
2000	112
2500	110
3000	109

dBL = decibels in the Linear or Unweighted mode; m = metre

Air vibration levels that might be produced at a receptor distance of 125 m and based on a maximum explosive weight per delay of 45 kg, would be 136 dBL. The estimated air vibration levels would be below the 140 dBL air vibration limit required for the protection of an occupied falcon aerie as shown in Table 5.1.5-3. It should be noted that most of the blasting will occur in winter when quarry material will be stockpiled for use along the road (i.e., before falcons nesting period).

Table 5.1.5-3: Air Vibration Limits for Falcon Aerie

Receptor	Receptor Distance (m)	Peak Air Vibration Limit AWAR Project (dBL)
Occupied Falcon Aerie	>125	140

dBL = decibels in the Linear or Unweighted mode; m = metre

5.1.5.3 Effects Summary

In evaluating the effects on the AWAR Project, all AWAR Project design and mitigation measures were incorporated in the assessment. Therefore, the effects being assessed are the AWAR Project's residual effects.

At 900 m from the road, construction noise levels are predicted to be up to 35 dBA. Therefore, within 900 m of the road construction activities, sound levels may be elevated above the existing sound level of 35 dBA. While the increase in sound level may be noticeable to people and animals, this effect is temporary and will fluctuate at a given location throughout the construction period. Beyond 900 m from the road construction activities, acoustic effects are expected to be negligible as the levels are expected to be below the existing sound levels.

At 350 m from the road, traffic noise levels are predicted to be at or below 35 dBA. Therefore, under a worst-case assessment (i.e., peak traffic volumes), road traffic noise can be above existing conditions within 350 m of the road. As this worst-case scenario is expected to be rare, elevated noise levels due to road traffic will typically be infrequent and further localized to the vicinity of the road. Beyond 350 m from the road, the acoustic effects are expected to be negligible as the levels are expected to be below the existing sound levels.

With respect to noise effects of the AWAR on Iqalugaarjuup Nunanga Territorial Park, the impact is predicted to be negligible. The road has been designed to avoid going through the Park (Figure 3.1-1). Although the AWAR passes adjacent to a moderate sized waterbody as shown in Figure 3.1-1, the closest distance from the AWAR to the rest of the Park is approximately 158 m. Borrow sites B15 and B19 are approximately 375 m and 533 m from the Park, respectively. As such, noise levels due to both construction and road traffic would be noticeable on the lake and the southeastern portion of the Park, but would be back to near background levels within about 900 m from the road, so the effects of noise from the road should be negligible for the remainder of the Park.

5.1.5.4 Uncertainty

As with all predictions, noise predictions have a degree of uncertainty. To mitigate the uncertainty, conservative assumptions with respect predictions have been used. For example, construction equipment was assumed to operate continuously with maximum noise emissions and road traffic noise predictions assume a volume of 40 vehicles per hour, which is substantially higher than expected traffic volumes. It is also worth noting that the noise assessment included non-project related traffic on the road, but there is currently considerable ATV and snowmobile traffic along existing trails along the AWAR route. This traffic is expected to primarily use the road after it has been constructed, so the incremental increase in noise would be lower than predicted (i.e., AEM has estimated that between 25 to 50% of the non-project related trips will be incremental to current access on the existing trails; see section 3.3.6)

5.1.5.5 Monitoring and Follow-up

To help verify acceptable construction noise levels are maintained, noise emissions for construction vehicles should be minimized as part of a best management practices plan by ensuring noise control features installed on construction vehicles are maintained and operating according to specifications.

For road traffic usage, noise emissions should be maintained by enforced of posted speed limits, maintaining manufacturer's noise control features (i.e., mufflers) for AWAR Project vehicles, and maintaining the road surface to minimize the occurrence of pot holes and ruts.

Given the isolated location of the AWAR, it is unlikely that noise from the road will affect human receptors (i.e., permanent residences). There may be areas along the AWAR route (e.g., Iqalugaarjuup Nunanga Territorial Park) where increased noise levels could be a concern from an aesthetic or ecological perspective. A focussed monitoring program will be implemented to collect noise data at the park during the period when construction activities occur in the area. In addition, a limited monitoring program will be undertaken to demonstrate that the predicted noise effects during operations are restricted to the areas immediately adjacent to the AWAR.

5.1.6 Effects on Climate Change

5.1.6.1 Summary of Primary Pathways

There was one primary pathway identified for climate change, namely

- Climate Change: GHG emissions from vehicle exhaust.

5.1.6.2 Effects Assessment

Greenhouse gas emissions associated with the AWAR Project will result from vehicle exhaust along the AWAR. Table 5.1.6-1 lists the annual GHG emissions associated with the AWAR Project, and considers the weekend, weekday, summer, and winter project traffic numbers presented in Table 5.1.4-1.

Table 5.1.6-1: Annual Project Greenhouse Gas Emissions from the All-weather Access Road

Vehicle Type	CO_2 (kg CO_2/year)
Pickup	1583.4
Cube Van	642.6
Passenger Van	443.8
Fuel Truck	136.9
Transport Truck	1122.2
Barge Transport Trucks	976.6
Snow Plow	859.8
Overall Values	**5765.3**

CO_2 = carbon dioxide; kg = kilogram

Table 5.1.6-2 provides a comparison of the AWAR Project GHG emissions to the territorial and national sectors and overall GHG totals for 2008. Overall the AWAR Project would represent less than a 2% increase in the transportation sector emissions for Nunavut. However, the AWAR Project GHG emissions represent 0.003% of the Canadian transportation sector GHG emissions and 0.001% of the overall Canadian GHG emissions. On a national scale, the GHG emissions from the AWAR Project would be negligible.

Table 5.1.6-2: Annual Greenhouse Gas Emissions Comparison between the All-weather Access Road Project and Territorial and National Sectors

Category	GHG Emissions (kt CO_2/year)	AWAR Project Emissions as a Fraction
AWAR Project	5.77	—
Nunavut Transport Sector	326	1.770%
Nunavut Total	361	1.598%
Canadian Transport Sector	198 000	0.003%
Canadian Total	**734 000**	**0.001%**

AWAR = all-weather access road; GHG = greenhouse gas emissions; CO_2 = carbon dioxide

As described in Section 5.1.3.1, there is no defined linkage that is considered valid between the AWAR Project and the meteorology and climate component. Therefore, the GHG emissions from the construction and operation of the AWAR will be too small to bring about a change in climate. This is supported by the federal government that states "…*the contribution of an individual project to climate change cannot be measured*" (FTPCCCEA 2003). This is confirmed in the above table where the GHG emissions from the AWAR Project represent 0.001% of the Canadian GHG emissions.

5.1.7 Impact of Helicopter Transport

For the Phase 1 of the AWAR Project, air and noise emissions associated with the use of helicopters in lieu of the AWAR have the potential to impact the atmospheric environment.

Emissions associated with helicopter activities were estimated using published emission factors for aviation activities. Average helicopter useage for the month of August was used to derive activity levels for helicopter transport. The existing useage was doubled to 9 hours per day to account for the increased activity levels for increased transport of fuel to the exploration site. Due to the uncertainty of the flight path, and the complexity of modelling aviation sources, these emissions were not modelled to determine ground level impacts.

Table 5.1.7-1 compares the average daily emissions associated with the traffic using the AWAR to the emissions associated with helicopters. The emissions from helicopter traffic were greater than the average daily emission rates for road traffic on the AWAR for NO_X, SO_2, and CO. It should be noted that the published SO_2 emissions factors for helicopter use do not consider the restrictions currently in place for limiting the sulphur content of fuels. Emissions of CO_2, TSP, PM_{10}, and $PM_{2.5}$ are lower for helicopter use than operations of the AWAR. With the helicopter, the re-entrainment of particulates from the unpaved roads is eliminated. However, the numbers do not consider the challenges associated with transporting large and bulky materials to or from the site using helicopters only. There is a high level of uncertainty in these numbers, due to lack of available information on helicopter traffic.

Table 5.1.7-1: Comparison of Average Daily Road Traffic Emissions to Daily Helicopter Emissions

Vehicle	Factors (kg/day)						
	TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO	CO_2
Road Transport	53.90	21.08	2.15	0.76	0.002	1.40	15.80
Helicopter Transport	0.14	0.14	0.14	18.21	1.330	1.50	1.29

kg/day = kilogram per day; TSP = total suspended particulate; PM_{10} = particles nominally smaller than 10 μm in diameter; $PM_{2.5}$ = particles nominally smaller than 2.5 μm in diameter; NO_2 = nitrogen dioxide; SO_2 = sulphur dioxide; CO = carbon monoxide; CO_2 = carbon dioxide

With respect to helicopter noise emissions, in the near-field there are several discrete sources including engine, gearbox, and those related to rotor interactions. The noise emission for each source varies in level and spectrum between helicopter models, operating parameters, and weather conditions. However, noise levels in close proximity to a helicopter can be conservatively estimated to 120 dBA (Annals of Occupation Hygiene 2004). Based on this level of noise emission and assuming a flight path level of 150 metres above the ground, the helicopter would generate an hourly L_{eq} sound level contribution above 35 dBA for a distance of approximately 2.0 km on either side of the flight path. In other words, the helicopter has the potential to raise the existing noise level 2.0 km on each side of its flight path, which is a substantially larger distance than predicted for the operations of the proposed AWAR.

5.1.8 References

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5.2 Aquatic Environment

5.2.1 Introduction

This section of the Phase 1-Meliadine All-weather Access Road (AWAR) Environmental Assessment (EA) (the AWAR Project) discusses the aquatic environment and includes a detailed assessment of effects on hydrology, surface water quality, and fish and fish habitat that could potentially be affected by the AWAR Project. There are strong links between surface water quantity and distribution (hydrology), surface water quality, and fish and fish habitat. Aquatic ecosystem function is dependent on the interactions between climate, atmospheric conditions, the adjacent terrestrial environment, hydrological cycle, water properties, and species composition. Natural and human related disturbances can change the interactions between the physical and biological components of the aquatic environment. As such, related assessments are provided in the following sections:

- Road Construction and Operation (Section 3.0);
- Air Quality (Section 5.1); and
- Permafrost (Section 5.4).

5.2.2 Study Area

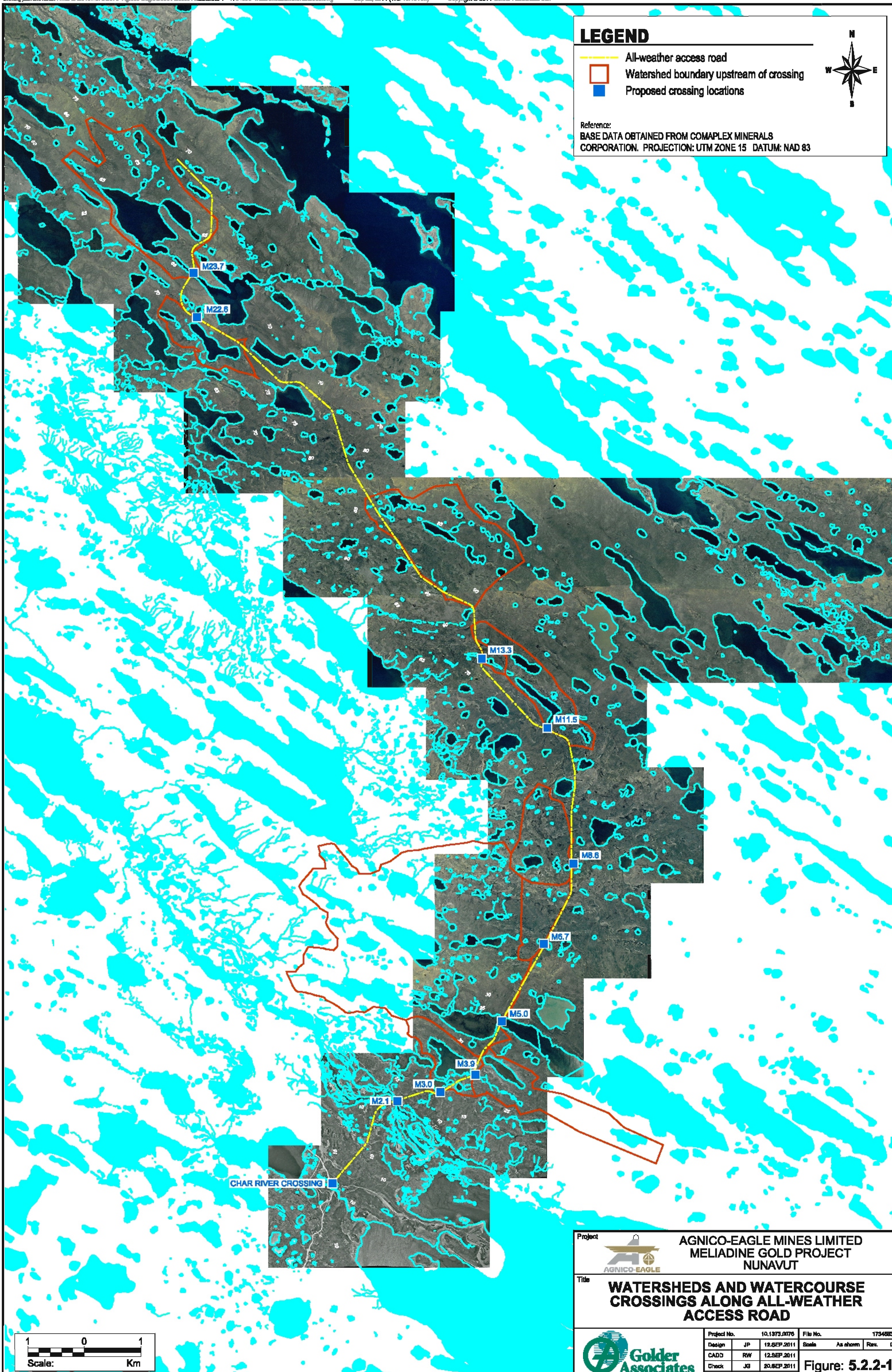
5.2.2.1 General Setting

The proposed AWAR Project is located in the Char River and Meliadine Lake watersheds, and extends from the Char River bridge turnoff to the Meliadine West Advanced Exploration site at Meliadine Lake. The AWAR crosses the Meliadine River near its mouth identified as M2.1, and 9 shallow ephemeral watercourses (M3.0, M3.9, M5.0, M6.7, M8.6, M11.5, M13.3, M22.6, and M23.7) (Figure 5.2.2-1). The AWAR will be 23.8 kilometres (km) in length and the road will stay east of and not enter Iqalugaarjuup Nunanga Territorial Park. At Char River, there is an existing bridge, which, as part of this AWAR Project, will be replaced with a wider and stronger single-span bridge to support the anticipated load requirements. At stream crossings M2.1 and M5.0, new single-span bridges will be installed, whereas culverts will be installed at the other 8 watercourses.

Meliadine Lake has a drainage area of 107 square kilometres (km^2), a maximum length of 31 km, and features a highly convoluted shoreline of 465 km in length and over 200 islands. Unlike most lakes, it has 2 outflows that drain into Hudson Bay through 2 separate river systems. Most drainage occurs via the Meliadine River, which originates at the south end of the lake. Meliadine River flows for a total distance of 39 km through a series of waterbodies until it reaches Little Meliadine Lake and then continues into Hudson Bay. At the proposed bridge crossing, the Meliadine River has a drainage area of 796 km^2. A second, smaller outflow from the west basin of Meliadine Lake drains into Peter Lake, which discharges into Hudson Bay through the Diana River system (a distance of 70 km). At the confluence, the Diana River has a drainage area of 1460 km^2. The Meliadine River-Meliadine Lake system supports a sea-going population of Arctic char that contributes to the domestic fishery in Rankin Inlet (Golder 2009).

The Char River originates from Char Lake and flows parallel to the Meliadine River, at an approximate distance of 1.5 km southwest, into Hudson Bay. It has a drainage area of 69 km^2 (Golder 2009). The Char River downstream of the crossing location supports Arctic grayling, round whitefish, ninespine stickleback, threespine stickleback, and slimy sculpin (RL&L 1999, 2000).

Drawing path and name: N:\CAD\2010\1373\0076 Agnico Eagle\9999\Access Road\5.2.2-1 - 1734693 watersheds&watercourses.dwg Sep 22, 2011 (Thu 10:13 AM)



Project	AGNICO-EAGLE MINES LIMITED MELIADINE GOLD PROJECT NUNAVUT
Title	WATERSHEDS AND WATERCOURSE CROSSINGS ALONG ALL-WEATHER ACCESS ROAD

Golder Associates
Edmonton, Alberta

Project No.		10.1373.0076	File No.		1734693
Design	JP	12.SEP.2011	Scale	As shown	Rev. 0
CADD	RW	12.SEP.2011	Figure: 5.2.2-1		
Check	JG	20.SEP.2011			
Review	GRA	20.SEP.2011			

The 9 ephemeral watercourses have drainage areas ranging from 0.16 to 11.0 km^2, which are often poorly defined because of low topographic relief.

5.2.2.2 Study Area

5.2.2.2.1 Hydrology

The local study area (LSA) was defined to include sub-basins of each watercourse crossing.

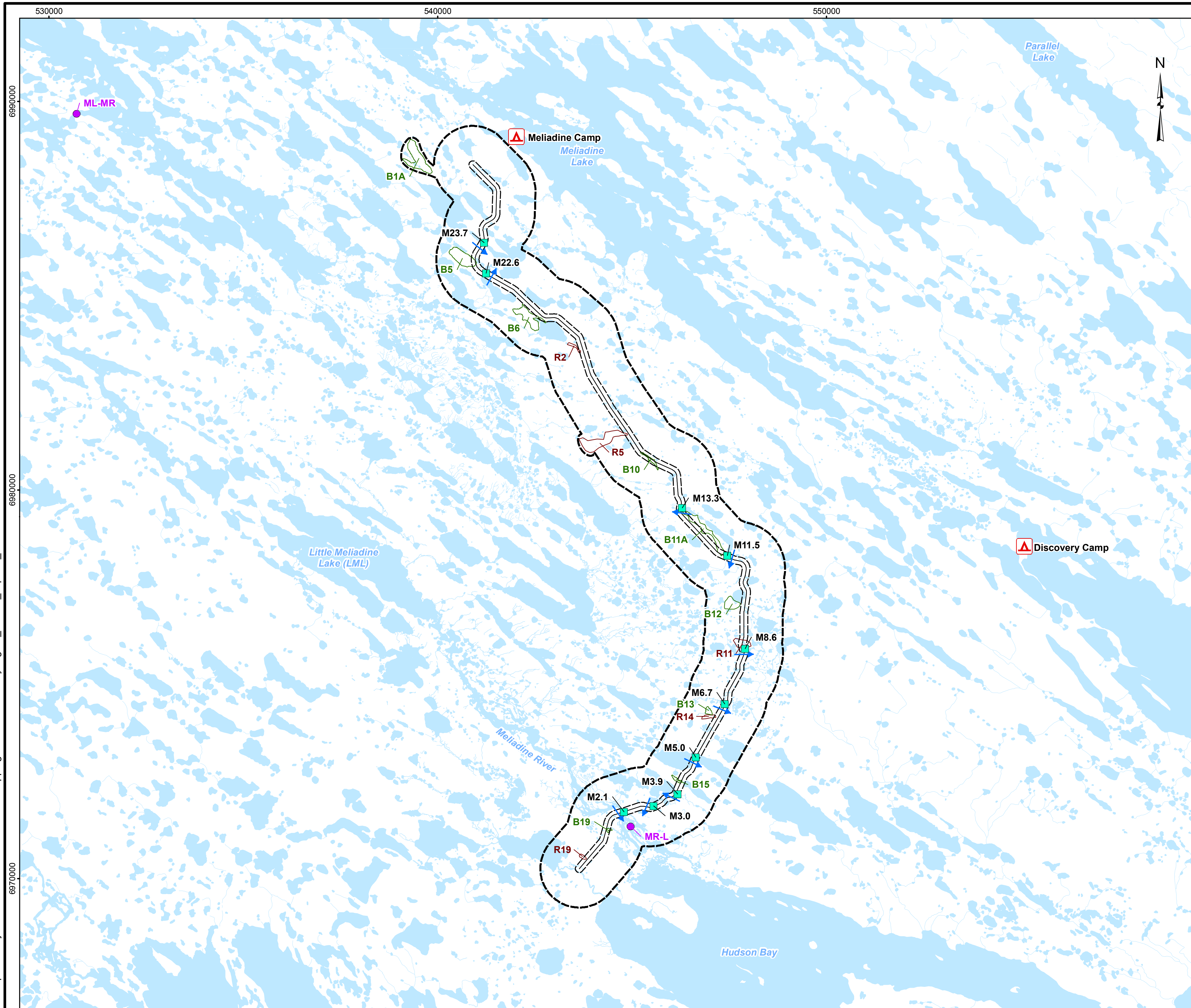
Given the AWAR is proposed to be constructed within the Meliadine Lake and Char River watersheds, the regional study area (RSA) was defined to consider the effects from the AWAR with other developments, activities, and natural factors that influence surface water quantity within these watersheds.

5.2.2.2.2 Surface Water Quality

A LSA and a RSA were defined for assessing potential effects to water quality (Figure 5.2.2-2). The LSA includes the road corridor and the area 100 metres (m) to either side of the centre line of the corridor. The RSA includes the road corridor and the area 1000 m to either side of the centre line of the corridor. Where the footprint for a borrow area or quarry fell within and outside of the RSA boundary, the RSA boundary was widened to include the entire footprint of the borrow area or quarry (Figure 5.2.2-2).

5.2.2.2.3 Fish and Fish Habitat

The LSA was defined to include the road corridor at watercourse crossings (with a 100 m buffer around the centre point of each crossing), extending 1000 m downstream of the crossing. Similar to hydrology, the RSA includes the Meliadine Lake and Char River watersheds.



N:\Bur-Graphics\Projects\2010\1373\10-1373-0076\Mapping\MXD\WaterQuality\Figure_5.2.2-2_Aquatic_Resources.mxd

LEGEND

- Camp
- Water Quality Station
- Ephemeral Water Crossing
- Flow Direction
- Phase 1 AWAR Road Alignment
- Local Study Area
- Regional Study Area
- Borrow Area
- Rock Quarry
- Watercourse
- Waterbody

REFERENCE

Base data obtained from Agnico-Eagle Mines Ltd (AEM).
Datum: NAD 83 Projection: UTM Zone 15

2 0 2
SCALE 1:100,000 KILOMETRES

PROJECT

AGNICO-EAGLE MINES LTD.
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

AQUATIC RESOURCES
LOCAL AND REGIONAL STUDY AREAS

Golder Associates
Greater Vancouver Office, B.C.

PROJECT NO. 10-1373-0076			FILE No.	
DESIGN	JG	09 Aug. 2011	SCALE AS SHOWN	REV. 0
GIS	CDB	09 Aug. 2011		
CHECK	JG	16 Sep. 2011	**FIGURE: 5.2.2-2**	
REVIEW	GRA	20 Sep. 2011		

5.2.3 Existing Environment

5.2.3.1 Hydrology

Methods

Each crossing location was assessed during a preliminary study (Golder 2010a) based on crossing descriptions and photographs in the Meliadine Gold Project Aquatics Baseline Synthesis Report (Golder 2009) to determine its potential for classification as navigable waters based on the *Navigable Waters Protection Act* (NWPA) administered by Transport Association of Canada (TAC 2009). For crossings of non-navigable waters, culverts were recommended as the preferred crossing method. For crossings of navigable waters, a bridge was recommended as the preferred crossing method. Navigability support material for all watercourse crossings, with the exception of the Char River where a bridge is already in place, was also sent to Transport Canada for determination of navigability (Golder 2010b).

The sizing of the culverts and bridges was based on an estimated peak flow at each crossing. Due to a lack of site-specific hydrometric data for the study area, the peak flow for each ephemeral crossing was estimated based on the 1:25 year 24-hour rainfall (52.3 millimetres [mm]); this was derived using rainfall data from Chesterfield Inlet (MSC Station Number 2300707), approximately 80 km north of the Meliadine Exploration site, which has a longer period of record than Rankin Inlet A (MSC Station 2303401) located approximately 26 km south of the Meliadine Exploration site. Corresponding water levels were derived using a 1-day flow model based on the channel cross-sections and peak flows. For the Meliadine River, the peak flow was estimated by extending the record of peak discharges from the crossing location by comparison with data from the regional Water Survey of Canada hydrometric stations 06NC001 Diana River near Rankin Inlet and 06NB002 Ferguson River below O'Neil Lake. The corresponding high water level was derived based on the peak flow and a 1-day flow model calibrated to water depths measured at the crossing location (Golder 2009). The 1:25 year rainfall event was selected as the design criterion because of the proposed use of the road for 2 years under Phase 1 for the exploration and bulk sampling program, and, if Phase 2 is approved, the road would be used for 10 years for the construction and operation of the proposed mine, and because of the general absence of additional public infrastructure in the vicinity of the road.

Results

Locations and hydraulic characteristics of water crossings are presented in Table 5.2.3-1. The Meliadine Lake watershed has a drainage area of 796 km^2 where the proposed bridge will cross the Meliadine River. The Char River has a drainage area of 69 km^2 at the existing bridge crossing. The watersheds of the 9 ephemeral streams are much smaller ranging in watershed area from 0.16 to 11.02 km^2.

Following a request of determination (Golder 2010b), Transport Canada determined that M2.1 (Meliadine River) was the only crossing with navigable waters (Appendix B) amongst the streams crossed by the proposed AWAR. Although M5.0 was determined as a crossing with non-navigable waters, a clear-span bridge is still planned for the crossing location. The proposed activity on the Char River is the installation of a new clear-span bridge, immediately adjacent to the existing bridge, to allow larger and heavier loads to pass, with the new bridge also meeting the NWPA requirements.

Table 5.2.3-1: Locations and Hydraulic Characteristics of Water Crossings (NAD 83)

Location	Latitude	Longitude	Drainage Area (km^2)	Design[a] Discharge (m^3/s)	Bankfull Width (m)	Bankfull Depth (m)	Design Depth (m)	Bridge Height (m)[d]
Char River	62°51'31.8"	93°51'27.9"	69	N/A	N/A	N/A	N/A	N/A
M2.1[b]	62°52'21.8"	92°07'10.4"	796	81	60	1.20	1.58	3.00
M3.0	62°52'26.6"	92°06'16.6"	2.77	1.50	2.5	0.12	0.24	c
M3.9	62°52'36.2"	92°05'32.5"	1.82	4.70	2.5	0.10	0.62	c
M5.0	62°53'06.5"	92°04'58.5"	11.02	9.10	10.0	0.20	0.81	1.81
M6.7	62°53'50.4"	92°04'04.3"	0.82	3.10	1.0	0.05	0.24	c
M8.6	62°54'36.1"	92°03'25.3"	1.40	4.00	3.9	0.16	0.57	c
M11.5	62°55'53.8"	92°03'55.7"	1.38	1.20	1.5	0.26	0.41	c
M13.3	62°56'34.0"	92°05'16.6"	0.16	0.40	3.8	0.20	0.27	c
M22.6	62°59'51.2"	92°11'08.8"	0.97	0.50	0.9	0.13	0.21	c
M23.7	63°00'16.6"	92°11'12.2"	3.62	0.50	3.2	0.25	0.31	c

[a] 1:25 year flood
[b] Meliadine River
[c] Culvert crossings
[d] The bridge height includes at least 1.0 m of freeboard
N/A = Not Available

5.2.3.2 Surface Water Quality

Methods

A variety of watercourses and lakes in the vicinity of the proposed Meliadine Gold Project have been studied for detailed water quality (Golder 2009); in contrast, most of the watercourses along the proposed AWAR corridor, except for Meliadine River, have been studied less extensively. The Meliadine River has been sampled between 1997 and 2011 at the outlet of Meliadine Lake (ML-MR) and above the confluence with Hudson Bay (MR-L) (Figure 5.2.2-2). The Char River has not been sampled for water quality, except for field parameters of water temperature, pH, and specific conductivity during the fish sampling program in 1998 and 2000 (RL&L 1999, 2001), and once in 2011 for a suite of conventional water quality parameters. The ephemeral watercourses along the proposed AWAR alignment that were flowing were sampled twice in 2011 (12 July and 29 August) by AEM. Results from 12 July 2011 are presented in this report; results from 29 August 2011 were not available for inclusion in this report.

Field-measured parameters and lab-measured parameters have been collected to describe the physical and chemical characteristics of the watercourses. Water samples generally were analyzed for conventional parameters, major ions, nutrients, chlorophyll *a*, cyanides, total and dissolved metals, and organic compounds (Table 5.2.3-2), although the samples collected in July 2011 along the AWAR were analysed for conventional parameters, major ions, nutrients, and total metals. Samples collected in August 2011 were analyzed for conventional parameters, major ions, nutrients, and total and dissolved metals.

Table 5.2.3-2: Water Quality Parameter List

Group Name	Parameters[a]
Field Measurements	Water temperature, dissolved oxygen, pH, specific conductivity, Secchi disk depth
Conventional Parameters	pH, specific conductivity, total dissolved solids, total alkalinity, total hardness, total suspended solids, total volatile solids, turbidity
Major Ions	Bicarbonate, bromide, calcium, carbonate, chloride, fluoride, hydroxide, magnesium, potassium, reactive silica, silicate, sodium, sulphate, ion balance
Organic/Inorganic carbon	Total carbon, total organic carbon, dissolved organic carbon, and total inorganic carbon
Nutrients and Chlorophyll *a*	Total ammonia, nitrate, nitrite, total Kjeldahl nitrogen, total phosphorus, total dissolved phosphorus, orthophosphate, chlorophyll *a*
Cyanides	Total cyanide
Total and Dissolved Metals[b]	Aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, cesium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, rubidium, selenium, silicon, silver, strontium, thallium, tin, titanium, tungsten, uranium, vanadium, and zinc
Organic Compounds	Oil and grease, phenols, benzene, ethylbenzene, toluene, xylenes, F1 (C6-C10), F1 (BTEX), F2 (>C10-C16), F3 (C16-C34), F4 (C34-C50), total volatiles, total extractables, total extractable hydrocarbons (C9-C40), total extractable hydrocarbons (C10-30)
Other	Biological oxygen demand, fecal coliforms

[a] Not all parameters were analyzed during every sampling program.

[b] The term “metals” is used to include metalloids such as arsenic and non-metals such as selenium.

Parameters were analyzed by standard methods published by internationally recognized agencies, such as the American Public Health Association (APHA) and the United States Environmental Protection Agency (US EPA). For example, conventional parameters, major ions, nutrients, and total cyanide were analyzed according to the procedures described in “Standard Methods for the Examination of Water and Wastewater” published by the American Public Health Association (e.g., APHA 1992 in Dillon 1994, 1995).

Detection limits varied among the studies. In general, detection limits were higher in the older datasets (e.g., 1997) than in more recent datasets (e.g., 2008/2009). The detection limits used in each study are provided in Golder (2009).

Quality assurance/quality control (QA/QC) procedures were used in the various water quality sampling programs conducted as part of the baseline characterization. Quality assurance procedures included appropriate training of sampling personnel, use of standard operating procedures when collecting the samples, appropriate sample handling and storage, use of accredited analytical laboratories, and data management systems. Quality control procedures included steps to assess data quality and included potential laboratory and field contamination through use of blanks, replicates, and spiked or reference materials. All baseline water quality results were uploaded to the project database except for any samples that did not pass the quality control procedures.

Water chemistry were compared to both the most recent Canadian Council of Ministers of the Environment’s (CCME) Canadian Water Quality Guidelines (CWQG) for the protection of aquatic life, Health Canada’s Guidelines for Canadian Drinking Water Quality (GCDWQ), and Environment Canada freshwater quality indicators (CCME 2007; Health Canada 2008; Environment Canada 2011). The aquatic life guidelines are based on the most current, scientifically defensible toxicological data and are intended to be protective of all forms and life stages of aquatic life (CCME 2007). Exceedance of a guideline does not, therefore, automatically imply unacceptable or harmful conditions. Guideline exceedances observed during baseline investigations are a result of naturally occurring conditions and thus are not of concern as local flora and fauna will be adapted to these natural conditions in the environment.

Results

Meliadine River

The Meliadine River was well-oxygenated during the open water seasons with dissolved oxygen concentrations ranging from 11.1 to 16.5 milligrams per litre (mg/L) and associated water temperatures from 5.6 to 12.7 Degrees Celsius (°C) (Table 5.2.3-3). All dissolved oxygen values were above the 9.5 mg/L CWQG (CCME 2007) for protection of early life stages of cold water fish. Field-measured conductivity ranged from 42 to 86 microsiemens per centimetre (µS/cm). Major ions were dominated by bicarbonate (15 to 25 mg/L), calcium (5.2 to 7.6 mg/L), chloride (4.2 to 9.6 mg/L), and sodium (2.5 to 5.6 mg/L). Total alkalinity values ranged from 15 to 20 mg/L. Total hardness concentrations ranged from 16 to 24 mg/L, which indicated the waters were very soft (as based on the rating of McNeely et al. 1979). Total suspended solids concentrations were generally below detection limits (i.e., less than 3 mg/L). Total cyanide was not detected in any sample (detection limits ranged from 1 to 5 mg/L).

Nutrient concentrations were similar among sampling events. Total phosphorus concentrations ranged from 0.002 to 0.009 mg/L, lower than the guideline of 0.03 mg/L in Northwest Territories and Nunavut (Environment Canada 2011). Total Kjeldahl nitrogen concentrations ranged from 0.11 to 0.43 mg N/L. Total ammonia was detected in less than half of the samples at concentrations ranging from 0.005 to 0.023 mg N/L. Nitrate concentrations were variable among sampling events and ranged from less than 0.005 to 0.032 mg N/L. Chlorophyll *a* concentrations were measured in 2 samples from ML-MR; concentrations were 0.355 micrograms per litre (µg/L) in spring and less than 1 µg/L in summer. Total organic carbon concentrations were variable among sampling events, ranging from 1.6 to 5.1 mg/L.

Detection limits for total metals have varied over the period of time in which water quality samples have been collected for this baseline program. For most metals, even the highest detection limit was less than the CWQG for protection of aquatic life. For cadmium, chromium, and selenium, detection limits were occasionally above the CWQG. Results for these 3 metals from Meliadine River samples are summarized as follows:

- Cadmium was not detected in most samples; however, detection limits ranged from 0.017 to 0.1 µg/L, which were at or higher than the CWQG of 0.017 µg/L. Cadmium was not above any detection limit from any sample.
- Total chromium was not detected in 5 of 9 samples (detection limits ranged from 0.06 to 2 µg/L). Two samples from station ML-MR (included on Figure 5.2.2-2) had a detection limit of 2.0 µg/L, which was higher than the CWQG of 1.0 µg/L for hexavalent chromium. Total chromium was detected in one of those samples. All other samples had detection limits lower than the CWQG, and when chromium was detected, it was less than the CWQG for hexavalent chromium.

Table 5.2.3-3: Water Quality in Streams Associated with the Meliadine River, Meliadine Gold Project, 1995 to 2009

Waterbody	Units	ML-MR									MR-L	
Date Sampled		19-Jun-97	24-Aug-97	24-Aug-97 (Dup)	12-Jun-98	18-Jul-98	20-Jun-99	22-Jun-00	21-Jun-08	19-Jul-08	12-Jun-98	20-Jul-98
GPS Coordinates		-	-	-	-	-	-	-	0530714, 6989630	0530712, 6989681	-	-
Source [a]		RL&L 1998	RL&L 1998	RL&L 1998	RL&L 1999	RL&L 1999	RL&L 2000	RL&L 2000	Golder 2009	Golder 2009	RL&L 1999	RL&L 1999
Field Measurements												
Water Temperature	°C	6.9	11.6	11.6	1.7	9.8	6.0	3.0	5.63	12.7	3.2	10.8
Dissolved Oxygen	mg/L	14.1	11.1	11.1	-	-	-	-	16.54	16.03	-	-
pH	pH	7.15	7.48	7.48	-	-	6.89	7.11	-	6.78	7.7	-
Specific Conductivity	µS/cm	62.0	61.6	61.6	79.8	-	-	72.9	42	63	85.5	-
Secchi Disk Depth	m	-	-	-	-	-	-	-	-	-	-	-
Conventional Parameters (Laboratory-Measured)												
pH	pH	7.22	7.32	7.36	7.1	7.2	7.0	6.9	7.06	7.5	7.2	7.1
Specific Conductivity	µS/cm	50.3	50.4	49.9	62.4	52.4	62.4	68.0	68.8	64.2	72.4	80.0
Total Dissolved Solids	mg/L	38	38	39	29	24	30	32	34	40	33	38
Total Dissolved Solids (Calculated)	mg/L	-	-	-	-	-	-	-	-	30	-	-
Total Alkalinity	mg $CaCO_3$/L	16.2	15.2	14.8	18	15	19	20	17.8	16	19	18
Total Hardness	mg $CaCO_3$/L	20.2	16.7	16.0	20	16	19	20	24	20	21	22
Total Suspended Solids	mg/L	<3	<3	<3	<2	2	<3	<3	<3.0	<3	<2	2
Turbidity	NTU	0.2	0.9	0.3	0.3	0.2	0.1	0.23	-	-	0.5	0.3
Major Ions												
Bicarbonate	mg/L	16.2	15.2	14.8	22	18	23	25	17.8	19	23	22
Bromide	mg/L		-	-	-	-	-	-	<0.050	-	-	-
Calcium	mg/L	6.86	5.43	5.17	6.5	5.23	6.3	5.93	7.59	5.97	6.9	6.94
Carbonate	mg/L	<0.3	<0.3	<0.3	<1	<1	<1	<5	<2.0	<5	<1	<1
Chloride	mg/L	4.24	4.25	4.24	4.7	4.19	4.67	5	6.91	5	6.3	9.60
Fluoride	mg/L	-	-	-	-	-	-	-	0.021	-	-	-
Hydroxide	mg/L	-	-	-	<1	<1	<1	<5	<2.0	<5	<1	<1
Magnesium	mg/L	0.743	0.77	0.76	0.88	0.71	0.90	0.816	1.12	0.865	0.97	1.23
Potassium	mg/L	1.71	0.725	0.702	0.90	0.70	0.81	0.740	<2.0	0.76	1.14	1.04
Reactive Silica (as SiO_2)	mg/L	0.297	0.385	0.388	0.6	0.3	0.2	0.2	-	-	0.5	0.6
Sodium	mg/L	2.53	2.59	2.57	2.9	2.6	3.2	2.61	4	3.22	3.7	5.6
Sulphate	mg/L	5	<3	<3	2.1	1.69	2.37	3.2	3.11	2.8	2.7	2.48
Ion Balance	%	-	-	-	102	101	99	90.6	-	Low EC	101	105
Organic/Inorganic Carbon												
Total Carbon	mg/L	6.0	6.1	6.0	9	6.7	7.1	7.4	5.97	3	10	7.0
Total Organic Carbon	mg/L	1.6	2.1	2.0	4.5	2.9	2.7	2.9	2.64	3	5.1	2.9
Dissolved Organic Carbon	mg/L	-	-	-	-	-	-	-	2.5	2.8	-	-
Total Inorganic Carbon	mg/L	4.0	4.0	4.0	4.6	3.8	4.4	4.5	3.32	6	4.5	4.2
Nutrients and Chlorophyll *a*												
Total Ammonia as Nitrogen	mg/L	0.005	0.010	0.008	<0.005	<0.005	<0.005	<0.005	<0.020	<0.05	0.023	0.015
Nitrate as Nitrogen	mg/L	<0.008	0.024	0.032	<0.006	<0.006	0.012	<0.006	<0.0050	<0.1	0.008	0.008
Nitrite as Nitrogen	mg/L	-	-	-	-	-	-	-	<0.0010	<0.05	-	-
Nitrate+Nitrite as Nitrogen	mg/L	<0.008	0.024	0.032	<0.006	<0.006	0.012	<0.006	-	<0.1	0.008	0.008
Total Kjeldahl Nitrogen	mg/L	0.25	0.28	0.20	0.43	0.28	0.16	0.11	0.167	<0.2	0.30	0.29
Phosphorus, Total	mg/L	0.004	0.009	0.009	0.004	0.005	0.002	0.004	0.0025	0.004	0.005	0.004
Phosphorus, Total Dissolved	mg/L	0.004	0.005	0.002	0.004	0.003	0.001	0.003	<0.0020	0.002	0.004	0.003
Orthophosphate (PO4-P)	mg/L	<0.002	<0.002	<0.002	<0.001	<0.001	<0.001	0.002	<0.0010	<0.001	<0.001	<0.001
Chlorophyll *a*	µg/L	-	-	-	-	-	-	-	0.355	<1	-	-
Cyanides												
Cyanide, Total	µg/L	-	-	-	<1	<1	<2	<2	<5.0	<2	<1	<1
Total Metals												
Aluminum (Al)	µg/L	<0.5	<0.5	<0.5	1.4	<0.3	2.2	3.0	<5.0	1.9	3.3	3.7
Antimony (Sb)	µg/L	0.3	0.3	0.2	0.31	0.20	<0.03	0.18	<0.50	<0.03	0.20	0.09
Arsenic (As)	µg/L	<0.3	<0.2	0.3	0.29	0.27	0.30	0.25	<0.50	0.22	0.25	0.33
Barium (Ba)	µg/L	6.8	6.3	6.1	8.3	0.66	8.41	8.2	<20	6.89	10.3	8.90
Beryllium (Be)	µg/L	<0.1	0.2	0.2	<0.2	<0.2	<0.2	<0.2	<1.0	<0.2	<0.2	<0.2
Bismuth (Bi)	µg/L	<0.1	<0.1	<0.1	<0.05	<0.03	<0.03	-	-	-	<0.05	<0.03
Boron (B)	µg/L	-	-	-	-	-	-	2	<100	3	-	-
Cadmium (Cd)	µg/L	<0.1	**0.1**	<0.1	<0.05	<0.05	<0.02	<0.05	<0.017	<0.05	<0.05	<0.05
Cesium (Cs)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	<0.1	<0.1
Chromium (Cr)	µg/L	0.9	**2.0**	<2	<0.06	<0.06	**1.10**	0.18	<1.0	<0.06	<0.06	**1.91**
Cobalt (Co)	µg/L	<0.1	0.2	0.1	<0.1	<0.1	<0.1	<0.1	<0.30	<0.1	<0.1	<0.1
Copper (Cu)	µg/L	1.4	1.0	1.0	0.8	<0.6	0.8	0.8	<1.0	0.7	1.0	1.0
Iron (Fe)	µg/L	13	21	25	<10	5	6	39	<30	10	10	12
Lead (Pb)	µg/L	<0.2	<0.2	0.2	<0.05	<0.05	0.05	<0.05	<0.50	<0.05	<0.05	<0.05
Lithium (Li)	µg/L	0.6	0.5	0.4	0.6	0.3	0.5	-	<5.0	-	0.6	<0.1

Table 5.2.3-3: Water Quality in Streams Associated with the Meliadine River, Meliadine Gold Project, 1995 to 2009 (continued)

Waterbody	Units	ML-MR									MR-L	
Date Sampled		19-Jun-97	24-Aug-97	24-Aug-97 (Dup)	12-Jun-98	18-Jul-98	20-Jun-99	22-Jun-00	21-Jun-08	19-Jul-08	12-Jun-98	20-Jul-98
GPS Coordinates		-	-	-	-	-	-	-	0530714, 6989630	0530712, 6989681	-	-
Source [a]		RL&L 1998	RL&L 1998	RL&L 1998	RL&L 1999	RL&L 1999	RL&L 2000	RL&L 2000	Golder 2009	Golder 2009	RL&L 1999	RL&L 1999
Magnesium (Mg)	µg/L	-	-	-	-	-	-	-	1120	865	-	-
Manganese (Mn)	µg/L	2.6	2.8	2.9	3.5	0.2	5.1	7.2	2.04	1.8	1.5	0.3
Mercury (Hg)	µg/L	-	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.020	<0.02	<0.02	<0.02
Molybdenum (Mo)	µg/L	0.2	0.1	0.1	0.11	0.07	0.08	0.08	<1.0	<0.06	0.12	0.13
Nickel (Ni)	µg/L	<0.1	0.6	0.3	0.4	0.11	0.52	0.48	<1.0	0.3	0.6	0.66
Potassium (K)	µg/L	-	-	-	-	-	-	-	<2000	760	-	-
Rubidium (Rb)	µg/L	1.1	-	-	-		-	-	-	-	-	-
Selenium (Se)	µg/L	*<10*	*<10*	*<10*	<0.1	<0.1	0.1	0.2	*<1.0*	<0.1	<0.1	0.3
Silver (Ag)	µg/L	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*<0.1*	<0.020	*<0.1*	*<0.1*	*<0.1*
Sodium (Na)	µg/L	-	-	-	-	-	-	-	3900	3220	-	-
Strontium (Sr)	µg/L	26.7	26.3	25.1	27.4	0.2	27.8	26.9	-	28	32.4	36.4
Thallium (Tl)	µg/L	<0.1	0.1	<0.1	<0.05	<0.03	<0.03	-	<0.20	<0.03	<0.05	0.05
Tin (Sn)	µg/L	-	-	-	-	-	-	-	<0.50	-	-	-
Titanium (Ti)	µg/L	<0.1	0.6	<0.1	<0.3	<0.1	<0.1	-	<10	-	<0.3	<0.1
Uranium (U)	µg/L	<0.1	<0.1	<0.1	<0.05	<0.05	<0.05	<0.05	<0.20	<0.05	<0.05	<0.05
Vanadium (V)	µg/L	0.2	0.1	0.1	0.4	0.26	<0.05	<0.05	<1.0	0.11	0.4	0.10
Zinc (Zn)	µg/L	<0.5	1.4	1.0	1.9	<0.8	13.1	<0.8	<5.0	<0.8	3.3	<0.8
Dissolved Metals												
Aluminum (Al)	µg/L	-	-	-	-	-	-	-	<5.0	1.6	-	-
Antimony (Sb)	µg/L	-	-	-	-	-	-	-	<0.50	<0.03	-	-
Arsenic (As)	µg/L	-	-	-	-	-	-	-	<0.50	0.2	-	-
Barium (Ba)	µg/L	-	-	-	-	-	-	-	<20	6.91	-	-
Beryllium (Be)	µg/L	-	-	-	-	-	-	-	<1.0	<0.2	-	-
Boron (B)	µg/L	-	-	-	-	-	-	-	<100	3	-	-
Cadmium (Cd)	µg/L	-	-	-	-	-	-	-	0.065	<0.05	-	-
Calcium (Ca)	µg/L	-	-	-	-	-	-	-	7760	5960	-	-
Chromium (Cr)	µg/L	-	-	-	-	-	-	-	*<1.0*	<0.06	-	-
Cobalt (Co)	µg/L	-	-	-	-	-	-	-	<0.30	<0.1	-	-
Copper (Cu)	µg/L	-	-	-	-	-	-	-	<1.0	<0.6	-	-
Iron (Fe)	µg/L	-	-	-	-	-	-	-	<30	<5	-	-
Lead (Pb)	µg/L	-	-	-	-	-	-	-	<0.50	<0.05	-	-
Lithium (Li)	µg/L	-	-	-	-	-	-	-	<5.0	-	-	-
Magnesium (Mg)	µg/L	-	-	-	-	-	-	-	1130	853	-	-
Manganese (Mn)	µg/L	-	-	-	-	-	-	-	2.83	1.1	-	-
Mercury (Hg)	µg/L	-	-	-	-	-	-	-	<0.020	<0.02	-	-
Molybdenum (Mo)	µg/L	-	-	-	-	-	-	-	<1.0	0.07	-	-
Nickel (Ni)	µg/L	-	-	-	-	-	-	-	<1.0	0.32	-	-
Potassium (K)	µg/L	-	-	-	-	-	-	-	<2000	750	-	-
Selenium (Se)	µg/L	-	-	-	-	-	-	-	<1.0	<0.1	-	-
Silver (Ag)	µg/L	-	-	-	-	-	-	-	<0.020	<0.1	-	-
Sodium (Na)	µg/L	-	-	-	-	-	-	-	3900	3200	-	-
Strontium (Sr)	µg/L	-	-	-	-	-	-	-	-	28	-	-
Thallium (Tl)	µg/L	-	-	-	-	-	-	-	<0.20	<0.03	-	-
Tin (Sn)	µg/L	-	-	-	-	-	-	-	<0.50	-	-	-
Titanium (Ti)	µg/L	-	-	-	-	-	-	-	<10	-	-	-
Uranium (U)	µg/L	-	-	-	-	-	-	-	<0.20	<0.05	-	-
Vanadium (V)	µg/L	-	-	-	-	-	-	-	<1.0	0.1	-	-
Zinc (Zn)	µg/L	-	-	-	-	-	-	-	<5.0	<0.8	-	-
Organic Compounds												
Oil and Grease	µg/L	-	-	-	-	-	-	-	-	-	-	-
Phenols	µg/L	**10**	<2	*<2*	<1	2	2	2	-	-	<1	2
Benzene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	-	<0.5	-	-	<0.5	<0.5
Ethylbenzene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	-	<0.5	-	-	<0.5	<0.5
Toluene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	-	<0.5	-	-	<0.5	<0.5
Xylenes	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5	-	<0.5	-	-	<0.5	<0.5
F1 (C6-C10)	µg/L	-	-	-	-	-	-	-	-	-	-	-
F1 -BTEX	µg/L	-	-	-	-	-	-	-	-	-	-	-
F2 (>C10-C16)	µg/L	-	-	-	-	-	-	-	-	-	-	-
F3 (C16-C34)	µg/L	-	-	-	-	-	-	-	-	-	-	-
F4 (C34-C50)	µg/L	-	-	-	-	-	-	-	-	-	-	-
Total Volatiles	µg/L	<100	<100	<100	<100	<100	-	<100	-	-	<100	<100
Total Extractables	µg/L	<50	<50	75	<50	<50	-	<50	-	-	<50	<50
Other												
Biological Oxygen Demand (BOD)	mg/L	-	-	-	-	-	-	-	-	-	-	-
Fecal Coliforms	CFU/100 mL	-	-	-	-		-	-	-	-	-	

[a] Data were obtained from the following sources: 1994 to 1995 = Dillon (1994 and 1995); 1997 to 2000 = RL&L (1998, 1999, 2000, 2001); 2007 = Comaplex Minerals Corporation, pers. comm.; 2008 and 2009 = Golder (2009).

Values in bold and in yellow shaded cells are equal to or greater than the Canadian Water Quality Guidelines for the Protection of Aquatic Life - Freshwater (CCME 2007, CWQG).

Underlined values are equal to or greater than the Guidelines for Canadian Drinking Water Quality (Health Canada 2007, GCDWQ).

Italicized values indicate the detection limit equals or exceeds either guideline.

(-) = No data available; °C = degrees Celsius; µS/cm = microseimens per centimetre; mg/L = milligrams per litre; µg/L = micrograms per litre; NTU = nephelometric turbidity units.

- Selenium was not detected in 7 of 9 samples (detection limits ranged from 0.1 to 10 µg/L). Three samples from station ML-MR had a detection limit of 10 µg/L, which was higher than the CWQG of 1.0 µg/L. None of the detectable concentrations were greater than the CWGQ value.

Watercourses Along the All-weather Access Road

Watercourses along the AWAR were sampled in July and August 2011 by AEM (Table 5.2.3-4). In July, 3 watercourses (M3.0, M3.9, and M6.7) were not sampled because they were dry. In August, the 2 major watercourse (Char and Meliadine rivers) were not sampled. Results from the July 2011 sampling program are summarized below; however, results from the August 2011 sampling program were not available for inclusion in this report.

Table 5.2.3-4: Water Quality Sampling in Streams Associated with the All-weather Access Road Project

Location	Sampled 12 July 2011	Sampled 29 August 2011
Char River	Yes	[c]
M2.1[a]	Yes	[c]
M3.0	[b]	Yes
M3.9	[b]	Yes
M5.0	Yes	Yes
M6.7	[b]	Yes
M8.6	Yes	Yes
M11.5	Yes	Yes
M13.3	Yes	Yes
M22.6	Yes	Yes
M23.7	Yes	Yes

[a] Meliadine River 1:25 year flood.
[b] Channel was dry.
[c] Not sampled.

The result for the sample collected at M11.5 should be viewed with caution because the bottom was disturbed during sampling. Results are provided in Table 5.2.3-5. Conductivity ranged from 46 to 176 µs/cm, with the highest conductivity in Stream M23.7. The major ions were bicarbonate (19.2 to 51 mg/L), calcium (5.2 to 26 mg/L), chloride (2.7 to 31.4 mg/L), sodium (1.7 to 13.4 mg/L), and sulphate (1.2 to 8.7 mg/L). The higher specific conductivity and higher calcium and chloride concentrations in Stream M23.7 in comparison to other streams along the AWAR is likely due to drilling activity, which uses $CaCl_2$ farther upstream at the Tiriganiaq deposit.

Total alkalinity ranged from 15.8 to 41.8 mg/L while hardness ranged from 15.5 to 78.0 mg/L, which indicated that the waters were soft (based on the ratings of McNeely et al. 1979). Total suspended solids were less than the detection limit in all samples except the one from M11.5.

Nutrient concentrations were very low. Total phosphorus ranged from less than the detection limit (0.01 mg/L) to 0.016 mg/L which is less than the guideline of 0.03 mg/L (Environment Canada 2011). Nitrogen compounds including ammonia, nitrate, and nitrite, were not detected in any water sample.

Water samples were tested for a suite of 34 different metals. There were no detectable concentrations for 17 of those metals, including antimony, beryllium, bismuth, cadmium, cesium, chromium, nickel, silver, tellurium, thallium, thorium, tin, tungsten, uranium, and zirconium. The detection limit for total mercury was higher than the guideline for inorganic mercury. Concentrations for other metals ranged from less than the detection limit to a value generally less than the CWQG for protection of aquatic life. For copper, iron, and selenium, maximum concentrations were above the CWQG in at least one sample. Copper exceeded the CWQG in M11.5 and M13.3, iron exceeded the guideline in M5.0, and selenium exceeded the guideline in M22.6.

Table 5.2.3-4: Water Quality in Streams Associated with the All-weather Access Road Project

Parameter[a]	Units	Char River	Meliadine River (M2.1)	M5.0	M8.6	M11.5	M13.3	M22.6	M23.7
Conventional Parameters (Laboratory-Measured)									
Total Alkalinity	mg/L	27	21.5	33.2	23.8	15.8	28.9	41.8	38.1
Specific Conductivity	µmS/cm	120	80.3	168	77.4	46.6	75.5	92.4	176
Total Hardness	mg/L	34.8	22.7	47.7	24.4	15.5	27.6	44.9	78
pH	pH	7.83	7.74	7.9	7.76	7.49	7.8	7.87	7.99
Total Dissolved Solids	mg/L	64	39.7	89.1	38.7	22.5	38	50.1	93
Total Suspended Solids	mg/L	<5.0	<5.0	<5.0	<5.0	28	<5.0	<5.0	<5.0
Turbidity	NTU	0.51	1.2	1.36	0.65	0.78	1	0.3	0.56
Major Ions									
Bicarbonate	mg $CaCO_3$/L	33	26.2	40.5	29	19.2	35.3	51	46.5
Calcium	mg/L	10.5	7.24	14.4	7.89	5.24	9.25	15.7	26
Carbonate	mg $CaCO_3$/L	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
Chloride	mg/L	18.2	9.55	28	6.79	2.66	4.29	3.68	31.4
Fluoride	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Hydroxide	mg/L	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
Magnesium	mg/L	2.09	1.12	2.85	1.13	0.576	1.11	1.37	3.18
Potassium	mg/L	1.51	0.86	1.83	1.26	0.393	0.935	0.534	1.39
Sodium	mg/L	10.5	4.68	13.4	3.49	1.71	2.46	2.54	4.72
Sulphate	mg/L	4.99	3.32	8.66	3.89	2.5	2.59	1.17	3.42
Nutrients									
Total Ammonia as Nitrogen	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nitrate+Nitrite as Nitrogen	mg/L	<0.071	<0.071	<0.071	<0.071	<0.071	<0.071	<0.071	<0.071
Nitrate as Nitrogen	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nitrite as Nitrogen	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phosphorus, Total	mg/L	0.012	<0.010	0.015	0.016	0.013	0.016	<0.010	0.014
Other									
Biological Oxygen Demand (BOD)	mg/L	<1.0	1.3	1.7	1.6	1.2	1.5	1.2	1.2
Total Metals									
Aluminum (Al)	µg/L	11.4	43.4	14.5	10.9	16.8	10	<5	<5
Antimony (Sb)	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

Table 5.2.3-4: Water Quality in Streams Associated with the All-weather Access Road Project (continued)

Parameter[a]	Units	Char River	Meliadine River (M2.1)	M5.0	M8.6	M11.5	M13.3	M22.6	M23.7
Arsenic (As)	µg/L	0.32	0.27	0.4	0.22	0.34	0.69	0.73	2.64
Barium (Ba)	µg/L	14.5	10.2	22.1	12.7	11.2	23.9	21.2	24.2
Beryllium (Be)	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Bismuth (Bi)	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Boron (B)	µg/L	14	<10	14	<10	<10	<10	<10	<10
Cadmium (Cd)	µg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cesium (Cs)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium (Cr)	µg/L	<1	<1	<1	<1	<1	<1	<1	<1
Cobalt (Co)	µg/L	<0.2	<0.2	<0.2	<0.2	0.24	<0.2	<0.2	<0.2
Copper (Cu)	µg/L	1.19	0.85	1.22	1.82	**2.74**	**2.11**	0.79	1.04
Iron (Fe)	µg/L	<100	<100	**300**	180	240	**410**	<100	120
Lead (Pb)	µg/L	<0.09	<0.09	<0.09	0.125	<0.09	<0.09	<0.09	<0.09
Lithium (Li)	µg/L	<2	<2	<2	<2	<2	<2	<2	7.5
Manganese (Mn)	µg/L	3.2	3.82	8.55	10.9	18.8	27.3	25.1	17.6
Mercury (Hg)	µg/L	*<0.05*	*<0.05*	*<0.05*	*<0.05*	*<0.05*	*<0.05*	*<0.05*	*<0.05*
Molybdenum (Mo)	µg/L	0.33	<0.2	0.53	<0.2	<0.2	<0.2	<0.2	<0.2
Nickel (Ni)	µg/L	<2	<2	<2	<2	<2	<2	<2	<2
Rubidium (Rb)	µg/L	1.99	1.48	2.17	2.33	1.09	1.49	0.82	1.62
Selenium (Se)	µg/L	<1	<1	<1	<1	<1	<1	**1.5**	<1
Silicon (Si)	µg/L	231	229	128	342	99	147	171	784
Silver (Ag)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Strontium (Sr)	µg/L	55	34.8	79.2	26.9	19.2	43.4	58	154
Tellurium (Te)	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thallium (Tl)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Thorium (Th)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin (Sn)	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Titanium (Ti)	µg/L	0.55	2.5	0.78	0.24	0.29	0.36	<0.2	<0.2
Tungsten (W)	µg/L	<1	<1	<1	<1	<1	<1	<1	<1
Uranium (U)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium (V)	µg/L	<0.2	0.22	0.34	<0.2	<0.2	<0.2	<0.2	<0.2
Zinc (Zn)	µg/L	<5	<5	<5	<5	<5	<5	9.2	<5
Zirconium (Zr)	µg/L	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4

[a] Data from samples collected by AEM, July 2011.

Bold values in yellow shaded cells are equal to or greater than the Canadian Water Quality Guidelines for the Protection of Aquatic Life - Freshwater (CCME 2007, CWQG).

Values in green shaded cells should be used with caution.

Underlined values are equal to or greater than the Guidelines for Canadian Drinking Water Quality (Health Canada 2007, GCDWQ).

Italicized values indicate the detection limit equals or exceeds either guideline.

(-) = No data available; °C = degrees Celsius; µS/cm = microseimens per centimetre; mg/L = milligrams per litre; µg/L = micrograms per litre; NTU = nephelometric turbidity units.

Other Watercourses

Water quality data collected from watercourses in the general area (close to the Meliadine West Advanced Exploration Project area) have been collected over various seasons and years and are used to provide a broader description of water quality for the AWAR study area.

Streams of the general area are generally well-oxygenated freshwater streams characterized by low ionic strength, very soft to soft water hardness, low alkalinity, and neutral to alkaline pH (Golder 2009). Major ions in stream waters were bicarbonate, calcium, chloride, and sodium. Measured nutrient concentrations were typical of oligotrophic waterbodies in subarctic regions. Baseline water quality parameters were less than CWQG for the protection of freshwater aquatic life (CCME 2007) and GCDWQ (Health Canada 2008) with the exception of 9 parameters including, nitrite, cadmium, chromium, lead, iron, manganese, selenium, silver, and phenol.

The major feature in the spatial trend of water quality within northern regions is relative homogeneity where there are no geological abnormalities. Spring runoff occurs mostly as flow on top of the frozen ground, thus limiting the amount of dissolved and particulate substances that can enter a waterbody. Very shallow and seasonal sub-soil flow can only occur during the short summer season when nutrients and any other substances in soils can enter surface waterbodies. Thus, opportunities for heterogeneity are limited in the northern region, resulting in similarities in the natural water quality between the different waterbodies.

5.2.3.3 Fish and Fish Habitat

Methods

The Char River, near the crossing location, was sampled by backpack electrofishing on 5 occasions, in June and July of 1998, and in June, July, and September of 2000 (RL&L 1999, 2001). The Meliadine River was sampled from 1997 to 1999 using a variety of capture techniques including angling, backpack electrofishing, gill netting, and a fish fence (Golder 2009). Assessments of fish and fish habitat were conducted at the 9 small watercourse crossings (Figure 5.2.2-1) during the period of 16 to 25 June 2008 (Golder 2009). Crossings M23.7 (also known as Stream A6-7), due to its proximity to the proposed mine location, was surveyed extensively during the 1997 to 2000 baseline studies for the Meliadine Gold Project (Golder 2009).

Habitat was surveyed at each of the proposed crossings to assess spawning, rearing, overwintering, and movement potential for fish. Parameters surveyed included channel and flooded width, depth, habitat type (e.g., riffle, run, pool), substrate composition, and availability of in-stream cover. General observations, such as channel type (e.g., single, double, braided, and dispersed) and the presence of movement barriers, were also noted. Channel width was defined as the distance between the banks of a watercourse. On occasion, flooded sections of watercourses were observed at widths greater than that of the defined channel; therefore, some study reaches had a wetted width greater than the channel width. Flooded width was a measurement of wetted width beyond, and including, that of the defined channel. Substrates were assessed using a modified Wentworth scale as follows:

- detritus (decomposed organic matter);
- fines (<2 mm diameter);
- gravel (2 to 64 mm);
- cobble (65 to 256 mm); and

- boulder (>256 mm).

Watercourses were divided into reaches of equal length (typically 50 m) with assessments of habitat parameters reflecting average conditions within each respective reach. Subsequently, mean values were calculated for each habitat parameter to describe average conditions for the stream as a whole. Cover types (e.g., vegetation, boulder areas, undercut banks) were estimated as proportions of available cover rather than proportions of stream area surveyed. Velocity was recorded with a direct-readout meter (Swoffer Model 2100). Readings were taken while wading along a tag line positioned perpendicular to flow. Habitat quality was rated using a modified Habitat Suitability Index (Golder 2010a).

Assessments of fish populations were conducted primarily by backpack electrofishing (Smith-Root Type 12B). Field biologists waded upstream and sampled available habitats in approximately equal proportions. A netter collected stunned fish and placed them in a holding container filled with water. Additional fish capture methods (i.e., fish fence, gill nets, and angling) used in the Meliadine River during 1997, 1998, and 1999 are described in Golder (2009).

Life history information collected included fork or total length, weight, and sexual maturity (if discernible through external examination). Relative abundance of fish was calculated in terms of catch-per-unit-effort (based on the number of fish captured or observed per one minute of sampling effort). Efforts were made to minimize mortalities and unnecessary harm to fish.

Egg sampling was completed to assess habitat potentially used by Arctic grayling for spawning in the streams along the proposed AWAR. All suitable spawning substrates observed by field biologists within the studied sections were sampled. The procedure involved positioning a fine-mesh D-ring kick net on the stream bottom immediately downstream from a potential egg deposition site (e.g., section of clean gravel) and disturbing the substrate with a foot for approximately 30 seconds (approximate area of 0.4 square metres [m^2]). The contents of each kick net were examined in the field. Recorded data included the number of areas sampled, number of areas with eggs, total number of eggs encountered, and the maximum number of eggs per sampled area. Eggs were returned to the watercourse immediately after counting.

Results

The total catch in the Char River during 1998 and 2000 included 52 fish represented by 5 species, Arctic grayling (n=15), round whitefish (n=4), ninespine stickleback (n=25), threespine stickleback (n=6), and slimy sculpin (n=2). Despite the name of this river, no char were captured, and members of the Rankin Inlet HTO mentioned that Arctic char have not been caught in the river for several decades (John Hickes, Rankin Inlet HTO, pers. comm.). Sampling for Arctic grayling eggs was completed in June 1998 and June 2000; however, eggs were not encountered.

The total catch in the Meliadine River during 1997, 1998, and 1999 included 3834 fish. The fish fence was the most productive sampling method, producing 98% (n=3761) of the catch. The fence was operated from 1997 to 1999 in the lower reaches of the Meliadine River (approximately 1.3 km upstream of the proposed bridge location) to determine the timing and magnitude of the Arctic char return migration from Hudson Bay to Little Meliadine and Meliadine lakes during late summer and early fall. Overall, the fish fence catch (n=3761) was dominated by Arctic char (86%) followed by Arctic grayling (7%), round whitefish (6%), with lake trout and cisco contributing less than 1% to the total catch.

Most of 9 small, ephemeral watercourses that will be crossed by the proposed AWAR are inhabited only by ninespine stickleback, which take advantage of shallow, ephemeral streams with predominantly fine-textured substrates. Others, including M5.0, M11.5, and M23.7, are also inhabited by Arctic grayling and slimy sculpin, species that require coarse substrates and riffle-run habitats. In total, 451 fish representing 3 species were captured or observed at 7 of the 9 small streams surveyed (Table 5.2.3-5). Ninespine stickleback (n=400) was the most abundant species, accounting for 89% of the total catch. Arctic grayling (n=29) were recorded at 2 sites (M11.5 and M23.7), whereas slimy sculpin (n=22) were recorded only at site M23.7.

None of the surveyed streams provided overwintering habitat because they all freeze to bottom during winter. Data summaries and photographs of each crossing are presented in Appendix C, Figures C1 to C9.

Table 5.2.3-5: Number of Fish Captured or Observed in Small Streams along the Proposed Meliadine Road Corridor, 1997 to 2008

Site	Date Sampled	Sampling Effort (s)	Number of Fish Captured or Observed				Total CPUE (fish/min)
			Arctic Grayling	Slimy Sculpin	Ninespine Stickleback	Total	
M3.0	20-Jun-08	211			2	2	0.6
M3.9	18-Jun-08	185				0	0.0
M5.0	18-Jun-08	293			260	260	53.2
M6.7	20-Jun-08	[a]				0	-
M8.6	18-Jun-08	262				0	0.0
M11.5	19-Jun-08	520	6		38	44	5.1
M13.3	19-Jun-08	222			10	10	2.7
M22.6	17-Jun-08	398			27	27	4.1
M23.7	19-Jun-97	829	17	6	5	28	2.0
	14-Jul-97	313		4	2	6	1.2
	15-Jun-98	624	4	2	1	7	0.7
	23-Jun-00	640		1	3	4	0.4
	22-Jul-00	450		5	8	13	1.7
	17-Sep-00	533	1	1	26	28	3.2
	17-Jun-08	409	1	3	18	22	3.2
Total		**5889**	**29**	**22**	**400**	**451**	**4.6**

[a] Fish sampling was not done because the stream was dry.

CPUE = Catch-per-unit-effort; min = minute

Sampling for Arctic grayling eggs was carried out in June 2008 at 3 streams (sites M5.0, M8.6, and M11.5); most of the remaining sites did not contain suitable spawning substrate. Seventeen individual areas (each approximately 0.1 m^2 in area) were sampled; however, eggs were not found. Sampling for Arctic grayling eggs was also completed at site M23.7 in 1997, 1998, and 2000; 18 individual areas were sampled, with 7 Arctic grayling eggs encountered in 4 areas. This result, corroborated by the capture of gravid and ripe adults in June 1997, demonstrated that Site M23.7 was used by Arctic grayling for spawning.

5.2.4 Effects Analysis

As discussed in Section 4.3, potential effects pathways for the AWAR Project were identified and assessed as to whether there was no linkage, or whether the linkage was secondary (minor) or primary, and, therefore, would be carried further into the assessment (refer to Section 4.3 for detailed description on pathway analysis). Potential pathways through which the AWAR Project could affect valued components (VCs) for the aquatic environment are presented in Table 5.2.4-1.

Pathways potentially leading to effects on water quantity and quality, aquatic habitat, and fish in the AWAR Project area include direct and indirect effects. These changes were assessed to determine if they could potentially affect the suitability of water quality to support a viable aquatic ecosystem, persistence of desired population(s) of key fish species, continued opportunity for traditional and non-traditional use of water and fish, and the protection of human health. Evaluation of effects on water quality, aquatic habitat (i.e., lower trophic levels, benthic invertebrates), and fish in the AWAR Project area also considers changes to permafrost, hydrology, and air quality, and during the construction, operations, and closure phases of the AWAR Project, as well as effects remaining after closure.

The major AWAR Project activities that have the potential to change aquatic resources are summarized in Table 5.2.4-1. Of these, accidental spills provide the greatest potential for changes to water quality that could result in adverse environmental impacts.

Table 5.2.4-1: Potential Pathways for Aquatic Environment

Project Component/ Activity	Aquatic Component	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
General construction and operation of the Phase 1 AWAR	Hydrology	Cross-drainage structures for the Phase 1 AWAR will alter stream hydraulics	Cross-drainage structures will be designed and constructed such that structures will not create a hydraulic barrier to fish passage and will convey peak flows corresponding to 1:25 year rainfall event.	Secondary
		Cross-drainage structures for the Phase 1 AWAR will alter stream geomorphology	Cross-drainage structures will be designed and constructed such that structures convey peak flows of 1:25 year event.	Secondary
		Freezing and plugging of culverts in the winter may result in 1. inadequate drainage during spring thaw and freshet, 2. over-topping and erosion of road surface releasing silt onto terrain and soils; 3. pooling of water adjacent to road flanks; 4. potential instability and thaw settlement of road shoulders; 5. thaw settlement beneath and adjacent to culverts; and 6. ice lens growth.	Use of staggered culvert configuration to promote drainage during spring thaw and freshet. Regular inspection of the road to identify any areas where ponding of water along the road represents a risk, and installing additional culverts or French drains to alleviate the risk.	No Linkage
		Cross-drainage structures for Phase 1 AWAR will prevent navigability	Cross-drainage structures will be designed to allow navigation (i.e., bridge) for crossings with navigable waters.	No Linkage
Installation of Stream Crossing Structures	Fish[a] and Fish Habitat[b]	Sediment releases	In-stream works conducted in winter, thereby avoiding critical periods for fish (i.e., installation prior to the 1 May to 15 July in-stream work exclusion window). Bridge abutment installation will occur outside of the high-water mark, and construction will occur in winter. Best management practices for erosion and sedimentation control (e.g., silt curtains, runoff management), where necessary. Disturbed areas along the streambanks will be stabilized and allowed to re-vegetated upon completion of work.	No linkage

Table 5.2.4-1: Potential Pathways for Aquatic Environment (continued)

Project Component/ Activity	Aquatic Component	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
		Loss of Habitat at crossing	Most streams crossed have low quality habitat. Rock material at inlet and outlet can improve habitat quality for species such as Arctic grayling. Assessment using the DFO Risk Based Technique indicates that risk to fish populations is low.	Secondary
Construction of the Phase 1 AWAR (continued)	Water Quality Fish[a] and Fish Habitat[b]	Sediment releases from road construction can affect surface water quality	In-stream works will be constructed in winter when watercourses are frozen. No in-stream works conducted between 1 May to 15 July to avoid critical periods for fish. Best management practices for erosion and sedimentation control (e.g., silt curtains, runoff management), where needed.	No linkage
	Water Quality	Release of potential acid generating materials from road building materials at the watercourse crossings can alter water quality	Use of non-acid generating material at all watercourse crossings (to date all testing has shown rock to be non-acid rock drainage). Borrow and rock quarry activity will be at least 100 m from the high water mark of any waterbody.	Secondary
		Introduction of dust (from traffic or construction activities) can alter water quality	Enforcing speed limits (maximum speed 50 km/h) to suppress dust production. Design road as narrow as possible while maintaining safe construction practices; passing turnouts will be placed to accommodate multi-directional traffic. Crossings will be perpendicular to watercourse. The running surface of the road will be maintained thereby reducing the generation of dust.	Secondary

Table 5.2.4-1: Potential Pathways for Aquatic Environment (continued)

Project Component/ Activity	Aquatic Component	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
Construction of the Phase 1 AWAR (continued)	Water Quality	Spills and leaks from equipment or accidents can affect surface water quality	Hazardous materials and fuels will be stored according to regulatory requirements. Explosives will be stored at the Meliadine site. Equipment will be re-fueled, serviced, and washed away from stream crossings. Fuel, lubricants, hydraulic fluids, etc. will be stored at least 30 m away from the high-water mark of any waterbody. Storage tanks and materials currently at the Meliadine exploration site will be used for the Phase 1 AWAR Project. Construction equipment will be regularly maintained Soils from any petroleum spills will be collected and treated on-site. If not possible, the contaminated soils will be shipped off-site for treatment and disposal. Construction of much of the road base during winter, so there would be opportunity to clean up any spills prior to spring thaw. An emergency response and spill contingency plan will be developed and implemented.	Secondary
		Opening of quarries and stockpiling of rock can alter flow of water to surface waterbodies and can affect surface water quality	Stockpiling of rock and fill from quarries and borrow sites will be placed such that surface water is not diverted through the piles with runoff to surface waterbodies.	Secondary
		Introduction of blasting residue (nitrogen compounds) to surface water can alter water quality	Using the required amount of explosive at each quarry location that is proportional to the amount of rock in the quarry. Placement of overburden away from drainage pathways to surface water.	Secondary

Table 5.2.4-1: Potential Pathways for Aquatic Environment (continued)

Project Component/ Activity	Aquatic Component	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
Operation of the Phase 1 AWAR	Water Quality	Release of potential acid generating materials during watershed runoff from materials at the watercourse crossings can alter water quality	Use of non-acid generating material at any watercourse crossings. Construction materials will be clean and contaminant free.	Secondary
	Water Quality, Fish[a] and Fish Habitat[b]	Introduction of dust (from traffic) can alter water quality	Enforcing speed limits, and regular road maintenance to suppress dust production.	Secondary
	Water Quality	Spills and leaks from transport and maintenance equipment and spills and leaks from accidents can affect surface water quality	An emergency response and spill contingency plan will be developed and implemented, including ready access to an emergency spill clean-up kit for cleaning up any spills. Drivers appropriately qualified and cautioned. Vehicles properly loaded and loads appropriately covered where necessary. Enforced speed limits. Equipment will be regularly maintained.	Secondary
		Runoff from road drainage can affect surface water quality	Runoff from roads, as well as ponding along the roads, will be monitored. Silt fences will be used near watercourses, if necessary, to prevent erosion.	Secondary
	Water Quality	Surface water drainage through quarries and transport of blasting residuals and metals directly into watercourses can affect surface water quality	Quarries will be excavated and sloped for positive drainage. Quarries will be inspected on a regular basis to monitor water ponding, particularly at spring melt. Excavations will be at least 100 m away from any watercourses. Drainage from quarries will not flow directly into any waterbodies or watercourses. When there is flow from a quarry that could enter a waterbody, a water quality sample will be collected and analyzed.	Secondary

Table 5.2.4-1: Potential Pathways for Aquatic Environment (continued)

Project Component/ Activity	Aquatic Component	Effects Pathway	Environmental Design Features and Mitigation	Pathway Assessment
	Fish[a] and Fish Habitat[b]	Blockage to fish movement	Single span bridges at the Char and Meliadine rivers and at the M5.0 crossing will be used to minimize blockages to fish movement. Culverts will be designed to allow fish movement throughout the open water period, including low-flow periods. Watercourses will be inspected upstream and downstream of the crossings for erosion, scour and flow blockages.	Secondary
	Fish (Arctic char, Arctic grayling)	Potential overexploitation of fish stocks due to improved road access	Mining staff are not allowed to hunt or fish while on their work rotation.	No linkage
Decommissioning/ Reclamation of the All-Weather Access Road	Water Quality, Fish[a] and Fish Habitat[b]	Sediment releases from road surface disturbance can affect surface water quality of nearby surface waters (e.g., increased total suspended solids loads)	Best management practices for erosion and sedimentation control (e.g., silt curtains, runoff management), as needed. In-stream work will be limited to when watercourses are not flowing for ephemeral watercourses or when watercourses are frozen. If any of the culverts need to be removed when the watercourses are flowing, the work will be completed late in the summer, and best management practices for erosion and sedimentation control (e.g., silt curtains, runoff management) will be employed.	No linkage
		Sediment and contaminant releases during removal of culverts can affect surface water quality	Best management practices for erosion and sedimentation control by installing coarse rip-rap on the banks to prevent erosion after removal of the culverts. In-stream work will be limited to when watercourses are not flowing for ephemeral watercourses or when watercourses are frozen. If any of the culverts need to be removed when the watercourses are flowing, the work will be completed late in the summer, and best management practices for erosion and sedimentation control (e.g., silt curtains, runoff management) will be employed.	Secondary

[a] Key fish species include Arctic char, Arctic grayling, round whitefish, slimy sculpin, ninespine stickleback.

[b] Benthic invertebrates, spawning, and rearing habitat.

The following sections discuss the potential pathways relevant to the aquatic environment.

5.2.4.1 Pathways with No Linkage

A pathway may have no linkage if the activity does not occur (e.g., flows not altered), or if the pathway is removed by environmental design features so that the AWAR Project results in no detectable (measurable) environmental change and residual effects to hydrology, surface water quality, and fish and fish habitat relative to baseline or guideline values. The following pathways are anticipated to have no linkage to hydrology, surface water quality, or fish and fish habitat, and will not be carried through the effects assessment (Table 5.2.4-1).

- **Freezing and plugging of culverts in the winter.**

The use of staggered culvert configuration and regular inspection of the road will alleviate the risk of freezing and plugging of culverts.

- **Cross-drainage structures for AWAR will prevent navigability.**

Cross drainage structures for crossings with navigable waters will be single span bridges, designed in accordance to Transportation Association of Canada (TAC 2009) with a minimum freeboard of 1.0 m over the peak flow elevation and will not impede navigability.

- **Sediment releases from road construction and land disturbance can affect surface water quality, and fish and fish habitat.**
- **Runoff from road drainage can affect surface water quality and fish habitat.**

Site contouring and excavation at stream crossings have the potential to increase soil erosion, suspended sediment concentrations, and deposition at and downstream of the zone of influence. Construction of the watercourse crossings will occur during winter when the streams are frozen or are not flowing. There will be no in-stream works except during frozen or non-flowing conditions. Any equipment used in the stream will be clean and inspected for leaks. These procedures will minimize the potential for erosion, sediment releases, and introduction of contamination. All construction activities will be subject to a sediment control plan, and best management practices, that will include standard erosion and sediment control measures (e.g., erosion mats, silt curtains) that will be used, as needed, during construction.

The road will be designed with a surface slope of 2° from the road centreline and side slope of 2.5H:1V to encourage drainage off the road surface. Silt curtains, or other best management practices, will be used as needed to prevent erosion and sedimentation in watercourses. Overall, drainage from the road is a small component of total drainage in the area, and any contribution from the road and effects on water quality should be negligible.

Through the use of best management practices (i.e., AWAR Project design to prevent direct drainage to watercourses) and monitoring during construction and decommissioning activities, effects to water quality are expected to be negligible; however, a water quality monitoring and reporting plan will be conducted to observe conditions.

- **Installation of stream crossing structures can affect fish and fish habitat.**

The installation of culverts has the potential to cause erosion, displace sediments, increase suspended sediments in the watercourse, and increase sediment deposition in the channel at and downstream of the zone of influence. Best management practices, with respect to sediment and erosion control, will be applied to prevent surface runoff from disturbed banks and subsequent sediment delivery to the channel during the construction period; particular attention will be directed to controlling runoff along the road during high precipitation events.

In-stream construction activities related to culvert installation on the 8 ephemeral streams will be completed during the winter before snowmelt, when the streams will be frozen to the substrate. Best management practices will be applied to prevent or minimize sediment delivery into the channel during the first spring after construction; particular attention will be paid to stream crossing M23.7, which has documented Arctic grayling spawning, egg incubation, and rearing.

The installation of the abutments for the single span bridges (at Char, Meliadine, and M5.0) will be done outside of the high-water mark of the watercourse; this, along with construction in the winter before spring melt should result in no effect since fish habitat should not be affected by channel disturbance or increased sediment delivery.

All construction materials (gravel fill, bridge components, miscellaneous tools, debris, and sediment) will be located a minimum of 31 m from the high water mark of a waterbody such that they do not enter the waterbody.

Fisheries and Oceans Canada, in a Screening Letter for the AWAR (dated 29 April 2011, Appendix D), concluded that the AWAR Project would not likely result in impacts to fish and fish habitat, if appropriate mitigation measures were applied. Seven measures were listed including the following:

1) no in-stream work from 1 May to 15 July;
2) implementation of sediment control measures prior to and during construction;
3) sediment control measures to be maintained until all disturbed areas have been stabilized;
4) all disturbed areas to be stabilized and re-vegetated upon completion of work;
5) machinery to arrive on-site in clean condition and be maintained leak-free;
6) machinery to be washed, re-fuelled, and serviced away from the water to prevent entry of deleterious substances; and
7) maintenance of an emergency spill kit on-site in case of fluid leaks or spills from equipment.

AEM has incorporated these conditions into the construction planning, and will abide by them during the construction program.

- **Road access to Meliadine River, Meliadine Lake, and other watercourses can alter fish stocks through increased fishing pressure.**

Development of the AWAR may increase the fishing pressure on the Meliadine River with potential adverse effects on the Arctic char population. To reduce the potential for overharvesting of fish along the AWAR, AEM staff and contractors will not permitted to fish while on working hours. However, their likely will be some increased fishing pressure related to non-project related road use. It should be noted, however, that the Meliadine River is currently accessible by local residents along ATV trails, so the incremental increase in fishing harvest is expected to be small.

Stream M23.7 contains a small, but apparently well-established Arctic grayling population (i.e., with catchable, adult-sized individuals at and near the crossing), which potentially could be affected if overharvest occurs. However, as this stream crossing is located in the industrial area around the exploration site, non-project related access will not be allowed without special permission, so excessive fishing pressure related to the AWAR is not expected to occur.

The remaining ephemeral streams are of lesser concern, either because they do not support Arctic grayling or because they are primarily used for rearing (i.e., based on present data, catchable-sized individuals do not inhabit the crossing areas).

5.2.4.2 Secondary Pathways

In some cases, both a source and a pathway exist, but the change caused by the AWAR Project is anticipated to result in a secondary environmental change, and would have a negligible residual effect on hydrology, surface water quality, or fish and fish habitat relative to baseline or guideline values. The following pathways are anticipated to be secondary (Table 5.2.4-1), and will not be carried through the effects assessment.

- **Cross-drainage structures for roads will alter stream hydraulics.**

The installation of cross-drainage structures to prevent roads from impeding water flow can result in the loss and alteration of aquatic habitat and shoreline vegetation, and a constriction of the stream channel, which could create a flow velocity barrier to fish passage. Though the loss of stream habitat and shoreline vegetation may be permanent, the potential barrier to fish passage can be mitigated through the application of hydraulic design principles. Cross-drainage structures will be implemented in such a way that they will provide sufficiently low flow velocity that the slowest local fish can navigate the structure under a particular design flow condition (i.e., 3-day delay; 1:10 year return flood condition). They will also provide a design conveyance for 1:25 year event without overtopping the roadway, which will result in minor changes in stream velocity. The implementation of appropriate cross-drainage structures is expected to result in minor changes to stream flow velocity in the vicinity of the structures relative to baseline conditions and have negligible residual effects on water quantity.

- **Cross-drainage structures for roads will alter stream geomorphology.**

As described previously, cross-drainage structures will be implemented in such a way that they will provide a design conveyance for 1:25 event without overtopping the roadway, which will result in minor changes in stream velocity preventing channel aggradation, degradation, erosion, or changes to bankfull width or depth. The implementation of appropriate cross-drainage structures is expected to result in minor changes to stream flow velocity in the vicinity of the structures relative to baseline conditions and have negligible residual effects on geomorphology.

- **Spills and leaks from equipment, and spills from accidents, can affect surface water quality.**

AEM has developed an emergency response and spill plan which is designed to minimize the likelihood of accidental spills, or if they do occur to quickly respond and clean-up any spills. AEM will not permit the deposit of chemicals, sediment, wastes, or fuels into any waterbody. During construction, hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and workers. During operation, hazardous materials will be stored at the Meliadine Exploration site. Individuals working on the AWAR Project and handling hazardous materials will be trained in the Transportation of Dangerous Goods. Emergency spill kits will be available near work areas.

The implementation of an emergency response and spill plan, and environmental design features including proper equipment maintenance and driver training, are expected to reduce the frequency and severity of spills. However, it is acknowledged that accidental spills, including vehicular accidents, have the greatest potential to affect water quality and possibly result in adverse environmental impacts. Should a spill occur, contaminated areas will be collected and treated on-site, or shipped off-site for treatment and disposal if not possible to treat on-site.

Based on AEM's experience with the Meadowbank AWAR, accidental spills (e.g., fuel) have occurred, but the volume of spill has been small, and clean-up has occurred with only minor effects to the environment.

- **Introduction of dust (from traffic or construction activities) can alter water quality.**

Dust from construction of the road and traffic may increase the deposition of particulate matter, which could increase acidity, suspended solids, and other substances (e.g., metals) in surface water. Environmental design and mitigation (e.g., reduced speed limits and regular maintenance) should reduce or eliminate potential effects from dust deposition. The environmental design of narrow roads may reduce potential impacts of dust generation (less surface area for wind generated dust off the road surface) but they can create a bigger risk of accidents and spills, based on results from another project (Meadowbank Gold Project, 2008 Annual Report).

This pathway was determined to have minor effects to surface water. A water quality monitoring program will be implemented (Appendix A, Section 6.2). Monitoring will be conducted at upstream and downstream stations at selected watercourse crossings. The upstream station will be established based on predicted air quality deposition rates with the station placed far enough upstream, where possible, to be outside the zone of influence (e.g., 100 m, see Table 5.1.4-4).

Effects to fish habitat are expected to be minor but they will be investigated as part of the monitoring program. If effects are noted, it may be necessary to use appropriate dust abatement measures (e.g., roadway watering near selected stream crossings) during critical periods of the Arctic grayling life-cycle (i.e., during spawning, egg incubation, early-stage rearing).

- **Surface water drainage through quarries and then directly into watercourses can affect surface water quality.**

The AWAR Project design includes the use of road building materials that are shown to be non-acid generating. Materials for road building will be extracted from identified quarry locations along the AWAR. Although the intent is to contour the quarries to have positive drainage, there may still be some ponding of water in the quarries, which will eventually drain to the land and possibly to surface waters. Water within the quarries will be in contact with rock material that may or may not have the potential to leach metals as well as blasting residuals (i.e., compounds high in nitrogen). Based on results from Meadowbank Gold Project, elevated concentrations of ammonia and metals are expected in quarries and pools of standing water. Water release from the quarries will have a fixed source of nitrogen but a potential long-term source of metals. If all drainage from the quarries is directed away from surface water, there is no potential impact, however if some drainage from the quarries enters surface water, there is the potential for impact and change in downstream water quality

Using environmental design features and best practices, water from the quarries, which would be located at least 100 m from any waterbody, should not drain directly to waterbodies and thus there should be negligible effects to water quality; however, water quality will be monitored. Quarries will be inspected on a regular basis to identify any areas of water ponding, particularly during spring freshet.

If there is noticeable flow from a quarry that could enter a waterbody, a water quality sample will be collected. Water quality samples for monitoring will be collected in the quarry and in the watercourse upstream and downstream of the point source impact. Samples will be analyzed for physical parameters, nutrients (i.e., phosphorus and nitrogen), and trace metals (see Appendix A, Section 6.2). Results will be reported in the monthly NWB report.

- **Release of potential acid generating materials at the watercourse crossings can alter water quality (during road construction and operation).**

The AWAR Project design includes the use rock and till materials, from identified quarry locations along the road, to be used for installation of culverts and bridges. All identified road building material comes from quarries and not from existing watercourses; no rock and construction material will be gathered from below the high water mark of any watercourse. Initial testing, using static methods to assess the chemical composition of the potential road building material, its potential to generate acid rock draining (ARD), and its potential to leach metals to the receiving environment upon exposure to ambient conditions was completed in 2010 (Golder 2010d). The quarry locations identified for the AWAR show no potential to generate acid drainage. The low ARD potential stems from the low sulphide content and high buffering capacity in the same material. Sulphide sulphur content ranges from <0.01 to 0.17% (in rock) and 0.07% (in till), and total sulphur ranges from <0.005 to 0.34% (in rock) and 0.09% (in till). Based on the low sulphide sulphur content, samples are classified as non-acid generating. Table 5.2.4-2 presents the summary of rock and till ARD potential for the identified quarry locations along the AWAR.

The sites chosen for potential quarry and borrow sites along the road alignment were also tested for metal leaching (Golder 2010d). The results indicated no acid rock drainage and low metal leaching. Water leach tests yielded chemical concentrations that were less than the Metal Mining Effluent Regulations guidelines and were less than the CWQG for the protection of aquatic life for most parameters except for arsenic, aluminum, copper, and pH.

Table 5.2.4-2: Summary of Rock and Till Acid Rock Drainage Potential

Proposed Location		Material Type	Sample Count	Sample Count		Median Paste pH Value	Average Sulphide (%)	Overall ARD Designation per Quarry/ Borrow Location
				non PAG	PAG			
Rock Quarries	R2	mafic volcanic	3	3	0	9.4	0.06	non PAG
	R5	granite	3	3	0	9.7	<0.01	non PAG
	R11	granite	5	5	0	9.8	<0.07	non PAG
	R14	mafic volcanic	5	4	1	9.4	0.07	non PAG
	R19	mafic volcanic	3	3	0	9.0	0.01	non PAG
Borrow Pit	B1A	glacial till	3	3	0	7.4	0.01	non PAG
	B5	glacial till	3	3	0	8.2	<0.02	non PAG
	B6A	glacial till	3	3	0	8.2	<0.01	non PAG
	B10	glacial till	3	3	0	7.8	<0.02	non PAG
	B11A	glacial till	3	3	0	7.6	0.02	non PAG
	B13	glacial till	2	2	0	6.1	0.05	non PAG
	B15	glacial till	3	3	0	8.1	<0.03	non PAG
	B19	glacial till	3	3	0	7.8	<0.03	non PAG

ARD = acid rock drainage; PAG = potential to generate acid rock; quarries and borrow pit locations are included in Figure 5.2.2-2.

Observations on arsenic leaching in the potential road construction material include the following:

- Arsenic concentrations leached from rock quarry material ranged from <0.0002 to 0.4 mg/L with a median of 0.001 mg/L.
- Arsenic concentrations leached from till material ranged from 0.0004 to 0.03 mg/L. The upper quartile concentrations were above the CWQG of 0.005 mg/L, the 75th percentile concentration (0.005 mg/L) was equal to CWQG and the median (0.002 mg/L) was well below CWQG guideline.
- Leachable arsenic concentrations correlated moderately with the total arsenic concentrations as indicated by an R^2 value of 0.8 and 0.6 for rock and till, respectively. The correlation between total and leachable arsenic and the lack of correlation between total arsenic and sulphide content suggested that arsenopyrite may not be the only source of labile arsenic in both rock and till material. Other mineral phases (possibly non-sulphide minerals) may contribute to the leached arsenic load observed.
- The proposed till borrow locations, including B5, with the highest arsenic leaching concentrations are all close to the AWAR Project site.

Observations on copper leaching in the potential road construction material include the following:

- Copper concentrations leached from rock quarry material ranged from <0.0005 to 0.06 mg/L. Median and 75th percentile copper concentrations (0.006 and 0.013 mg/L, respectively) were above the CWQG guideline (0.002 mg/L).

- Copper concentrations leached from till material ranged from 0.002 to 0.032 mg/L. Median and 75th percentile copper concentrations (0.009 and 0.013 mg/L, respectively) were above the CWQG guideline of 0.002 mg/L.
- Leachable copper concentrations did not correlate with the total copper concentrations as indicated by R^2 values of 0.01 and 0.4 for rock and till, respectively. The correlation was also weak between total copper and sulphide content. It is likely that the source of copper in the leachate is contributed by mineral phases other than sulphides.
- Copper concentrations were above CWQG aquatic life criteria in most locations. However, sample groups R14, B5, and B19 reported average copper concentrations one order of magnitude or more above the criteria. Given that the CCME criteria apply to receiving waterbodies, material extracted from these locations should be placed on high ground away from surface waterbodies.

Results from the laboratory testing serve to highlight chemicals of environmental interest and are not necessarily indicative of actual drainage quality because this will depend on the exposure of the materials to ambient conditions, particularly to water and snow melt.

Visual examinations of the quarry material for sulphur species and additional testing for acid rock drainage/metal leaching from each quarry and borrow will be conducted before and during construction. All material used at the watercourse crossings will be non-acid generating; however, this will be verified through testing of the rock fill material and through monitoring of water quality in the watercourse during and after construction.

In addition, it is anticipated that the largest watercourse crossings (M3.0, M5.0, and M23.7) have the highest likelihood of metal leaching due to the size of the watershed and quantity of water that will move through the watercourse crossing. At these locations, monthly water sampling over the first open water period is proposed. Parameters analyzed from each of these watercourses include physical parameters, nutrients, and trace metals (see Appendix A, Section 6.2 for more detail). Results would be reported monthly in the Nunavut Water Board report.

- **Sediment releases from removal of culverts can affect surface water quality.**

Removal of culverts during road decommissioning can potentially lead to the release of sediments and associated contaminants into the watercourse. Through the use of best management practices and monitoring, effects to water quality are expected to be minor; however, water quality will be monitored. The present reclamation and closure plan for the Meliadine Exploration Site will be expanded to include the AWAR and will feature erosion and sedimentation protection during the decommissioning phase.

- **Crossing structures have the potential to block or delay fish movement.**

Major streams (Char and Meliadine rivers) will be crossed with clear-span bridges; therefore, Arctic char migrations in the Meliadine River (and seasonal movements by other documented fish species in the Meliadine and Char rivers) will not be affected. Construction at the Char River will involve the installation of a new clear-span bridge, immediately adjacent to the existing bridge, with a wider base clear-span bridge.

None of the ephemeral streams crossed are inhabited by Arctic char; however, Arctic grayling, a species with well-documented migratory tendencies, were recorded at 2 crossings (M11.5 and M23.7). The culvert installations for the 8 ephemeral streams will be designed and constructed for unobstructed fish passage (i.e., multiple/offset stacked circular pipe culverts to provide fish passage during low-flow conditions and to enable flow conveyance prior to complete ice break-up, culverts adequately sized to achieve culvert flow velocities not exceeding 0.8 m/s during the 1:10 yr 3-day event, etc.). There is the potential for minor effects if connectivity between the upstream and downstream portions of the watercourse are not maintained. Inspection of the culverts, as part of weekly inspections along the road during the spring-summer time, will be undertaken to ensure connectivity is maintained. If not, mitigation measures will be implemented to re-position the culvert correctly.

5.2.4.3 Primary Pathways

A pathway analysis was completed to determine which pathways had no linkage, a secondary linkage, or were primary with respect to hydrology, surface water quality, and fish and fish habitat. In total, 21 pathways related to hydrology, surface water quality, and fish and fish habitat were identified and assessed. None of the pathways are anticipated to have a measurable change to hydrology, water quality, or to the persistence of fish populations and habitat.

5.2.5 Cumulative Effects

5.2.5.1 Hydrology

Effects to surface water quantity were anticipated to be confined to the Meliadine River and Diana River watersheds. Effects to surface water quantity in one part of the watershed may overlap with effects to other areas of the watershed. The database of existing and historic development indicated that there have been very few developments within these watersheds and no other projects, other than the existing Meliadine Advanced Exploration and proposed Meliadine Gold Project facilities, which were identified in the Meliadine River and Diana River watersheds that may also affect hydrology. Planned developments of the proposed Meliadine Gold Project are anticipated to have negligible effects on surface water quantity in the Meliadine River and Diana River watersheds. Thus, the cumulative effect is expected to be negligible.

The bridge crossing the Char River is being installed next to the existing bridge and is not anticipated to create cumulative effects on surface water quantity.

5.2.5.2 Surface Water Quality

The Meliadine Advanced Exploration and proposed Meliadine Gold Projects are the only projects in the study area of the AWAR with the potential to have a long-term effect on water quality. Presently, the only other anthropogenic activities in the study area that could directly affect the environment, other than long-distance atmospheric deposition of substances from other areas, is ATV usage. At several watercourse crossings, ATV use has badly degraded streams banks and produced local impacts (Section 3, Plate 3.1-3).

Other major developments that may occur in the foreseeable future are listed in Table 5.2.5-1. None of these developments, if they occur, are expected to have effects within the AWAR LSA or RSA. As the AWAR is not expected to have any significant residual effects on water quality, it is unlikely that the effects of the AWAR would add cumulatively to other potential impacts on water quality within the watersheds.

Table 5.2.5-1: 2010 Advanced Exploration Projects in Nunavut Falling on Subsurface Inuit Owned Land

Kivalliq Region	
Meadowbank[a]	Agnico-Eagle Mines Ltd.
Ukalik	Forum Uranium Corp.
Sedna	4579 Nunavut Ltd.
Cache	Full Metal Minerals
Lac Cinquante	Kivalliq Energy Corporation
Peter Lake	Glen Dickson Group
Kitikmeot Region	
Hope Bay[b]	Hope Bay Mining Ltd.
Contwoyto	Shear Minerals, Golden River Resources
Hood River	Shear Minerals, Golden River Resources
High Lake[c]	MMG Resources Inc. (MMG)
Muskox[d]	Adriana Resources
Arcadia Bay	Full Metal Minerals
Rockinghorse[e]	Golden River Resources
Strongbow	North Arrow Minerals Inc.

[a] The project involves land held under NTI exploration agreements and grandfathered leases.

[b] The Boston deposit is located on surface Inuit owned land, while the Doris, Madrid, South Patch, Naartok and Suluk are on subsurface Inuit owned land, distributed among grandfathered leases and NTI exploration agreements. Potential extension of the Boston deposit down-dip or along strike to the north will also be on subsurface Inuit owned land.

[c] The project involves Crown land and land held under NTI exploration agreements and grandfathered leases.

[d] The project involves Crown land, surface Inuit owned land, and subsurface Inuit owned land under NTI exploration agreements.

[e] The project involves Crown land, surface Inuit owned land, and subsurface Inuit owned land under NTI exploration agreements.

5.2.5.3 Fish and Fish Habitat

Effects to fish and fish habitat were anticipated to be confined to the Meliadine River and Char River watersheds. The database of existing and historic development indicated that there have been very few developments within these watersheds and no other industrial projects, other than the existing Meliadine Advanced Exploration and proposed Meliadine Gold Project facilities in the Meliadine River watershed that may also affect fish and fish habitat. Due to the negligible effects expected on fish and fish habitat resulting from the AWAR, and the limited overlap between AWAR and the larger mine development project in terms of sub-watersheds affected, the cumulative additive effect of the AWAR is expected to be negligible.

The bridge crossing the Char River is being installed adjacent to the existing bridge and is not anticipated to create cumulative effects on fish and fish habitat.

5.2.6 Uncertainty

5.2.6.1 Hydrology

Predictions of potential effects were made in a qualitative manner and thus the pathway assessment is subjective even though it is based on previous experience and knowledge with similar projects. There is sufficient existing data on watercourses within the general study area such that the limited of data for the specific watercourses along the AWAR is not a major uncertainty.

The sizing of culvert and bridge crossings were based on standard design methods which do not create a source of major uncertainty. There is however a minor source of uncertainty that arises from the lack of detailed topographic data within watersheds of ephemeral watercourses (Golder 2010a) resulting in error in calculated drainage areas for these watercourse crossings. Given the magnitude of these drainage areas, the error may result in some minor and short-term surcharging of culvert head ponds if these areas were underestimated.

5.2.6.2 Water Quality

Predictions of potential impacts were made in a qualitative manner and thus the pathway assessment is subjective even though it is based on previous experience and knowledge with similar projects. There is sufficient existing data on watercourses within the general study area as well as at least one set of water quality data for the specific watercourses along the AWAR. Water quality will be monitored during construction (after spring thaw) and post construction. Areas of uncertainty for the assessment of effects to water quality (including sediment quality) are as follows:

- material used to construct the road at the watercourse crossings and the actual potential for metal leaching from this material;
- connectivity of flow from the quarries to surface waterbodies;
- dust deposition; and
- accidental spills.

There is some uncertainty around the material that will be used to construct the road, particularly around the watercourse crossings, and there is uncertainty around the leaching potential of this material. Testing and monitoring will reduce these uncertainties.

The potential quarry locations have been identified, but exact shape and drainage outlets (if required) have not been identified, thus flow of water from the quarries to surface waterbodies is unknown. The volume, rate, timing of discharge, and quality of water is required to make quantitative predictions about potential effects. Monitoring will address this uncertainty as long as it is done to capture spatial and temporal scales and water is analyzed for a sufficient suite of parameters (e.g., general chemistry, nutrients, total and dissolved trace metals) to sufficiently low detection limits.

It was assumed that the amount of dust generated and resultant suspended solid and possibly other substances (e.g., metals) loading would be minor and that no measureable effects could be discerned. The accuracy of that statement depends on implementation of appropriate dust management procedures. Monitoring programs will be used to track this potential pathway with the upstream stations selected outside the zone of dusting influence and downstream stations selected within the potential zone of influence. It is also noted that monitoring for total suspended and dissolved matter could potentially capture inputs from both fugitive air emission (i.e., dusting) and sediments from the newly installed watercourse crossings.

It was assumed that accidental spills would be infrequent and would not result in substantial releases of deleterious substances, and any spills would be quickly cleaned up as addressed in the Appendix A. However, this assumption remains uncertain since accidents can happen despite the best preparations and training.

5.2.6.3 Fish and Fish Habitat

A source of uncertainty is associated with the use and performance of culverts in the fish bearing streams, as it relates to fish passage and maintaining connectivity between stream reaches and interconnected waterbodies upstream and downstream of the crossings. Five of the 8 streams scheduled for culvert installation are fish bearing (M3.0, M11.5, M13.3, M22.6, M23.7). Each of these streams are inhabited by ninespine stickleback, but 2 (M11.5, M23.7) are known to be inhabited by Arctic grayling. Stream M23.7 was inhabited by 3 fish species including Arctic grayling, slimy sculpin, and ninespine stickleback, and is known to support Arctic grayling spawning and rearing. Uncertainty can be reduced by undertaking follow-up monitoring during the Arctic grayling spawning period at crossings M11.5 and M23.7 to ensure that migrating fish are not being blocked at the culverts. If it is found that the culverts are not operating as planned, then remedial actions will be implemented.

An additional source of uncertainty is the effectiveness of regulations put in place by the developer and by regulators to control fishing pressure on the Meliadine River and stream M23.7. It would take a relatively small number of anglers, a limited period of time (e.g., 1 to 3 years) to reduce the viability of these populations. A policy has been developed by AEM to effectively regulate (i.e., a no angling policy for staff and contractors) and monitor fishing pressure along the proposed AWAR (i.e., through regular inspections along the road). This would limit much of the potential increase in fishing pressure on the Meliadine River and stream M23.7. There is some uncertainty as the potential increase in fishing pressure by non-project related staff, but this would likely be directed towards Arctic char fishing in the Meliadine River. If it becomes apparent that there is a substantial increase in fishing pressure at the AWAR crossing of the Meliadine River, then AEM would notify the HTO and DFO, so that other regulatory measures could be implemented by these organizations, as appropriate.

5.2.7 Monitoring and Follow-up

5.2.7.1 Hydrology

A monitoring plan is addressed in the Phase 1 AWAR Operation and Maintenance Manual (Appendix A). The monitoring plan specifically addresses hydrology monitoring prior to spring freshet and post major precipitation events.

5.2.7.2 Water Quality

Water quality monitoring will be completed to better characterize water quality in the watercourses during road construction (open water period) and subsequently during operation and decommissioning. Monthly monitoring during the open water period will be conducted in watercourses that are most likely to be affected by the road and which have high habitat for Arctic grayling (M5.0, M11.5, M23.7) and have the highest potential for metal leaching due to the size of the drainage basin (M3.0, M5.0, and M23.7). Water samples will be collected monthly during the open water period, at stations upstream and downstream of the road, in each of the above 5 watercourses. Water quality will be analyzed for conventional parameters (total suspended solids, alkalinity, hardness), major ions, total and dissolved metals (including in particular metals of potential concern due to elevated background concentrations or potential inputs from runoff as a result of vehicle operations [arsenic, copper, zinc, and cadmium]), and petroleum hydrocarbons. Monitoring will be adaptive in that, if changes to water quality are detected, causation will be determined to allow for appropriate remedial actions and subsequent monitoring will be revisited to ensure it is appropriate both to monitor the effectiveness of remedial actions and future operations. More details on the water management plan are included in the Operations and Maintenance Manual (Appendix A).

5.2.7.3 *Fish and Fish Habitat*

Field monitoring will be conducted to characterize fish and fish habitat conditions in the watercourses that are fish bearing during the first year post-construction and during decommissioning. Monitoring will focus on the effects of any sediment release and deposition during the first year after construction. Post-construction monitoring will be conducted in watercourses most likely to be affected by the road culvert crossings to evaluate the effects of any sediment releases and deposition at crossing sites, and to evaluate fish passage potential through the culverts on the 2 streams used by Arctic grayling. The effectiveness of habitat reclamation following construction will also be evaluated. Monitoring will be adaptive in that, if changes to fish and fish habitat are detected, appropriate remedial actions will be implemented and subsequent monitoring programs adjusted to ensure the effectiveness of remedial actions and future operations.

5.2.8 References

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