7.3 PHYSICAL ENVIRONMENT

7.3.1 Greenhouse Gas Emissions

The Proponent recognizes that the industrial activities associated with the Howse Project will emit substances in the air (Section 7.3.2) which can affect human health (Section 7.5.2.2). This section focuses on GHG emissions from the Howse Project by first describing the general climatic conditions of the Schefferville area (temperature, precipitation and climate change) and also providing an estimate of the GHG emissions resulting from the Howse Project activities. GHG are not considered a VC under the Howse Project EIS as their effects on climate are difficult to quantify, and they were not raised as an issue during public consultations.

7.3.1.1 Component Description

LSA, RSA and Temporal Boundaries

The LSA for climate/GHG includes a 30 km radius centered on the Howse Project which encompasses one government weather station at the Schefferville airport (Schefferville A, 522 m asl., No. 7117825, 1948-present).

The climate of central Ungava has been classified as humid micro-thermal under the Koppen-Gieger system (Pollard, 2005). This area is considered as the RSA for the present study.

The temporal effects of GHG emissions from the Howse Project could be far-reaching and the duration of their synergistic effects on the global climate are impossible to predict a priori. We therefore define the temporal boundary as that when the GHG are emitted from the Howse Project, or the Project duration.

Located at 54° north, the Howse project lies in the path of the dominant westerlies of the mid-latitudes. Long-term records indicate a mean annual air temperature of -5.3 °C at Schefferville, but tundra ridge areas have been documented as having a mean annual air temperature as low as -7 °C (Pollard, 2005). The seasonal pattern of air temperature is typically continental and is characterized by dramatic extremes, with minima as low as -50.6 °C and maxima above 34.3 °C. On average, the first day of frost is September 11 and the last is June 13, yielding 92 frost-free days per year (Cournoyer *et al.,* 2007). Mean annual precipitation is 791 mm, with a peak in summer. The Project area, like elsewhere along the western boundary, is among the driest in Labrador. A little more than half the precipitation falls as snow, the average maximum thickness of which is 71 cm in March. There are 216 days with precipitation in one form or another.

Variation in Snow Cover

Two recent surveys of the snow cover in the Howells River Valley reveal some variations that depend on the type of biotope (Gartner Lee Limited 2006; SNC-Lavalin, 2013a). Results indicate that snow depth is greater but less dense in forest and scrublands than in wetlands and tundra. On average (± standard deviation), the snow thickness was 50.1 (±31.4) cm in March 2012, the water equivalent was 11.0 (±9.1) cm and the density was 22.4 (±7.3).

Wind

Wind speed, with a mean value of 15.5 km/h, varies little from month to month. The wind direction is almost always northwest. Extreme statistics from data collected between 1953 and 2009 show a maximum gust speed of 153 km/h in December, while a sustained wind speed of 97 km/h was recorded for one hour in June.

Existing Literature

Results of air modelling for the Howse Project included an estimate of GHG emissions, which is provided below. Further, the Environment Canada climate station in Schefferville (1948-present, provide climate data to describe, analyze and monitor climate in the area (Figure 7-1).

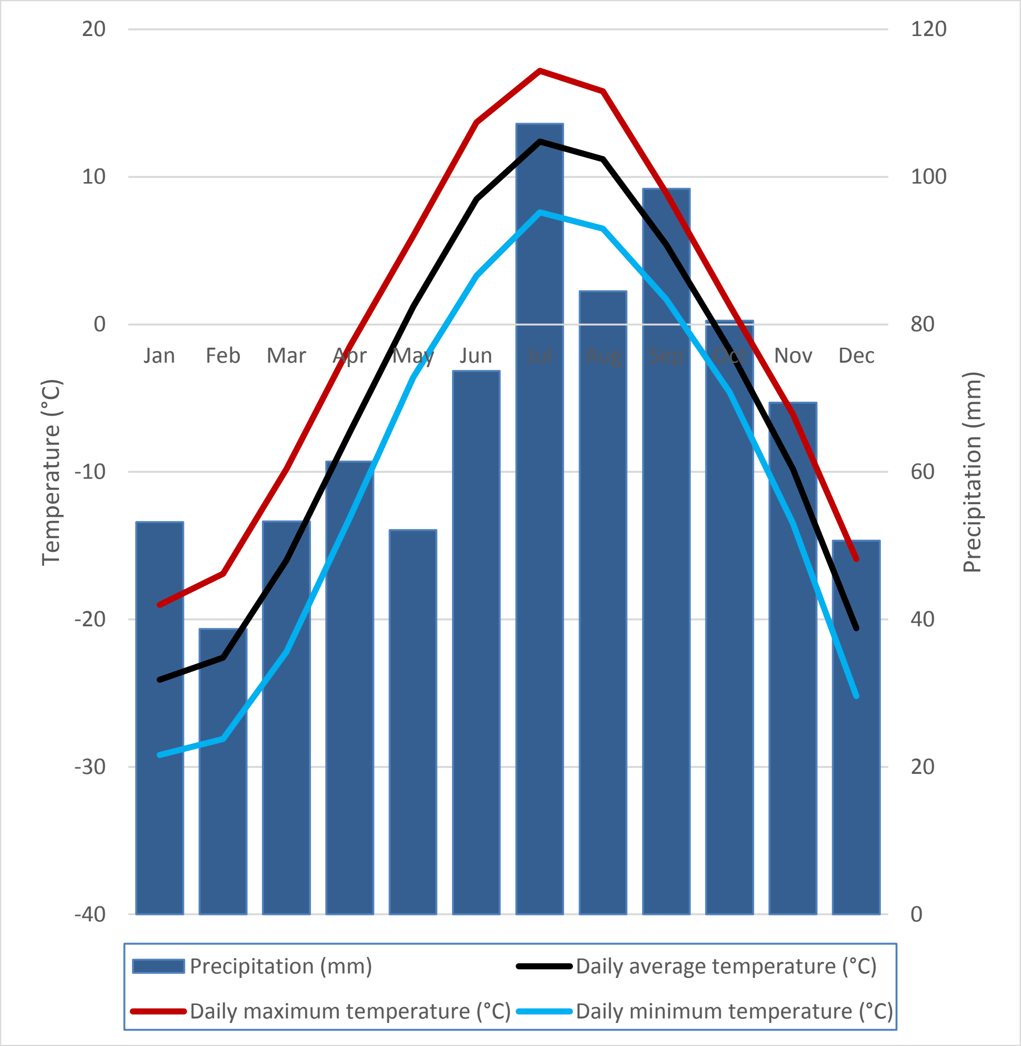


Figure 7-1 Climograph for Schefferville

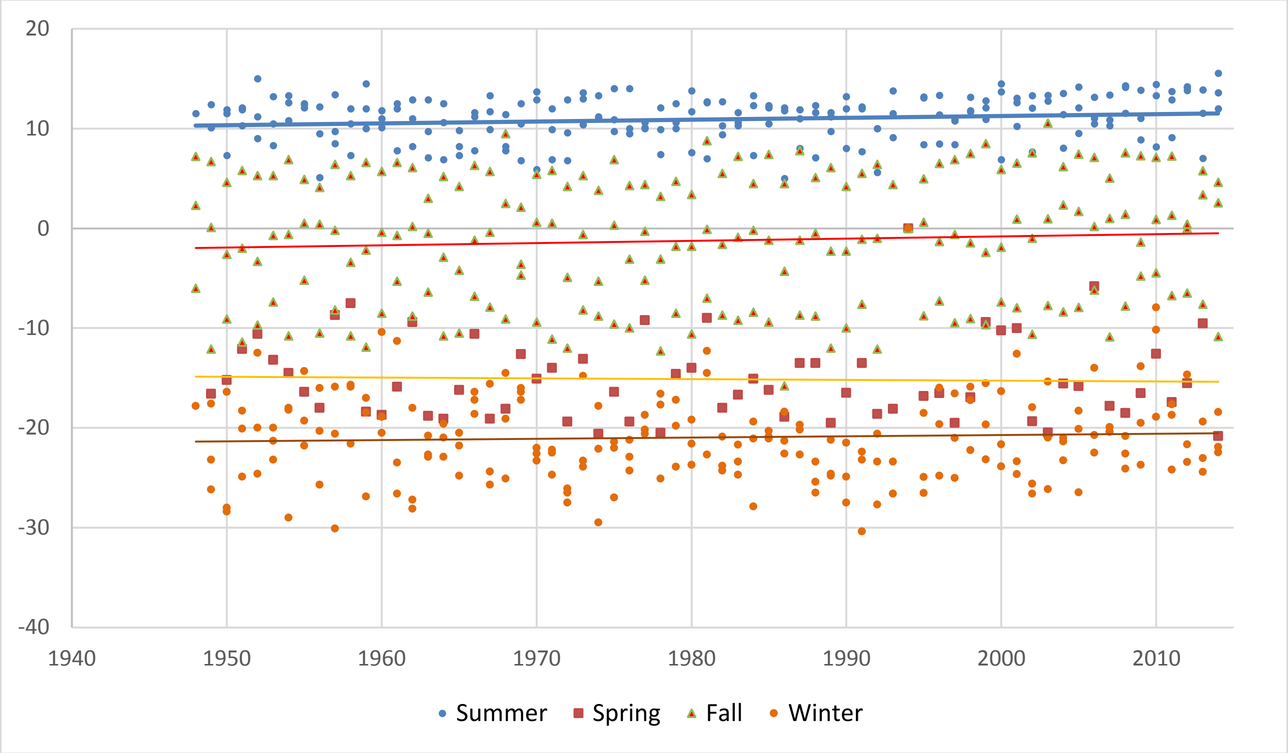


Figure 7-2 Seasonal mean monthly temperature values for Schefferville A station

Finnis (2013) draws the latest provincial climate change projection from an ensemble local-level projection (2038-2070) from seven scenarios from four global models. Results for Wabush Lake and Churchill Falls are considered representative of the LSA/RSA. Seasonally, mean daily minimum (nighttime) temperatures are expected to rise by 3.7 °C in winter (DJF) for Churchill Falls and 3.8 °C at Wabush, 2.4 °C in spring (MAM), 2.1 °C in summer (JJA) (Churchill Falls) and 2.3 °C in Wabush, and 2.5 °C in fall (SON). These changes in minimum daily temperatures are reflective of nighttime temperatures which are predicted to be warmer due to an enhanced greenhouse effect. In particular, with this predicted warming, current mean daily minimum temperatures in fall (-3.9 °C for Churchill Falls and -3.3 °C for Wabush) will approach the thawing mark, and could potentially change snow/ice cover to wet precipitation and increased thawing.

Main daily precipitation is expected to increase by 0.24 mm or 8.1% over the year. For extreme precipitation events, the increase grows with the length of the return period. For a 24-hour duration and a 100-year event, which is the maximum return period analyzed, the projected change is an increase of 8.9% in mean daily precipitation.

An analysis of the effects of climate change on the Project is available in Section 6.6.

Greenhouse Gases

GHG emissions from the Howse Project activities were calculated for all three phases as a whole, since the Construction and Decommissioning and Reclamation phases will be largely limited to road traffic, resulting in negligible emission (as compared to the operations phase). Emissions were estimated based on the amount of fuel burned and the emission factors of the National Inventory Report, 1990-2011 (Environment Canada, 2013a). According to this report, each litre of diesel fuel burned results in the emission of 2,663 g of CO_2, 0.13 g of CH_4 and 0.4 g of N_2O.

Carbon dioxide equivalents (CO2 eq) were determined by multiplying the amount of emissions of a particular gas by the global warming potential (GWP) of that gas. GHGs differ in their ability to absorb heat in the atmosphere due to their differing chemical properties and atmospheric lifetimes. For example, over a period of 100 years, methane's (CH4) potential to trap heat in the atmosphere is 25 times greater than carbon dioxide's potential, and thus it is considered to have a GWP of 25. The IPCC publishes the GWPs and atmospheric lifetimes for each GHG which can be found in Environment Canada (2013a).

Table 7-3 Estimated diesel consumption for the Howse Project

HOWSE MINI-PLANT*						
Description	**Unit**	**L/HR**			**HR/YR**	**L/YR**
2MW Diesel Generator - HOWSE Mini-Plant	1	397			5110	2,028,670
Diesel burner for ore dryer (125 MMBtu/hr)	1	3719			5110	9,502,624
Diesel burner for ore dryer (125 MMBtu/hr)	1	3719			5110	9,502,624
					Total	21033917
HOWSE HAULING TRUCKS **						
Description	**Trips/yr**	**L/HR**	**Trip (km)**	**Time/trip (hr)**	**HR/YR**	**L/YR**
Hauling Trucks - Howse haul road to Howse O.B	211802.0	78.55	2	0.05	12102.97	950688.40
Hauling Trucks - Howse haul road to Howse Waste	124015.5	78.55	0.6	0.01	2125.98	166995.82
Hauling Trucks - Howse pit to Howse haul road and Portion of Howse Main road	124016 (Howse pit to waste) 211802 (Howse pit to O.B)	78.55	2.4	0.06	10805.33	848759.23
Howse haul Road (close to Howse Waste) to Main Plant	96153.84	78.55	2.8	0.08	7692.30	604230.76
Hauling Trucks - Main Plant to Rail loop	96153.84	78.55	0.8	0.02	2197.80	172637.36
Hauling Trucks - Rail loop to Howse Mini-Plant	192307.69	78.55	1.2	0.03	6593.40	517912.08
					Total	3,261,223.65
HOWSE PIT MINING EQUIPMENT GROUP ***						
Description	**Units**	**L/HR/Unit**			**HR/YR**	**L/YR**
HOWSE Pit Mining Activities (Truck+Excav+Excav+Loader+Drill)	5 units	26.28			8760	1151064

* Operation 24HR - 7 months per year

** Speed 35 km/HR

*** Operation 24HR 12 months per year

The GHG emissions were calculated as CO_2 equivalent per year (CO_2eq/yr) using the following IPCC (2013) global warming potentials: 25 for CH_4 and 298 for N_2O. GHG emissions from the Howse Project are estimated to be 0.018 $MtCO_2eq/yr$. Newfoundland and Labrador total GHG emissions for the years 1990, 2005 and 2013 are 9.8, 10.3 and 8.6, respectively (Environment Canada, 2013a https://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=18F3BB9C-1). The Howse emissions represent roughly 0.2% of Newfoundland and Labrador total emissions (based on a mean GHG emissions value of 9.56 MT CO2 eq/YR).

Table 7-4 Estimate of Greenhouse Gases Emissions from the Howse Project

	L/YR	KG CO_2/YR	KG CH_4/YR (KG CO2 EQ)	KG N_2O/YR (KG CO2 EQ)	MT CO2 EQ / YR
Mini-plant	21,033,918	5,601,332.36	2734.41 (68360.25)	8413.57 (2507243.86)	0.0081
Hauling trucks	3,261,223.65	8,684,638.58	423.96 (10599)	1304.49 (388738.02)	0.0091
Pit mining equipment	1,151,064	402,283.43	19.64 (491)	60.43 (18008.14)	0.0004
Total	**348,307,347**	**14,688,254.37**	**3178.01** **(79450.25)**	**9778.49** **(2913990.02)**	**0.018**

The Construction and Decommissioning and Reclamation phases are limited, in their GHG emissions, to truck traffic. Based on the table above, it is expected that GHG emissions for the Construction and Decommissioning and Abandonment phases (1 year each) will be 0.0091 MT CO2 eq/YR. This represents 0.09% of Newfoundland and Labrador total annual emissions (based on a mean GHG emissions value of 9.56 MT CO2 eq/YR).

HML expects to produce an action plan to reduce its GHG emissions in spring 2016. This plan will be based on real data (as opposed to theoretical data, as is the case presently) for while the plant is fully operational.

Aboriginal Traditional Knowledge

Climate change is affecting the ice-free period in the northern part of Nunavik but this is not the case around Schefferville, according to the Kawawachikamach Naskapi community (Tremblay *et al.*, 2006).

7.3.2 Air Quality

The Air Quality effects assessment in this chapter derives from the data presented in the federal report (Volume 2 Supporting Study E). Further to these federal guidelines, 20 new sensitive receptors were added to the Howse Project EIS in compliance with federal guidelines (Figure 7-3). A unique subsection (7.3.2.2.2) is provided which presents the Air Quality results in compliance with the EPR guidelines.

7.3.2.1 Component Description

Mining activities generate air emissions via vehicle travel on roads, diesel engines, power generation and ore mining and processing. The effects of air emissions are particularly apparent during summer, when there is no snow or ice cover on roads and stockpiles. When concentrations of some pollutants in ambient air exceed recognized standards, air quality can provoke complaints and potentially affect the health of ecosystems and humans. Air quality is an important component and clearly outlined in the CEAA guidelines for the preparation of an EIS.

Furthermore, air quality can affect other biophysical components, such as dust settling on water bodies, thereby affecting fish habitat, and human health. Dust effects on air quality was a concern raised 24 times during Aboriginal consultations in the fall of 2014. For all these reasons, air quality is selected as a VC.

LSA, RSA and Temporal Boundaries

The LSA is selected based on the requirements of the air dispersion modelling software used for effects assessments and on provincial regulatory requirements on dispersion modelling methodology. As such, the LSA covers an area of 340 km^2 centered at the UTM coordinates East – 623 000 m, North – 6 082 500 m, located at the center of DSO3, this area extends 17 km north to south and 20 km east to west (see Figure 7-3).

The RSA is a larger area extending east to include the towns of Schefferville and Kawawachikamach, and the Matimekush-Lac John community, located approximately 20 km towards the east of the project. The RSA covers an area of 520 km^2. Centered at the UTM coordinates East – 628 200 m, North – 6 082 130 m, located half way between DSO2 and DSO3, this area extends 17 km north to south and 40.5 km east to west (see Figure 7-3).

The LSA and RSA are characterized by rugged relief, with drops of up to 300 metres. It is covered in large part by coniferous forests and tundra. Sensitive receptors, defined as strategic locations within the RSA where human activities are common, were identified and are also shown in Figure 7-3.

An air quality modelling perimeter was established and air emissions from sources located within this perimeter were included in the air quality modelling study. This way, air emission sources from Howse and DSO3 activities were considered in the study, in addition to emissions due to ore hauling from the DSO4 mining areas (e.g., on the portion of the Goodwood Road located within the air quality modelling perimeter).

The highest air quality effects will be observed during the Operation phase of the Project due to the operation of the processing plants and full scale production (e.g. mining and ore hauling).

During all three project phases, air emissions from diesel powered engines, dust emissions from vehicles and blasting will occur, but rates of air emissions during the operation phase will be continuous and of a higher intensity. One important reason why the nature of the air contaminants remains the same during the three phases is the fact all power used at the site is generated by diesel equipment; the site is not connected to the power grid. Air emissions intensity during the Operation phase will be higher due to continuous intensive mining and processing at the Howse Mini-Plant. Consequently, the air quality effects study was conducted for the Operation phase only.

Mining activities at the Howse Property are expected to be ongoing until 2032, for a total of 15 years. Air emission release rates used in the air modelling study were calculated based on the maximum production year of the project. Similarly, other projects in the vicinity of Howse will also effects air quality, namely DSO3 and DSO4. These two projects, currently in start-up mode, were incorporated in the air modelling study (as baseline or pre-Howse conditions) and the maximum production year for each, were used in emission rates calculations. Therefore, the temporal boundaries for the Air Quality component covers the Operation phase of the project, using the maximum annual production rates available.

Existing Literature

Air emissions effects assessment is performed using an air dispersion modelling software predicting air quality at selected receptors in terms of pollutant concentrations in µg/m^3. Resulting concentrations can then be compared to ambient air quality standards promulgated by federal and provincial authorities (Canada, Québec and Newfoundland and Labrador, in this case).

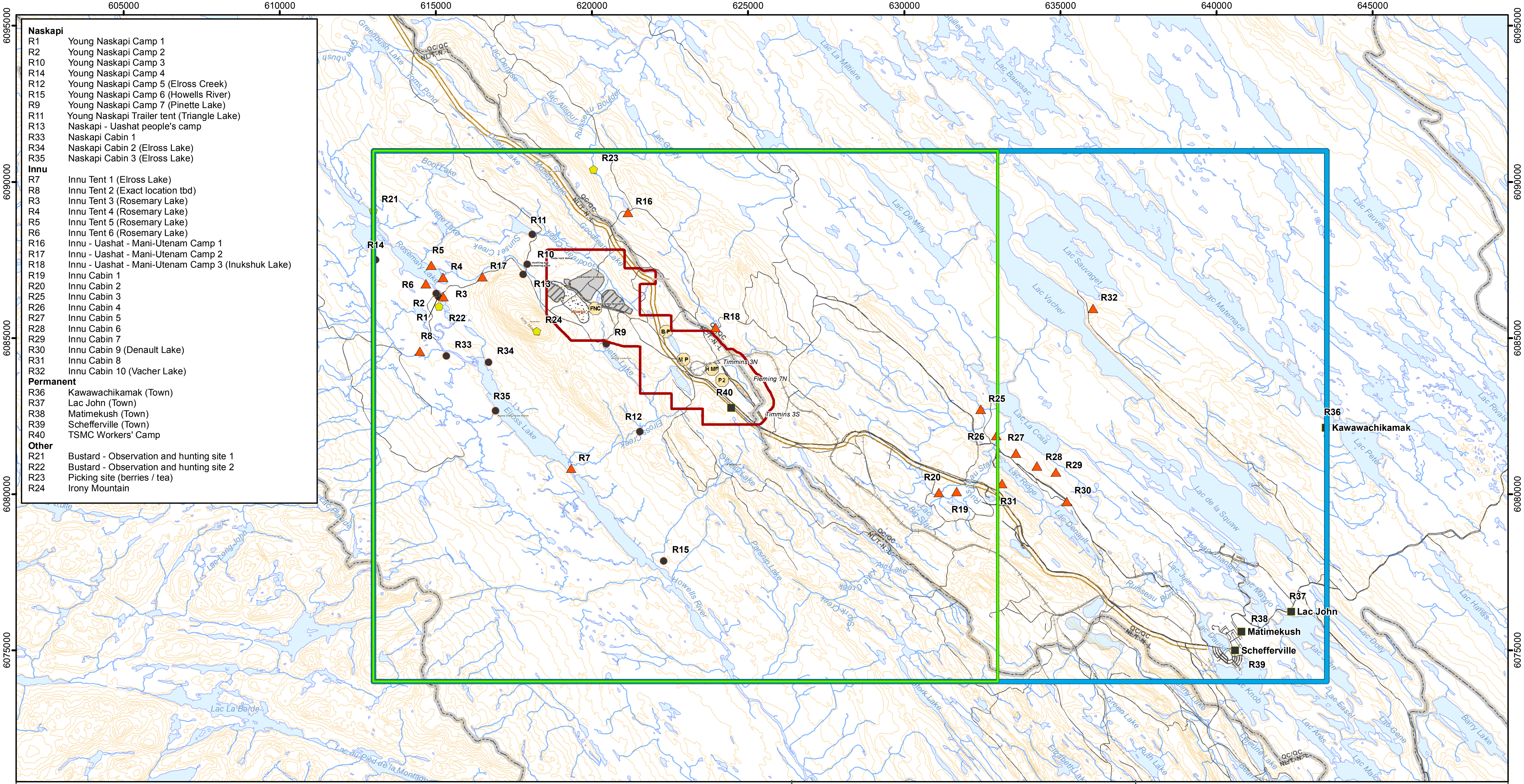
In the past, for different DSO phases, air dispersion modelling was conducted for compliance demonstration or EIS purposes. Examples of previous air dispersion modelling studies are:

- Environmental Impact Assessment (EIA) for the Elross Lake Area Iron Ore Mine (ELAIOM) submitted to the GNL in 2009 (NML and PFWA, 2009);
- EIA for the Direct-Shipping Ore Project 2A (Goodwood, Leroy1, Sunny1 and Kivivik 3S deposits) submitted to the Government of Québec in 2009 (NML and PFWA, 2010);
- Environmental license application for DSO3 mining and processing application (TSMC, 2014); and
- Environmental license application for Joan Lake Project - Kivivic 1c and 2, part of the DSO4 Area (TSMC, 2015).

Reports, data and methodologies from these previous air modelling efforts were incorporated in the current Howse project assessment. To ensure consistency, some key aspects and/or methodologies of previous studies were used for the Howse Project EIS and include the following:

- CALPUFF dispersion modelling software;
- meteorological data;
- topographical data;
- terrain usage; and
- methodologies to calculate emission factors for sources such as roads, vehicle engines, diesel generators, drills, mining activities, truck loading and unloading and ore processing activities.

To establish background air concentrations, which for this study would represent air concentrations prior to the start of DSO3/DSO4, a review of existing monitoring data and guidance information documents provided by provinces and applicable to the region was conducted. A memo summarizing this review is available in the Air Dispersion Modelling Report (Volume 2 Supporting Study E). Background air concentrations selected for the Howse EIS were based on the conclusions presented in the memo.



Naskapi	
R1	Young Naskapi Camp 1
R2	Young Naskapi Camp 2
R10	Young Naskapi Camp 3
R14	Young Naskapi Camp 4
R12	Young Naskapi Camp 5 (Elross Creek)
R15	Young Naskapi Camp 6 (Howells River)
R9	Young Naskapi Camp 7 (Pinette Lake)
R11	Young Naskapi Trailer tent (Triangle Lake)
R13	Naskapi - Uashat people's camp
R33	Naskapi Cabin 1
R34	Naskapi Cabin 2 (Elross Lake)
R35	Naskapi Cabin 3 (Elross Lake)
Innu	
R7	Innu Tent 1 (Elross Lake)
R8	Innu Tent 2 (Exact location tbd)
R3	Innu Tent 3 (Rosemary Lake)
R4	Innu Tent 4 (Rosemary Lake)
R5	Innu Tent 5 (Rosemary Lake)
R6	Innu Tent 6 (Rosemary Lake)
R16	Innu - Uashat - Mani-Utenam Camp 1
R17	Innu - Uashat - Mani-Utenam Camp 2
R18	Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake)
R19	Innu Cabin 1
R20	Innu Cabin 2
R25	Innu Cabin 3
R26	Innu Cabin 4
R27	Innu Cabin 5
R28	Innu Cabin 6
R29	Innu Cabin 7
R30	Innu Cabin 9 (Denault Lake)
R31	Innu Cabin 8
R32	Innu Cabin 10 (Vacher Lake)
Permanent	
R36	Kawawachikamak (Town)
R37	Lac John (Town)
R38	Matimekush (Town)
R39	Schefferville (Town)
R40	TSMC Workers' Camp
Other	
R21	Bustard - Observation and hunting site 1
R22	Bustard - Observation and hunting site 2
R23	Picking site (berries / tea)
R24	Irony Mountain

LEGEND

Sensitive Receptors
- ● Naskapi
- ▲ Innu
- ■ Permanent
- ⬟ Other

Study Areas
- 🟩 Local Study Area (LSA)
- 🟦 Regional Study Area (RSA)
- 🟥 Air Quality Modelling Perimeter

Infrastructure and Mining Components
- P2 Plant 2
- MP Main processing Plant
- HMP Howse Mini-Plant
- BP Batch Plant
- FNC First Nations crusher/screener
- — DSO Haul Road
- ┼ Existing Railroad
- ▨ Deposit
- ▨ Proposed Howse Pit
- ■ Proposed Topsoil/ Overburden Stockpile
- ▨ Proposed Waste Dump/ In-Pit Dump
- ▭ Proposed Mine Haul Road

Basemap
- — Existing road
- — Contour Line (50 ft)
- — Provincial Border
- — Watercourse
- ■ Water Body

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0672 , PR185-19-14, 2016-03-23, edickoum

N

0 2 4
Kilometers
SCALE: 1:120 000

UTM 19N NAD 83

SOURCES:

Basemap and Land Use Components
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec,

Mining Components
Howse Minerals Limited/
MET-CHEM Howse Deposit Design
for General Layout., 2015
Groupe Hémisphères, Hydrology and update, 2013

AECOM

ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Study Areas for Air Quality Modelling

Howse Minerals Limited

GroupeHemispheres

5731, rue Saint-Louis,
Bureau 201, Lévis (QC)
Canada, G6V 4E2

1453, rue Beaubien est,
Bureau 301, Montréal (QC)
Canada, H2G 3C6

Figure 7.3

Data Gaps

It is anticipated that during normal operation, blasting at the Howse Property will occur approximately once per week during summer and infrequently during winter. Blasting will also occur at the Fleming 7N pit, and since this pit is part of the DSO3 area and may have parallel operations with Howse, blasting events at both pits are included in the dispersion modelling study. Blasting events are short in duration and infrequent. The air dispersion software input requirements limits the representativeness of these blasting events, which leads to an overestimation of the resulting short-term effects on air quality. The methodology used to capture a wide variety of meteorological conditions in the air model, was to assume one blast per day at each pit would be conducted. At the Fleming 7N pit, the blast was assumed to occur between 11AM-12PM. At the Howse pit, the blast was assumed to occur between 1PM-2PM. Using this methodology, the number of blasting events entered in the model is 730 (365 blasts/yr/2 pits), while in reality approximately 60 blasting events are expected for the two pits (Fleming 7N and Howse). An additional data gap related to blasting events is the limited knowledge on actual emissions from blasts. Conservative emission factors from USEPA AP-42 were used in the calculations. These factors have a rating of “D” on a scale of A to E. One way to minimize to minimize the emission factors lack of representativeness would be to obtain more precise factors to depict emissions from explosive detonation during the blasts. Such factors were not available at the time of preparing this air quality assessment.

7.3.2.2 Effects Assessment

This section contains two subsections which present the results which comply with the Government of Newfoundland and Labrador Air Quality modelling requirements and the CEAA guidelines, respectively. We begin with the EPR requirements.

7.3.2.2.1 Effects Assessment on EPR guidelines

Modelling Results and Discussion

To optimize air dispersion modelling and computing time, project sources have been divided into several CALPUFF modelling input files. Concentration results obtained for each modelling have been compiled with CALSUM and then post processed with CALPOST. CALPUFF and CALPOST input files are referenced in Volume 2 Supporting Study E, but due to their number and volume, they are available electronically on request.

Volume 2 Supporting Study E explains how background concentrations and baseline concentrations due to other projects (e.g. DSO3 and DSO4) are incorporated in the results. Resulting concentrations are compared to the NL ambient air quality standards presented in Volume 2 Supporting Study E.

The results from the air dispersion modelling for all air pollutants assessed in this study are presented in this report in tabular format at the sensitive receptor locations, and also at grid receptors having the highest impacts.

Each table has a similar format and contains:

- Identification of averaging period and pollutants
- NL Ambient Air Quality Standards
- Background concentrations
- Separate resulting concentrations for each DSO Areas included in the air modelling study:
    - DSO3 and DSO4 only;
    - Howse Only;
    - Combined DSO3, DSO4 and Howse;
    - All: Background + DSO3, DSO4 and Howse.

- Selected Sensitive Receptors. Volume 2 Supporting Study E describes the 23 sensitive receptors located in NL and included in this study.
- Grid Receptors with highest impacts. The maximum modelled concentrations at grid receptors located on or outside the air quality modelling perimeter (e.g. typically referred to as "Off-Property Limits" concentrations). Maximum concentrations in NL are reported. These grid receptors are NOT sensitive receptors; they are just equally spaced geographical points entered in the Calpuff model as per air modelling guidelines.

Table 7-5 Summary Results – Annual Concentrations

RESULTS - 1 Yr AVG.

Pollutant	TPM	PM10	PM2.5	SO2	NO2
Averaging Period	1-yr	1-yr	1-yr	1-yr	1-yr
NL Ambient Air Quality Standard	**60**	**--**	**8.8**	**60**	**100**
Level or rank *	1st	1st	1st	1st	1st
BACKGROUND CONCENTRATIONS - PRE-DSO3	**15**	**10**	**5**	**5**	**3.8**

DSO3 + DSO4 ONLY

ID	Description	TPM, 1-yr	PM10, 1-yr	PM2.5, 1-yr	SO2, 1-yr	NO2, 1-yr
R1	Young Naskapi Camp 1	0.1	0.0	0.0	0.0	0.2
R2	Young Naskapi Camp 2	0.1	0.0	0.0	0.0	0.2
R3	Innu Tent 3 (Rosemary Lake)	0.1	0.0	0.0	0.0	0.2
R4	Innu Tent 4 (Rosemary Lake)	0.1	0.0	0.0	0.0	0.2
R5	Innu Tent 5 (Rosemary Lake)	0.1	0.0	0.0	0.0	0.2
R6	Innu Tent 6 (Rosemary Lake)	0.1	0.0	0.0	0.0	0.3
R7	Innu Tent 1 (Elross Lake)	0.1	0.0	0.0	0.0	0.3
R8	Innu Tent 2 (Exact location tbd)	0.1	0.0	0.0	0.0	0.3
R9	Young Naskapi Camp 7 (Pinette Lake)	0.4	0.2	0.1	0.0	1.5
R10	Young Naskapi Camp 3	0.3	0.1	0.0	0.0	0.6
R11	Young Naskapi Trailer tent (Triangle Lake)	0.2	0.1	0.0	0.0	0.6
R12	Young Naskapi Camp 5 (Elross Creek)	0.2	0.1	0.1	0.0	1.1
R13	Naskapi - Uashat people's camp	0.3	0.1	0.0	0.0	0.7
R14	Young Naskapi Camp 4	0.0	0.0	0.0	0.0	0.2
R15	Young Naskapi Camp 6 (Howells River)	0.1	0.0	0.0	0.0	0.4
R17	Innu - Uashat - Mani-Utenam Camp 2	0.1	0.0	0.0	0.0	0.3
R21	Bustard - Observation and hunting site 1	0.0	0.0	0.0	0.0	0.1
R22	Bustard - Observation and hunting site 2	0.1	0.0	0.0	0.0	0.3
R24	Irony Mountain	0.4	0.2	0.1	0.0	1.5
R33	Naskapi Cabin 1	0.1	0.0	0.0	0.0	0.3
R34	Naskapi Cabin 2 (Elross Lake)	0.1	0.0	0.0	0.0	0.3
R35	Naskapi Cabin 3 (Elross Lake)	0.1	0.0	0.0	0.0	0.4
R40	TSMC Workers' Camp	2.5	1.3	0.7	0.1	18.6
--	"Off-Property Limit" Maximum - Newfoundland/Labrador	9.8	3.6	0.9	0.0	13.8

HOWSE ONLY

ID	Name	TPM, 1-yr	PM10, 1-yr	PM2.5, 1-yr	SO2, 1-yr	NO2, 1-yr
R1	Young Naskapi Camp 1	0.1	0.0	0.0	0.0	0.1
R2	Young Naskapi Camp 2	0.1	0.0	0.0	0.0	0.1
R3	Innu Tent 3 (Rosemary Lake)	0.1	0.0	0.0	0.0	0.1
R4	Innu Tent 4 (Rosemary Lake)	0.1	0.0	0.0	0.0	0.1
R5	Innu Tent 5 (Rosemary Lake)	0.1	0.0	0.0	0.0	0.1
R6	Innu Tent 6 (Rosemary Lake)	0.1	0.0	0.0	0.0	0.1
R7	Innu Tent 1 (Elross Lake)	0.1	0.0	0.0	0.0	0.1
R8	Innu Tent 2 (Exact location tbd)	0.1	0.0	0.0	0.0	0.1
R9	Young Naskapi Camp 7 (Pinette Lake)	1.0	0.5	0.1	0.0	1.2
R10	Young Naskapi Camp 3	0.6	0.3	0.1	0.0	0.8
R11	Young Naskapi Trailer tent (Triangle Lake)	0.4	0.2	0.0	0.0	0.5
R12	Young Naskapi Camp 5 (Elross Creek)	0.2	0.1	0.0	0.0	0.3
R13	Naskapi - Uashat people's camp	0.6	0.3	0.1	0.0	1.0
R14	Young Naskapi Camp 4	0.0	0.0	0.0	0.0	0.1
R15	Young Naskapi Camp 6 (Howells River)	0.1	0.0	0.0	0.0	0.1
R17	Innu - Uashat - Mani-Utenam Camp 2	0.1	0.1	0.0	0.0	0.2
R21	Bustard - Observation and hunting site 1	0.0	0.0	0.0	0.0	0.0
R22	Bustard - Observation and hunting site 2	0.1	0.0	0.0	0.0	0.1
R24	Irony Mountain	0.8	0.4	0.1	0.0	1.2
R33	Naskapi Cabin 1	0.1	0.0	0.0	0.0	0.1
R34	Naskapi Cabin 2 (Elross Lake)	0.1	0.0	0.0	0.0	0.1
R35	Naskapi Cabin 3 (Elross Lake)	0.1	0.0	0.0	0.0	0.1
R40	TSMC Workers' Camp	1.7	0.7	0.2	0.0	2.1
--	"Off-Property Limit" Maximum - Newfoundland/Labrador	4.7	2.1	0.5	0.0	5.5

- all values in μg/m^3. Red cell, if any, indicates above criteria.
* nth highest levels as per NL Guidance Document GD-PPD-009.4 (2012)

RESULTS - 1 Yr AVG. (cont'd)

Pollutant	TPM	PM10	PM2.5	SO2	NO2
Averaging Period	1-yr	1-yr	1-yr	1-yr	1-yr
NL Ambient Air Quality Standard	**60**	**--**	**8.8**	**60**	**100**
Level or rank *	1st	1st	1st	1st	1st
BACKGROUND CONCENTRATIONS - PRE-DSO3	**15**	**10**	**5**	**5**	**3.8**

	ID	Name	TPM, 1-yr	PM10, 1-	PM2.5, 1-	SO2, 1-yr	NO2, 1-yr
DSO3 + DSO4 + HOWSE	R1	Young Naskapi Camp 1	0.1	0.1	0.0	0.0	0.3
	R2	Young Naskapi Camp 2	0.1	0.1	0.0	0.0	0.3
	R3	Innu Tent 3 (Rosemary Lake)	0.1	0.1	0.0	0.0	0.3
	R4	Innu Tent 4 (Rosemary Lake)	0.1	0.1	0.0	0.0	0.3
	R5	Innu Tent 5 (Rosemary Lake)	0.1	0.1	0.0	0.0	0.3
	R6	Innu Tent 6 (Rosemary Lake)	0.1	0.1	0.0	0.0	0.3
	R7	Innu Tent 1 (Elross Lake)	0.1	0.1	0.0	0.0	0.4
	R8	Innu Tent 2 (Exact location tbd)	0.1	0.1	0.0	0.0	0.4
	R9	Young Naskapi Camp 7 (Pinette Lake)	1.4	0.7	0.2	0.0	2.7
	R10	Young Naskapi Camp 3	0.8	0.4	0.1	0.0	1.4
	R11	Young Naskapi Trailer tent (Triangle Lake)	0.6	0.3	0.1	0.0	1.1
	R12	Young Naskapi Camp 5 (Elross Creek)	0.4	0.2	0.1	0.0	1.3
	R13	Naskapi - Uashat people's camp	0.9	0.5	0.1	0.0	1.6
	R14	Young Naskapi Camp 4	0.1	0.0	0.0	0.0	0.2
	R15	Young Naskapi Camp 6 (Howells River)	0.1	0.1	0.0	0.0	0.5
	R17	Innu - Uashat - Mani-Utenam Camp 2	0.2	0.1	0.0	0.0	0.5
	R21	Bustard - Observation and hunting site 1	0.1	0.0	0.0	0.0	0.2
	R22	Bustard - Observation and hunting site 2	0.1	0.1	0.0	0.0	0.4
	R24	Irony Mountain	1.1	0.6	0.2	0.0	2.6
	R33	Naskapi Cabin 1	0.1	0.1	0.0	0.0	0.4
	R34	Naskapi Cabin 2 (Elross Lake)	0.1	0.1	0.0	0.0	0.4
	R35	Naskapi Cabin 3 (Elross Lake)	0.1	0.1	0.0	0.0	0.5
	R40	TSMC Workers' Camp	4.2	2.1	0.8	0.1	19.8
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	12.8	4.9	1.1	0.0	16.4

	ID	Name	TPM, 1-yr	PM10, 1-yr	PM2.5, 1-yr	SO2, 1-yr	NO2, 1-yr
ALL: Background + DSO3 + DSO4 + HOWSE	R1	Young Naskapi Camp 1	15.1	10.1	5.0	5.0	4.1
	R2	Young Naskapi Camp 2	15.1	10.1	5.0	5.0	4.1
	R3	Innu Tent 3 (Rosemary Lake)	15.1	10.1	5.0	5.0	4.1
	R4	Innu Tent 4 (Rosemary Lake)	15.1	10.1	5.0	5.0	4.1
	R5	Innu Tent 5 (Rosemary Lake)	15.1	10.1	5.0	5.0	4.1
	R6	Innu Tent 6 (Rosemary Lake)	15.1	10.1	5.0	5.0	4.1
	R7	Innu Tent 1 (Elross Lake)	15.1	10.1	5.0	5.0	4.2
	R8	Innu Tent 2 (Exact location tbd)	15.1	10.1	5.0	5.0	4.2
	R9	Young Naskapi Camp 7 (Pinette Lake)	16.4	10.7	5.2	5.0	6.5
	R10	Young Naskapi Camp 3	15.8	10.4	5.1	5.0	5.2
	R11	Young Naskapi Trailer tent (Triangle Lake)	15.6	10.3	5.1	5.0	4.9
	R12	Young Naskapi Camp 5 (Elross Creek)	15.4	10.2	5.1	5.0	5.1
	R13	Naskapi - Uashat people's camp	15.9	10.5	5.1	5.0	5.4
	R14	Young Naskapi Camp 4	15.1	10.0	5.0	5.0	4.0
	R15	Young Naskapi Camp 6 (Howells River)	15.1	10.1	5.0	5.0	4.3
	R17	Innu - Uashat - Mani-Utenam Camp 2	15.2	10.1	5.0	5.0	4.3
	R21	Bustard - Observation and hunting site 1	15.1	10.0	5.0	5.0	4.0
	R22	Bustard - Observation and hunting site 2	15.1	10.1	5.0	5.0	4.2
	R24	Irony Mountain	16.1	10.6	5.2	5.0	6.4
	R33	Naskapi Cabin 1	15.1	10.1	5.0	5.0	4.2
	R34	Naskapi Cabin 2 (Elross Lake)	15.1	10.1	5.0	5.0	4.2
	R35	Naskapi Cabin 3 (Elross Lake)	15.1	10.1	5.0	5.0	4.3
	R40	TSMC Workers' Camp	19.2	12.1	5.8	5.1	23.6
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	27.8	14.9	6.1	5.0	20.2

- all values in µg/m3. Red cell, if any, indicates above criteria.
*** nth highest levels as per NL Guidance Document GD-PPD-009.4 (2012)**

Table 7-6 Summary Results – Daily (24-hr) Concentrations

			RESULTS - 24-Hr AVG.				
		Pollutant	TPM	PM10	PM2.5	SO2	NO2
		Averaging Period	24-hr	24-hr	24-hr	24-hr	24-hr
		NL Ambient Air Quality Standard	**120**	**50**	**25**	**300**	**200**
		Level or rank *	2nd	2nd	2nd	2nd	2nd
		BACKGROUND CONCENTRATIONS - PRE-DSO3	**15**	**10**	**5**	**5**	**3.8**
DSO3 + DSO4 ONLY	**ID**	**Description**	TPM, 24-hr	PM10, 24-hr	PM2.5, 24-hr	SO2, 24-hr	NO2, 24-hr
	R1	Young Naskapi Camp 1	0.8	0.4	0.3	0.0	5.8
	R2	Young Naskapi Camp 2	0.8	0.4	0.3	0.0	5.6
	R3	Innu Tent 3 (Rosemary Lake)	0.8	0.4	0.3	0.0	5.7
	R4	Innu Tent 4 (Rosemary Lake)	0.8	0.4	0.2	0.0	4.9
	R5	Innu Tent 5 (Rosemary Lake)	0.8	0.4	0.2	0.0	4.8
	R6	Innu Tent 6 (Rosemary Lake)	0.9	0.5	0.3	0.0	5.5
	R7	Innu Tent 1 (Elross Lake)	0.8	0.5	0.3	0.0	6.1
	R8	Innu Tent 2 (Exact location tbd)	0.9	0.6	0.4	0.0	10.3
	R9	Young Naskapi Camp 7 (Pinette Lake)	4.4	2.6	2.0	0.0	44.5
	R10	Young Naskapi Camp 3	2.6	1.0	0.7	0.0	17.1
	R11	Young Naskapi Trailer tent (Triangle Lake)	2.0	1.0	0.5	0.0	13.7
	R12	Young Naskapi Camp 5 (Elross Creek)	2.0	1.4	1.2	0.0	25.2
	R13	Naskapi - Uashat people's camp	3.1	1.2	0.6	0.0	14.9
	R14	Young Naskapi Camp 4	0.6	0.4	0.2	0.0	4.5
	R15	Young Naskapi Camp 6 (Howells River)	0.9	0.5	0.3	0.0	7.7
	R17	Innu - Uashat - Mani-Utenam Camp 2	1.1	0.6	0.3	0.0	6.7
	R21	Bustard - Observation and hunting site 1	0.6	0.3	0.1	0.0	2.3
	R22	Bustard - Observation and hunting site 2	0.9	0.5	0.4	0.0	7.0
	R24	Irony Mountain	4.5	2.4	1.3	0.0	34.3
	R33	Naskapi Cabin 1	1.0	0.7	0.5	0.0	10.8
	R34	Naskapi Cabin 2 (Elross Lake)	0.8	0.5	0.3	0.0	8.7
	R35	Naskapi Cabin 3 (Elross Lake)	0.9	0.6	0.4	0.0	7.5
	R40	TSMC Workers' Camp	16.1	7.9	5.6	0.5	203.7
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	85.9	31.1	6.2	0.1	139.6
HOWSE ONLY	**ID**	**Name**	TPM, 24-hr	PM10, 24-hr	PM2.5, 24-hr	SO2, 24-hr	NO2, 24-hr
	R1	Young Naskapi Camp 1	1.5	0.7	0.2	0.0	1.8
	R2	Young Naskapi Camp 2	1.5	0.7	0.2	0.0	1.8
	R3	Innu Tent 3 (Rosemary Lake)	1.5	0.7	0.2	0.0	1.8
	R4	Innu Tent 4 (Rosemary Lake)	1.8	0.9	0.2	0.0	2.0
	R5	Innu Tent 5 (Rosemary Lake)	1.9	0.9	0.2	0.0	2.3
	R6	Innu Tent 6 (Rosemary Lake)	1.6	0.8	0.2	0.0	1.8
	R7	Innu Tent 1 (Elross Lake)	1.1	0.5	0.1	0.0	1.4
	R8	Innu Tent 2 (Exact location tbd)	1.1	0.6	0.2	0.0	1.6
	R9	Young Naskapi Camp 7 (Pinette Lake)	9.1	4.0	1.0	0.0	10.2
	R10	Young Naskapi Camp 3	10.4	5.0	1.1	0.0	10.2
	R11	Young Naskapi Trailer tent (Triangle Lake)	5.6	2.5	0.5	0.0	6.5
	R12	Young Naskapi Camp 5 (Elross Creek)	2.3	1.1	0.3	0.0	2.4
	R13	Naskapi - Uashat people's camp	11.1	7.2	1.5	0.0	13.7
	R14	Young Naskapi Camp 4	0.9	0.4	0.1	0.0	1.4
	R15	Young Naskapi Camp 6 (Howells River)	0.8	0.4	0.1	0.0	1.3
	R17	Innu - Uashat - Mani-Utenam Camp 2	3.1	1.6	0.5	0.0	5.2
	R21	Bustard - Observation and hunting site 1	0.7	0.4	0.1	0.0	0.8
	R22	Bustard - Observation and hunting site 2	1.4	0.8	0.2	0.0	2.2
	R24	Irony Mountain	10.1	6.2	1.4	0.0	16.7
	R33	Naskapi Cabin 1	1.2	0.7	0.2	0.0	1.8
	R34	Naskapi Cabin 2 (Elross Lake)	1.5	0.7	0.1	0.0	1.5
	R35	Naskapi Cabin 3 (Elross Lake)	1.1	0.6	0.1	0.0	1.3
	R40	TSMC Workers' Camp	15.3	7.9	2.5	0.2	33.2
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	74.9	32.3	8.6	0.4	81.4

- all values in µg/m3. Red cell, if any, indicates above criteria.
*** nth highest levels as per NL Guidance Document GD-PPD-009.4 (2012)**

RESULTS - 24-Hr AVG. (cont'd)

		Pollutant	TPM	PM10	PM2.5	SO2	NO2
		Averaging Period	24-hr	24-hr	24-hr	24-hr	24-hr
		NL Ambient Air Quality Standard	**120**	**50**	**25**	**300**	**200**
		Level or rank *	2nd	2nd	2nd	2nd	2nd
		BACKGROUND CONCENTRATIONS - PRE-DSO3	**15**	**10**	**5**	**5**	**3.8**
DSO3 + DSO4 + HOWSE	**ID**	**Name**	TPM, 24-hr	PM10, 24-hr	PM2.5, 24-hr	SO2, 24-hr	NO2, 24-hr
	R1	Young Naskapi Camp 1	2.1	1.0	0.4	0.0	7.4
	R2	Young Naskapi Camp 2	2.1	1.0	0.4	0.0	7.2
	R3	Innu Tent 3 (Rosemary Lake)	2.1	1.0	0.4	0.0	7.3
	R4	Innu Tent 4 (Rosemary Lake)	2.4	1.2	0.4	0.0	7.0
	R5	Innu Tent 5 (Rosemary Lake)	2.4	1.3	0.4	0.0	7.1
	R6	Innu Tent 6 (Rosemary Lake)	2.2	1.0	0.4	0.0	6.9
	R7	Innu Tent 1 (Elross Lake)	2.1	1.0	0.3	0.0	7.1
	R8	Innu Tent 2 (Exact location tbd)	1.6	1.1	0.5	0.0	11.7
	R9	Young Naskapi Camp 7 (Pinette Lake)	11.1	5.4	2.0	0.0	44.5
	R10	Young Naskapi Camp 3	12.0	5.8	1.4	0.0	27.3
	R11	Young Naskapi Trailer tent (Triangle Lake)	6.8	3.2	0.8	0.0	14.0
	R12	Young Naskapi Camp 5 (Elross Creek)	3.9	1.8	1.2	0.0	25.4
	R13	Naskapi - Uashat people's camp	15.8	8.0	1.7	0.0	20.1
	R14	Young Naskapi Camp 4	1.3	0.7	0.3	0.0	5.5
	R15	Young Naskapi Camp 6 (Howells River)	1.7	0.9	0.3	0.0	7.7
	R17	Innu - Uashat - Mani-Utenam Camp 2	4.1	2.0	0.7	0.0	12.1
	R21	Bustard - Observation and hunting site 1	1.4	0.7	0.1	0.0	3.1
	R22	Bustard - Observation and hunting site 2	2.0	1.2	0.5	0.0	8.9
	R24	Irony Mountain	14.3	8.6	1.9	0.1	37.1
	R33	Naskapi Cabin 1	1.8	1.1	0.6	0.0	12.0
	R34	Naskapi Cabin 2 (Elross Lake)	2.0	0.9	0.4	0.0	8.7
	R35	Naskapi Cabin 3 (Elross Lake)	1.8	1.0	0.4	0.0	7.6
	R40	TSMC Workers' Camp	29.3	14.6	5.6	0.5	204.3
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	99.2	37.1	8.8	0.4	139.6
ALL: Background + DSO3 + DSO4 + HOWSE	**ID**	**Name**	TPM, 24-hr	PM10, 24-hr	PM2.5, 24-hr	SO2, 24-hr	NO2, 24-hr
	R1	Young Naskapi Camp 1	17.1	11.0	5.4	5.0	11.2
	R2	Young Naskapi Camp 2	17.1	11.0	5.4	5.0	11.0
	R3	Innu Tent 3 (Rosemary Lake)	17.1	11.0	5.4	5.0	11.1
	R4	Innu Tent 4 (Rosemary Lake)	17.4	11.2	5.4	5.0	10.8
	R5	Innu Tent 5 (Rosemary Lake)	17.4	11.3	5.4	5.0	10.9
	R6	Innu Tent 6 (Rosemary Lake)	17.2	11.0	5.4	5.0	10.7
	R7	Innu Tent 1 (Elross Lake)	17.1	11.0	5.3	5.0	10.9
	R8	Innu Tent 2 (Exact location tbd)	16.6	11.1	5.5	5.0	15.5
	R9	Young Naskapi Camp 7 (Pinette Lake)	26.1	15.4	7.0	5.0	48.3
	R10	Young Naskapi Camp 3	27.0	15.8	6.4	5.0	31.1
	R11	Young Naskapi Trailer tent (Triangle Lake)	21.8	13.2	5.8	5.0	17.8
	R12	Young Naskapi Camp 5 (Elross Creek)	18.9	11.8	6.2	5.0	29.2
	R13	Naskapi - Uashat people's camp	30.8	18.0	6.7	5.0	23.9
	R14	Young Naskapi Camp 4	16.3	10.7	5.3	5.0	9.3
	R15	Young Naskapi Camp 6 (Howells River)	16.7	10.9	5.3	5.0	11.5
	R17	Innu - Uashat - Mani-Utenam Camp 2	19.1	12.0	5.7	5.0	15.9
	R21	Bustard - Observation and hunting site 1	16.4	10.7	5.1	5.0	6.9
	R22	Bustard - Observation and hunting site 2	17.0	11.2	5.5	5.0	12.7
	R24	Irony Mountain	29.3	18.6	6.9	5.1	40.9
	R33	Naskapi Cabin 1	16.8	11.1	5.6	5.0	15.8
	R34	Naskapi Cabin 2 (Elross Lake)	17.0	10.9	5.4	5.0	12.5
	R35	Naskapi Cabin 3 (Elross Lake)	16.8	11.0	5.4	5.0	11.4
	R40	TSMC Workers' Camp	44.3	24.6	10.6	5.5	208.1
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	114.2	47.1	13.8	5.4	143.4

- all values in µg/m3. Red cell, if any, indicates above criteria.

*** nth highest levels as per NL Guidance Document GD-PPD-009.4 (2012)**

Table 7-7 Summary Results – 1-Hr, 3-Hr, 8-Hr Concentrations

	RESULTS - 1-Hr, 3-Hr, 8-Hr Averages							
Pollutant	SO2	SO2	NO2	CO	CO	TPM	PM10	PM2.5
Averaging Period	3-hr	1-hr	1-hr	8-hr	1-hr	1-hr	1-hr	1-hr
NL Ambient Air Quality Standard	**600**	**900**	**400**	**15000**	**35000**	--	--	--
Level or rank *	6th	9th	9th	3rd	9th	9th	9th	9th
BACKGROUND CONCENTRATIONS - PRE-DSO3	**5**	**5**	**4**	**114**	**114**	**15**	**10**	**5**

DSO3 + DSO4 ONLY

ID	Description	SO2, 3-hr	SO2, 1-hr	NO2, 1-hr	CO, 8-hr	CO, 1-hr	TPM, 1-hr	PM10, 1-hr	PM2.5, 1-hr
R1	Young Naskapi Camp 1	0.0	0.0	19.2	1.6	2.6	2.7	1.6	1.0
R2	Young Naskapi Camp 2	0.0	0.0	20.3	1.6	2.6	2.7	1.7	1.0
R3	Innu Tent 3 (Rosemary Lake)	0.0	0.0	18.8	1.5	2.5	2.6	1.5	1.0
R4	Innu Tent 4 (Rosemary Lake)	0.0	0.0	17.3	1.4	2.5	2.3	1.3	0.8
R5	Innu Tent 5 (Rosemary Lake)	0.0	0.0	17.2	1.5	2.4	3.0	1.3	0.8
R6	Innu Tent 6 (Rosemary Lake)	0.0	0.0	23.1	1.6	2.7	3.0	1.8	1.0
R7	Innu Tent 1 (Elross Lake)	0.0	0.0	20.7	1.4	2.3	2.5	1.6	1.0
R8	Innu Tent 2 (Exact location tbd)	0.0	0.0	35.6	2.7	3.4	2.5	2.0	1.6
R9	Young Naskapi Camp 7 (Pinette Lake)	0.1	0.1	94.9	6.3	10.3	14.3	7.4	4.2
R1	Young Naskapi Camp 3	0.0	0.0	42.8	2.8	4.6	9.8	3.6	1.8
R1	Young Naskapi Trailer tent (Triangle Lake)	0.0	0.0	31.1	2.5	4.0	5.1	2.5	1.3
R1	Young Naskapi Camp 5 (Elross Creek)	0.0	0.1	57.5	2.9	4.3	4.8	3.0	2.5
R1	Naskapi - Uashat people's camp	0.0	0.0	42.9	3.4	4.8	12.4	4.4	1.8
R1	Young Naskapi Camp 4	0.0	0.0	18.1	1.1	1.9	2.2	1.2	0.8
R1	Young Naskapi Camp 6 (Howells River)	0.0	0.0	17.0	1.1	2.2	3.0	1.6	0.8
R1	Innu - Uashat - Mani-Utenam Camp 2	0.0	0.0	24.7	1.5	2.5	3.3	1.7	1.0
R2	Bustard - Observation and hunting site 1	0.0	0.0	8.4	0.7	1.1	1.8	0.8	0.3
R2	Bustard - Observation and hunting site 2	0.0	0.0	22.3	1.6	2.7	3.2	1.7	1.2
R2	Irony Mountain	0.1	0.1	110.2	7.4	12.0	14.5	7.9	4.3
R3	Naskapi Cabin 1	0.0	0.0	33.7	2.7	3.7	2.9	2.1	1.4
R3	Naskapi Cabin 2 (Elross Lake)	0.0	0.0	23.4	1.4	2.4	2.2	1.5	1.0
R3	Naskapi Cabin 3 (Elross Lake)	0.0	0.0	29.8	1.9	3.2	2.2	1.6	1.3
R4	TSMC Workers' Camp	0.7	0.7	382.8	62.7	100.3	67.9	33.6	11.2
--	"Off-Property Limit" Maximum - Newfoundland/Labrador	0.3	0.3	311.2	69.5	96.8	345.7	118.5	16.4

HOWSE ONLY

ID	Name	SO2, 3-hr	SO2, 1-hr	NO2, 1-hr	CO, 8-hr	CO, 1-hr	TPM, 1-hr	PM10, 1-hr	PM2.5, 1-hr
R1	Young Naskapi Camp 1	0.0	0.0	7.6	3.3	5.6	4.2	2.8	0.7
R2	Young Naskapi Camp 2	0.0	0.0	7.3	3.1	5.3	4.6	2.7	0.7
R3	Innu Tent 3 (Rosemary Lake)	0.0	0.0	7.3	3.2	5.4	4.1	2.6	0.7
R4	Innu Tent 4 (Rosemary Lake)	0.0	0.0	6.3	2.4	5.0	4.4	2.5	0.7
R5	Innu Tent 5 (Rosemary Lake)	0.0	0.0	6.4	2.6	4.8	5.6	3.0	0.7
R6	Innu Tent 6 (Rosemary Lake)	0.0	0.0	5.9	2.4	4.8	4.4	2.5	0.6
R7	Innu Tent 1 (Elross Lake)	0.0	0.0	3.7	1.7	2.8	3.1	1.6	0.4
R8	Innu Tent 2 (Exact location tbd)	0.0	0.0	5.3	2.1	4.3	3.4	2.1	0.6
R9	Young Naskapi Camp 7 (Pinette Lake)	0.0	0.1	43.9	20.4	39.7	27.0	16.7	4.6
R10	Young Naskapi Camp 3	0.0	0.0	48.8	21.4	43.2	39.7	19.6	5.3
R11	Young Naskapi Trailer tent (Triangle Lake)	0.0	0.0	25.6	11.0	25.8	14.5	7.8	2.9
R12	Young Naskapi Camp 5 (Elross Creek)	0.0	0.0	9.7	5.3	7.7	6.8	3.9	1.0
R13	Naskapi - Uashat people's camp	0.0	0.1	72.8	29.9	67.4	53.9	33.1	8.1
R14	Young Naskapi Camp 4	0.0	0.0	3.8	1.5	2.7	2.6	1.7	0.4
R15	Young Naskapi Camp 6 (Howells River)	0.0	0.0	3.4	1.3	2.4	3.0	1.7	0.4
R17	Innu - Uashat - Mani-Utenam Camp 2	0.0	0.0	21.9	10.4	22.8	8.8	5.4	2.4
R21	Bustard - Observation and hunting site 1	0.0	0.0	3.4	1.0	2.4	3.2	1.8	0.4
R22	Bustard - Observation and hunting site 2	0.0	0.0	8.5	3.0	6.5	4.4	2.9	0.8
R24	Irony Mountain	0.1	0.2	61.6	22.3	49.5	35.9	24.2	5.7
R33	Naskapi Cabin 1	0.0	0.0	5.7	2.8	5.1	3.5	2.3	0.6
R34	Naskapi Cabin 2 (Elross Lake)	0.0	0.0	5.4	2.1	4.2	3.4	2.0	0.5
R35	Naskapi Cabin 3 (Elross Lake)	0.0	0.0	4.7	2.0	4.6	3.3	2.2	0.6
R40	TSMC Workers' Camp	0.6	0.8	149.7	17.1	32.9	53.2	25.3	10.3
--	"Off-Property Limit" Maximum - Newfoundland/Labrador	0.9	1.2	225.6	149.7	210.4	312.4	154.7	29.0

- all values in µg/m3. Red cell, if any, indicates above criteria.
nth highest levels as per NL Guidance Document GD-PPD-009.4 (2012)

RESULTS - 1-Hr, 3-Hr, 8-Hr Averages (cont'd)

Pollutant	SO2	SO2	NO2	CO	CO	TPM	PM10	PM2.5
Averaging Period	3-hr	1-hr	1-hr	8-hr	1-hr	1-hr	1-hr	1-hr
NL Ambient Air Quality Standard	**600**	**900**	**400**	**15000**	**35000**	--	--	--
Level or rank *	6th	9th	9th	3rd	9th	9th	9th	9th
BACKGROUND CONCENTRATIONS - PRE-DSO3	**5**	**5**	**4**	**114**	**114**	**15**	**10**	**5**

DSO3 + DSO4 + HOWSE

ID	Name	SO2, 3-hr	SO2, 1-hr	NO2, 1-hr	CO, 8-hr	CO, 1-hr	TPM, 1-hr	PM10, 1-hr	PM2.5, 1-hr
R1	Young Naskapi Camp 1	0.0	0.0	22.5	4.1	6.9	5.6	3.6	1.3
R2	Young Naskapi Camp 2	0.0	0.0	23.0	4.2	6.7	5.7	3.5	1.2
R3	Innu Tent 3 (Rosemary Lake)	0.0	0.0	21.7	4.2	6.8	5.5	3.4	1.2
R4	Innu Tent 4 (Rosemary Lake)	0.0	0.0	20.1	3.1	6.4	5.6	3.3	1.0
R5	Innu Tent 5 (Rosemary Lake)	0.0	0.0	21.7	3.3	6.2	7.0	3.7	1.1
R6	Innu Tent 6 (Rosemary Lake)	0.0	0.0	27.1	3.9	6.4	6.5	3.5	1.3
R7	Innu Tent 1 (Elross Lake)	0.0	0.0	22.1	2.5	3.7	4.8	2.9	1.2
R8	Innu Tent 2 (Exact location tbd)	0.0	0.0	40.1	4.4	6.2	5.2	3.4	1.7
R9	Young Naskapi Camp 7 (Pinette Lake)	0.1	0.1	97.6	21.3	41.7	33.7	18.8	5.1
R10	Young Naskapi Camp 3	0.1	0.1	61.8	22.6	44.3	42.8	20.6	5.8
R11	Young Naskapi Trailer tent (Triangle Lake)	0.0	0.0	36.1	11.6	26.1	16.5	9.0	3.0
R12	Young Naskapi Camp 5 (Elross Creek)	0.0	0.1	57.7	5.5	9.1	9.8	5.2	2.6
R13	Naskapi - Uashat people's camp	0.0	0.1	77.2	30.6	69.4	57.2	34.0	8.8
R14	Young Naskapi Camp 4	0.0	0.0	20.5	2.3	4.2	4.0	2.3	1.0
R15	Young Naskapi Camp 6 (Howells River)	0.0	0.0	18.4	2.0	3.5	5.3	3.0	1.1
R17	Innu - Uashat - Mani-Utenam Camp 2	0.0	0.0	27.5	10.9	23.8	9.6	6.1	2.8
R21	Bustard - Observation and hunting site 1	0.0	0.0	10.9	1.5	3.1	4.4	2.4	0.6
R22	Bustard - Observation and hunting site 2	0.0	0.0	25.2	4.8	7.8	6.1	3.9	1.3
R24	Irony Mountain	0.2	0.3	123.7	28.2	51.2	46.4	26.7	6.3
R33	Naskapi Cabin 1	0.0	0.0	40.5	4.6	6.5	5.8	3.5	1.9
R34	Naskapi Cabin 2 (Elross Lake)	0.0	0.0	25.9	2.8	5.8	4.9	2.8	1.2
R35	Naskapi Cabin 3 (Elross Lake)	0.0	0.0	34.5	2.9	6.1	5.0	3.5	1.4
R40	TSMC Workers' Camp	0.9	1.1	384.7	62.9	100.4	108.3	55.4	12.1
--	"Off-Property Limit" Maximum - Newfoundland/Labrador	0.9	1.2	313.4	152.7	212.1	358.7	158.3	29.3

ALL: Background + DSO3 + DSO4 +

ID	Name	SO2, 3-hr	SO2, 1-hr	NO2, 1-hr	CO, 8-hr	CO, 1-hr	TPM, 1-hr	PM10, 1-hr	PM2.5, 1-hr
R1	Young Naskapi Camp 1	5.0	5.0	26.3	118.1	120.9	20.6	13.6	6.3
R2	Young Naskapi Camp 2	5.0	5.0	26.8	118.2	120.7	20.7	13.5	6.2
R3	Innu Tent 3 (Rosemary Lake)	5.0	5.0	25.5	118.2	120.8	20.5	13.4	6.2
R4	Innu Tent 4 (Rosemary Lake)	5.0	5.0	23.9	117.1	120.4	20.6	13.3	6.0
R5	Innu Tent 5 (Rosemary Lake)	5.0	5.0	25.5	117.3	120.2	22.0	13.7	6.1
R6	Innu Tent 6 (Rosemary Lake)	5.0	5.0	30.9	117.9	120.4	21.5	13.5	6.3
R7	Innu Tent 1 (Elross Lake)	5.0	5.0	25.9	116.5	117.7	19.8	12.9	6.2
R8	Innu Tent 2 (Exact location tbd)	5.0	5.0	43.9	118.4	120.2	20.2	13.4	6.7
R9	Young Naskapi Camp 7 (Pinette Lake)	5.1	5.1	101.4	135.3	155.7	48.7	28.8	10.1
R10	Young Naskapi Camp 3	5.1	5.1	65.6	136.6	158.3	57.8	30.6	10.8
R11	Young Naskapi Trailer tent (Triangle Lake)	5.0	5.0	39.9	125.6	140.1	31.5	19.0	8.0
R12	Young Naskapi Camp 5 (Elross Creek)	5.0	5.1	61.5	119.5	123.1	24.8	15.2	7.6
R13	Naskapi - Uashat people's camp	5.0	5.1	81.0	144.6	183.4	72.2	44.0	13.8
R14	Young Naskapi Camp 4	5.0	5.0	24.3	116.3	118.2	19.0	12.3	6.0
R15	Young Naskapi Camp 6 (Howells River)	5.0	5.0	22.2	116.0	117.5	20.3	13.0	6.1
R17	Innu - Uashat - Mani-Utenam Camp 2	5.0	5.0	31.3	124.9	137.8	24.6	16.1	7.8
R21	Bustard - Observation and hunting site 1	5.0	5.0	14.7	115.5	117.1	19.4	12.4	5.6
R22	Bustard - Observation and hunting site 2	5.0	5.0	29.0	118.8	121.8	21.1	13.9	6.3
R24	Irony Mountain	5.2	5.3	127.5	142.2	165.2	61.4	36.7	11.3
R33	Naskapi Cabin 1	5.0	5.0	44.3	118.6	120.5	20.8	13.5	6.9
R34	Naskapi Cabin 2 (Elross Lake)	5.0	5.0	29.7	116.8	119.8	19.9	12.8	6.2
R35	Naskapi Cabin 3 (Elross Lake)	5.0	5.0	38.3	116.9	120.1	20.0	13.5	6.4
R40	TSMC Workers' Camp	5.9	6.1	388.5	176.9	214.4	123.3	65.4	17.1
--	"Off-Property Limit" Maximum - Newfoundland/Labrador	5.9	6.2	317.2	266.7	326.1	373.7	168.3	34.3

- all values in µg/m3. Red cell, if any, indicates above criteria.
nth highest levels as per NL Guidance Document GD-PPD-009.4 (2012)

Discussion of Results

All NL ambient air quality standards are met, except for the NO2 (24-hr) at the workers' camp (R40). This receptor is located within the air quality monitoring perimeter. As can be seen in Table 7-6, the maximum result at R40 when all cumulative sources are considered, NO2 (24-hr) is 208.1 µg/m3, slightly above the NL standard of 200 µg/m3. Also shown in Table 7-9, the impact of the Howse project only at receptor R40 is 33.2 µg/m3 for NO2 (24-hr), which is well below the 200 µg/m3.

Considering the inputs to the air modelling study were conservative (e.g. worse-case), the noted exceedance for the single parameter NO2 (24-hr) is highly unlikely to occur in reality.

7.3.2.2.2 Effects Assessment on CEAA guidelines

All three phases involve similar equipment and activities; however the operation phase has the highest effects on air quality due to the operation of the processing plants and full-scale production. Consequently, an air quality effects study was conducted for the operation phase; summary results and conclusions are presented in the section below, while a detailed report is available in the Air Dispersion Modelling Report (Volume 2 Supporting Study E).

Literature review and Current Studies Data Used to Assess the Potential Effect

The addition of the Howse Mine will result in the following operational changes, which will influence air quality:

- operation of the new Howse Mine site (typical mining and blasting operations);
- additional Crushing/Screening/Drying equipment, referred to as Howse Mini-Plant in the air quality study. The Howse Mini-Plant will be located to the East of the rail loop, as shown on Figure 3-1 ; and
- increased haul truck and train operations.

The proposed Howse Mine will be located in close proximity to the DSO3 project area. As such, the air quality in the vicinity of the proposed Howse Mine site will be directly influenced by DSO3 operations. Air emissions sources associated with DSO3 include excavation, drilling, blasting, grading, trucking activities, and ore processing such as crushing, screening, and drying at the main plant and Plant 2. Additionally, ore from mining area DSO4 (from pits such as Kivivik, Goodwood, Sunny, etc..) will be hauled towards the DSO3 processing complex and road dust/engine emissions resulting from this hauling activity may influence air quality levels in the vicinity of the proposed Howse Mine site.

Consequently, air emissions associated to the DSO3 and DSO4 projects as indicated above are included in the assessment of air quality effects of the Howse Project and can be summarized by the following equation:

(1) Background concentrations (pre-DSO3/DSO4 conditions)
\+ (2) Concentrations due to emissions from DSO3 operations
\+ (3) Concentrations due to emissions from ore hauling from the DSO4
\+ (4) Concentrations due to emissions from other Projects in the RSA

= Pre-Howse Air Quality Condition ("Baseline Condition")

\+ (5) Concentrations due to emissions from Howse operations

= Cumulative Air Quality Effect

The overall methodological approach to assess the environmental effects is presented in previous sections. However, in order to apply this methodology to the Air Quality VC, it is essential to consider assessment criteria applicable specifically to this VC.

The Howse Property and DSO3 complex mining areas are located in the Province of Newfoundland and Labrador, in close proximity to the Québec (QC) border. The Howse Project is located in the vicinity of the larger DSO complex operated by TSMC, which includes several mining and ore processing areas. From start-up to decommissioning and reclamation, the mining and operation schedules of each area vary in time and this was taken into account when establishing the air dispersion modelling approach. From an air quality effects perspective, Table 7-10 lists the key areas of the DSO and Howse projects and how they were integrated in this air quality assessment for the Howse Project, based on their respective schedule of operation and locations.

Criteria Air Contaminants (CAC) evaluated for the air quality assessment study are:

- total Particulate Matter (TPM);
- particulate Matter less than 10 microns (PM10);
- particulate Matter less than 2.5 microns (PM2.5);
- nitrogen Dioxide (NO2);
- sulfur Dioxide (SO2); and
- carbon Monoxide (CO).

Non-Criteria Air Contaminants (CAC) evaluated for the air quality assessment study are:

- dust deposition (Dustfall);
- metals (Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Silver, Thallium, Vanadium, Zinc); and
- Volatile Organic Compounds or VOC (1,3-Butadiene, Acetaldehyde, Acrolein, Benzene and Formaldehyde).

Table 7-8 presents ambient air quality standards and objectives for the three jurisdictions (Canada, QC and NL) for the six Criteria Air Contaminants (CAC) evaluated in this study. Table 7-9 presents ambient air quality standards for the twenty non-Criteria Air Contaminants (non-CAC) evaluated in this study and the selected assessment criteria based on air quality standards from QC, NL and ON. In all cases, the most stringent air quality standards were selected as assessment criteria for this study. Note that each jurisdiction has its own procedure for comparing air modelling results to air quality standards. For example, compliance with the Canada $PM_{2.5}$ standard is based on the 98th percentile ambient annual measurements, averaged over 3 consecutive years. Another example is in NL, compliance for modelled effects for any given year is to be based on the 2nd highest level to the 9th highest level depending on the averaging period of air quality standards. In this study, maximum modeled results are compared to the selected assessment criteria, regardless of their percentile or ranked levels.

Table 7-8 Air Quality Standards/Objectives and Selected Assessment Criteria – CAC

POLLUTANT	AVERAGING PERIOD	NL AIR QUALITY STANDARDS (1) (µG/M³)	QC AIR QUALITY STANDARDS (2) (µG/M³)	CANADA AIR QUALITY STANDARDS/OBJECTIVES(3) (µG/M³)	SELECTED ASSESSMENT CRITERIA (µG/M³)
TPM	1-yr	60	70	70	**60**
	24-hr	120	120	120	**120**

POLLUTANT	AVERAGING PERIOD	NL AIR QUALITY STANDARDS (1) (µG/M^{3})	QC AIR QUALITY STANDARDS (2) (µG/M^{3})	CANADA AIR QUALITY STANDARDS/OBJECTIVES(3) (µG/M^{3})	SELECTED ASSESSMENT CRITERIA (µG/M^{3})
PM$_{10}$	24-hr	50	--	--	**50**
PM$_{2.5}$	1-yr	--	--	10 (8.8 after 2020)	**8.8**
	24-hr	25	30	28 (27 after 2020)	**25**
SO$_2$	1-yr	60	52	60	**52**
	24-hr	300	288	300	**288**
	3-hr	600	--	--	**600**
	1-hr	900	--	900	**900**
NO$_2$	1-yr	100	103	100	**100**
	24-hr	200	207	200	**200**
	1-hr	400	414	400	**400**
CO	8-hr	15 000	12 700	15 000	**12 700**
	1-hr	35 000	34 000	35 000	**34 000**

(1) Reference: Air Pollution Control Regulations, 2004 Newfoundland and Labrador Regulations 39/04, Schedule A – Table I: Ambient Air Quality Standards at Reference Conditions.
(2) Reference: Atmospheric quality standards, Sections 197 and 198 and Schedule K of the Clean Air Regulation, Q-2, r. 4.1.
(3) Federal PM$_{2.5}$ standards published on May 25, 2013: Sections 54 and 55 of the Canadian Environmental Protection Act, 1999. For other pollutants, in 2004, the federal government sets national ambient air quality objectives (NAAQOs) on the basis of recommendations from the Federal–Provincial Working Group on Air Quality Objectives and Guidelines consisting of representatives from both the health and environment departments. NAAQOs are structured in three-tiered: maximum desirable levels, maximum acceptable levels and maximum tolerable levels. Maximum acceptable levels are listed in the table.

Table 7-9 Air Quality Standards/Objectives and Selected Assessment Criteria – Non-CAC

POLLUTANT		AVERAGING PERIOD	NL AIR QUALITY STANDARDS 1 (µG/M^{3})	QC AIR QUALITY STANDARDS 2 (µG/M^{3})	ON AIR QUALITY STANDARDS 3 (µG/M^{3})	SELECTED ASSESSMENT CRITERIA (µG/M^{3})
Metals	Antimony (Sb)	1-yr	--	0.17	--	**0.17**
	Arsenic (As)	1-yr	--	0.003	--	**0.003**
		24-hr	0.3	--	0.3	**0.3**
	Barium (Ba)	1-yr	--	0.05	--	**0.05**
	Beryllium (Be)	1-yr	--	0.0004	--	**0.0004**

POLLUTANT		AVERAGING PERIOD	NL AIR QUALITY STANDARDS [1] ($\mu G/M^3$)	QC AIR QUALITY STANDARDS [2] ($\mu G/M^3$)	ON AIR QUALITY STANDARDS [3] ($\mu G/M^3$)	SELECTED ASSESSMENT CRITERIA ($\mu G/M^3$)
	Cadmium (Cd)	1-yr	--	0.0036	0.005	**0.0036**
		24-hr	2	--	0.025	**0.025**
	Chromium (Cr)	1-yr	--	0.004	--	**0.004**
	Copper (Cu)	24-hr	50	2.5	50	**2.5**
	Lead (Pb)	1-yr	--	0.1	--	**0.1**
		30 days	0.7	--	0.2	**0.2**
		24-hr	2	--	0.5	**0.5**
	Mercury (Hg)	1-yr	--	0.005	--	**0.005**
		24-hr	2	--	2	**2**
	Nickel (Ni)	24-hr	2	0.014	0.2	**0.014**
	Silver (Ag)	1-yr	--	0.23	--	**0.23**
	Thallium (Tl)	1-yr	--	0.25	--	**0.25**
	Vanadium (V)	1-yr	--	1	--	**1**
		24-hr	2	--	2	**2**
	Zinc	24-hr	120	2.5	120	**2.5**
Volatile Organic Compounds (VOC)	Benzene	24-hr	--	10	2.3	**2.3**
	1,3-Butadiene	1-yr	--	0.3	2	**0.3**
		24-hr	--	--	10	**10**
	Formaldehyde	24-hr	--	6.5	65	**6.5**
	Acetaldehyde	24-hr	--	--	500	**500**
	Acrolein	24-hr	--	--	0.4	**0.4**
Other	Dustfall	30 days	7.0 g/m^2 per 30 days	--	7.0 g/m^2 per 30 days	**7.0 g/m^2 per 30 days**
		1-yr	4.6 g/m^2 per 30 day avg.	--	4.6 g/m^2 per 30 day avg.	**4.6 g/m^2 per 30 day avg.**

(1) Air Pollution Control Regulations, 2004 Newfoundland and Labrador Regulations 39/04, Schedule A – Table I: Ambient Air Quality Standards at Reference Conditions.
(2) Atmospheric quality standards, Sections 197 and 198 and Schedule K of the Clean Air Regulation, Q-2, r. 4.1. When necessary, averaging time conversion was made.
(3) Ontario's Ambient Air Quality Criteria, Standards Development Branch Ontario Ministry of The Environment, April 2012

The Howse Project is located in the vicinity of the larger DSO complex operated by TSMC, which includes several mining and ore processing areas. From startup to decommissioning and reclamation, the mining and operation schedules of each area vary in time and this was taken into account when establishing the air dispersion modelling approach. From an air quality effects perspective Table 7-10 lists the key areas of the DSO and Howse projects and how they were integrated in this air quality assessment for the Howse Project, based on their respective schedule of operation and locations.

More specifically, this assessment evaluates the effects on air quality from activities related to these main sources:

- mining (drilling, blasting, excavation, loading, unloading, piles, etc.);
- power generation (diesel generators);
- transportation (emissions from vehicle engines and road dust);
- operation of the main processing plant (diesel generators, crushing, screening, ore drying, stockpiles, train loading, etc.);
- operation of Plant 2 (ore crushing, drying, screening, stockpiles); and
- operation of Howse Mini-Plant on the east side of the rail loop (ore crushing, drying, screening, stockpiles).

Detailed source descriptions and emissions can be found in the Air Dispersion Modelling Report (Volume 2 Supporting Study E). A project description with additional information on the DSO process and context of the project can be found in previous sections of this EIS. Emission rates calculations were performed in accordance with best practices and recent air modelling efforts for other areas of the TSMC DSO project. Most emission rates were calculated based on data and methodologies from USEPA (2014). When available site-specific emissions data provided by equipment suppliers were used instead of those from USEPA (2014). Table 7-11 and Table 7-12 show annual emissions from Howse and DSO3/DSO4 respectively.

Table 7-10 DSO and Howse Projects - Schedules and Inclusion in the Air Quality Study

PROJECT AREA	AIR EMISSION SOURCES	EXPECTED OPERATION SCHEDULE	INCLUSION IN THIS AIR QUALITY STUDY	MAXIMUM MINING RATE* USED IN AIR QUALITY STUDY
DSO3	Mining activities at Fleming 7N and Timmins 3N deposits Ore processing at the Main Processing Plant Ore processing at Plant 2 Road transportation and ore hauling Ore loading to rail cars Workers' Camp	DSO3 operations started in 2015 (currently in commissioning stages). DSO3 and Howse will operate simultaneously after Howse starts up in 2017.	The DSO3 complex is located within the Air Quality LSA. DSO3 air emission sources are included in this study and considered as part of the baseline (pre-Howse) condition.	3 383 MT/yr
DSO4	Mining activities at Kivivic and Goodwood/Sunny deposits Road transportation and ore hauling (on Goodwood Road)	DSO4 operations started in 2015 (currently in commissioning stages). DSO4 and Howse will operate simultaneously after Howse starts up in 2017.	The DSO4 deposits are located approximately 22 km from Howse, are outside the LSA and emissions associated to DSO4 mining activities are not included in air quality study. However, the ore mined at DSO4 will be hauled to the DSO3 Main processing plant. Air emissions from ore hauling on the 9.6 km portion of the Goodwood road located within the LSA are included in this air quality study and considered as part of the baseline (pre-Howse) condition.	7 384 MT/yr
HOWSE	Mining activities at Howse deposit Road transportation and ore hauling Ore processing at the Howse Mini-Plant FN crushing/Screening facility	2017-2032	Included in this air quality study.	13 823 MT/yr

*Mining rate includes: Activities related to ore mining and waste + overburden removal. Detailed mining plans are available in the Air Dispersion Modelling Report (Volume 2 Supporting Study E).

Table 7-11 Annual Emissions Inventory – Howse Project

PROJECT AREA	ANNUAL EMISSIONS INVENTORY (1)						
	TPM	PM_{10}	$PM_{2.5}$	NOX	CO	SO_2	HC (2)
HOWSE	231.4	121.9	64.2	283.2	146.3	2.2	13.1

(1) Based on maximum production year of the Project

(2) HC = Hydrocarbons. HC = VOC in this air quality study.

Table 7-12 Annual Emissions Inventory – DSO3 and DSO4 Areas

PROJECT AREA	ANNUAL EMISSIONS INVENTORY (1)						
	TPM	PM_{10}	$PM_{2.5}$	NOX	CO	SO_2	HC (3)
DSO3	301.9	99.1	22.8	1550.7	200.1	3.2	41.9
DSO4 (2)	259.2	73.9	8.4	124.6	68.7	0.1	7.8

(1) Based on maximum production year of each project area

(2) Includes a 9.6 km section of the Goodwood Road where Hauling trucks transport ore from the DSO4 area. DSO4 mining activities not included.

(3) HC = Hydrocarbons. HC = VOC in this air quality study.

Description of the dispersion model and meteorological data used for the air quality study

The CALPUFF model is the atmospheric pollution dispersion model recommended in the NLDEC's *Guideline for Plume Dispersion Modelling* (2012).

CALPUFF is a Lagrangian puff modelling system for the simulation of variable spatial and temporal conditions. Atmospheric emissions are modeled as a series of puffs which disperse according to wind direction over a given period. These puffs disperse vertically and horizontally in the atmosphere. They are influenced by the topography. Thus, a change in wind direction will influence the results of the modelling. The CALPUFF model adapts to various modelling situations. The flexibility of the model allows for the various characteristics associated with the local context to be taken into account. CALPUFF is especially useful in situations in which particulate matter is transported over long distances, with light and calm wind conditions (speed less than 0.5 m/s), wind inversions such as land breezes and sea breezes, and complex wind configurations associated with very rugged terrains. In addition, parameters such as dry deposition, wet deposition and particulate matter sizing have been incorporated into the CALPUFF input files as described in the *Guideline for Plume Dispersion Modelling*.

The system is made up of three programs: CALMET, CALPUFF and CALPOST. CALMET allows for the processing of meteorological data and the obtaining of hourly tridimensional meteorological data specific to the study area. Once processed, the meteorological data obtained with CALMET are used by CALPUFF, the atmospheric dispersion modelling program. Lastly, CALPOST allows for the processing and analysis of the modelling results. The V6.334, V6.42 and V6.292 versions of CALMET, CALPUFF and CALPOST were used within the framework of this study.

The CALMET program was used to generate meteorological data files. The program used meteorological data obtained by a non-hydrostatic mesoscale assessment technique using Mesoscale Model (MM 5) (operated by the Canadian company Lakes Environmental) for years 2004 to 2008 as baseline data. Meteorological data from years 2004 to 2008 were used in the Howse evaluation because they were used for all previous air modelling studies for other TSMC DSO projects. Data from this timeframe were considered representative of current conditions and met the objectives of the air modelling study. The data grid provided by Lakes Environmental had a resolution of 14 km and covered a surface area of 40 km by 40 km. The UTM coordinates of the central point were: East – 628 000 m, North – 6 081 000 m.

More information about the CALPUFF model and meteorological data can be found in the Air Dispersion Modelling Report (Volume 2 Supporting Study E).

Sensitive receptors used in the air quality study

A list of 40 discrete sensitive receptors was determined and used for the air dispersion modelling study (Table 7-13). The location of these receptors can be seen in Figure 7-3.

Table 7-13 Sensitive Receptors

ID	FINAL DESCRIPTION	PROVINCE	X EASTING (KM)	Y NORTHING (KM)	Z ELEVATION (M)	DISTANCE AND DIRECTION RELATIVE TO HOWSE DEPOSIT
R1	Young Naskapi Camp 1	NL	615.0828	6086.3313	498	4.21 km, W
R2	Young Naskapi Camp 2	NL	615.0068	6086.4258	498	4.29 km, W
R3	Innu Tent 3 (Rosemary Lake)	NL	615.2457	6086.3324	499	4.05 km, W
R4	Innu Tent 4 (Rosemary Lake)	NL	615.2376	6086.9500	499	4.11 km, W
R5	Innu Tent 5 (Rosemary Lake)	NL	614.8537	6087.3314	500	4.56 km, WNW
R6	Innu Tent 6 (Rosemary Lake)	NL	614.6857	6086.7490	498	4.63 km, W
R7	Innu Tent 1 (Elross Lake)	NL	619.3356	6080.8277	500	5.44 km, S
R8	Innu Tent 2 (Exact location tbd)	NL	614.4960	6084.5808	505	5.08 km, WSW
R9	Young Naskapi Camp 7 (Pinette Lake)	NL	620.4557	6084.8152	636	1.86 km, SE
R10	Young Naskapi Camp 3	NL	617.9290	6087.3644	606	1.75 km, NW
R11	Young Naskapi Trailer tent (Triangle Lake)	NL	618.0872	6088.3173	580	2.38 km, NNW
R12	Young Naskapi Camp 5 (Elross Creek)	NL	621.5380	6082.0124	579	4.81 km, SSE
R13	Naskapi - Uashat people's camp	NL	617.7971	6087.0367	619	1.68 km, WNW
R14	Young Naskapi Camp 4	NL	613.0674	6087.5092	514	6.35 km, WNW
R15	Young Naskapi Camp 6 (Howells River)	NL	622.2957	6077.8614	515	8.92 km, SSE
R16	Innu - Uashat - Mani-Utenam Camp 1	QC	621.1566	6089.0311	624	3.34 km, NE
R17	Innu - Uashat - Mani-Utenam Camp 2	NL	616.4962	6086.9704	556	2.88 km, WNW

ID	FINAL DESCRIPTION	PROVINCE	X EASTING (KM)	Y NORTHING (KM)	Z ELEVATION (M)	DISTANCE AND DIRECTION RELATIVE TO HOWSE DEPOSIT
R18	Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake)	QC	623.9650	6085.3445	718	4.76 km, E
R19	Innu Cabin 1	QC	631.6822	6080.0850	551	13.85 km, ESE
R20	Innu Cabin 2	QC	631.1136	6080.0592	558	13.35 km, ESE
R21	Bustard - Observation and hunting site 1	NL	612.9988	6089.0819	521	6.89 km, WNW
R22	Bustard - Observation and hunting site 2	NL	615.1038	6086.0116	514	4.19 km, W
R23	Picking site (berries / tea)	QC	620.0463	6090.4069	606	4.21 km, N
R24	Irony Mountain	NL	618.2357	6085.2228	835	1.48 km, SW
R25	Innu Cabin 3	QC	632.4583	6082.717	496	13.64 km, ESE
R26	Innu Cabin 4	QC	632.9582	6081.877	491	14.35 km, ESE
R27	Innu Cabin 5	QC	633.5804	6081.318	502	15.12 km, ESE
R28	Innu Cabin 6	QC	634.2557	6080.909	487	15.89 km, ESE
R29	Innu Cabin 7	QC	634.862	6080.707	493	16.53 km, ESE
R30	Innu Cabin 9 (Denault Lake)	QC	635.213	6079.776	504	17.19 km, ESE
R31	Innu Cabin 8	QC	633.1337	6080.34	539	15.06 km, ESE
R32	Innu Cabin 10 (Vacher Lake)	QC	636.0547	6085.953	492	16.77 km, E
R33	Naskapi Cabin 1	NL	615.3395	6084.424	502	4.36 km, WSW
R34	Naskapi Cabin 2 (Elross Lake)	NL	616.6907	6084.223	502	3.3 km, SW
R35	Naskapi Cabin 3 (Elross Lake)	NL	616.9098	6082.671	498	4.31 km, SSW
R36	Kawawachikamak (Town)	QC	643.5	6082.132	474	24.56 km, E
R37	Lac John (Town)	QC	642.39	6076.24	505	25.18 km, ESE
R38	Matimekush (Town)	QC	640.8	6075.6	516	24.01 km, ESE
R39	Schefferville (Town)	QC	640.6	6075	511	24.1 km, ESE
R40	TSMC Workers' Camp	NL	624.465	6082.765	742	6.25 km, SE

General grid receptors used in the air quality study

To meet the requirements of the *Guideline for Plume Dispersion Modelling* of the Department of Environment and Conservation of the GNL (GNL 2002), two Cartesian grids of receptors as well as discrete receptors were defined. The terrain elevation data used in the grids was obtained from a digital database having a precision of ± 5m.

The larger Cartesian grid covers a surface area of 340 km^2. It covers the DSO2 and DSO3 sites and is centered by Main Plant. The North-west corner start close to Howells Rover and the South-eastern corner extends close to Stork Lake. This grid resolution is 500 m by 500 m.

The second Cartesian grid covers a surface area of 16 km^2. It extends along the DSO3 facilities for a distance of 4 km and covers a strip of land of 4 km in width. Its resolution is 200 m by 200 m. It was not necessary to use a grid of 50 m resolution (as required in the *Guideline for Plume Dispersion Modelling*) because the zone for which such a grid is required falls within the boundaries of the air quality perimeter.

The receptors were positioned at ground level. General grid receptors located within the air quality modelling perimeter were removed from the modelling file in order to evaluate the ambient concentrations outside this boundary. General grid receptors located at less than 100 m from roads were also removed.

This removal process only excludes grid receptors, which are not specifically designated as sensitive receptors where humans live, hunt or do other activities. None of the sensitive receptors discussed in the next paragraph were removed from the model.

Air Modelling Results and Conclusions

The Air Dispersion Modelling Report (Volume 2 Supporting Study E) contains the detailed discussion, results and figures (such as isoconcentration plots). All results presented in this study are maximum concentrations outputted by the model; no statistical treatment was performed on the data, such as determining the 98% percentile average or removing highest outliers. Due to the limitations in modelling blasting events, air modelling results are presented for two scenarios: "With Blasts" and "No Blasts".

Air modelling results indicate that no exceedances of assessment criteria are predicted for dustfall, metals and VOCs reviewed in this EIS.

The results show that for annual averaging periods, for both the "With Blasts" and "No Blasts" scenarios, no exceedances of assessment criteria are predicted for all CAC and for all receptors types (e.g. Sensitive and Grid). Table 7-14 summarizes results for annual averaging periods and shows the contribution of Howse and DSO3/DSO4 separately. Due to the large amount of results (for both the "With Blasts" and "Without Blasts" scenarios) and the number of sensitive and grid receptors, the tables of results include a list of 13 selected sensitive receptors reflecting highest effects or cluster of representative receptors; results for the remaining 27 sensitive receptors not shown in the tables, all meet air quality assessment criteria. Complete tables of results with all 40 sensitive receptors are available in the Air Dispersion Modelling Report (Volume 2 Supporting Study E). Table 7-15 and Table 7-16 summarize CAC air modelling results for daily and short-term averaging periods (e.g. 24-hr, 8-hr, 3-hr, and 1-hr), respectively.

Sensitive receptors R36 to R39 are located at the nearest towns (Kawawachikamak, Lac John, Matimekush and Schefferville). The effects of the modelled Howse Project activities on these four receptors' air quality is minimal and meet the air quality assessment criteria. For example, the NO_2 1-hr concentration in Schefferville and due to the Howse project is 20.0 $\mu g/m^3$ vs an assessment criteria of 400 $\mu g/m^3$. In considering the cumulative effects of all mining activities included in the air quality study (e.g. DSO3 + DSO4 + Howse + Background), the cumulative NO_2 1-hr concentration in Schefferville is 74.3 $\mu g/m^3$ vs an assessment criteria of 400 $\mu g/m^3$. The effects at sensitive receptors R36, R37 and, R38 is lower than at Schefferville.

The results show that for CAC for short-term averaging periods (24-hr, 8-hr, 3-hr, and 1-hr), results sometimes exceed the project's air quality assessment criteria for both scenarios ("With Blasts" and "No Blasts"). Table 7-17 shows at which sensitive receptors exceedances may occur and also shows the frequency count of these exceedances. A similar frequency analysis table has also been generated for non-sensitive "Off-Property Limits" grid receptors and is presented in Table 7-18.

CAC Results - Short-Term Averaging Periods – at Sensitive Receptors

Based on the results presented herein, the following observations can be made:

- For TPM (24-hr), no exceedances are predicted under the "No Blasts" scenario, while 2 exceedances are predicted to occur under the "With Blasts" scenario at Receptor R40 (Workers' Camp), over the 5 years of meteorological data studied. These 2 exceedances are equivalent to 0.11% of the time during which a maximum of 137.1 µg/m3 (vs criteria of 120 µg/m3) is predicted to occur.
- For PM10 (24-hr), no exceedances are predicted under the "No Blasts" scenario, while under the "With Blasts" scenario, 1 exceedance (0.05% of the time) is predicted to occur at Receptor R13 (Naskapi - Uashat people's camp) and 6 exceedances (0.33% of the time) at Receptor R40 (Workers' Camp), over the 5 years of meteorological data studied.
- For NO2 (24-hr), 7 exceedances (0.38% of the time) are predicted to occur under both "With Blasts" and "No Blasts" at 315.8 µg/m3 and 315.0 µg/m3, respectively. The occurrence of the same number of exceedances under both scenarios indicates that the cause of higher NOx during that time period and specific meteorological conditions is not due to blasting events. In addition, for Receptor R40, for Howse only (No Blasts) the predicted contribution is 43.2 µg/m3, which in itself does not exceed the criterion. In the same table, the contribution of DSO3 + DSO4 at R40 is 285.0 µg/m3. This explains that the Howse Project itself does not create the exceedance, but the cumulative effect of all projects combined causes the exceedance.
- For NO2 (1-hr), exceedances are predicted at 8 sensitive receptors (R9, R10, R11, R13, R16, R17 and R24) in the "With Blasts" scenario, while no exceedances would occur at these same receptors in the "No Blasts" scenario. Note that the 8 receptors are located in the vicinity of the Howse deposit. The maximum number of exceedances is 13 (0.71% of the time) at R9 – Young Naskapi Camp 7 (Pinette Lake). A more detailed review indicated that all exceedances at these 8 receptors occur during winter (November to March period) and are due to blasting events at the Howse pit. By minimizing blasting at the Howse pit during the winter period (which the Proponent will do), exceedances would also be minimized.
- For NO2 (1-hr), 9 exceedances (0.49% of the time) are predicted at sensitive receptor R18 - Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake) in the "With Blasts" scenario, while no exceedances would occur in the "No Blasts" scenario.
- For NO2 (1-hr), exceedances at Receptor R40 (Workers' Camp) occur less than 1% of the time for both "With Blasts" and "No Blasts" scenarios. Looking at the "No Blasts" scenario in Table 7-17 for Receptor R40, for Howse only, No Blasts, the predicted contribution is 199.5 µg/m3, which in itself does not exceed the criterion. In the same table, the contribution of DSO3 + DSO4 at R40 is 423.0 µg/m3. This explains that the Howse Project itself does not create the exceedance, but the cumulative effect of all projects is above the assessment criteria at this receptor. Furthermore, it was determined that the principal cause of the 99 exceedances at the Workers' Camp is the continuous operation of diesel generators located on the premises of the camp to produce electricity used at the camp.

CAC Results - Short-Term Averaging Periods – at "Off-Property Limit" Grid Receptors

Based on the results, the following observations can be made:

- For the "No Blasts" scenario results, exceedances are predicted for the following averaging periods and pollutants: 24-hr (TPM, PM10, PM2.5, and NO2), 1-hr (NO2). The maximum number of predicted exceedances is 15 (0.82% of the time) for PM10 (24-hr) at "Off-Property Limit" grid receptor UTM coordinates 622.2434, 6085.7298 in NL. Figure 3.17 of the Air Dispersion Modelling Report shows the points at which maximum concentrations are predicted to occur; these points are located on the edge of the air quality modelling perimeter.
- For the "With Blasts" scenario results, exceedances are predicted for the following averaging periods and pollutants: 24-hr (TPM, PM10, PM2.5, and NO2), 1-hr (NO2, SO2, CO). The

maximum number of predicted exceedances is 2.85% of the time for PM10 (24-hr) at "Off-Property Limit" grid receptor UTM coordinate 625.6801, 6083.313 in QC. Figure 3.16 of the Air Dispersion Modelling Report shows the points at which maximum concentrations are predicted to occur; these points are located on the edge of the air quality modelling perimeter.

- Zones of air quality effects exceeding assessment criteria on "Off-Property Limit" grid receptors are:
  - restricted to small areas along perimeter limits;
  - pollutants concentrations drop-off quickly by distance; and
  - zones where no people live, not sensitive receptors.

Table 7-14 Summary Results – CAC – Maximum Annual Concentrations – With Blasts and No Blasts

			WITH BLASTS					NO BLASTS				
		Pollutant	TPM	PM10	PM2.5	SO2	NO2	TPM	PM10	PM2.5	SO2	NO2
		Averaging Period	1-yr	1-yr	1-yr	1-yr	1-yr	1-yr	1-yr	1-yr	1-yr	1-yr
		Selected Air Quality Assessement Criteria for Howse	**60**	**--**	**8.8**	**52**	**100**	**60**	**--**	**8.8**	**52**	**100**
		BACKGROUND CONCENTRATIONS - PRE-DSO3	**8**	**4**	**3**	**2**	**10**	**8**	**4**	**3**	**2**	**10**
DSO3 + DSO4 ONLY	**ID**	**Description**	TPM	PM10	PM2.5	SO2	NO2	TPM	PM10	PM2.5	SO2	NO2
	R5	Innu Tent 5 (Rosemary Lake)	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.2
	R7	Innu Tent 1 (Elross Lake)	0.1	0.0	0.0	0.0	0.4	0.1	0.0	0.0	0.0	0.3
	R9	Young Naskapi Camp 7 (Pinette Lake)	0.4	0.2	0.1	0.0	1.5	0.4	0.2	0.1	0.0	1.5
	R10	Young Naskapi Camp 3	0.3	0.1	0.0	0.0	0.7	0.3	0.1	0.0	0.0	0.6
	R11	Young Naskapi Trailer tent (Triangle Lake)	0.2	0.1	0.0	0.0	0.6	0.2	0.1	0.0	0.0	0.6
	R13	Naskapi - Uashat people's camp	0.3	0.1	0.0	0.0	0.7	0.3	0.1	0.0	0.0	0.7
	R16	Innu - Uashat - Mani-Utenam Camp 1	0.9	0.4	0.1	0.0	1.7	0.9	0.4	0.1	0.0	1.6
	R17	Innu - Uashat - Mani-Utenam Camp 2	0.1	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.3
	R18	Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake)	1.7	1.1	0.4	0.1	8.8	1.5	0.9	0.4	0.0	8.5
	R20	Innu Cabin 2	0.1	0.1	0.0	0.0	0.4	0.1	0.0	0.0	0.0	0.3
	R24	Irony Mountain	0.4	0.2	0.1	0.0	1.5	0.4	0.2	0.1	0.0	1.5
	R39	Schefferville (Town)	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1
	R40	TSMC Workers' Camp	3.7	2.1	0.7	0.4	19.3	2.5	1.3	0.7	0.1	18.5
	--	"Off-Property Limit" Maximum - Quebec	11.0	6.4	1.1	2.3	21.3	8.4	3.1	0.8	0.0	11.0
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	9.8	3.6	0.9	0.3	14.2	9.8	3.6	0.9	0.0	13.8
HOWSE ONLY	**ID**	**Name**	TPM	PM10	PM2.5	SO2	NO2	TPM	PM10	PM2.5	SO2	NO2
	R5	Innu Tent 5 (Rosemary Lake)	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1
	R7	Innu Tent 1 (Elross Lake)	0.1	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.1
	R9	Young Naskapi Camp 7 (Pinette Lake)	1.4	0.8	0.1	0.2	2.2	1.0	0.5	0.1	0.0	1.2
	R10	Young Naskapi Camp 3	0.9	0.5	0.1	0.1	1.5	0.6	0.3	0.1	0.0	0.8
	R11	Young Naskapi Trailer tent (Triangle Lake)	0.7	0.4	0.1	0.1	1.2	0.4	0.2	0.0	0.0	0.5
	R13	Naskapi - Uashat people's camp	0.8	0.5	0.1	0.1	1.6	0.6	0.3	0.1	0.0	1.0
	R16	Innu - Uashat - Mani-Utenam Camp 1	0.5	0.3	0.1	0.1	0.9	0.4	0.2	0.0	0.0	0.5
	R17	Innu - Uashat - Mani-Utenam Camp 2	0.2	0.1	0.0	0.0	0.4	0.1	0.1	0.0	0.0	0.2
	R18	Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake)	1.4	0.7	0.2	0.0	2.2	1.3	0.6	0.2	0.0	2.0
	R20	Innu Cabin 2	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1
	R24	Irony Mountain	1.0	0.6	0.1	0.1	1.8	0.8	0.4	0.1	0.0	1.2
	R39	Schefferville (Town)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	R40	TSMC Workers' Camp	1.7	0.8	0.2	0.0	2.3	1.7	0.7	0.2	0.0	2.1
	--	"Off-Property Limit" Maximum - Quebec	3.3	1.5	0.3	0.1	4.3	3.2	1.4	0.3	0.0	4.0
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	5.3	2.8	0.5	0.7	7.6	4.7	2.1	0.5	0.0	5.4
ALL: Background + DSO3 + DSO4 + HOWSE	**ID**	**Name**	TPM	PM10	PM2.5	SO2	NO2	TPM	PM10	PM2.5	SO2	NO2
	R5	Innu Tent 5 (Rosemary Lake)	8.1	4.1	3.0	2.0	10.4	8.1	4.1	3.0	2.0	10.3
	R7	Innu Tent 1 (Elross Lake)	8.2	4.1	3.0	2.0	10.5	8.1	4.1	3.0	2.0	10.4
	R9	Young Naskapi Camp 7 (Pinette Lake)	9.8	5.0	3.2	2.2	13.7	9.4	4.7	3.2	2.0	12.7
	R10	Young Naskapi Camp 3	9.1	4.6	3.1	2.1	12.2	8.8	4.4	3.1	2.0	11.4
	R11	Young Naskapi Trailer tent (Triangle Lake)	9.0	4.5	3.1	2.1	11.8	8.6	4.3	3.1	2.0	11.1
	R13	Naskapi - Uashat people's camp	9.1	4.6	3.1	2.1	12.3	8.9	4.5	3.1	2.0	11.6
	R16	Innu - Uashat - Mani-Utenam Camp 1	9.5	4.7	3.1	2.1	12.5	9.3	4.6	3.1	2.0	12.1
	R17	Innu - Uashat - Mani-Utenam Camp 2	8.3	4.2	3.0	2.0	10.7	8.2	4.1	3.0	2.0	10.5
	R18	Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake)	11.1	5.7	3.6	2.1	20.9	10.8	5.5	3.6	2.0	20.5
	R20	Innu Cabin 2	8.2	4.1	3.0	2.0	10.5	8.1	4.1	3.0	2.0	10.4
	R24	Irony Mountain	9.3	4.8	3.2	2.1	13.2	9.1	4.6	3.2	2.0	12.6
	R39	Schefferville (Town)	8.0	4.0	3.0	2.0	10.2	8.0	4.0	3.0	2.0	10.2
	R40	TSMC Workers' Camp	13.1	6.7	3.8	2.4	30.7	12.2	6.1	3.8	2.1	29.7
	--	"Off-Property Limit" Maximum - Quebec	19.5	10.6	4.2	4.3	32.1	17.6	7.7	3.9	2.0	23.3
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	21.0	9.1	4.1	2.7	27.2	20.8	8.9	4.1	2.0	26.4

- all values in μg/m^3. Red cell indicates above criteria.

Table 7-15 Summary Results – CAC – Maximum Daily Concentrations – With Blasts and No Blasts

			WITH BLASTS					NO BLASTS				
		Pollutant	TPM	PM10	PM2.5	SO2	NO2	TPM	PM10	PM2.5	SO2	NO2
		Averaging Period	24-hr	24-hr	24-hr	24-hr	24-hr	24-hr	24-hr	24-hr	24-hr	24-hr
		Selected Air Quality Assessement Criteria for Howse	**120**	**50**	**25**	**288**	**200**	**120**	**50**	**25**	**288**	**200**
		BACKGROUND CONCENTRATIONS - PRE-DSO3	**40**	**20**	**15**	**10**	**30**	**40**	**20**	**15**	**10**	**30**
DSO3 + DSO4 ONLY	**ID**	**Description**	TPM	PM10	PM2.5	SO2	NO2	TPM	PM10	PM2.5	SO2	NO2
	R5	Innu Tent 5 (Rosemary Lake)	1.5	0.5	0.3	0.1	7.9	1.5	0.5	0.3	0.0	7.7
	R7	Innu Tent 1 (Elross Lake)	1.4	0.9	0.5	0.3	10.6	1.0	0.6	0.5	0.0	10.6
	R9	Young Naskapi Camp 7 (Pinette Lake)	6.2	4.1	2.6	1.7	63.2	6.2	3.1	2.6	0.1	59.6
	R10	Young Naskapi Camp 3	3.6	1.4	0.9	0.6	20.0	3.6	1.3	0.9	0.0	19.9
	R11	Young Naskapi Trailer tent (Triangle Lake)	2.5	1.6	0.9	0.7	20.0	2.5	1.3	0.9	0.0	19.4
	R13	Naskapi - Uashat people's camp	5.1	1.9	0.8	0.5	19.8	5.1	1.9	0.8	0.0	19.7
	R16	Innu - Uashat - Mani-Utenam Camp 1	7.1	2.6	1.1	0.6	24.5	7.1	2.6	1.1	0.0	24.5
	R17	Innu - Uashat - Mani-Utenam Camp 2	1.4	1.0	0.3	0.4	7.2	1.4	0.6	0.3	0.0	6.9
	R18	Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake)	36.6	26.3	5.5	11.6	119.0	11.7	7.3	5.5	0.1	119.0
	R20	Innu Cabin 2	1.8	1.5	0.4	0.6	9.9	1.1	0.6	0.3	0.0	9.3
	R24	Irony Mountain	4.7	2.6	1.5	0.7	39.5	4.7	2.6	1.4	0.0	35.8
	R39	Schefferville (Town)	0.6	0.4	0.2	0.1	4.6	0.5	0.3	0.2	0.0	4.5
	R40	TSMC Workers' Camp	97.1	70.6	7.7	31.3	283.3	20.2	10.7	7.7	0.6	283.3
	--	"Off-Property Limit" Maximum - Quebec	211.3	137.1	14.2	58.1	333.7	82.1	35.2	10.0	0.2	171.5
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	105.8	44.9	8.2	19.5	175.9	105.8	35.8	8.2	0.2	175.9
HOWSE ONLY	**ID**	**Name**	TPM	PM10	PM2.5	SO2	NO2	TPM	PM10	PM2.5	SO2	NO2
	R5	Innu Tent 5 (Rosemary Lake)	3.6	3.3	0.2	1.4	11.1	1.9	1.0	0.2	0.0	3.2
	R7	Innu Tent 1 (Elross Lake)	2.6	2.4	0.2	1.0	8.4	1.2	0.6	0.1	0.0	1.5
	R9	Young Naskapi Camp 7 (Pinette Lake)	41.0	29.2	1.9	13.1	90.7	9.2	4.4	1.3	0.0	11.9
	R10	Young Naskapi Camp 3	33.4	25.9	1.8	11.2	72.2	10.7	5.1	1.2	0.0	12.9
	R11	Young Naskapi Trailer tent (Triangle Lake)	17.7	14.2	1.0	6.2	44.1	5.9	2.7	0.8	0.0	9.5
	R13	Naskapi - Uashat people's camp	45.6	36.1	2.6	15.5	101.3	14.9	7.5	1.8	0.0	18.2
	R16	Innu - Uashat - Mani-Utenam Camp 1	14.7	10.3	0.6	4.6	35.5	4.3	2.0	0.5	0.0	5.7
	R17	Innu - Uashat - Mani-Utenam Camp 2	13.8	12.1	0.8	5.2	37.6	3.4	1.6	0.6	0.0	5.9
	R18	Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake)	12.1	10.5	3.4	4.4	52.2	11.8	6.5	3.4	0.2	52.2
	R20	Innu Cabin 2	1.7	1.0	0.2	0.4	3.3	1.7	1.0	0.2	0.0	2.0
	R24	Irony Mountain	33.8	20.3	1.8	8.9	56.6	12.5	7.8	1.7	0.0	18.0
	R39	Schefferville (Town)	0.6	0.4	0.1	0.1	1.2	0.6	0.4	0.1	0.0	0.9
	R40	TSMC Workers' Camp	17.9	8.4	2.7	3.3	43.2	17.7	8.3	2.7	0.2	43.2
	--	"Off-Property Limit" Maximum - Quebec	54.8	27.0	5.8	10.4	83.8	54.5	26.8	5.8	0.4	80.1
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	123.6	83.4	10.7	37.0	196.3	82.7	42.7	10.6	0.4	89.6
ALL: Background + DSO3 + DSO4 + HOWSE	**ID**	**Name**	TPM	PM10	PM2.5	SO2	NO2	TPM	PM10	PM2.5	SO2	NO2
	R5	Innu Tent 5 (Rosemary Lake)	44.1	23.8	15.5	11.5	43.6	42.5	21.3	15.5	10.0	40.9
	R7	Innu Tent 1 (Elross Lake)	42.6	22.4	15.5	11.0	40.6	42.1	21.0	15.5	10.0	40.6
	R9	Young Naskapi Camp 7 (Pinette Lake)	81.0	49.2	17.6	23.1	121.0	52.4	25.7	17.6	10.1	89.6
	R10	Young Naskapi Camp 3	74.8	47.2	16.9	21.7	107.6	52.2	25.8	16.7	10.0	61.8
	R11	Young Naskapi Trailer tent (Triangle Lake)	58.2	34.6	16.2	16.3	78.3	47.5	23.5	16.2	10.0	53.5
	R13	Naskapi - Uashat people's camp	87.3	57.5	17.8	26.0	136.9	56.2	28.1	16.9	10.0	57.6
	R16	Innu - Uashat - Mani-Utenam Camp 1	54.8	30.4	16.1	14.6	69.6	48.9	23.6	16.1	10.0	54.5
	R17	Innu - Uashat - Mani-Utenam Camp 2	54.8	33.1	15.9	15.6	71.2	44.1	22.1	15.7	10.0	42.6
	R18	Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake)	76.8	46.5	20.5	21.6	149.1	62.2	33.8	20.5	10.2	149.1
	R20	Innu Cabin 2	43.0	22.0	15.4	10.8	40.0	42.7	21.6	15.4	10.0	39.3
	R24	Irony Mountain	73.8	40.4	17.6	18.9	87.4	56.3	29.7	17.5	10.1	75.8
	R39	Schefferville (Town)	41.2	20.7	15.2	10.2	34.7	41.1	20.7	15.2	10.0	34.6
	R40	TSMC Workers' Camp	137.1	90.6	22.7	41.3	315.8	73.9	36.3	22.7	10.7	315.0
	--	"Off-Property Limit" Maximum - Quebec	251.4	157.2	29.2	68.2	364.2	127.8	64.5	25.0	10.4	201.5
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	184.9	103.7	26.0	47.0	232.1	184.1	77.1	25.8	10.4	205.9

- all values in µg/m^3. Red cell indicates above criteria.

Table 7-16 Summary Results – CAC – Maximum 1-hr, 3-hr and 8-hr Concentrations – With Blasts and No Blasts

			WITH BLASTS					NO BLASTS				
		Pollutant	SO2	SO2	NO2	CO	CO	SO2	SO2	NO2	CO	CO
		Averaging Period	3-hr	1-hr	1-hr	8-hr	1-hr	3-hr	1-hr	1-hr	8-hr	1-hr
		Selected Air Quality Assessement Criteria for Howse	**600**	**900**	**400**	**12700**	**34000**	**600**	**900**	**400**	**12700**	**34000**
		BACKGROUND CONCENTRATIONS - PRE-DSO3	**18**	**24**	**50**	**400**	**600**	**18**	**24**	**50**	**400**	**600**
DSO3 + DSO4 ONLY	**ID**	**Description**	SO2	SO2	NO2	CO	CO	SO2	SO2	NO2	CO	CO
	R5	Innu Tent 5 (Rosemary Lake)	1.1	1.8	31.8	33.3	138.7	0.0	0.0	31.8	1.9	4.2
	R7	Innu Tent 1 (Elross Lake)	2.3	6.0	56.0	43.6	259.6	0.0	0.1	56.0	1.8	5.0
	R9	Young Naskapi Camp 7 (Pinette Lake)	12.8	28.5	191.9	207.7	1138.9	0.1	0.2	180.3	8.7	13.4
	R10	Young Naskapi Camp 3	4.6	7.9	61.4	72.0	350.1	0.0	0.1	49.0	4.1	5.7
	R11	Young Naskapi Trailer tent (Triangle Lake)	5.2	9.9	74.8	83.7	517.7	0.0	0.0	39.4	3.1	9.5
	R13	Naskapi - Uashat people's camp	4.1	8.2	64.1	74.6	364.9	0.0	0.1	50.1	3.9	6.4
	R16	Innu - Uashat - Mani-Utenam Camp 1	3.9	8.2	83.7	81.0	293.2	0.1	0.1	83.7	6.2	11.3
	R17	Innu - Uashat - Mani-Utenam Camp 2	3.0	6.0	46.8	62.6	285.4	0.0	0.0	34.4	1.8	3.7
	R18	Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake)	68.3	205.0	1428.5	1260.4	7378.7	0.2	0.3	269.2	31.9	54.9
	R20	Innu Cabin 2	4.2	11.6	86.8	76.9	457.4	0.0	0.0	25.8	2.1	3.7
	R24	Irony Mountain	5.1	9.4	183.6	88.9	413.3	0.1	0.2	183.6	10.5	16.9
	R39	Schefferville (Town)	1.1	2.6	22.0	28.7	112.8	0.0	0.0	9.4	0.7	1.6
	R40	TSMC Workers' Camp	202.9	608.5	2961.1	3422.5	21957.0	0.8	0.8	423.0	78.8	120.8
	--	"Off-Property Limit" Maximum - Quebec	402.0	1206.0	5339.8	6291.5	42341.0	0.3	0.4	327.3	193.7	319.0
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	139.1	417.1	2161.0	2101.6	14721.0	0.4	0.5	373.8	82.0	104.7
HOWSE ONLY	**ID**	**Name**	SO2	SO2	NO2	CO	CO	SO2	SO2	NO2	CO	CO
	R5	Innu Tent 5 (Rosemary Lake)	10.6	30.4	240.1	182.8	1335.4	0.0	0.0	11.3	3.3	8.7
	R7	Innu Tent 1 (Elross Lake)	7.5	21.9	173.6	161.1	990.7	0.0	0.0	9.4	2.4	4.5
	R9	Young Naskapi Camp 7 (Pinette Lake)	104.4	237.4	1586.9	1419.2	8569.9	0.1	0.2	67.7	35.5	63.0
	R10	Young Naskapi Camp 3	89.7	197.1	1293.3	1285.2	7386.2	0.0	0.1	75.1	27.7	77.2
	R11	Young Naskapi Trailer tent (Triangle Lake)	49.5	81.8	608.4	713.4	3139.3	0.0	0.0	47.2	22.4	48.0
	R13	Naskapi - Uashat people's camp	124.0	247.6	1523.6	1774.0	9409.3	0.1	0.1	93.7	48.5	92.0
	R16	Innu - Uashat - Mani-Utenam Camp 1	36.5	82.6	635.8	496.9	3000.1	0.1	0.1	35.2	13.9	32.4
	R17	Innu - Uashat - Mani-Utenam Camp 2	41.6	87.5	625.6	631.1	3539.2	0.0	0.0	26.8	13.4	27.5
	R18	Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake)	35.3	78.7	609.2	522.6	3092.7	0.7	0.9	160.2	20.2	38.2
	R20	Innu Cabin 2	3.0	7.9	63.6	59.2	323.9	0.0	0.0	7.7	2.1	4.5
	R24	Irony Mountain	71.4	188.1	1181.2	939.4	6599.8	0.2	0.3	91.8	37.7	78.2
	R39	Schefferville (Town)	0.8	2.5	20.0	14.9	94.6	0.0	0.0	3.0	0.9	1.8
	R40	TSMC Workers' Camp	26.3	52.6	413.9	388.4	2068.5	1.0	1.1	199.5	20.1	41.1
	--	"Off-Property Limit" Maximum - Quebec	83.2	191.9	1459.8	1135.8	6955.0	1.7	1.8	269.6	37.0	67.0
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	295.5	769.4	3525.5	3975.8	27484.0	1.7	1.8	269.6	162.7	227.9
ALL: Background + DSO3 + DSO4 + HOWSE	**ID**	**Name**	SO2	SO2	NO2	CO	CO	SO2	SO2	NO2	CO	CO
	R5	Innu Tent 5 (Rosemary Lake)	29.6	56.2	303.5	616.2	2074.1	17.9	24.4	84.5	405.1	610.4
	R7	Innu Tent 1 (Elross Lake)	25.4	46.2	224.0	561.5	1591.9	17.9	24.4	106.3	403.4	606.8
	R9	Young Naskapi Camp 7 (Pinette Lake)	122.3	261.7	1636.9	1819.2	9169.9	18.1	24.6	231.7	437.3	667.7
	R10	Young Naskapi Camp 3	111.6	227.4	1391.3	1756.9	8300.6	18.0	24.4	131.9	428.4	678.9
	R11	Young Naskapi Trailer tent (Triangle Lake)	68.2	107.2	658.7	1130.1	3791.8	18.0	24.4	98.6	423.1	648.8
	R13	Naskapi - Uashat people's camp	146.0	280.1	1637.7	2248.6	10374.2	18.0	24.4	146.1	449.4	693.8
	R16	Innu - Uashat - Mani-Utenam Camp 1	54.4	107.0	687.9	899.4	3601.4	18.0	24.5	136.2	416.2	633.0
	R17	Innu - Uashat - Mani-Utenam Camp 2	62.5	113.9	693.9	1093.7	4293.1	17.9	24.4	93.5	414.8	630.5
	R18	Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake)	86.2	229.4	1478.5	1660.4	7978.7	18.6	25.2	329.3	432.2	654.9
	R20	Innu Cabin 2	22.3	35.9	137.5	515.4	1058.0	17.9	24.4	77.7	404.0	607.2
	R24	Irony Mountain	89.3	212.4	1232.0	1340.0	7200.3	18.2	24.7	234.3	438.8	680.2
	R39	Schefferville (Town)	19.0	26.9	74.3	431.3	713.0	17.9	24.4	61.5	401.5	603.4
	R40	TSMC Workers' Camp	220.8	632.9	3011.1	3822.5	22557.0	19.1	25.6	487.3	479.1	721.0
	--	"Off-Property Limit" Maximum - Quebec	419.9	1230.3	5391.0	6696.3	42942.0	19.6	26.1	388.3	593.7	926.8
	--	"Off-Property Limit" Maximum - Newfoundland/Labrador	313.4	793.8	3577.3	4376.7	28085.0	19.6	26.1	431.9	565.0	830.1

- all values in μg/m^3. Red cell indicates above criteria.

Table 7-17 Frequency of Exceedances at Sensitive Receptors

POLLUTANT	AVERAGING PERIOD	ASSESSMENT CRITERIA (µG/M^3)	RECEPTORS WITH PREDICTED EXCEEDANCE		MAXIMUM CONCENTRATION* (EXCEEDANCE COUNT / % OF TIME)**			
			ID	NAME	WITH BLASTS		NO BLASTS	
TPM	24-hr	120	R40	TSMC Workers' Camp	**137.1**		**Meets Criteria**	
					2	0.11%	--	--
PM$_{10}$	24-hr	50	R13	Naskapi - Uashat people's camp	**57.5**		**Meets Criteria**	
					1	0.05%	--	--
			R40	TSMC Workers' Camp	**90.6**		**Meets Criteria**	
					6	0.33%	--	--
NO$_2$	24-hr	200	R40	TSMC Workers' Camp	**315.8**		**315.0**	
					7	0.38%	7	0.38%
NO$_2$	1-hr	400	R9	Young Naskapi Camp 7 (Pinette Lake)	**1636.9**		**Meets Criteria**	
					13	0.71%	--	--
			R10	Young Naskapi Camp 3	**1391.3**		**Meets Criteria**	
					10	0.55%	--	--
			R11	Young Naskapi Trailer tent (Triangle Lake)	**658.7**		**Meets Criteria**	
					8	0.44%	--	--
			R13	Naskapi - Uashat people's camp	**1637.7**		**Meets Criteria**	
					8	0.44%	--	--
			R16	Innu - Uashat - Mani-Utenam Camp 1	**687.9**		**Meets Criteria**	
					6	0.33%	--	--
			R17	Innu - Uashat - Mani-Utenam Camp 2	**693.9**		**Meets Criteria**	
					1	0.05%	--	--
			R18	Innu - Uashat - Mani-Utenam Camp 3 (Inukshuk Lake)	**1478.5**		**Meets Criteria**	
					9	0.49%	--	--
			R24	Irony Mountain	**1232.0**		**Meets Criteria**	
					6	0.33%	--	--
			R40	TSMC Workers' Camp	**3011.1**		**487.3**	
					128	0.93%	99	0.23%

* Maximum modelled concentration over 5 year’s meteorological data.

** Exceedance count = Number of times concentration above the standard in the 5 year period. The exceedance count is for the cumulative air quality effect e.g. Background + DSO3 + DSO4 + HOWSE.

% of time = Count ÷ Number of averaging period in 5 years. For hourly averaging period With Blasts, a day corresponds to the averaging period, due to the way blasting is modelled. At the R40 receptor, for the "With Blasts" scenario the % of time exceedance was calculated based on the number hours in 5 years (5 yrs x 8760 hrs/yr = 43 800 hrs/5 yrs) and the 29 exceedances due to blasting, while the "No Blasts" % of time exceedance was calculated based on the number of hours in 5 years (5 yrs x 8760 hrs/yr = 43 800 hrs/5 yrs).

Table 7-18 Frequency of Exceedances at Maximum “Off-Property” Grid Receptors

POLLUTANT	AVERAGING PERIOD	ASSESSMENT CRITERIA	RECEPTORS WITH PREDICTED EXCEEDANCE	MAXIMUM CONCENTRATION* (EXCEEDANCE COUNT / % OF TIME)**

		(µG/M^3)	PROV.	NAME	WITH BLASTS		NO BLASTS	
TPM	24-hr	120	QC	"Off-Property Limit" Maximum - QC	**251.4**		**127.8**	
					26	1.42%	4	0.22%
			NL	"Off-Property Limit" Maximum - NL	**184.9**		**184.1**	
					8	0.44%	8	0.44%
PM$_{10}$	24-hr	50	QC	"Off-Property Limit" Maximum - QC	**157.2**		**64.5**	
					52	2.85%	7	0.38%
			NL	"Off-Property Limit" Maximum - NL	**103.7**		**77.1**	
					17	0.93%	15	0.82%
PM$_{2.5}$	24-hr	25	QC	"Off-Property Limit" Maximum - QC	**29.2**		**Meets Criteria**	
					5	0.27%	--	--
			NL	"Off-Property Limit" Maximum - NL	**26.0**		**25.8**	
					1	0.05%	1	0.05%
NO$_2$	24-hr	200	QC	"Off-Property Limit" Maximum - QC	**364.2**		**201.5**	
					9	0.49%	1	0.05%
			NL	"Off-Property Limit" Maximum - NL	**232.1**		**205.9**	
					3	0.16%	1	0.05%
NO$_2$	1-hr	400	QC	"Off-Property Limit" Maximum - QC	**5391.0**		**Meets Criteria**	
					358	< 1.19%	--	--
			NL	"Off-Property Limit" Maximum - NL	**3577.3**		**431.9**	
					46	2.52%	3	0.00002%
SO$_2$	1-hr	900	QC	"Off-Property Limit" Maximum - QC	**1230.3**		**Meets Criteria**	
					6	< 1.19%	--	--
			NL	"Off-Property Limit" Maximum - NL	**Meets Criteria**		**Meets Criteria**	
					--	--	--	--
CO	1-hr	34 000	QC	"Off-Property Limit" Maximum - QC	**42942**		**Meets Criteria**	
					4	< 1.19%	--	--
			NL	"Off-Property Limit" Maximum - NL	**Meets Criteria**		**Meets Criteria**	
					--	--	--	--

* Maximum modelled concentration over 5 year's meteorological data.

** Exceedance count = Number of times with concentration above the standard during the 5 year modelling period. The exceedance count is for the cumulative air quality effect e.g. Background + DSO3 + DSO4 + HOWSE.

% of time = Count ÷ Number of averaging period in 5 years. For NO2 1-hr, SO2 1-hr and CO 1-hr averaging periods, the No Blasts result is "Meets Criteria", which means that results for the With Blast scenario are all caused by blasting events. Blasting events will occur once per week at most. Conservatively assuming that each blast at Howse and Fleming 7N causes a 1-hr air quality exceedance, this would translate to: 52 blasts/yr x 2 pits x 5 years = 520 blasts per 5 year. There are 5 yrs x 8760 hrs/yr = 43 800 hrs/5 yrs. Resulting in 520 ÷ 43 800 x 100 = 1.19% of time exceedance. In reality, the annual number of blasts per year is expected to be less at 30 and 33 for Fleming 7N and Howse, respectively.

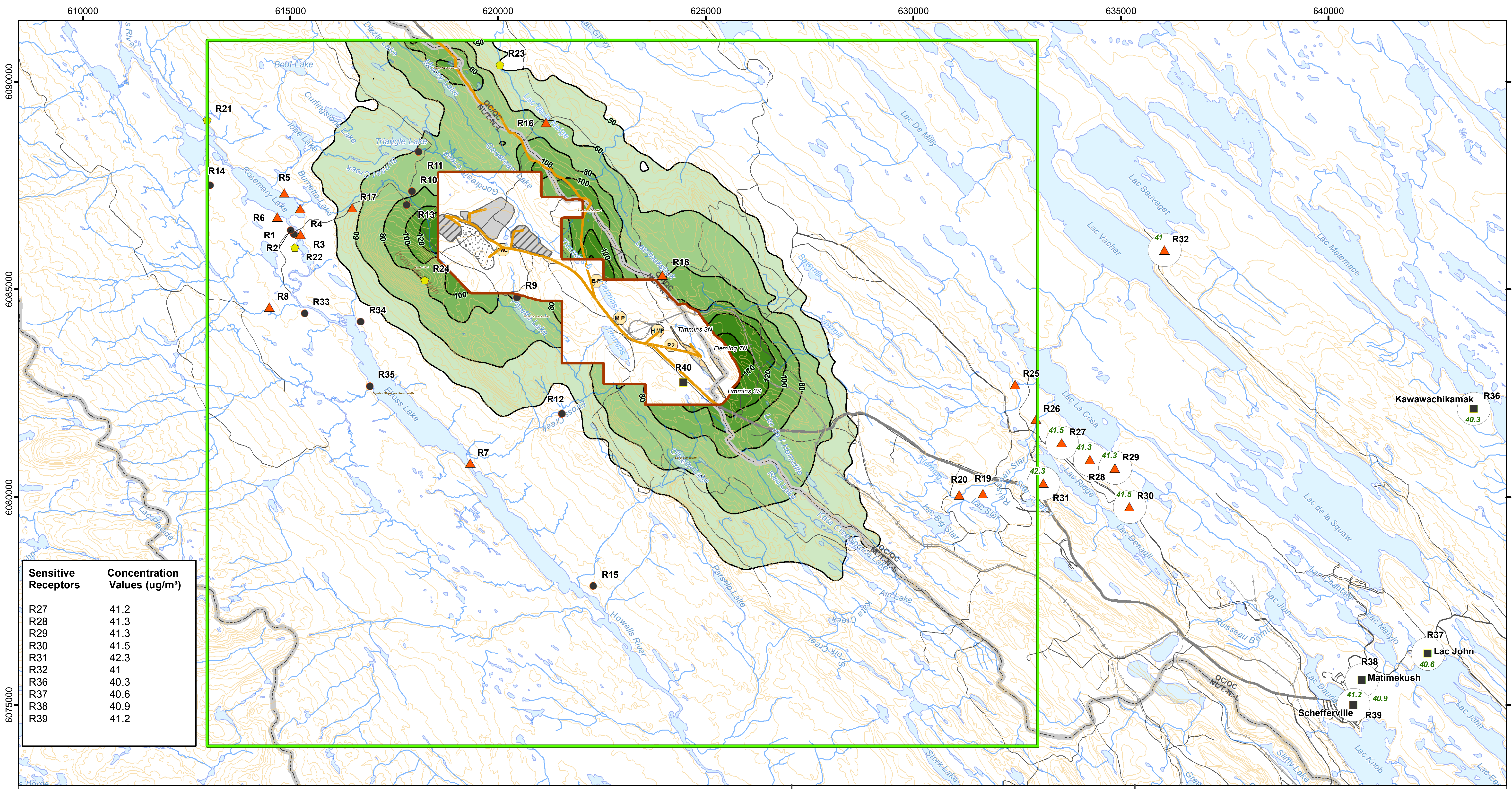
*** Figures 3.16 and 3.17 of the Air Dispersion Modelling Report show the locations of grid receptors with maximum predicted concentration for the "With Blasts" and "No Blasts" scenarios respectively.

Isoconcentration Contour Plots and Figures

In this section, for air pollutants having predicted maximum concentrations that exceed the applicable Project Air Quality Assessment Criteria, concentrations are presented in graphical format, eg.

isoconcentrations contour plots. It is important to note that the maximum predicted concentrations shown on the contour plots represent the single highest concentration predicted to occur at each location, at any time during the 5-year assessment period, and include background concentrations. Therefore, the contours shown do not represent a snapshot in time as these maxima may occur on different days, under different meteorological conditions. It should also be emphasized that the model results are based on the conservative emissions scenario described in Volume 2, Supporting Study E, which assumes that all sites within the LSA (DSO3, DSO4 and Howse) operate at their maximum capacities over the entire 5 year meteorological assessment period. Therefore, the results presented below are expected to be lower than those predicted by the model.

Results are also shown for 10 sensitive receptors which are outside of the study area, and so have no contour plots but have otherwise been included in the modelling process. Their values are shown and represented in a manner that corresponds with the corresponding Figure legend.



Sensitive Receptors	Concentration Values (ug/m³)
R27	41.2
R28	41.3
R29	41.3
R30	41.5
R31	42.3
R32	41
R36	40.3
R37	40.6
R38	40.9
R39	41.2

LEGEND

Sensitive Receptors

- ● Naskapi
- ▲ Innu
- ■ Permanent
- ⬠ Other

Study Areas

- 🟩 Local Study Area (LSA)
- 🟥 Air Quality Modelling Perimeter
- — Road Included in the Model
- — Road Not-included in the Model

TPM (24-hour) - With Blasts

- — Isocontour

Concentration Range (ug/m³)

- 0-50
- 50-60
- 60-80
- 80-100
- 100-120
- 120-170
- 170-252

Infrastructure and Mining Components

- P2 Plant 2
- MP Main processing Plant
- HMP Howse Mini-Plant
- BP Batch Plant
- FNC First Nations crusher/screener
- Existing Railroad
- Deposit
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Waste Dump/ In-Pit Dump
- Proposed Mine Haul Road

Basemap

- Existing road
- Contour Line (50 ft)
- Provincial Border
- Watercourse
- Water Body

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0678 , PR185-19-14, 2016-04-14, edickoum

N

0 2 4
Kilometers
SCALE: 1:90 000

UTM 19N NAD 83

SOURCES:

Basemap and Land Use Components
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec,

Mining Components
Howse Minerals Limited/
MET-CHEM Howse Deposit Design
for General Layout., 2015
Groupe Hémisphères, Hydrology and update, 2013

ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

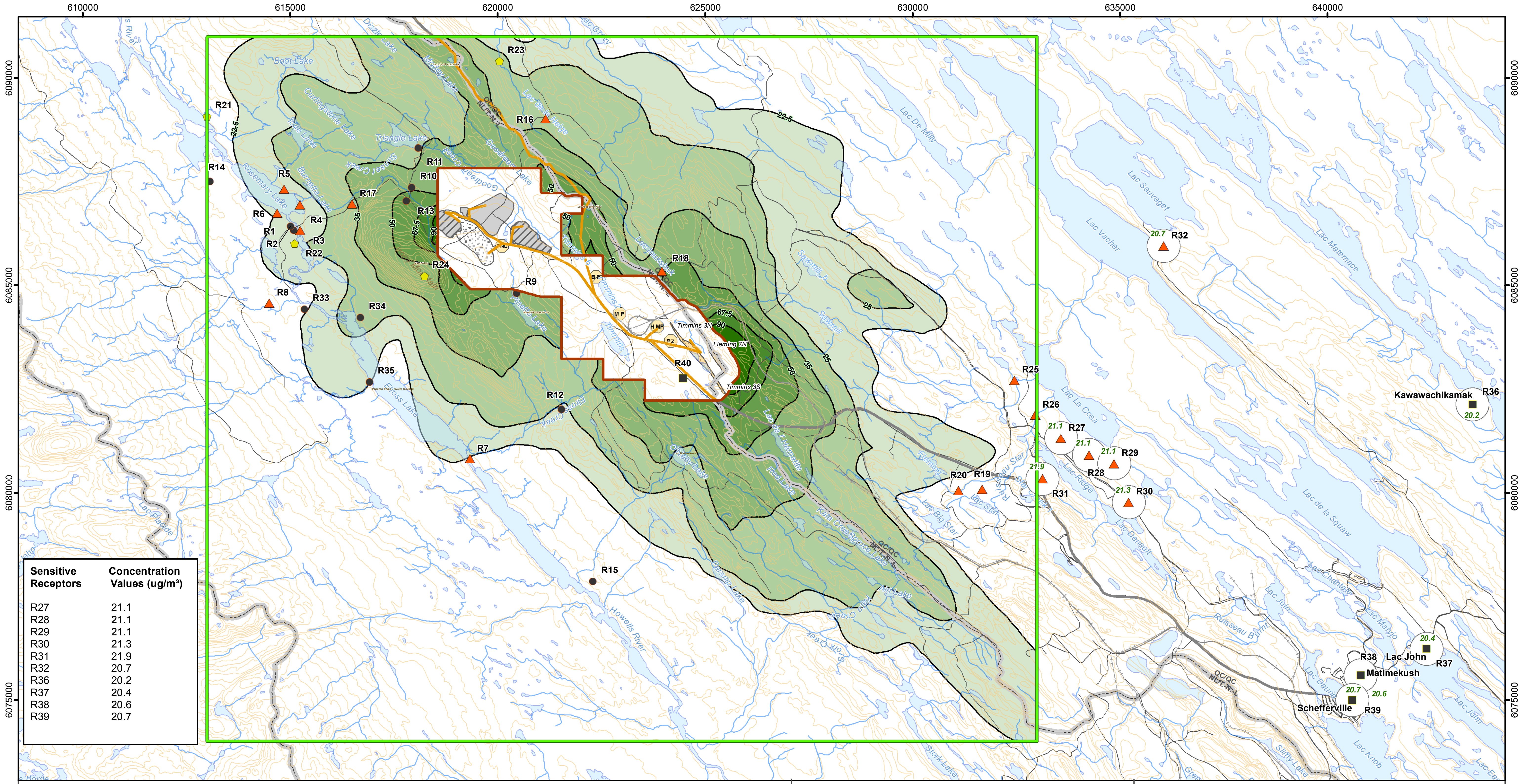
Maximum Concentrations - TPM (24-hour) - With Blasts

Howse Minerals Limited

5731, rue Saint-Louis,
Bureau 201, Lévis (QC)
Canada, G6V 4E2

1453, rue Beaubien est,
Bureau 301, Montréal (QC)
Canada, H2G 3C6

Figure 7.4



Sensitive Receptors	Concentration Values (ug/m³)
R27	21.1
R28	21.1
R29	21.1
R30	21.3
R31	21.9
R32	20.7
R36	20.2
R37	20.4
R38	20.6
R39	20.7

LEGEND

Sensitive Receptors

- ● Naskapi
- ▲ Innu
- ■ Permanent
- ⬟ Other

Study Areas

- 🟩 Local Study Area (LSA)
- 🟥 Air Quality Modelling Perimeter
- — Road Included in the Model
- — Road Not-included in the Model

PM10 (24-hour) - With Blasts

- — Isocontour

Concentration Range (ug/m³)

- ☐ 0-22.5
- 🟩 22.5-25
- 🟩 25-35
- 🟩 35-50
- 🟩 50-67.5
- 🟩 67.5-90
- 🟩 90-158

Infrastructure and Mining Components

- P2 Plant 2
- M P Main processing Plant
- H MP Howse Mini-Plant
- B P Batch Plant
- FNC First Nations crusher/screener
- Existing Railroad
- Deposit
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- ▨ Proposed Waste Dump/ In-Pit Dump
- Proposed Mine Haul Road

Basemap

- Existing road
- Contour Line (50 ft)
- Provincial Border
- Watercourse
- Water Body

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0678 , PR185-19-14, 2016-04-14, edickoum

N

0 2 4
Kilometers

UTM 19N NAD 83

SCALE: 1:90 000

SOURCES:

Basemap and Land Use Components
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec,

Mining Components
Howse Minerals Limited/
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AECOM

ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Maximum Concentrations - PM10 (24-hour) - With Blasts

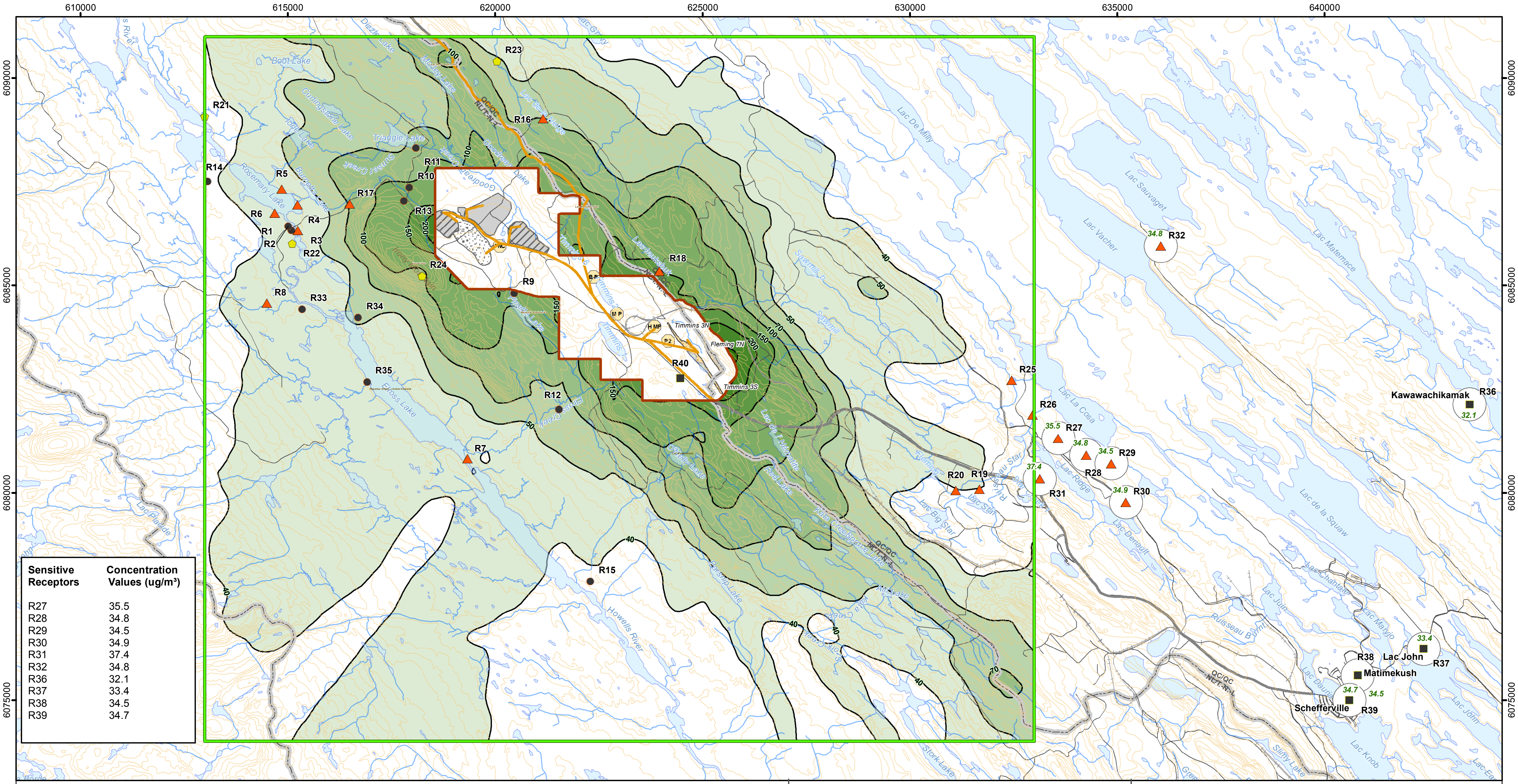
Howse Minerals Limited

GroupeHemispheres

5731, rue Saint-Louis,
Bureau 201, Lévis (QC)
Canada, G6V 4E2

1453, rue Beaubien est,
Bureau 301, Montréal (QC)
Canada, H2G 3C6

Figure 7.5



Sensitive Receptors	Concentration Values (ug/m³)
R27	35.5
R28	34.8
R29	34.5
R30	34.9
R31	37.4
R32	34.8
R36	32.1
R37	33.4
R38	34.5
R39	34.7

LEGEND

Sensitive Receptors

- ● Naskapi
- ▲ Innu
- ■ Permanent
- ⬟ Other

Study Areas

- 🟩 Local Study Area (LSA)
- 🟥 Air Quality Modelling Perimeter
- — Road Included in the Model
- — Road Not-included in the Model

NO2 (24-hour) - With Blasts

- — Isocontour

Concentration Range (ug/m³)

- ☐ 0-40
- 🟩 40-50
- 🟩 50-70
- 🟩 70-100
- 🟩 100-150
- 🟩 150-200
- 🟩 200-290
- 🟩 290-365

Infrastructure and Mining Components

- P2 Plant 2
- MP Main processing Plant
- HMP Howse Mini-Plant
- BP Batch Plant
- FNC First Nations crusher/screener
- Existing Railroad
- Deposit
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Waste Dump/ In-Pit Dump
- Proposed Mine Haul Road

Basemap

- Existing road
- Contour Line (50 ft)
- Provincial Border
- Watercourse
- Water Body

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Kilometers

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ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Maximum Concentrations - NO2 (24-hour) - With Blasts

Howse Minerals Limited

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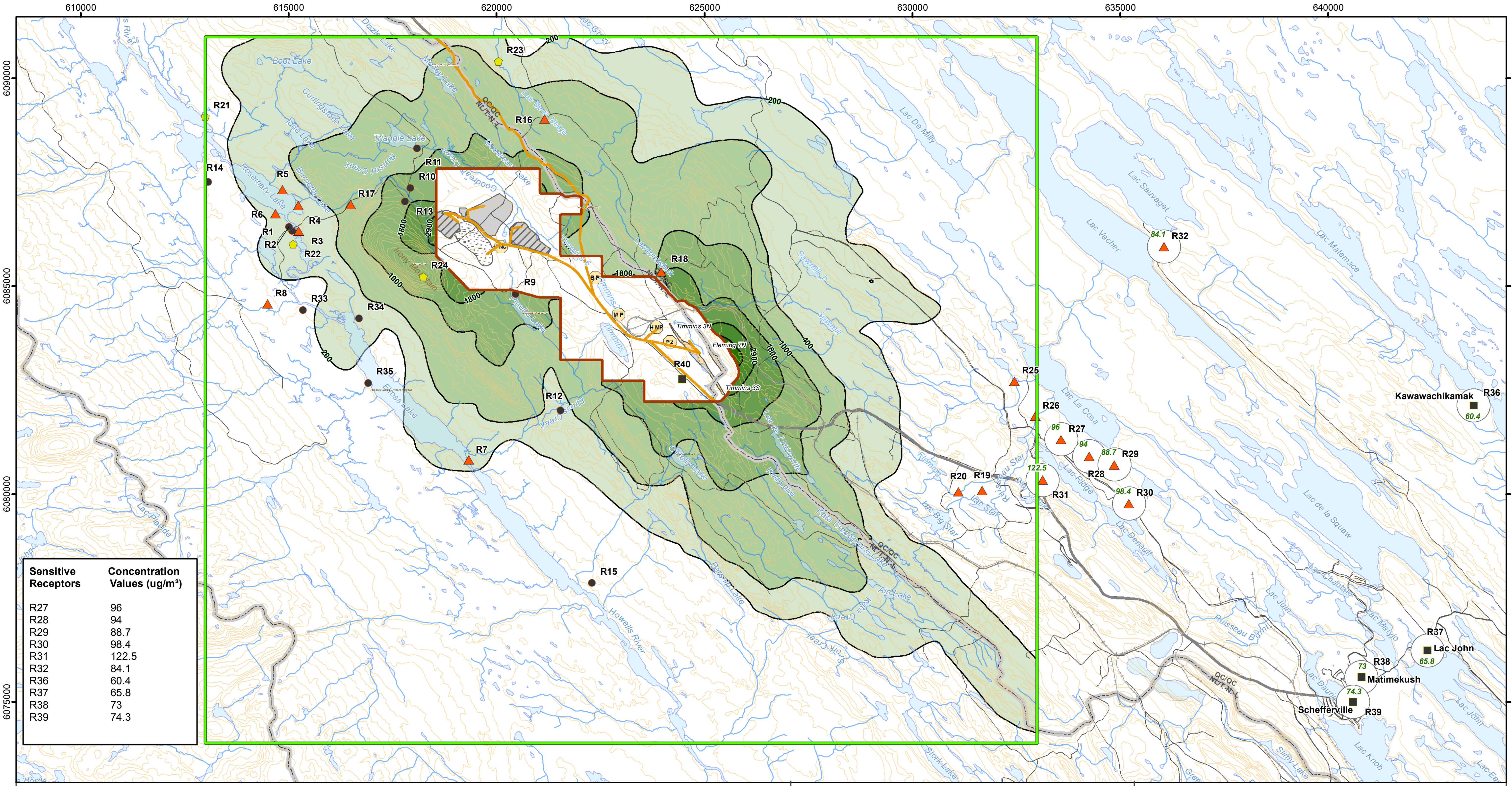
Figure 7.6



Sensitive Receptors	Concentration Values (ug/m³)
R27	96
R28	94
R29	88.7
R30	98.4
R31	122.5
R32	84.1
R36	60.4
R37	65.8
R38	73
R39	74.3

LEGEND

Sensitive Receptors
- ● Naskapi
- ▲ Innu
- ■ Permanent
- ⬟ Other

Study Areas
- 🟩 Local Study Area (LSA)
- 🟥 Air Quality Modelling Perimeter
- Road Included in the Model
- Road Not-included in the Model

NO2 (1-hour) - With Blasts
- Isocontour

Concentration Range (ug/m³)
- ☐ 0-200
- 200-400
- 400-1000
- 1000-1800
- 1800-2900
- 2900-4000
- 4000-5391

Infrastructure and Mining Components
- P2 Plant 2
- MP Main processing Plant
- HMP Howse Mini-Plant
- BP Batch Plant
- FNC First Nations crusher/screener
- Existing Railroad
- Deposit
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- ▨ Proposed Waste Dump/ In-Pit Dump
- Proposed Mine Haul Road

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Kilometers
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ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Maximum Concentrations - NO2 (1-hour) - With Blasts

Howse Minerals Limited

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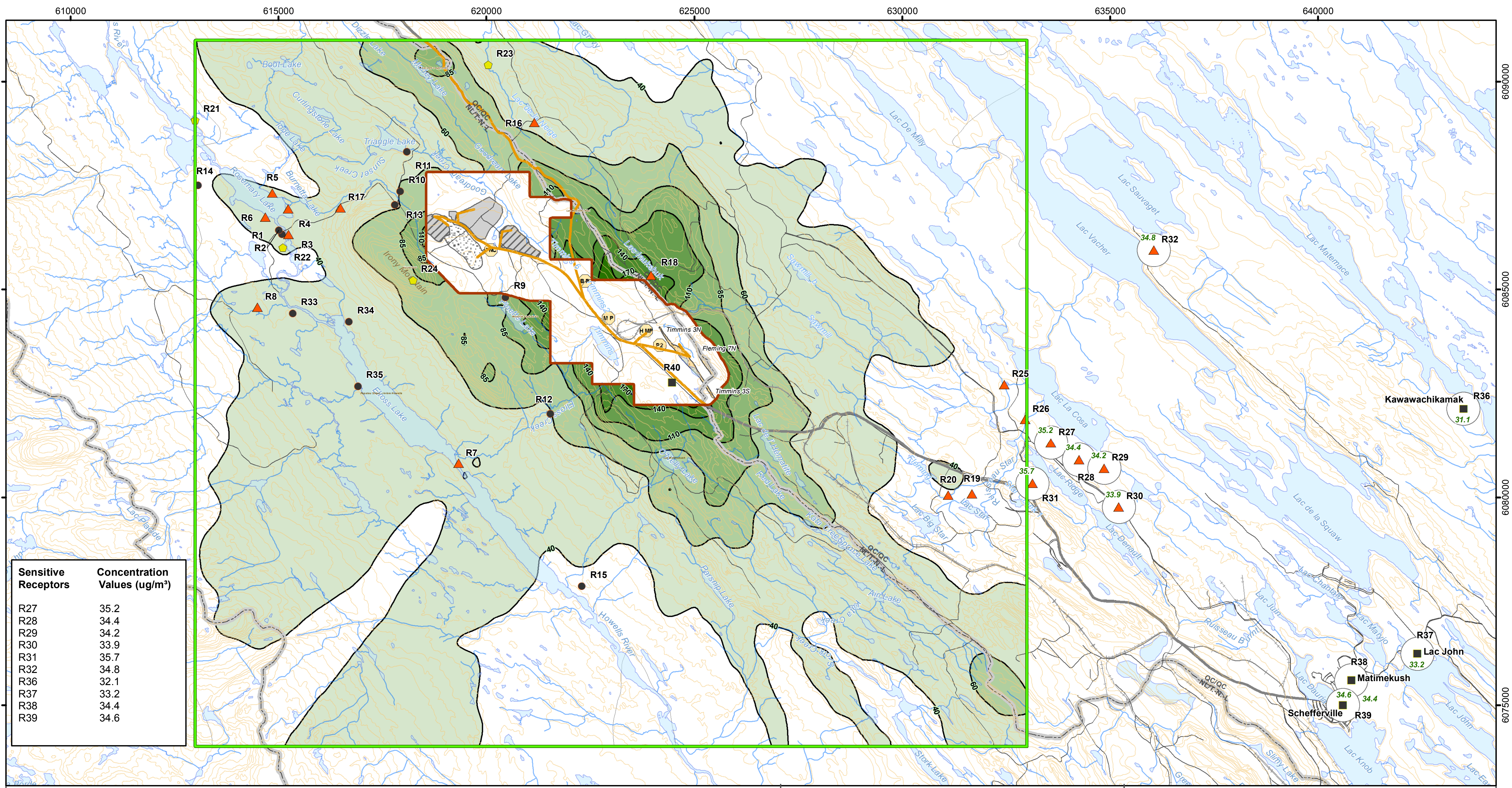
Figure 7-7



Sensitive Receptors	Concentration Values (ug/m³)
R27	35.2
R28	34.4
R29	34.2
R30	33.9
R31	35.7
R32	34.8
R36	32.1
R37	33.2
R38	34.4
R39	34.6

LEGEND

Sensitive Receptors
- ● Naskapi
- ▲ Innu
- ■ Permanent
- ⬟ Other

Study Areas
- ☐ Local Study Area (LSA)
- ☐ Air Quality Modelling Perimeter
- — Road Included in the Model
- — Road Not-included in the Model

NO2 (24-hour) - No Blasts
- — Isocontour

Concentration Range (ug/m³)
- ☐ 0-40
- 🟩 40-60
- 🟩 60-85
- 🟩 85-110
- 🟩 110-140
- 🟩 140-170
- 🟩 170-316

Infrastructure and Mining Components
- P2 Plant 2
- MP Main processing Plant
- HMP Howse Mini-Plant
- BP Batch Plant
- FNC First Nations crusher/screener
- Existing Railroad
- Deposit
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- Proposed Topsoil/ Overburden Stockpile
- ▨ Proposed Waste Dump/ In-Pit Dump
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GH-0678 , PR185-19-14, 2016-04-14, edickoum

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AECOM

ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Maximum Concentrations - NO2 (24-hour) - No Blasts

Howse Minerals Limited

GroupeHemispheres

5731, rue Saint-Louis,
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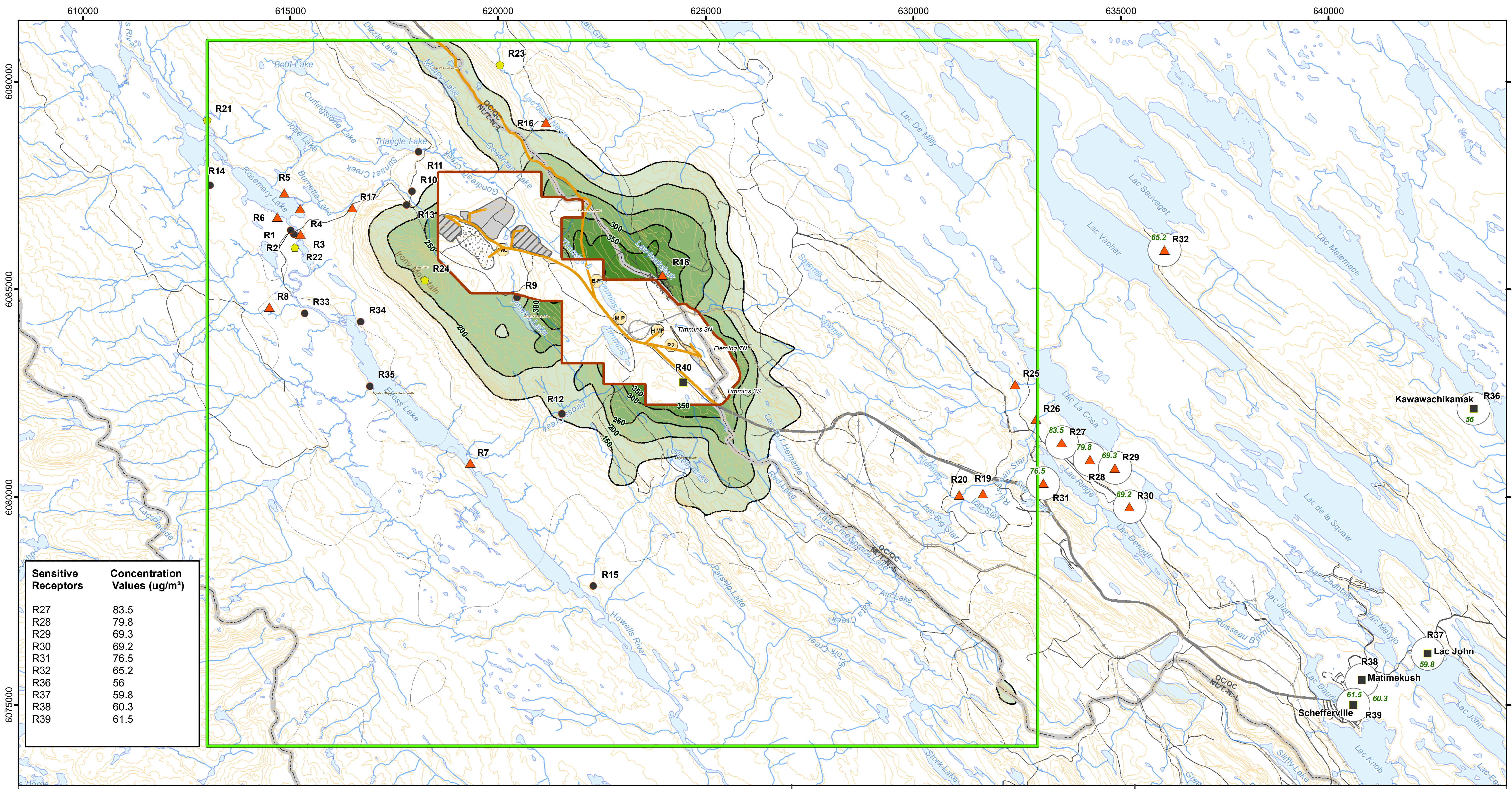
Canada, G6V 4E2

1453, rue Beaubien est,
Bureau 301, Montréal (QC)
Canada, H2G 3C6

Figure 7.8



Sensitive Receptors	Concentration Values (ug/m³)
R27	83.5
R28	79.8
R29	69.3
R30	69.2
R31	76.5
R32	65.2
R36	56
R37	59.8
R38	60.3
R39	61.5

LEGEND

Sensitive Receptors
- ● Naskapi
- ▲ Innu
- ■ Permanent
- ⬟ Other

Study Areas
- 🟩 Local Study Area (LSA)
- 🟥 Air Quality Modelling Perimeter
- Road Included in the Model
- Road Not-included in the Model

NO2 (1-hour) - No Blasts
- Isocontour

Concentration Range (ug/m³)
- 0-150
- 150-200
- 200-250
- 250-300
- 300-350
- 350-400
- 400- 488

Infrastructure and Mining Components
- P2 Plant 2
- MP Main processing Plant
- HMP Howse Mini-Plant
- BP Batch Plant
- FNC First Nations crusher/screener
- Existing Railroad
- Deposit
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Waste Dump/ In-Pit Dump
- Proposed Mine Haul Road

Basemap
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*Hydronyms are oriented along the direction of water flow

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Kilometers

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ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Maximum Concentrations - NO2 (1-hour) - No Blasts

Howse Minerals Limited

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Canada, G6V 4E2

1453, rue Beaubien est,
Bureau 301, Montréal (QC)
Canada, H2G 3C6

Figure 7.9

Interaction of the Project with Air Quality and Potential Effects

Site Preparation and Construction Phase

During the site preparation and construction phase, all project activities will have potential interaction with air quality.

Potential interaction

- upgrading/construction of the Howse haul road, upgrading of the bypass road and water management infrastructures;
- pit development;
- installation of the Howse ore processing plant near the rail loop (e.g. Howse Mini-Plant);
- transportation and traffic;

➔ The effect associated with the above potential interactions is a **decrease in air quality**.

The nature of the effect is direct and the effect is adverse.

As indicated in the LSA, RSA and Temporal Boundaries section for the air quality component, the types of air contaminants and the areas from which air emissions will occur during the *Site Preparation and Construction* and *Decommissioning and Reclamation* phase will be similar to those encountered during the Operation phase. During all three phases, air emissions from diesel powered engines, dust emissions due to vehicle movements and blasting will occur, but rates of air emissions during the Operation phase will be continuous and of a higher intensity. One important reason why the nature of the air contaminants remains the same during the three phases is the fact all power used at the site is generated by diesel equipment; the site is not connected to the power grid. Consequently, the air quality effects study was conducted for the Operation phase only. Therefore, the effect assessment, mitigation measures, specific mitigation measures and methodological approach used to assess the air quality component are covered in the Operation phase section below and are applicable to all phases of the project.

Operation Phase

No potential interaction

During the operation phase, the following activities will have no interaction with air quality:

- hazardous waste disposal;
- explosives waste management; and
- treatment of sanitary wastewater.

Potential interaction

- removal and storage of remaining overburden and topsoil;
- blasting and ore-extraction;
- mineral processing;
- operation of waste rock dumps;
- dewatering;
- transportation of ore and traffic;

- solid waste disposal; and
- ongoing site restoration.

➔ The effect associated with the above potential interactions is a **decrease in air quality**.

The nature of the effect is direct and the effect is adverse.

Decommissioning and Reclamation Phase

No potential interaction

During the decommissioning and reclamation phase, all project activities will have potential interaction with air quality.

Potential interaction

- Demobilization of Howse facilities and heavy machinery;
- Transportation and traffic;
- Final site restoration.

➔ The effect associated with the above potential interactions is a **decrease in air quality**.

The nature of the effect is direct and the effect is adverse.

For the reasons indicated previously, the air quality effect assessment was conducted for the Operation phase only.

7.3.2.3 Mitigation Measures

Standard Mitigation Measures

The following standard mitigation measures will be applied during all project phases (Table 7-19).

Table 7-19 Standard Mitigation Measures for Air Quality

CODE	MEASURE	MITIGATION EFFECT
Tree removal and timber management (TM)		
TM10	Ensure that cleared areas that are left bare and exposed to the elements are kept to a strict minimum.	Minimizing bare areas will reduce potential for airborne dust generation by wind erosion during dry periods
Erosion and Sedimentation Control (ES)		
ES15	Avoid storing excavated material on steep slopes and ensure they are properly compacted. To ensure better compaction of fill more than 60 cm thick, it is preferable to deposit several thin layers rather than a single layer. In zones with no transversal slope, the height and depth of the fill must be limited to three metres.	Airborne dust from wind erosion of excavated material piles will be transported on shorter distances if their height is limited
Waste Management (WM)		
WM2	Emphasize, in the following order, reduction at source re-use, recycling and conversion of	

CODE	MEASURE	MITIGATION EFFECT
	waste. Replace hazardous products with less harmful ones if possible. The quantity of waste can be reduced at source by using up products completely, buying in bulk and accurately estimating required amounts.	Waste reduction will minimize potential air emissions due to landfilling of organic wastes and transport to the landfill site
WM7	Comply with applicable regulations that prohibit the burning of waste.	
Drilling and Blasting (DB)		
DB3	Only properly qualified and trained personnel may handle and detonate explosives as per the manufacturer’s instructions and applicable laws and regulations.	Best practices used for drilling and blasting will minimize short-term air emissions associated with these activities. Combine these standard measures to the specific measure for management of NOx from Blasts.
DB4	The manufacturer’s instructions must be followed to ensure that blasting procedures are safe both for humans and the environment.	
DB21	Take the necessary precautions to control dust emissions from drilling.	
DB22	Fill borehole necks with clean crushed rock to eliminate dust and gas emissions during blasting.	
Construction Equipment (CE)		
CE4	Construction equipment must be delivered to the site in good working order, without leaks and equipped with all emissions filters required to comply with emissions regulations and reduce noise disturbance. The equipment must be regularly inspected to detect any leaks or mechanical defects that could lead to fuel, lubricant or hazardous material spills.	Well maintained engines will keep air emissions in-line with regulations
CE8	Install appropriate road signs and follow speed limits in order to minimize accidents and disturbance to the environment.	Road dust emissions are minimized at lower speed.
CE14	Use low sulfur content fuels.	There is a direct relationship between SO_2 emissions and fuel sulfur content. Low fuel sulfur content, means low SO_2 emissions. Fuel sulfur content is limited to 15 ppm, as per Canadian regulations
CE15	The dust-control liquid used must comply with GNL regulations.	Application of a dust control agent will reduce road dust emissions
Mining Operations (M)		
M3	Reports required by governments must be submitted by the stipulated deadlines.	n/a
Management of Ore, Rock Piles, Waste Rock, Tailings and Overburden (MO)		
MO1	Take the necessary steps to prevent wind erosion of stored tailings and avoid slippage around the mine tailing storage sites.	Reduce dust emissions by minimizing tailings disturbances Minimizing tailings volumes reduces dust emissions caused by erosion
MO4	Prepare scenarios for using tailings, particularly waste rock. For example, tailings could be used to build roads and railways.	
MO5	The physico-chemical parameters of the ore and tailings must be characterized.	

CODE	MEASURE	MITIGATION EFFECT
MO6	Control dust emissions from tailing storage and handling.	
Air Quality Control (AQ)		
AQ1	Dust extractors with filter bags will be used to control dust emissions at the Howse Mini-Plant dryers.	Well maintained fabric filter dust emission control reduces dust emissions by >95%
AQ2	Dust recovered from the dust extractor must be disposed of in a manner that prevents dust emissions.	Good practices in dust handling minimizes punctual releases in the environment
AQ3	Use a water-spraying system at conveyor transfer and drop points.	Water spraying is efficient in reducing dust releases
AQ4	Mix the ore with water in the drum scrubber.	Water mixing is efficient in controlling dust from being released at the source
AQ5	A dust extractor will be used to limit dust emissions from drills.	The dust extractor limits the area in which wind gusts could blow dust away from the drill
AQ6	Roads will be sprayed to reduce dust emissions during dry periods.	Application of a dust control agent will reduce road dust emissions
Rehabilitation (R)		
R1	Follow good practices presented in the rehabilitation plan.	Dust emissions from wind erosion will be minimized by considering it as a specific issue in the rehabilitation plan
R2	Draw up a rehabilitation plan	
R3	Produce post-mining and post-rehabilitation monitoring reports.	

Specific Mitigation Measures

The following specific mitigation measures will be applied to limit effects on air quality by the Project activities (Table 7-20).

Table 7-20 Specific Mitigation Measures for Air Quality

SPECIFIC MITIGATION MEASURES FOR AIR QUALITY	
Measure	**Mitigation Effect**
TSMC will develop a plan for the prevention and management of blast generated NOx. This plan will be based on the Code of Good Practice prepared by the Australian Explosives Industry and Safety Group Inc. (2011). A draft version of the Plan is available in Volume 1 Appendix XIX.	The plan will provide information and recommended guidelines to assist in the prevention and management of blast generated NOx gases from blasting operations and will be specific to NOx.
SPECIFIC MITIGATION MEASURES FOR AIR QUALITY	
Measure	**Mitigation Effect**
TSMC will develop a plan for the prevention and management of blast generated NOx (Volume 1 Appendix XIX). This plan will be based on the Code of Good Practice prepared by the Australian Explosives Industry and Safety Group Inc. (2011).	The plan will provide information and recommended guidelines to assist in the prevention and management of blast generated NOx gases from blasting operations and will be specific to NOx.

7.3.2.4 Residual Effects Significance Assessment

The overall methodological approach to assess the environmental effects is presented in Section 5. However, in order to apply this methodology to the air quality VC, it is essential to consider assessment criteria applicable specifically to this VC (Table 7-21). The project's air quality assessment criteria are based on air quality standards promulgated by environmental authorities. These air quality standards were developed to protect human health. From an ecological perspective, short-term exceedances of air quality assessment criteria as identified in this EIS have limited effects. Air quality resilience to disturbance is largely good after the completion of the project. After completion of the project, major active sources of air emissions (ore mining, transport and processing) will stop. Inactive sources of air emissions (piles) may continue to be affected by wind erosion.

Table 7-21 Assessment Criteria Applicable to Air Quality

TIMING		
Inconsequential timing	**Moderate timing**	**Unfavorable timing**
Timing of predicted Howse air emissions has no consequences on air quality	Timing of predicted Howse air emissions may have consequences on air quality	Timing of predicted Howse air emissions has consequences on air quality
SPATIAL EXTENT		
Site specific	**Local**	**Regional**
Effects are limited to the footprint of the project.	Effects extend beyond the footprint, but do not extend outside the LSA.	The effect of the Howse Project will affect air quality in substantial part or the entire RSA.
DURATION		
Short	**Medium**	**Long**
>1 hour Air quality standards for 1-hour periods are applicable. Effects of blasts are modelled as one hour events.	>24 hours Air quality standards for 24-hour periods are applicable. Maximum activities can occur on a continuous basis over several periods of 24 hours	>1 year Air quality standards for 1-year periods are applicable. Project activities will be conducted at varying intensities all year long
REVERSIBILITY		
Reversible	**Partially reversible**	**Not reversible**
Air quality returns to pre-project levels	Air quality degradation persist after source of effect ceases, but its magnitude is significantly lower	Air quality degradation persist after source of effect ceases
MAGNITUDE		
Low	**Moderate**	**High**
Air quality at sensitive receptors within the RSA is barely or not affected by the Howse Project (all parameters meet Project's air quality assessment criteria)	Air quality at sensitive receptors in the RSA is moderately affected by the Howse Project because air modelling results do not meet the Project's air quality assessment criteria.	Air quality at sensitive receptors in the RSA is severely affected by the Howse Project because air modelling results persistently do not meet the Project's air quality assessment criteria.
FREQUENCY		
Once	**Intermittent**	**Continual**

Air quality standards will be exceeded once	Air quality standards will be exceeded occasionally, such as during blasting events.	Air quality standards will be exceeded year round.

Timing

Howse Project activities will occur throughout the year. The air quality modelling study included hourly meteorological conditions over a 5 year period. Maximum predicted results for several pollutants were compared were compared to project specific assessment criteria, regardless of season and timing. Logically, dust emissions from the project are expected to be higher and more visible during the summer. Additionally, withstanding modelling limitations, blasting events at the Howse pit are predicted to create short-term air quality exceedances, and so the effect is high (Value of 3).

Spatial Extent

The air dispersion modelling study predicts that short-term air quality assessment criteria may be exceeded at certain sensitive receptors and at geographical grid receptors mostly due to the methodology used to input blasting events in the air modelling software. These short-term exceedances are limited to the LSA. No exceedances of air quality assessment criteria are predicted outside the LSA. As such, the geographic effect of the Howse Project is expected to extend beyond the footprint, but does not extend outside the LSA (Value of 2).

Duration

Air quality will be negatively impacted from the beginning of the construction phase up to the end of the Howse Project, and even after. Air emissions will be generated during all phases of the project. The nature of the air pollutants will be similar throughout all phases of the project, but the highest air emissions effects will occur during the Operation phase, due to the intensity of mining, transportation and processing activities. Air modelling results predicted that all long term (e.g. 1-yr averaging period) project air quality assessment criteria are met, but nonetheless the duration of the effect will last throughout the life of the mine. For this reason, the duration is considered to be long (Value of 3).

Reversibility

After the high intensity operation phase stops, air quality will mostly return to pre-project conditions. Airborne dust due to wind erosion from piles may still occur after the Project but with the proposed mitigation measures and pit design, if dust from piles becomes airborne, its effects will be limited to the project footprint. As such, the air quality effect of the Howse Project is considered reversible (Value of 1).

Magnitude

When considering the Howse Project only and sensitive receptors, the single air quality assessment criterion for which exceedances are predicted is NO_2 (1-hr) under the “With Blasts” scenario only, see Table 7-16. The exceedances frequency at the 9 sensitive receptors identified in Table 7-16 (R9, R10, R11, R13, R16, R17, R18, R24, and R40) is less than 1% of the time. Predicted exceedances correspond to the worse meteorological condition during a blasting event that will generate the highest concentration at a receptor. When blasting events are excluded from the model, the Howse Project in itself does not create exceedances of air quality assessment criteria at any receptor (neither sensitive nor non-sensitive). Finally, at non-sensitive receptors (e.g. geographical grid receptors) located on or in close proximity to the air quality modelling perimetre, the model predicts limited exceedances of air quality assessment criteria when the worse-case scenario (e.g. “With Blasts”). For these reasons, the magnitude is considered to be moderate (Value of 3).

Frequency

The frequency is intermittent, since even though activities of the Howse Project will occur on a continuous basis for at least 7 months per year, exceedances of air quality standards are predicted to occur infrequently. (Value of 2).

7.3.2.4.1 Significance

The residual effects of the Howse Project on air quality are expected to be significant (value of 14). This is representative of the magnitude of the effects of the Project as well as the expected reversibility of the effects on air quality. The primary disturbance caused to air quality at sensitive receptors by the Howse Project is due to intermittent blasting events at the pit.

Likelihood

The likelihood of Howse having an effect on air quality is **high**, since air emissions will be generated throughout the duration of the project and air dispersion modelling is showing non-negligible air quality impacts from the Howse project.

7.3.3 Noise

Noise and vibration can provoke complaints and negatively affect quality of life when levels exceed a pre-existing background level or attain a certain absolute level. The negative effects may include sleep disturbance, annoyance, stress, and potential hearing damage (at high noise levels). Vibration also has the potential to damage structures. For those reasons, noise and vibration is identified as a VC. As mentioned previously, typical daily operations (without blasting) were assessed separately from blasting.

All three project phases consist of similar equipment and activities; however, the operation phase has the highest noise effects, due to the processing plant operation and full-scale production. Consequently, a noise effects study was conducted for the operation phase; summary results and conclusions are presented in the section below, while a detailed report is available in Volume 2 Supporting Study F.

Noise and/or vibration were mentioned six times during Aboriginal consultations in 2015. Concerns raised were:

- effects of noise made by helicopters, planes, train, trucks and blasting on resources, which leave the area was mentioned as an issue;
- the impacts of vibrations are a preoccupation;
- noise from machinery is a source of disturbance; and
- noise can be heard from far away and it drives the animals away.

The effect of noise on caribou and avifauna are described in Sections 7.4.3 and Section 7.4.8 below, respectively, and further in the cumulative effects sections of these components in Sections 8.6 and 8.7, respectively.

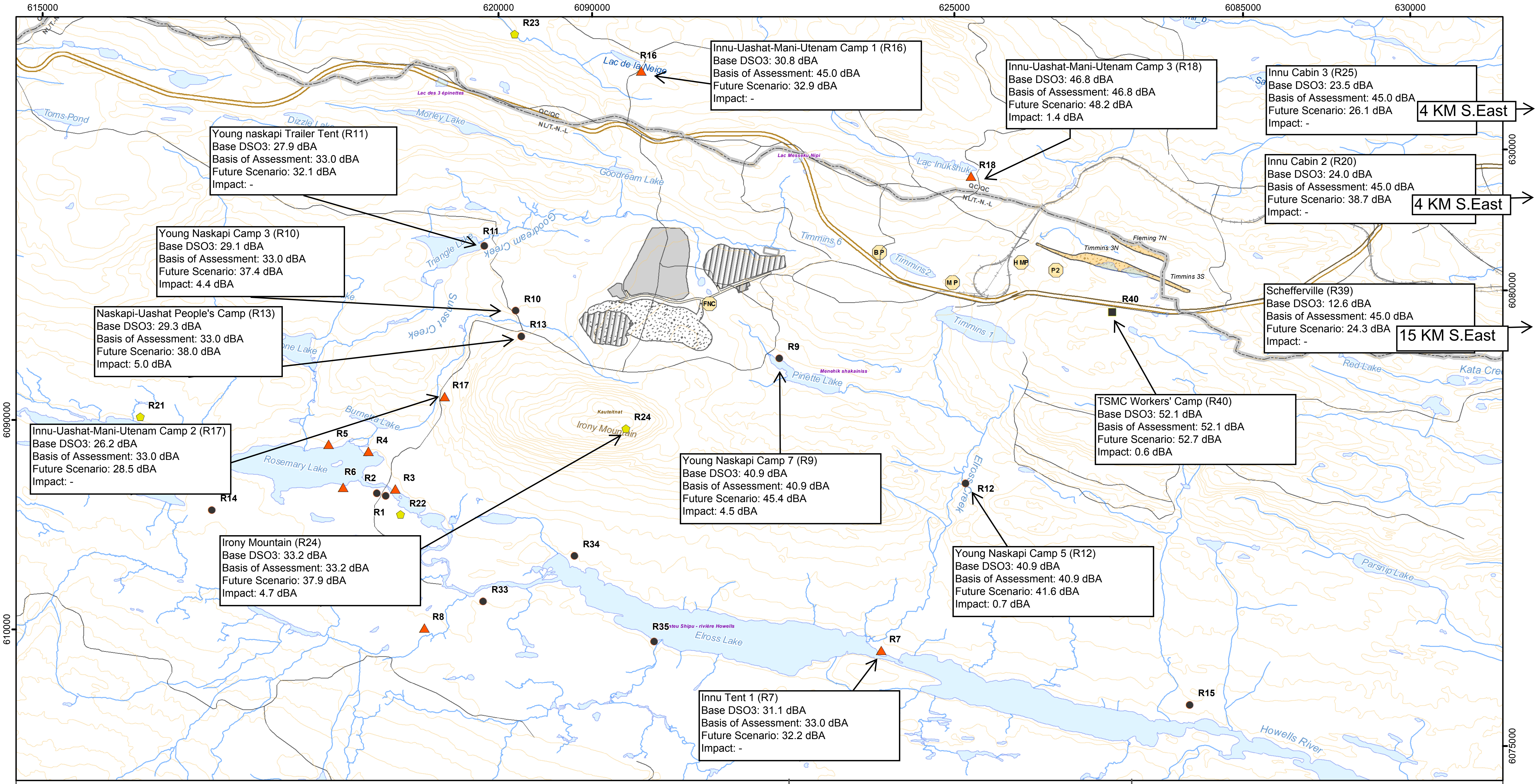
7.3.3.1 Component Description

LSA, RSA and Temporal Boundaries

The LSA is limited to within mapping of the DSO3 and Howse Mine study area (see Figure 7-10). This includes noise-sensitive areas near the Howse Mine, Irony Mountain, and Pinette, Rosemary, Elross, and Triangle Lakes. The Town of Schefferville was also assessed, as it is the closest town to the Howse Mine. The assessed areas are representative of the worse-case locations for each noise sensitive area. Areas further from mining operations will receive lower noise and vibration impacts.

The RSA includes areas outside mapping. As project noise is not expected to be above background levels at approximately 5 kilometers from the Howse Mine (within the LSA), project-related noise and vibration were not assessed in the RSA.

Mining activities at the Howse Property are expected to be ongoing until 2032, for a total of 15 years. Technical data used in the noise modelling study was obtained for equipment and activities in use at the project. Similarly, other projects in the vicinity of Howse will also impact noise levels, namely DSO3 and DSO4. Noise data for equipment and activities, within the LSA, at these two projects that are currently in startup mode, were incorporated in the noise modelling study. Therefore, the temporal boundaries for the Noise/Vibration component study covers the Operation phase of the project.



Innu-Uashat-Mani-Utenam Camp 1 (R16)
Base DSO3: 30.8 dBA
Basis of Assessment: 45.0 dBA
Future Scenario: 32.9 dBA
Impact: -

Innu-Uashat-Mani-Utenam Camp 3 (R18)
Base DSO3: 46.8 dBA
Basis of Assessment: 46.8 dBA
Future Scenario: 48.2 dBA
Impact: 1.4 dBA

Innu Cabin 3 (R25)
Base DSO3: 23.5 dBA
Basis of Assessment: 45.0 dBA
Future Scenario: 26.1 dBA
Impact: -

4 KM S.East

Young naskapi Trailer Tent (R11)
Base DSO3: 27.9 dBA
Basis of Assessment: 33.0 dBA
Future Scenario: 32.1 dBA
Impact: -

Innu Cabin 2 (R20)
Base DSO3: 24.0 dBA
Basis of Assessment: 45.0 dBA
Future Scenario: 38.7 dBA
Impact: -

4 KM S.East

Young Naskapi Camp 3 (R10)
Base DSO3: 29.1 dBA
Basis of Assessment: 33.0 dBA
Future Scenario: 37.4 dBA
Impact: 4.4 dBA

Naskapi-Uashat People's Camp (R13)
Base DSO3: 29.3 dBA
Basis of Assessment: 33.0 dBA
Future Scenario: 38.0 dBA
Impact: 5.0 dBA

Schefferville (R39)
Base DSO3: 12.6 dBA
Basis of Assessment: 45.0 dBA
Future Scenario: 24.3 dBA
Impact: -

15 KM S.East

TSMC Workers' Camp (R40)
Base DSO3: 52.1 dBA
Basis of Assessment: 52.1 dBA
Future Scenario: 52.7 dBA
Impact: 0.6 dBA

Innu-Uashat-Mani-Utenam Camp 2 (R17)
Base DSO3: 26.2 dBA
Basis of Assessment: 33.0 dBA
Future Scenario: 28.5 dBA
Impact: -

Young Naskapi Camp 7 (R9)
Base DSO3: 40.9 dBA
Basis of Assessment: 40.9 dBA
Future Scenario: 45.4 dBA
Impact: 4.5 dBA

Irony Mountain (R24)
Base DSO3: 33.2 dBA
Basis of Assessment: 33.2 dBA
Future Scenario: 37.9 dBA
Impact: 4.7 dBA

Young Naskapi Camp 5 (R12)
Base DSO3: 40.9 dBA
Basis of Assessment: 40.9 dBA
Future Scenario: 41.6 dBA
Impact: 0.7 dBA

Innu Tent 1 (R7)
Base DSO3: 31.1 dBA
Basis of Assessment: 33.0 dBA
Future Scenario: 32.2 dBA
Impact: -

LEGEND

Sensitive Receptors

- ● Naskapi
- ▲ Innu
- ■ Permanent
- ⬠ Other

Infrastructure and Mining Components

- P2 Plant 2
- MP Main processing Plant
- HMP Howse Mini-Plant
- BP Batch Plant
- FNC First Nations crusher/screener
- Road to DSO Area 4
- Existing Railroad
- Deposit
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Site Infrastructure
- Proposed Waste Dump/ In-Pit Dump
- Proposed Sedimentation Pond
- Proposed Mine Haul Road

Basemap

- Existing road
- Contour Line (50 ft)
- Provincial Border
- Watercourse
- Water Body

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0674 , PR185-19-14, 2015-10-15, edickoum

N

0 2 4
Kilometers

UTM 19N NAD 83

SCALE: 1:50 000

SOURCES:

Basemap and Land Use Components
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec,

Mining Components
TATA Steel Minerals Canada Limited/
MET-CHEM Howse Deposit Design
for General Layout., 2013
Groupe Hémisphères, Hydrology and update, 2013

ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Noise and Vibration Receiver Location and Impact Results

Howse Minerals Limited

GroupeHemispheres

5731, rue Saint-Louis,
Bureau 201, Lévis (QC)
Canada, G6V 4E2

1453, rue Beaubien est,
Bureau 301, Montréal (QC)
Canada, H2G 3C6

Figure 7.10

Existing Literature

The ambient background noise level measurements taken by Tecsult in 2006 (Groupe Hémisphères, 2014a) are used to describe ambient noise levels prior to the start of mining. The ambient noise in the area is controlled by the natural environment (and not by human activity) and which can be considered fairly uniform. As such, two of the measurement sites can be considered as representative of the LSA.

Noise measurements taken by Tecsult were measured using a Type-2 sound level meter (TES-1358), as prescribed in Publication 651 Electroacoustics – Sound Level Meters (1979) of the International Electrotechnical Commission. Tecsult operated the sound level meter in slow mode with a frequency weighting in A-weighted decibels (dBA). The noise measurements were performed outdoors away from human activity. The microphone was placed at a height of 1.2 meters above ground level, away from obstacles and traffic.

Table 7-22 presents the relevant results of the ambient noise level measurements obtained at the two representative measurement locations, during day and night-time periods. The Tecsult report defined the ambient background as the L_{95} measurement. The L_{95} value is the noise level that matched or exceeded 95% of the measurement period which typically is representative of the base background noise level, without short duration effects (e.g. without plane flybys). Background noises (L_{95}) fluctuated between 33 and 36 dBA. Noise levels are considered controlled by natural and not man-made sounds, as the measured background night time levels are higher than the day time background noise.

Table 7-22 Results of Ambient Noise Measurements (Tecsult, 2006)

LOCATION		PERIOD	AMBIENT NOISE (DBA)	OBSERVATIONS AT TIME OF NOISE MEASUREMENTS
ID	COORDINATES (DECIMAL DEGREES)		L95	
Station 1	-67.21595 54.89924	Day 10:26-11:26 10/02/2006	33	Light wind Presence of birds Passing of an airplane Passing of two trucks
		Night 0:38-1:36 10/03-2006	36	Light wind Passing of a truck
Station 2	-67.23445 54.89814	Day 14:12-15:12 10/02/2006	34	Light wind Presence of birds Passing of a helicopter
		Night 4:17-4:59 10/03/2006	35	Light wind Presence of birds Passing of an airplane Passing of one truck

Data Gaps

Insufficient detail on topographical and soil conditions was available for blasting vibration and overpressure assessment. As such, prediction adjustments to suit site-specific conditions could not be completed. Therefore, blast vibration and overpressure predictions are based on generic conservative environmental and topographical conditions.

7.3.3.2 Effects Assessment

Literature review and Current Studies Data Used to Assess the Potential Effect

Current Study

A review of Newfoundland and Labrador Department of Environment and Conservation information has revealed that there are no available noise and vibration guidelines. A review of CEAA sources has also revealed no specific guidelines or limits. In addition, Health Canada states: "Health Canada does not have noise guidelines or enforceable noise thresholds or standards" (Health Canada, 2010).

However, Health Canada does recommend a change in highly annoyed percentage (%HA_n) as a measure for determining health impacts of noise generated by wind turbine, road traffic, and industrial noise sources. Health Canada has recommended that noise mitigation be investigated when a project related increase in %HA_n is greater than 6.5%. Detailed explanations of criteria can be found in Volume 2 Supporting Study F.

Receivers in Newfoundland and Labrador were assessed with respect to the anticipated community response to changes in noise level due to the Project. Guidance on this relationship is provided in ISO/R 1996, *Assessment of Noise with Respect to Community Response*. Similar to traffic noise impact assessments and other projects with criteria based on noise level difference, a 5dB exceedance of criteria was adopted as the threshold for noise mitigation investigation for Newfoundland and Labrador receivers. Receivers in Quebec were assessed against the Quebec Guidelines for stationary sources (MDDEFP, 2006). Detailed explanations of criteria can be found in Volume 2 Supporting Study F.

Noise levels for the base and future scenarios were modeled with the ISO 9613 noise prediction algorithm implemented in the CadnaA modelling package. Noise levels for the train were modeled using the railroad Federal Transit Association (FTA) methodology, also implemented in CadnaA (USDT, 2006b). Only the worse-case (closest) receptors were modelled. Receptors further removed will have lower noise impacts. A total of 40 receptors were identified (towns consisting of many houses were counted as a single receptor). The 14 modelled receptors are representative of the worse-case locations.

Project Related Noise and Potential Effects During Typical Daily Operations

Noise modelling for two scenarios was required for the typical daily operations assessment: Base DSO3, and future case. The base DSO3 case was modeled with noise sources at the following areas:

- Main Processing Plant;
- Production Plant 2 (currently operating east of the Main Processing Plant);
- Timmins 3,4,7 Mining Sites;
- Fleming 7 Mining Site;
- roads connecting the production plants and the Timmins and Fleming mining sites;
- road connecting DSO3 to Kivivic mine site (e.g. DSO4).

Trains are not currently in daily operation during the Base DSO3 operations, and therefore were excluded from the base DSO3 noise modelling. The future worse-case scenario with the highest amount of mine production contains noise sources at the same areas listed above, (with the exceptions of Timmins mine sites which will no longer be active during the worse-case scenario), in addition to the following:

- Howse mining site;
- roads connecting plants and the Howse mining site;
- daily train operations east of Plant 1;
- Howse mini-plant (processing plant for Howse ore) located near the rail loop;
- First Nations crushing site (located next to the Howse Mine Site, on the east side)[5].

Equipment noise data was gathered from manufacturer data, previous equipment measurements, BSI British Standards (BSI, 2008), and Roadway Construction Noise Model (RCNM) data (USDT, 2006a). Train data was provided by Howse Minerals Limited. Detailed sound power levels and source data can be found in Volume 2 Supporting Study F.

Equipment types included in the noise modelling is listed below. A full detailed equipment list (including make, model number, serial number [as applicable], negligible sources, and number at each location) for all locations are provided in Volume 2 Supporting Study F.

- vibrating screen;
- apron feeder;
- feed hopper;
- hydraulic rock breaker;
- primary sizer;
- secondary sizer;
- roof fans;
- wall fans;
- ventilation fans;
- HVAC ventilation unit;
- 2MW generators;
- generator rad fans;
- hydraulic excavators;
- production drill;
- track dozer;
- road grader;
- haul trucks;
- train (idling and traveling); and

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[5] Although a First Nations Quarry was in the initial planning stages under the Howse Project (see section 2.5 for a description of all Project Alternatives), this activity is currently no longer considered, and that for the foreseeable future. However, the First Nations Quarry was included as a noise source in the Noise and Vibration Modelling Report (Volume 2 Supporting Study F) and consequently in the results presented herein. We propose that this scenario is a 'worse-case' scenario and will continue to be evaluated for its effects on the present component.

- diesel-fired burners;
- induced draft fans; and
- Drill noise was modeled using RCNM noise data, and will require mitigation if noise reaches predicted levels. However, RCNM data is conservative. This data does not account for localized conditions and additional factors (drill speed, drilling time, equipment used). Mitigation for drilling may not be required if noise levels are lower than predicted.

A number of areas around the mining operations were identified as noise and vibration sensitive. The areas were located in the provinces of Quebec, and Newfoundland and Labrador. These locations included:

- Innu camps;
- Uashat-Mani-Utenam Camps;
- Naskapi camps;
- workers' camp; and
- towns (Schefferville, Kawawachikamach, Lac John and Matimekush[6]).

Predicted day-time and night-time noise level impacts at each nearby Newfoundland and Labrador receptor are presented in Table 7-23 and Table 7-24. Each receptor is representative of noise sensitive areas surrounding the two production plants and each mining site.

Table 7-23 Day-Time Base and Future Scenario Noise Levels - Newfoundland and Labrador

RECEPTOR	RECEPTOR ID	BASE DSO3 NOISE LEVEL (DBA)	BASIS OF ASSESSMENT (DBA)[1]	FUTURE SCENARIO NOISE LEVEL (DBA)	IMPACT (DBA)
TSMC Workers' Camp	R40	52.1	52.1	52.7	0.6
Innu Tent 1 (Elross Lake)	R7	31.1	33.0	32.2	-
Young Naskapi Camp 7 (Pinette Lake)	R9	40.9	40.9	45.4	4.5
Young Naskapi Camp 3	R10	29.1	33.0	37.4	4.4
Young Naskapi Trailer Tent (Triangle Lake)	R11	27.9	33.0	32.1	-
Young Naskapi Camp 5 (Elross Creek)	R12	40.9	40.9	41.6	0.7
Naskapi – Uashat People's Camp	R13	29.3	33.0	38.0	5.0
Innu - Uashat - Mani-Utenam Camp 2	R17	26.2	33.0	28.5	-
Irony Mountain	R24	33.2	33.2	37.9	4.7

1: Ambient background measurements indicate an existing noise level without mining of 33-35 dBA.

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[6] Schefferville was assessed instead of Kawawachikamach, Lac John and Matimekush as Schefferville is in closer proximity to the mining operations.

Table 7-24 Night-Time Base and Future Scenario Noise Levels - Newfoundland and Labrador

RECEPTOR	RECEPTOR ID	BASE DSO3 NOISE LEVEL (DBA)	BASIS OF ASSESSMENT (DBA)	FUTURE SCENARIO NOISE LEVEL (DBA)	IMPACT (DBA)
TSMC Workers' Camp	R40	52.1	52.1	52.7	0.6
Innu Tent 1 (Elross Lake)	R7	31.1	34.9	32.1	-
Young Naskapi Camp 7 (Pinette Lake)	R9	40.9	40.9	45.4	4.5
Young Naskapi Camp 3	R10	29.1	34.9	37.4	2.5
Young Naskapi Trailer Tent (Triangle Lake)	R11	27.9	34.9	32.1	-
Young Naskapi Camp 5 (Elross Creek)	R12	40.9	40.9	41.6	0.7
Naskapi – Uashat People's Camp	R13	29.3	34.9	38.0	3.1
Innu - Uashat - Mani-Utenam Camp 2	R17	26.2	34.9	28.4	-
Irony Mountain	R24	33.2	34.9	37.7	2.8

1: Ambient background measurements indicate an existing noise level without mining of 33-35 dBA.

The predicted noise impact (≥ 5dB) at the Naskapi – Uashat People's Camp (R13) camp site (west of Howse Mine) triggers mitigation investigation. The noise sources creating the greatest noise impact on the camp site are predicted to be the drill operating at the Howse mining site (for the blast charges), and the First Nations crusher operation near Howse mine (note: FN crusher is no longer considered, see Footnote 5). Sporadic noise complaints are expected if no mitigation is implemented. Noise impact at Irony Mountain is close to but does not exceed criteria. Moving the First Nations crusher further north behind an existing berm or overburden pile may reduce likelihood of noise complaints (note: FN crusher is no longer considered, see Footnote 5 in previous page).

Predicted day-time and night-time noise level impacts at each nearby Quebec receptor are presented in Table 7-25 and Table 7-26. For receptors in Quebec, sound levels were assessed against the greater of predicted base level ambient noise or maximum L_{eq} levels set for Zone I areas.

Table 7-25 Day-Time Base and Future Scenario Sound Levels - Quebec

RECEPTOR	RECEPTOR ID	BASE DSO3 NOISE LEVEL (DBA)	BASIS OF ASSESSMENT (DBA)	FUTURE SCENARIO NOISE LEVEL (DBA)	Impact (dBA)
Innu Cabin 3	R25	23.5	45.0	26.1	-
Innu - Uashat - Mani-Utenam Camp 1	R16	30.8	45.0	32.9	-
Innu - Uashat - Mani-Utenam Camp 3	R18	46.8	46.8	48.2	1.4
Innu Cabin 2	R20	24.0	45.0	38.7	-
Schefferville (town)	R39	12.6	45.0	24.3	-

Table 7-26 Night-Time Base and Future Scenario Sound Levels - Quebec

RECEPTOR	RECEPTOR ID	BASE DSO3 NOISE LEVEL (DBA)	BASIS OF ASSESSMENT (DBA)	FUTURE SCENARIO NOISE LEVEL (DBA)	IMPACT (DBA)
Innu Cabin 3	R25	23.5	40.0	24.3	-
Innu - Uashat - Mani-Utenam Camp 1	R16	30.8	40.0	32.8	-
Innu - Uashat - Mani-Utenam Camp 3	R18	46.8	46.8	48.2	1.4
Innu Cabin 2	R20	24.0	40.0	24.5	-
Schefferville (town)	R39	12.6	40.0	13.1	-

There were no predicted noise impact exceedances for any receptors in Quebec. Table 7-27 presents the Day-Night noise levels and change in Highly Annoyed percentage for each receptor.

Table 7-27 Day-Night Noise Levels and Change in Highly Annoyed Percentage

RECEPTOR NAME AND ID	RECEPTOR ID	BASE DSO3 DAY-NIGHT LEVEL (DBA)	FUTURE SCENARIO DAY-NIGHT (DBA)	BASE DSO3 HIGHLY ANNOYED PERCENTAGE (%)	BASE DSO3 HIGHLY ANNOYED PERCENTAGE (%)	CHANGE IN HIGHLY ANNOYED PERCENTAGE (%)
Innu Tent 1	R7	37.5	38.5	0.43	0.49	0.06
Young Naskapi Camp 7	R9	47.3	51.8	1.54	2.76	1.22
Young Naskapi Camp 3	R10	35.5	43.8	0.33	0.98	0.65
Young Naskapi Trailer Tent	R11	34.3	38.5	0.28	0.49	0.21
Young Naskapi Camp 5	R12	47.4	48.0	1.56	1.69	0.13
Naskapi – Uashat People’s Camp	R13	35.7	44.4	0.34	1.06	0.72
Innu - Uashat - Mani-Utenam Camp 1	R16	37.2	39.3	0.41	0.54	0.13
Innu - Uashat - Mani-Utenam Camp 2	R17	32.6	34.8	0.22	0.30	0.08
Innu - Uashat - Mani-Utenam Camp 3	R18	53.2	54.6	3.30	3.94	0.64
Innu Cabin 2	R20	30.4	37.6	0.17	0.43	0.27
Irony mountain	R24	39.6	44.2	0.56	1.03	0.47
Innu Cabin 3	R25	29.9	31.0	0.16	0.18	0.02
Schefferville (town)	R39	19.0	23.9	0.04	0.07	0.03
TSMC Worker's Camp	R40	58.5	59.1	6.43	6.92	0.49

No receptors have a Highly Annoyed percentage change of 6.5% or greater. Therefore, Highly Annoyed percentage will not trigger mitigation per Health Canada criteria at any receptors. However, the Naskapi-Uashat People's Camp receptor (R13) will still undergo mitigation investigation due to the ≥5dB noise impact at that location.

Project Related Vibration and Potential Effects of Blasting Operations

There are two main effects from blasting: ground vibration and overpressure. When explosives detonate in a borehole, shock waves (energy from the detonation) radiate outward and crush the material adjacent to the borehole. Energy not used in the fracturing and displacement of bedrock dissipates in the form of ground vibration and air overpressure.

A review of Newfoundland and Labrador Department of Environment and Conservation information and federal sources has revealed that there are no available noise and vibration guidelines. Therefore, the ground vibration and overpressure from blasting operations are assessed per Quebec's "DIRECTIVE 019-SUR L'INDUSTRIE MINIÈRE, MARS 2012", and Ontario's Ministry of the Environment (MOE) NPC-119 Guideline. The MOE criteria are similar to Quebec's criteria, but are slightly more conservative. Therefore, MOE criteria were adopted for this assessment.

Since the blasting plan is still in development, vibration and overpressure levels from the blasting were predicted using MOE 1985 "Guidelines on Information Required for Assessment of Blasting Noise and Vibration" models. As no blast vibration and overpressure data is available for the site, conservative generic empirical formulae (which do not take local ground conditions into consideration) were used to estimate the impact of blast vibration and overpressure at the closest point of reception.

The closest sensitive receiver (Receptor ID#13) is approximately 900 m from the site perimeter. The maximum allowable charge per delay (using generic conditions) for the closest receiver is summarized in Table 7-28.

Table 7-28 Generic Maximum Allowable Charge per Delay for the Closest Point of Reception Located 900 Meters from the Site

CHARGE PER DELAY (KG)	CRITERIA
3,128	Blast Vibration Limit – 12.5 mm/sec
1,092	Blast Overpressure Limit – 128 dBL

The impact is dominated by the overpressure limit, so the charge per delay should be restricted to below 1,092 kg. However, blasting vibration and overpressure is complex in nature, and variability in ground type and meteorological conditions makes it difficult to accurately predict ground vibration and overpressure without site specific measurement data. Test blasting using a lower charge should first be conducted. Although meeting overpressure criteria may satisfy regulatory requirements, the short duration, high noise level may be a source of complaints.

Interaction of the Project with Noise and Potential Effects

Site Preparation and Construction Phase

No potential interaction

During the site preparation and construction phase, all project activities will have potential interaction with noise/vibration levels.

Potential interaction

- upgrading/construction of the Howse haul road and upgrading of the bypass road;
- pit development;

- installation of the ore processing plant (Howse Mini-Plant) in close proximity to the rail loop;
- transportation and traffic; and
- heavy machinery use and light vehicle traffic

➔ The effect associated with the above potential interactions is an **increase in noise and vibration levels**.

The nature of the effect is direct and the effect is adverse.

The nature of noise and vibrations and the areas where they will occur during the *Site Preparation and Construction* and *Decommissioning and Reclamation* phase will be similar to those encountered during the Operation phase. During all three phases, noise and/or vibrations from diesel powered engines, vehicle movements and blasting will occur, but intensity during the Operation phase will be continuous and of a higher level. One important reason why the nature of the noise/vibration remains the same during the three phases is the fact all power used at the site is generated by diesel equipment; the site is not connected to the power grid. Consequently, the noise and vibration effects study was conducted for the Operation phase only. Therefore, the effect assessment, mitigation measures, specific mitigation measures and methodological approach used to assess the noise and vibration component are covered for the Operation phase section below and are applicable to all phases of the project.

Operation Phase

No potential interaction

During the operation phase, all project activities will have potential interaction with noise/vibration levels.

Potential interaction

- removal and storage of remaining overburden and topsoil;
- blasting and ore extraction;
- mineral processing;
- dewatering;
- operation of waste rock dumps;
- transportation of ore and traffic;
- solid waste disposal;
- hazardous waste disposal;
- treatment of sanitary wastewater;
- explosives waste management; and
- ongoing site restoration.

➔ The effect associated with the above potential interactions is an increase in the ambient noise level and vibration.

The nature of the effect is direct and the effect is adverse.

Decommissioning and Reclamation Phase

No potential interaction during the decommissioning and reclamation phase, all project activities will have potential interaction with noise/vibration levels.

Potential interaction

- demobilization of Howse facilities and heavy machinery;
- transportation and traffic; and
- final site restoration.

➔ The effect associated with the above potential interactions is an **increase in the ambient noise level**.

The nature of the effect is direct and the effect is adverse.

7.3.3.3 Mitigation Measures

Standard Mitigation Measures

The following standard mitigation measures will be applied during all project phases (Table 7-29).

Table 7-29 Standard Mitigation Measures for Noise

CODE	MEASURE	MITIGATION EFFECT
Drilling and Blasting (DB)		
DB2	All explosives must be used in accordance with applicable laws, orders and regulations.	Using best practices will ensure efficient blasting is achieved. Efficient blasting procedures lead to a reduction of explosives use and consequently of noise and vibration due to these blasting events.
DB3	Only properly qualified and trained personnel may handle and detonate explosives as per the manufacturer's instructions and applicable laws and regulations.	
DB4	The manufacturer's instructions must be followed to ensure that blasting procedures are safe both for humans and the environment.	
DB16	Use multiple detonators in bore holes as per the manufacturer's recommendations and optimize the arrangement of blasting holes to minimize misfires.	
DB18	Prevent misfires by establishing time delay blasting cycles as per the explosives manufacturer's recommendations.	
DB19	Use reliable triggering systems that allow for precise firing of the explosives.	
DB20	Use blasting mats, if necessary, to prevent excessive scatter of rock.	For safety and nuisance reduction
DB24	Keep blasting data for two years, including the following: vibration speed, vibration frequency on the ground, air pressure and blasting patterns. Respect maximum vibration speeds.	Keeping complete historical records helps troubleshooting, if necessary.
DB25	Blasting must be carried out in such a way that air pressure at the receptors (camps) is less than 128 db.	Minimize nuisance due to blasting
Construction Equipment (CE)		

CODE	MEASURE	MITIGATION EFFECT
CE4	Construction equipment must be delivered to the site in good working order, without leaks and equipped with all emissions filters required to comply with emissions regulations and reduce noise disturbance. The equipment must be regularly inspected to detect any leaks or mechanical defects that could lead to fuel, lubricant or hazardous material spills.	Well maintained engines will keep noise levels in-line with regulations
CE16	When making the final choice of equipment, ensure that their noise levels are equal or less than those described in the environmental impact study.	Noise assessment for this EIS is based on a series of noise data for equipment and shows compliance with standards
Mining Operations (M)		
M2	The noise level of mining operations must be no higher than 40 dba at night and 45 dba during the day at each receiver (Quebec Guidelines for Stationary Noise Sources for Type I Zoning Area).	Meets Quebec regulations
M3	Reports required by governments must be submitted by the stipulated deadlines.	n/a

Specific Mitigation Measures

The following specific mitigation measures will be applied to limit impacts of noise by the Project activities:

SPECIFIC MITIGATION MEASURES FOR NOISE	
Measure	**Mitigation Effect**
Should noise complaints occur, prepare a mitigation plan for drilling to be implemented. Example methods of reducing drill noise include: ▪ Reducing drilling speed; ▪ Reducing drilling time; ▪ Using a noise shroud around the drill; and ▪ Use of a mobile noise screen.	Adaptive Management
A blast monitoring specialist will monitor a minimum of an initial four blasts to obtain site-specific data. It is recommended that the four initial test blasts be conducted with a charge of less than 700 kg per delay.	The site-specific data is needed to develop attenuation formulae, confirm the applicability of the initial guideline parameters, and assist in developing future blast designs. Vibration and overpressure will be monitored to provide an update to the prediction model parameters.
Blast designs shall be continually reviewed with respect to ground vibration and overpressure. Blast designs shall be modified as required to ensure compliance with applicable guidelines and regulations. Decking, reduced hole diameters, and sequential blasting techniques will be used to ensure minimal explosives per initiated delay period.	Adaptive Management
Maintain blast records. Records will include information such as: Location, date and time of the blast; Dimensional sketch including photographs, if necessary, of the location of the blasting operation, and the nearest point of reception; Type of material being blasted; Prevailing meteorological conditions including wind speed in m/s, wind direction, air temperature in °C; Number of drill holes; Pattern and pitch of drill holes; Size of holes; Weight of charge per delay; Number and time of delays. MOE (1985) will be consulted to determine an applicable list of records.	Documentation provides information for adaptive management measures

7.3.3.4 Residual Effects Significance Assessment

The noise/vibration residual effects significance assessment is to be reviewed in parallel with the ecological contexts of the Caribou (Section 7.4.3) and the Avifauna (Section 7.4.8) both of which are valued components.

The Howse Project is located in an area that has historically been continuously and significantly altered by human activities. Within this context of a pre-established mining complex, the Howse footprint is not expected to cause significant detrimental additions to this unfavorable ecological context. The fauna has experienced fluctuations over the last several decades but is known to be resilient to disturbances caused by mining infrastructures and has shown plasticity in their adaptability to anthropogenically-altered landscaped. Noise and vibration are short-term effects that cease immediately when activities cease.

Table 7-30 Assessment Criteria Applicable to Noise

<table>
<tr><th colspan="3">TIMING</th></tr>
<tr><th>Inconsequential timing</th><th>Moderate timing</th><th>Unfavorable timing</th></tr>
<tr><td>Timing of predicted Howse activities are not expected to affect any human activities or sensitive activities in wildlife life cycles.</td><td>Timing of predicted Howse activities may affect some human activities or wildlife activities, i.e.: during migrating seasons.</td><td>Timing of predicted Howse activities may affect some human activities or key wildlife activities, i.e.: the calving/breeding periods.</td></tr>
<tr><th colspan="3">SPATIAL EXTENT</th></tr>
<tr><th>Site specific</th><th>Local</th><th>Regional</th></tr>
<tr><td>Effects are limited to the footprint of the project.</td><td>Effects extend beyond the footprint, but do not extend outside the LSA.</td><td>The effect of the Howse Project will affect air quality in substantial part or the entire RSA.</td></tr>
<tr><th colspan="3">DURATION</th></tr>
<tr><th>Short</th><th>Medium</th><th>Long</th></tr>
<tr><td>Less than 12 months.
Limited to the construction and/or decommissioning and abandonment phase.</td><td>12-24 months.
Extends beyond the preparation/construction phase, but shorter than the lifespan of the Project.</td><td>More than 24 months
Or as long as the Project duration</td></tr>
<tr><th colspan="3">REVERSIBILITY</th></tr>
<tr><th>Reversible</th><th>Partially reversible</th><th>Not reversible</th></tr>
<tr><td>Ambient noise expected to return to its pre-Howse level</td><td>Altered ambient noise levels persists after the decommissioning and abandonment phase</td><td>Ambient noise permanently altered by the Howse Project.</td></tr>
<tr><th colspan="3">MAGNITUDE</th></tr>
<tr><th>Low</th><th>Moderate</th><th>High</th></tr>
<tr><td>Affects <5% of the population in the LSA or 5% of the activity in question and few or no people in the RSA.</td><td>Affects 5%-15% of the population in the LSA or of the activity in question and a few people in the RSA.</td><td>Affects >15% of the population in the LSA or of the activity in question and more than a few people in the RSA.</td></tr>
<tr><th colspan="3">FREQUENCY</th></tr>
<tr><th>Once</th><th>Intermittent</th><th>Continual</th></tr>
<tr><td>One time</td><td>Occasional or intermittent</td><td>Year round</td></tr>
</table>

Timing

Howse Project activities will occur throughout the year, with the potential exception of winter blasting (which is expected to be infrequent). Since some of the noise produced by the Howse Project activities will be generated continuously after daylight hours, the timing of the disturbance may occur during periods of human/wildlife in the LSA, and so the effect is high (Value of 3).

Spatial Extent

The noise modelling study predicts that noise assessment criteria are met at all sensitive receptors in the LSA and RSA. A noise impact of 5 dBA was predicted at Receptor R13 (Naskapi - Uashat people's camp, located in NL, approximately 1.68 km from the center of the Howse Project). A cause of this impact is the inclusion of the projected First Nations crushing site (note: FN crusher is no longer considered, see footnote 1 in previous page) and the Howse Mine Site track drill used to drill blasting holes. By making a provision for a mobile screen, the spatial effect of the Howse Project remains within the Project's footprint (Value of 1).

Duration

Ambient noise levels will be negatively impacted from the beginning of the construction phase up to the end of the Howse Project. Project's noise will stop after the Decommissioning and Abandonment Phase is completed. Noise and vibration will be generated during all phases of the project. The nature of the Noise and vibration will be similar throughout all phases of the project, but the highest effects will occur during the Operation phase, due to the intensity of mining, transportation and processing activities. For this reason, the duration is considered to be long (Value of 3).

Reversibility

Project's noise and vibration will stop after the Decommissioning and Abandonment Phase is completed. As such, the noise effect of the Howse Project is considered reversible (Value of 1).

Magnitude

A noise impact of 5 dBA was predicted at Receptor R13 (Naskapi - Uashat people's camp, located in NL, approximately 1.68 km from the center of the Howse Project). A cause of this impact is the inclusion of the projected First Nations crushing site (note: FN crusher is no longer considered, see footnote 1 in previous page). Noise and vibration impacts at all other sensitive receptors are below the assessment criteria. For that reason, the magnitude is considered to be low (Value of 1).

Frequency

The noise frequency is continual, since activities of the Howse Project will occur on a continuous basis for at least 7 months per year. The associated value is 3.

Blasting events are planned to be conducted on a weekly basis during warmer months. Winter months blasting will be conducted at a reduced frequency (if at all) of approximately once per month. Blasting events are intermittent by nature and the associated value is 2, but this value is not retained for effect assessment, since the noise frequency has a higher value.

7.3.3.4.1 Significance

The residual effects of the Howse Project on noise are evaluated at non-significant (value of 12-13). This is representative of the moderate magnitude of the effects of the Project as well as the reversibility of the effects on ambient noise levels.

Likelihood

The likelihood of Howse having an effect on ambient noise levels and vibration is **high**, since noise and blasting events will occur throughout the duration of the project.

7.3.4 Light

7.3.4.1 Component Description

Night-time illumination level is an important component and it is highlighted in the CEAA EIS Guidelines. Ambient light assessment is primarily an assessment of the effects of the Howse Project's lighting on sensitive receptors within a zone of influence. Light pollution is an issue that has gained prominence within the context of environmental assessment because:

- it is recognized that the esthetic components of the environment have value; in particular, daytime vistas (viewsheds) and night-time skies are valued social components; and
- light pollution is associated with nuisance-related effects of stray light, physiological changes in humans (similar to those experienced by shift workers), and disorientation of migrating wildlife.

Outdoor lighting is essential at industrial development projects to provide safe work conditions during night-time hours and to provide security for the workers and the facility. Light in itself is not a pollutant. However, inappropriately designed lighting or excessive lighting can cause effects that can range from a minor nuisance to a disruptive effect. This assessment considers the potential effect that the Howse Project lighting could have on the existing ambient light levels surrounding the Project.

Light pollution was mentioned three times during Aboriginal consultations in the fall of 2014. The concerns raised were:

- lights on top of trucks are unnecessary left open at night and disturb the community; and
- effects of lights on the population and the wildlife.

The effect of lights on caribou and avifauna are described in Sections 7.4.3 and 7.4.8 below, respectively, and further in the cumulative effects sections of these components in Sections 8.6 and 8.7, respectively.

Consequently, in and of itself, night-time illumination is not considered as a VC for the physical environment assessment. However, an effects assessment for light is present here in order to support the cumulative effects assessment for caribou and avifauna.

LSA, RSA and Temporal Boundaries

The spatial boundaries for effects assessment of ambient light are described as follows:

The LSA is the area within 25 km^2 of the Howse Project. This area is estimated as the distance at which artificial lighting from the project could be visible.

The RSA is the area within 625 km^2 of the Howse Project. This area includes the towns of Schefferville and Kawawachikamach, both of which are located approximately 23 km southwest of the Howse Mining Project. The RSA also includes the future mining pits of DSO4 (i.e., Goodwood and Sunny). This RSA was selected to include the nearest towns where artificial and permanent lighting is prevalent and also additional mining pits of the whole TSMC DSO project, where artificial lighting is almost non-existent. Figure 7-11 presents the LSA and the RSA for ambient light.

The ambient light study covers different seasons and weather conditions, as required in the Project's EIS preparation guidelines.

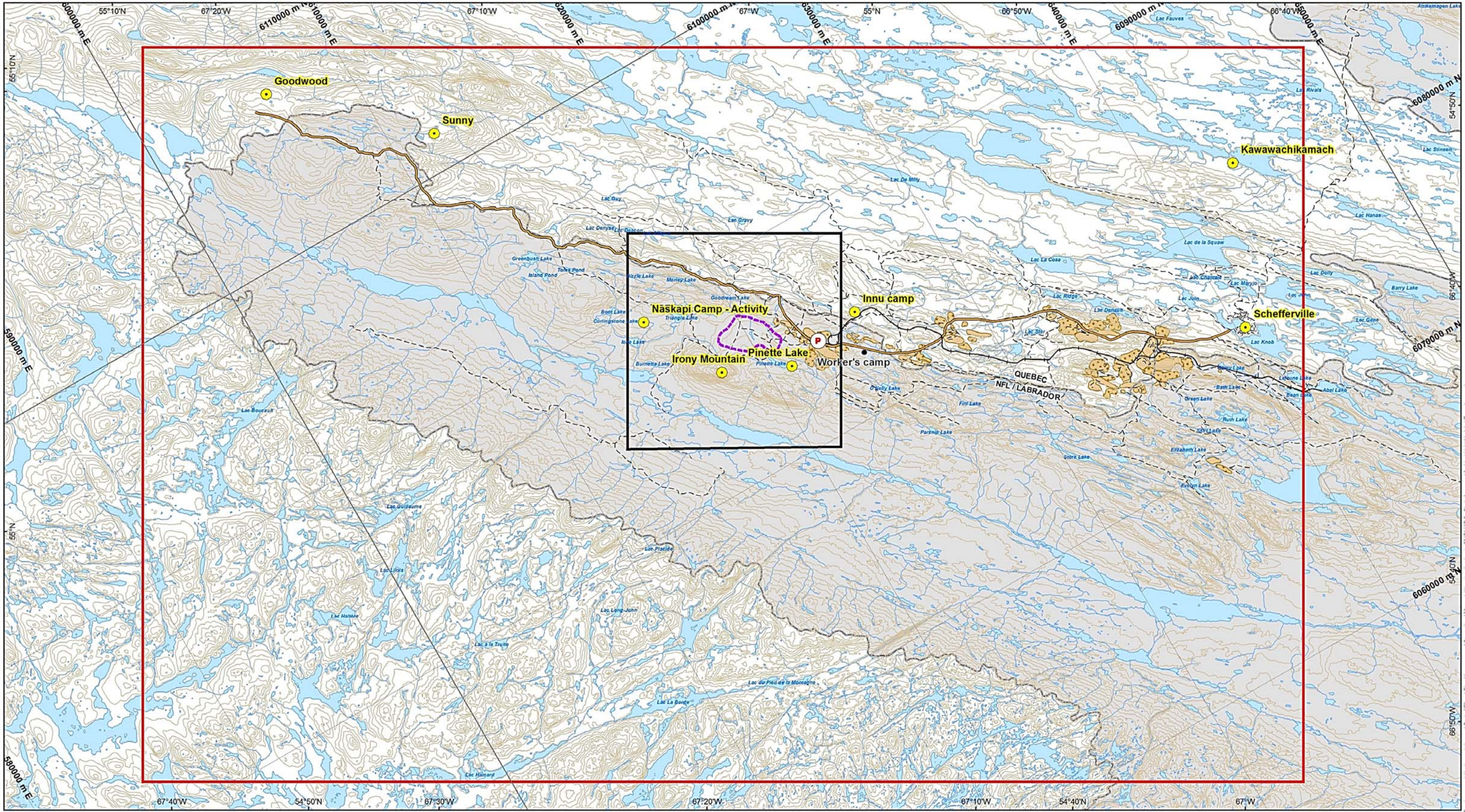
Existing Literature

Assessment of a project's effects on night-time light levels is an issue that has recently gained prominence in the context of environmental assessments. Consequently, knowledge and examples of previous effects assessments in this domain are limited to non-existent. An internet-based search for regulations or policies in northern parts of Canada of the amount of obtrusive light emitted from industrial facilities revealed that no information is available.

There are no legal requirements in place (e.g., regulations, guidelines, or policies) in Québec or Newfoundland and Labrador that regulate the amount of obtrusive light being emitted from facilities. However, the *Commission Internationale de l'Éclairage* (CIE), also known as the International Commission on Illumination, has developed maximum values for light spill and glare that should not be exceeded (CIE, 2003). These guidelines have been adopted in Great Britain and form the basis of a number of recommendations in the Leadership in Energy and Environmental Design (LEED) Green Building Council Certification Program of Canada (LEED, 2004). Such guidelines have also been adopted for other industrial projects in Canada. However, the CIE guidelines are considered to be more applicable to industrial or institutional installations with permanent lighting systems (e.g., electricity to power the lights is readily available from the grid), which is not the case for the Howse Project.

Ambient night-time light levels is a relatively recent component included in CEAA Guidelines for the Preparation of Environmental Impact Statements. In general, CEAA EIS guidelines documents for industrial projects from 2013 on, now include requirements for describing ambient night-time light levels; prior to 2013, only specific projects included this type of requirement. However, few EIS reports with ambient light evaluation requirements are currently available. Table 7-31 presents a review of several CEAA projects for which an ambient light assessment is (or was) required, and includes a comment describing the applicability to the Howse Project.

Based on a review of the ambient light evaluation requirements for the 10 projects presented in Table 7-31, in our opinion there are no comparable projects that provide a description of night-time light levels in different weather conditions and seasons, as required by the CEAA for the Howse Project.



Legend

● Sky Radiance Receptors used in modelling

▭ Regional Study Area

▭ Local Study Area

╲ Border

Infrastructure and Mining Components

Existing Mined-out Pit

Existing Waste Dump

Main Access Road

Road

Howse Mining Area (approximative)

Ⓟ Main Processing Plant Area

Railway

1:170 000

0 2 4 km

UTM 19N NAD 83

SOURCES:

NTDB, 1:50,000, edition 3.1
Gov. of NL and Gov. of Qc, Border
NML, Mining sites and roads
GH, Hydrology update, 2008

DSO Howse Project EIS

Study Areas and Ambiant Light Modeled Receptors

January 2015

MAP 2

Figure 7-11

AECOM

Table 7-31 Select CEAA Projects Reviewed for Night-time Light Assessment (as of January, 2015)

CEAA #(2)	NAME	EIS GUIDELINES DATE REFERENCE TO AMBIENT LIGHT?	EIS SUBMITTED?	COMMENT IN RELATION TO THE HOWSE PROJECT
80066	Highway 947 Extension Project **Alberta Transportation** **Edson, Alberta**	July 2014 Ambient light requirement? Yes, the same requirements as for Howse(1)	Not yet (3)	Not applicable
80068	Hardrock Deposit Project **Premier Gold Mines Hardrock Inc.** **Geraldton, Ontario**	August 5, 2014 Ambient light requirement? Yes, the same requirements as for Howse(1)	Not yet (3)	Not applicable
47632	Canpotex Potash Terminal Project **Prince Rupert, British Columbia**	November 22, 2011 Ambient light requirement? Yes	Dec. 13, 2011	Contains ambient light assessment, mostly focused on the terminal. Typical good practices and mitigation measures listed. Different weather conditions and seasons not assessed.
80032	Pacific Northwest LNG Project **Port Edward, British Columbia**	June 7, 2013 Ambient light requirement? Yes, the same requirements as for Howse(1)	Feb. 28, 2014	Contains an ambient light assessment, mostly focused on communities close to project. Typical good practices and mitigation measures listed. Different weather conditions and seasons not assessed.
64575	Kami Iron Ore Project Alderon Iron Ore Corp. Labrador, NFLD **Pointe-Noire, Québec**	February 6, 2012 By CEAA and NFLD DEC Ambient light requirement? Yes, but limited.	Oct. 1, 2102	The EIS report contains baseline ambient light measurements at three sites in Northern Québec (Kami terminal, a cabin and Baie de Sept-Îles). These light measurements were taken on one day from three to seven minutes per site. This data is not representative of the Howse Project or the Schefferville region and cannot be used to describe illumination levels during different weather conditions and seasons.
80036	Côté Gold Mine Project IAMGOLD Corporation **Gogama, Ontario**	July 9, 2013 Ambient light requirement? Yes, the same requirements as for Howse(1)	May 21, 2014	No light assessment submitted
80017	Blackwater Gold Project New Gold Inc.	February 19, 2013 Ambient light requirement? Yes, the same requirements as for Howse(1)	Not yet (3)	Not applicable

CEAA #[2]	NAME	EIS GUIDELINES DATE REFERENCE TO AMBIENT LIGHT?	EIS SUBMITTED?	COMMENT IN RELATION TO THE HOWSE PROJECT
	Vanderhoof (British Columbia)			
80021	Whabouchi Mining Project Nemaska Lithium inc. **Nemiscau and west-north-north of Chibougamau, Québec**	March 18, 2013 Ambient light requirement? Yes, the same requirements as for Howse[1]	May 17, 2013	Ambient light assessed as non-significant. Limited information on mitigation measures and good practices Different weather conditions and seasons not assessed.
80015	Joyce Lake Direct Shipping Iron Ore Project Labec Century Iron Ore **Labrador (approximately 20 km northeast of Schefferville, QC), Newfoundland and Labrador**	March 5, 2013 Ambient light requirement? Yes, the same requirements as for Howse[1]	Not yet [3]	Not applicable
80008	Hopes Advance Iron Mining Project Oceanic Iron Ore Corporation **Aupaluk, Québec**	December 10, 2012 Ambient light requirement? Yes, the same requirements as for Howse[1]	Not yet [3]	Not applicable

[1] The general requirement in the CEAA Howse EIS Guidelines is: Describe existing ambient night-time light levels at the project site and at any other areas where project activities could have an effect on light levels. The EIS will describe night-time illumination levels during different weather conditions and seasons.

[2] For detailed information on each project, enter the CEAA # from the table on this website http://www.ceaa-acee.gc.ca/050/index-eng.cfm

[3] No document submitted as of January, 2015

Definition of Types of Lighting Effects

Table 7-32 presents a summary of the definitions of types of lighting effects. Sky glow is the predominant type of lighting effect that could be expected from the Howse Project. No legal requirements pertaining to sky glow could be found.

Table 7-32 Definitions of Types of Lighting Effects

TYPE OF LIGHTING EFFECT	DEFINITION
Light Spill	Refers to the spilling of light from fixtures within a facility to the environment and receptors outside the facility. The unit of measure for light spill is a lux. A lux is equal to 1 lumen per square metre (lumen/m^2). For example, problematic light spill would occur when lights located on the outside of an industrial facility shine in through the windows of nearby residential homes. In the middle of the night, light spill at residential properties should not exceed 1 lux (CIE, 2003). An example of this effect is the excess light that may shine into a sleeping space and disrupt the ability of the residents to achieve a good night's sleep.
Glare	Refers to intense, harsh, or contrasting lighting conditions that reduce the ability of humans, birds, and other organisms to see. The most common example is oncoming high-beam headlights that provide lots of light but paradoxically make it difficult to see. The unit of measure for glare, sometimes referred to as luminance, is lumens per steradian, which equals a candela (cd).
Sky glow	Refers to the illumination of the clouds by light sources on the surface of the earth, such as street lighting, and haze in the atmosphere that replaces the natural night-time sky with a translucent to opaque lighted dome. The sky appears washed out or brownish-purple and may be devoid of visible stars in the extreme. Sky glow is the cumulative effect of all of the lights at the surface either emitting upward or being reflected upward by the surface. The unit of measure for sky glow is mag/arcsec^2. Values for sky glow range from approximately 22 mag/arcsec^2 in a rural environment where stars are abundant to approximately 18 mag/arcsec^2 in an urban environment where stars are barely visible.

Data Gaps

As previously noted, assessment of a project effects on night-time illumination levels is a developing environmental issue, and knowledge in this domain and its application to the Howse Project is limited to non-existent. No applicable "sky quality" standards could be found for comparable projects.

Tools and/or models for interpreting sky brightness measurements are varied and typically custom-made. For the Howse Mining project EIS, the Illumina model was selected as the most adequate to provide representative results for the study area. The Illumina model was developed by Professor Martin Aubé, an international expert who has been involved in studies to reduce light pollution at the Dark-Sky Reserve of Mont-Mégantic in the province of Québec (Astrolab, 2014).

7.3.4.2 Effects Assessment

Literature review and Current Studies Data Used to Assess the Potential Effect

Current Study

The proposed Howse mining site is located in Newfoundland and Labrador, approximately 23 kilometres northwest of Schefferville, Québec, near the provincial border of Newfoundland and Labrador, and Québec. The site will be located in close proximity to the DSO3 project. DSO3 consists of Timmins 3, Timmins 4, Timmins 7, and Fleming 7 mining sites, in addition to a processing plant complex. The ore from the Howse mining area will be transported to DSO3 loading facility and shipped by rail.

The Howse Mining Project will have limited effects on ambient light levels since:

- no power lines will be constructed to bring electricity to the Howse Mining site due to its relatively remote location, consequently no permanent light fixtures will be installed at the mine site;
- most activities at the site will be during the day time; and
- limited mining activities will occur during the winter months, when the nights are longer and there is snow on the ground which reflects light (artificial or natural).

Light pollution is an issue that has gained prominence within the context of environmental assessment. However, standardized quantification methods, procedures and standards are limited to non-existent, particularly in a remote location such as the region of Schefferville where artificial light is minimal and the sky and air are clear (compared to more densely populated areas).

Taking the above project specificities into consideration, TSMC decided to use an innovative baseline assessment methodology that combines on-site ambient light measurements, a radiative transfer model and the most recent available satellite images in order to characterize ambient light on a set of identified sensitive receptors in the vicinity of the Howse/DSO project region. Detailed results of the baseline assessment study are presented in the Ambient Light Technical Report for the Howse Project (Volume 2 Supporting Study G). Summary methodology and results are presented below.

Recent Portrait of Night-time Illumination Levels within the RSA

The use of Sky Quality Meters (SQM) manufactured by Unihedron inc. for measuring night-time illumination levels (e.g., sky glow) is prevalent in the literature. A simple portable photometer device, the SQM was designed for the purpose of measuring the subtle light of the rural night sky with high enough sensitivity, and it is used widely for light pollution monitoring. The SQM is a handheld device and collects the light from a relatively large solid angle (1.5 steradians, approximately a cone with a 20-degree half angle). The device displays the average luminance of this solid angle in astronomical units: magnitude per square arcsecond (mag/arcsec^2). SQM is temperature-calibrated and gives the luminance with the precision of 0.1 mag/arcsec^2, which is equivalent to 10 percent in linear luminance (cd/m^2) units. This type of SQM was used for measuring current sky glow levels in the vicinity of the Howse Project.

In November 2014, an *in-situ* night-time illumination measurement program was conducted by TSMC within the RSA. A SQM (Model SQM-LU-DL by Unihedron) was used to measure sky brightness at seven sites located in the vicinity of the Howse project site. A figure showing measurement locations is available in the Ambient Light Technical Report (Volume 2 Supporting Study G). Table 7-33 presents the measurement results. The SQM provides measurements in units of mag/arcsec^2**,** which are commonly used in astronomy to measure sky brightness. As indicated in Table 7-34, the higher the number, the more the sky is dominated by the natural background. In order to be representative and useable for modelling purposes, measurements were conducted under strict night sky conditions. Based on best practices found in the literature review, strict night sky conditions can be described as follows:

- moonless night;
- no clouds or fog;
- the sun is at least 18 degrees below the horizon (astronomical twilight); and
- no direct light from artificial sources reaches the detector of the device.

The SQM measurements were then used to calibrate the radiative transfer model (Illumina). Using the Illumina model, it was possible to conduct an assessment of ambient light in the Project region for the winter season (with snow cover and clear skies) and the summer season (without snow on the ground, with clean air or during sporadic air pollution events caused by forest fires). The Illumina model outputs were used to generate maps and tables of the sky radiance for different seasons and air quality levels at eight sensitive receptors.

Table 7-33 In Situ Night-Time Illumination Results, November 26 to 28, 2014

SITE ID	DESCRIPTION	DATE AND TIME OF MEASUREMENT	AVG. SQM READING MAG/ARCSEC^2
Irony Mountain / Howse	Important site for First Nations and project site, ≈1.5 km west of Howse	27-Nov-14 00:37 to 00:43	20.52
Pinette Lake	Innu camp, hunting site and potential migratory birds area. ≈2 km southeast of Howse	26-Nov-14 23:14 to 23:20	20.50
Kawawachikamach-1	Town center ≈26 km east to southeast of Howse	26-Nov-14 20:40 to 20:46	19.95
Kawawachikamach-2	On the road out of town	26-Nov-14 21:05 to 21:11	21.16
Schefferville-1	Town center ≈24 km east-southeast of Howse	26-Nov-14 21:30 to 21:36	19.13
Schefferville-2	On the road out of town	26-Nov-14 21:49 to 21:54	20.50
Dark point	Old Goodwood Rd, on the way to Kivivik. ≈13 km from Howse.	27-Nov-14 to 28-Nov-14 21:14 to 05:09	21.74*

* Maximum reading over the period of unattended sampling

Table 7-34 Reference Night Sky Brightness Scale as Defined by Berry in 1976

SKY GLOW (MAG/ARCSEC^2)	NAKED-EYE APPEARANCE OF THE SKY (M.W. = MILKY WAY)
21.7	The sky is crowded with stars, extending to the horizon in all directions. In the absence of haze the M.W. can be seen to the horizon. Clouds appear as black silhouettes against the sky. Stars look large and close.
21.6	Essentially as above, but a glow in the direction of one or more cities is seen on the horizon. Clouds are bright near the city glow.
21.1	The M.W. is brilliant overhead but cannot be seen near the horizon. Clouds have a greyish glow at the zenith and appear bright in the direction of one or more prominent city glows.
20.4	To a city dweller the M.W. is magnificent, but contrast is markedly reduced, and delicate detail is lost. Limiting magnitude is noticeably reduced. Clouds are bright against the zenith sky. Stars no longer appear large and near.

SKY GLOW (MAG/ARCSEC²)	NAKED-EYE APPEARANCE OF THE SKY (M.W. = MILKY WAY)
19.5	M.W. is marginally visible, and only near the zenith. Sky is bright and discoloured near the horizon in the direction of cities. The sky looks dull grey.
18.5	Stars are weak and washed out, and reduced to a few hundred. The sky is bright and discoloured everywhere.

Table 7-35 presents the ratio of artificial sky radiance to natural sky radiance, and Table 7-36 presents modeled winter sky brightness and the artificial light origin in percent. A full night-time illumination level technical report with more detailed explanations is available in Volume 2 Supporting Study G.

Table 7-35 Artificial Sky Radiance to Natural Sky Radiance Ratio

RECEPTOR ID	LONGITUDE	LATITUDE	WINTER[1]	SUMMER1[2]	SUMMER2[3]
			%	%	%
Goodwood ≈25 km NNE of Howse	55° 6'2.87"N	67°20'12.05"W	0.2	0.1	0.0
Sunny ≈17 km NNE of Howse	55° 2'59.99"N	67°14'47.30"W	0.5	0.2	0.0
Naskapi camp/activity ≈4 km NNE of Howse	54°56'06.48"N	67°11'19.19"W	3.5	0.9	0.5
Irony Mountain ≈1.5 km ESE of Howse	54°54'3.71"N	67° 9'29.59"W	8.9	1.9	2.0
Innu camp ≈6 km WSW of Howse	54°53'37.10"N	67° 3'9.10"W	37.5	6.3	13.6
Pinette Lake ≈3 km SSE of Howse	54°53'16.91"N	67° 6'43.63"W	66.1	9.1	19.6
Kawawachikamach ≈25 km ESE of Howse	54°51'49.03"N	66°45'39.00"W	404.3	39.5	120.0
Schefferville ≈24 km SE of Howse	54°48'7.09"N	66°48'57.18"W	492.8	53.0	149.6

1. Winter: covers the period with a snow cover.
2. Summer1: Covers the majority bare soil periods. Such a situation occurs most of the time in late spring, summer and early fall.
3. Summer2: Covers sporadic air pollution events caused by forest fires. This case typically occurs in summer and early fall.

Table 7-36 Modeled Winter Sky Brightness and Origin

RECEPTOR ID	MODELED WINTER SKY BRIGHTNESS	RATIO OF ARTIFICIAL TO NATURAL[1]	ORIGIN OF ARTIFICIAL SKY RADIANCE (%)	
	mag/arcsec^2		Towns	Existing activities
Goodwood ≈25 km NNE of Howse	21.29	0.2	46.1	53.9
Sunny ≈17 km NNE of Howse	21.29	0.5	37.9	62.1
Naskapi camp/activity ≈4 km NNE of Howse	21.26	3.5	17.6	82.4
Irony Mountain ≈1.5 km ESE of Howse	21.20	8.9	10.4	89.6
Innu camp ≈6 km WSW of Howse	20.95	37.5	4.8	95.2
Pinette Lake ≈3 km SSE of Howse	20.75	66.1	2.2	97.8
Kawawachikamach ≈25 km ESE of Howse	19.54	404.3	99.8	0.2
Schefferville ≈24 km SE of Howse	19.36	492.8	99.8	0.2

1: The lower the ratio, the smaller the contribution of artificial light.

Table 7-35 indicates that, as expected, sky radiance is higher during winter due to light reflection on the snow.

The results of Table 7-36 indicate that artificial lighting from activities outside of Kawawachikamach and Schefferville has a negligible effects (<0.2%) on sky brightness in these towns. Light pollution comes from the towns themselves. In contrast, artificial lighting originating from Kawawachikamach and Schefferville have a very small effects (<10%) on receptors close to the Howse pit, such as Irony Mountain and Pinette Lake, for example. Sky brightness due to artificial lighting at these receptors is due to existing activities (such as construction of the main processing plant for DSO3). It is reasonable to assume that any lighting used for the Howse Project would add to the sky brightness.

Interaction of the Project and Potential Effects

Several factors have to be taken into account for each phase of the Project:

- During the site preparation and construction phase, all lighting at the Howse pit will not be permanent due to its remote location.
- It is anticipated that the majority of the site preparation and construction phase will occur during the warmer months, between April and October. Given that the proposed Howse Mine site is located close to the 55th parallel, summer days are considered to be long in terms of daylight hours. Consequently, night-time operation and subsequent sky illumination by artificial lights is expected to be limited.

- During the operation phase, the Project will have limited effects on ambient light levels since:
    - No power lines will be constructed to bring electricity to the Howse Mining site due to its relatively remote location, and consequently no permanent light fixtures will be installed at the mine site;
    - Most activities at the site will be during the day-time;
    - Limited mining activities will occur during the winter months, when the nights are longer and there is snow on the ground which reflects light (artificial or natural).
    - The Howse ore processing activities will be conducted at the Howse Mini-Plant located close to the rail loop in the DSO3 area for a period of 7 months. Lighting from the Howse Mini-Plant will be intertwined with that of DSO3.
- The effect is reversible, because natural light will be restored to its original pre-Project state once all work areas are fully rehabilitated at the end of the Project.

Light concerns are related to the whole DSO area and not solely to the Howse Project. The "lights on top of trucks" concern will be addressed by specific mitigation measures (see list below). As shown in Table 7-36, the towns (Schefferville and Kawawachikamach) own lighting system currently accounts for 99.8% of the night time sky radiance; due to the distance between the Project and the towns, the effects of the Project's lighting on the population will not be perceptible.

The nature of the effect is direct and the effect is adverse.

7.3.4.3 Mitigation Measures

Standard Mitigation Measures

No standard mitigation measures apply to ambient light, however, specific mitigation measures are listed below.

Specific Mitigation Measures

Even if night-time illumination is not considered a VC, the following specific mitigation measures will be applied during the construction, operation and decommissioning and reclamation phase of the Project to ensure that the night-time illumination level remains close to the pre-Project level (Table 7-37).

Table 7-37 Specific Mitigation Measures for Light

MEASURE	MITIGATION EFFECT
Shield your outdoor lighting (1)	When personnel safety is not jeopardized, the Measures will minimize effects of the Project on ambient light. It is anticipated that light fixtures for the Howse Project will be portable and diesel powered; limiting the use of these lights will enable savings on diesel fuel usage, while limiting night-time illumination levels.
Only use the light when you need it (1)	
Shut off the lights when you can (1)	
Use only enough light to get the job done (1)	
Use long wavelength light with a red or yellow tint to minimize effects (1)	
Staff will be informed to turn off lights on top of trucks at night, when not necessary,	Minimize nuisance
The minimum amount of pilot warning and obstruction avoidance lighting should be used on tall structures.	Minimize risk of attraction of migratory birds

MEASURE	MITIGATION EFFECT
Lighting for the safety of employees should be shielded to shine down and only to where it is needed, without compromising safety.	Minimize nuisance and radiance towards the sky
When possible, LED lights will be used	LED light fixtures are less prone to light trespass

(1): Measures proposed by the International Dark-Sky Association in the document Light Pollution and Wildlife (IDA, 2008)

7.3.4.4 Residual Effect Significance Assessment

The overall methodological approach to assess the environmental effects is presented in Section 5. Even if night-time illumination is not considered a VC and does not have an ecological context in and of itself, an assessment of the residual effects significance is presented in Table 7-38 The night-time illumination residual effects significance assessment is to be reviewed in parallel with the ecological contexts of the Caribou (Section 7.4.3) and the Avifauna (Section 7.4.8) both of which are VCs.

Table 7-38 Assessment Criteria Applicable to Night-time Illumination

TIMING		
Inconsequential timing	**Moderate timing**	**Unfavorable timing**
Timing of predicted Howse activities are not expected to affect any sensitive activities in wildlife life cycles.	Timing of predicted Howse activities may affect some wildlife activities, i.e.: during migrating seasons.	Timing of predicted Howse activities may affect some key wildlife activities, i.e.: the calving/breeding periods.
Site specific	**Local**	**Regional**
The effect of the Howse Project lights will be visible in the LSA.	The effect of the Howse Project lights will be visible in the LSA.	The effect of the Howse Project will be predominant in the LSA.
DURATION		
Short	**Medium**	**Long**
Less than 12 months. Limited to the construction and/or decommissioning and reclamation phase.	12-24 months. Extends beyond the preparation/construction phase, but shorter than the lifespan of the Project.	More than 24 months Or long as the Project duration
REVERSIBILITY		
Reversible	**Partially reversible**	**Not reversible**
The nighttime illumination is expected to return to its pre-Howse level	The nighttime illumination will persist after the decommissioning and reclamation phase	The nighttime illumination will be permanently altered by the Howse Project.
MAGNITUDE		
Low	**Moderate**	**High**
Howse Project will likely have no effects on night sky brightness, relative to the closest light sources	Howse Project will have little effects on night sky brightness, relative to the closest light source	Howse Project will have an important effect on nighttime illumination levels and significantly deteriorate night sky brightness
FREQUENCY		

Once	Intermittent	Continual
The disturbance will occur once	The disturbance will be occasional	The disturbance will be year round.

Timing

Howse Project activities will occur throughout the year, with the potential exception of winter blasting (which will be infrequent). Since the light produced by the Howse Project activities will be generated continuously after daylight hours, the timing of the disturbance may occur during periods of human/wildlife in the LSA, and so the effect is high (Value of 3).

Spatial Extent

The Howse Project lighting is expected to extend beyond the LSA, but will not be the predominant source of illumination due to the presence of the DSO3 processing plant nearby (Value of 2).

Duration

For safety reasons, lighting at the Howse project will last as long as the project duration (Value of 3).

Reversibility

After decommissioning, all light sources from the Howse project will be removed and the illumination levels will return to pre-Howse levels (Value of 1).

Magnitude

Lights will be used at the Howse project, but the absence of permanent power lines reduces the potential for over-lighting due to the high cost of generating power with portable diesel engines. The main source of light in the LSA will be the DSO3 processing plant nearby. As such the effect is low (Value of 1).

Frequency

The frequency of light generation is expected to be continuous, although artificial light disturbance will only occur at night. (Value of 3).

7.3.4.4.1 Significance

The residual effects of the Howse Project on light (night sky brightness) are expected to be non-significant (value of 13). This value is representative of the low magnitude of the effects of the Project as well as the full reversibility of the effect.

Likelihood

The likelihood of Howse having an effect on night sky illumination is **likely** because the presence of any artificial lights in a region relatively free of artificial lights will have an effect.

Night-time illumination in and of itself is not a VC, therefore an assessment of light cumulative effects has been integrated in the caribou and avifauna sections.

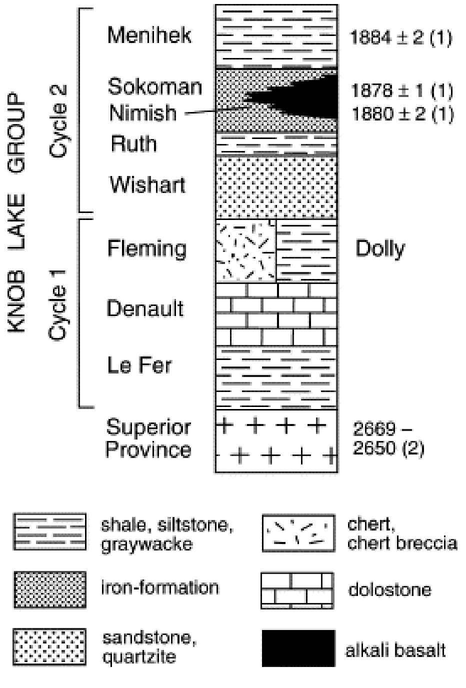
7.3.5 Geology

7.3.5.1 Component Description

The geology of the site will not be affected by the Project. Geology is thus not retained as a VC.

The Labrador-Québec Trough, 1,200 km long and up to 100 km in width, is a complexly folded and faulted geosyncline bearing sedimentary, volcanic and intrusive rocks. The Trough is divided into North (Ungava Bay Region), Central (Schefferville Region), and South (The Grenville). Sedimentary and meta-sedimentary rocks overlie unconformably the Archaen basement granodioritic and granitic gneisses. The 100-km wide belt (central part) tapers considerably towards the north and south. The DSO style of mineralization is mostly concentrated in the central part of the Trough, and historically dominantly mined in the Schefferville region. Several processes have been put forward by different schools of thought on the genetic model of the DSO; however, the leaching process is generally adopted for this region. Another style of mineralization also present in this region is Taconites, a fine-grained, weakly metamorphosed iron formation with magnetite as the primary iron oxide mineral and secondary hematite, with smaller amounts of iron carbonates and iron silicates.

The Knob Lake group is believed to have been deposited in two cycles, and the Sokoman Formation, which is the principal host of the iron mineralization, was deposited during the second cycle (Williams and Schmidt, 2004). This group of rocks is generally considered as a chemical precipitate of sedimentary origin. Below is a summary description of the different Knob Lake group formations in the Schefferville area (Figure 7-12). Some of the formations that have been intersected only locally are not shown. For example, the Purdy dolomite formation overlies the Sokoman formation locally.



Source: Williams and Schmidt, 2004

Figure 7-12 Stratigraphy of the Knob Lake Group

Menihek Formation (MS)

A dark, fine-grained, thin to medium bedded graphitic shale, the formation commonly contains chert laminations and pyrite layers or nodules, and its color is almost always black or greenish-grey. The thickness of this upper shale or slate (US), if weakly metamorphosed, is unknown.

Sokoman Formation

The Sokoman formation is the main iron formation host throughout the Labrador-Québec Trough, and its thicknesses vary between 120 and 240 metres. The essential minerals are chert, iron oxides, iron hydroxides and iron silicates with minor carbonates. The principal ore mineralogy in the DSO category is hematite, martite, and goethite, generally distributed into red, blue and yellow ores. Mineralization of the Sokoman formation can be widely classified across the Trough as follows: Upper iron formation (UIF), Middle iron formation (MIF) and Lower iron formation (LIF), which are in turn further divided into several subclasses.

Upper Iron Formation (UIF)

This formation encompasses three main subclasses. Grey Upper Iron Formation (GUIF) is a unit that is somewhat similar to PGC, although the overall iron content is usually significantly less. The unit shows disseminated iron oxides in a grey cherty matrix mixed with carbonates, and seldom makes DSO grade Blue ore because of its low primary iron content. The GUIF has also been identified as the Jasper Upper Iron Formation (JUIF) with increasing Jasper content, and produces DSO-grade Red Ore upon leaching.

Lean Chert (LC), overlaid by MS and grades to JUIF, is an oxide facies almost void of primary iron oxides. The chert displays a variety of colors but is generally green to greenish-grey and the unit rarely grades into ore.

The lower limit of the UIF is Green Chert, usually 1.2 to 9.4 m in thickness.

Middle Iron Formation (MIF)

This formation encompasses four main units:

Lower Red Green Cherty (LRGC) is the lower contact with the LIF. This unit, which is not always present, is chert, magnetite, silicates and carbonate bearing, with minor hematite.

Lower Red Cherty (LRC) is an oxide facies rich in hematite, martite and minor magnetite occurring in bands alternating with jasper, and when leached results in DSO-grade Blue ore.

Pink Grey Cherty (PGC) is a thick unit, rich in hematite, with minor magnetite, sometimes bearing considerable iron carbonates. Upon leaching, the unit produces Blue ore with some Yellow ore characterize by goethite. The PGC occasionally bears bands rich in iron silicates, carbonates and iron oxides resembling SCIF. When present, these units are identified as yellow MIF (YMIF) and produces Yellow ore upon leaching.

Upper Red Cherty (URC) is often not well developed and is thus challenging to distinguish from PGC. It is an oxide-rich facies bearing jasper lenses and laminae, and produces DSO-grade Blue ore upon leaching.

Lower Iron Formation (LIF)

This is the lowest member in the Sokoman formation stratigraphy column in contact with the Wishart formation. Based on field observation, it can be described as laminated to bedded. The LIF consists of two units: silicate carbonate iron formation (SCIF) and Ruth Shale (RS). The SCIF is the main unit, consisting of chert interbedded with iron silicate minerals, iron oxides and carbonates, and produces DSO-grade Yellow Ore when leached. Green chert and higher magnetite is a key for this submember. The Ruth Shale unit, previously considered as a separate formation, occasionally contains black shale bearing trace pyrite and also magnetite, hematite or quartz at the upper contact.

The LIF also bears discontinuous oxide-rich layers that produce DSO-grade Blue and Red ores upon leaching.

Ruth Formation

The Ruth formation consists of laminated to micro-bedded black, grey-green or maroon chert-carbonate ferruginous slate 3 to 36 metres thick, bearing minor pyrite. Lenses of black chert and various amounts of iron oxides are also present. This unit produces Red ore upon leaching. When present, the jaspilite produces Blue ore upon leaching. Much of the slate contains more than 20% iron.

Wishart Formation

This formation consists of quartzite and arkose and is a persistent unit in the Kaniapiskau Supergroup. Thick beds of massive quartzite bear well-rounded intraclasts of glassy quartz and 10-30% rounded clasts of pink and grey feldspar, with a cement of silica and minor amounts of hematite and other iron oxides. Thicknesses of 10-75 m have been intersected.

Fleming Formation

This formation commonly ascribes as chert breccias (CB) consisting of rectangular fragments of chert and quartz within a matrix of chert grading to dolomitic downwards. It has a maximum thickness of about 100 metres.

Denault Formation

This dolomite and calcite formation is 20-60 m thick, bearing cherty bands and pebbles of black chert, and exhibits buff-grey to brown hummocky alteration and/or weathering. The formation grades upwards into the chert breccia and or quartzite.

Attikamagen Formation: (thickness >300 m)

This formation is commonly exposed in folded and faulted segments of the stratigraphic succession and varies in thickness from 30 m to over 300 m. The lower part of the formation has not been observed. It consists of laminated to micro-bedded argillaceous material (2-3 mm), fine-grained (0.02 to 0.05 mm), grayish-green, dark grey to black or reddish-grey. Calcareous or arenaceous lenses up to 30 cm thick occur locally inter-bedded with the argillite and slate, and lenses of chert are common. The formation grades upwards into Denault dolomite, or into Wishart quartzite in areas where dolomite is absent. Other prominent structures are drag-folds, and well developed cleavages parallel with axial planes, perpendicular to axial lines of folds and parallel with bedding planes.

LSA, RSA and Temporal Boundaries

The Howse deposit is classified under the DSO3 area. The deposit stratigraphy of this area is dominated by iron formation, quartzite and lower shale with occasional Fleming chert breccias and Denault dolomite. The beds are generally interpreted to be dipping at 65º ENE, though variations are also noted locally. Faults are easily recognized by the rapid change and intersected points of lithology, as well as a hiatus of successive formations between the juxtaposed areas.

The Howse deposit is classified as the Lake Superior type of mineralization, a style of mineralization that is strongly structurally controlled. Complex structures have been recorded in the DSO project area, including faults and folds. The folds in this area are closely spaced and strike in a northwesterly direction. The major axis of the folds plunges NW or SE. Faults are high angle reverse or cross faults with dips greater than 60º.

The Howse deposit is buried in unconsolidated overburden (OB) with thicknesses of 12 to 52 m. This OB comprises sand, gravel and silt material deposited by glacial melting.

The 2014 drilling indicate three DSO-grade ore types: Blue, Red, and Yellow. The Blue and Red ores are dominant, with only narrow intervals of Yellow ore intersected so far. The ore is dominantly friable, porous and soft, with locally alternating layers of high-grade iron ore and hard, partly altered/leached zones of iron formation.

Table 7-39 presents a summary of the formations intersected during hydrogeology and geotechnical drilling at Howse.

Table 7-39 Formations Intersected During Hydrogeology and Geotechnical Drilling at Howse

DDH	FROM	TO	TITLE	DESCRIPTION
HW-GT13-01	0	43	Overburden	No core
	43	201.5	Chert	Pink leached chert, alternating hard leached chert and soft clayey leach chert, fractures infilled with talc. Soft leached chert contain slightly more hematite than the harder sections.
HW-GT13-02	0	33.6	Overburden	OB
	33.6	61.3	Iron Ore Formation	Blue ore, pronounced limonite alteration @ upper contact, shale @42.0m, locally bedded @ 50deg to Core Axis(CA), core lost @50.0m & 55.0m, the ore grades into Red (30cm thick) @ 53.0m. Blue hem bearing disseminated jasper and localized strong limonitisation @59.4m, fracture zone @45deg. CA at the distinct lower contact.
	61.3	70.7	Iron Formation	Clay zones up to 1.5m thick intercalated with red hematite zone @ 35 deg. CA @68.6m. Core lost @68.8m & 70.7m. Distinct Lower contact with Wishart Quartzite.
	70.7	87	Wishart Fm (WQTZ)	Wishart Quartzite; 20cm fractures // to CA at 77.0m. There are some carbonate blebs associated with this unit. The fractures are varying between 45.
	87	120.9	Wishart Fm (WQTZ)	This section is red in color associated with clay and carbonate. The core is fractured along the CA at 86m, filled with calcite and also limonitisation. There is some bedding @40 degree CA at 87.5 m, becoming parallel to CA at 93m. There are 35 degree veins filled by calcite cutting across the bedding at 95.3m.
	120.9	146	Wishart Fm (WQTZ)	This section is constituted of shale associated with green chert. Presence of disseminated sulfur (pyrite). There is some bedding associated with hematite. The core is fractured along the CA at 122.2m. There is some micro faulting at 123.9m. There is 45 degree bedding at 128.6m. Fracture at 137.9m filled with hematite.
	146	200.8	Wishart Fm (WQTZ)	This section bears more shale. The texture is layered. There is more bedding @30 degree to CA at 145.6m. Presence of limonite alteration at 149m. Presence of hydraulic fracture at 155.5m filled by hematite. 40 degree fracture at 155.8 filled by hematite. From 169.5 to 172.5 m there is a fault zone associated with graphite and brecciated. Bedding became parallel to CA at 170.5m. From 174 to 121m the core is badly broken and redder in color. 45 degree fracture at 188.2 m bearing limonite alteration.
HW-RC13-02	0	36	Overburden	Large blue chert fragments, significant magnetite, decreases in grain size with depth. Dull blue chert with minor magnetite and brown coating. Mostly sandy with grain size decreasing down hole.

DDH	FROM	TO	TITLE	DESCRIPTION
				36-39: Transition between overburden and MIF. Fine-grained sand, hard to distinguish, rounded quartz and dark grey chert. Minor hematite and trace coarse-grained magnetite.
	36	39	Iron Formation	Chert fragments and hematite with dark coating.
	39	105	Iron Ore Formation	Dominantly Blue, and locally Red, fine-grained and strongly leached, dominantly high-grade (>60% Fe) DSO, averaging ~65% Fe; dominantly hematite and locally very weakly magnetic depicting the presence of martite. Gangues include locally red clay and chert. Mineralization is dominantly Blue and high-grade from the upper contact, and grades into Red and low-medium-grade towards the lower contact.
	105	108	Iron Ore Formation	Red hematite, red iron clay coating. White chert fragments, clay pockets.
	108	114	Iron Formation	Blue hematite with dark brown clay coating, mostly white with minor blue chert.
	114	129	Iron Formation	Blue hematite with dark brown clay coating. White/blue chert fragments.
	129	162	Wishart Fm (WQTZ)	Very fine-grained sand with large- to medium-grained quartz sand and medium-grained goethite and hematite.
HW-RC14-WE01R	0	44.15	Overburden	Light to dark brown, predominantly very-fine-grained to coarse-grained sand with abundant, subrounded to rounded, pebble-sized clasts up to a few cm in diameter; consisting of chert, quartz and other rock fragments.
	44.15	59.4	Iron Ore Formation	Dark brown, fine- to coarse-grained hematite ore with locally minor clay component. Dominantly sandy size fraction with minor gravel. Ore type is Blue at the upper contact grading into dominantly Red from 68m down to the lower contact.
	126.5	164	Wishart Fm (WQTZ)	Quartz-rich sand that characterizes an intensely altered Wishart formation. EOH
HW-RC14-WE02R	0	25.8	Overburden	From 0m to 13.6m the rock chips are medium reddish-brown in color with minor clay component. Grain size ranges from fine-grained sand to pebble sized clasts up to 1-1.5cm; From 13.6m to 19.7m color changes to a light-medium brown and grain size measures from fine-grained sand particles to pebbles sized material up to 0.5cm. Deep reddish brown regolith from 19.7m-22.75m -with minor clay intercalations and particles that measure up to 1-2cm. gradational transition from OB to ore in interval 22.75m-25.8m. Overall, the particles are rounded to subrounded and consist of chert and other rock fragments.
	25.8	60.3	Iron Ore Formation	Blue/red to red/brown gravel ore with abundant sand-sized particles composed mostly of quartz and chert with minor martite. Color becomes more reddish-brown downhole with the presence of minor clay as gangue.
	60.3	109.1	Iron Ore Formation	Reddish-brown gravel ore with an abundant fine-grained sandy component of quartz, chert, martite and possibly trace carbonate?
				Rock chips become more medium reddish-brown downhole; Grains are rounded to subrounded and sometimes angular; Rare yellow limonitic alteration visible on some grains from interval 90.8m to 93.85m; Unit becomes more sandy downhole
	109.1	182.3	Iron Ore Formation	Predominantly medium reddish-brown in color, very sandy intervals of quartz, chert and locally minor martite; rare carbonate grains visible in most interval along with some

DDH	FROM	TO	TITLE	DESCRIPTION
				visible limonitic alteration; minor gravel ore component in intervals 124.35m-127.40m; 133.5m-145.7m; and from 151.8m - 164.0m
HW-RC14-WE03R	0	22.8	Overburden	Brown gravel with a mix of sand. Gravel ranges in size from 1mm to 2cm and is mostly well-rounded with some angular pieces. Mostly chert, with some minor magnetite.
	22.8	35	Iron Ore Formation	Red gravel mixed with a minor amount of sand. The gravel is very hard and doesn't leave much of a streak.
	35	47.2	Iron Ore Formation	Mostly reddish-blue hematite that is largely gravel mixed with sand.
	47.2	108.2	Iron Formation	Red, TRX that is mostly gravel with lesser sand. Mostly chert with minor hematite. Water seen from 88m to 106m. Short interval of possibly carbonate-rich rock between 71.60m-74.65m.
	108.2	180.25	Wishart Fm (WQTZ)	Quartz-rich sand that characterizes the Wishart formation.
HW-RC15-WE05R	0.0	54.86	Overburden	Grey to Brown gravel with a mix of sand. Gravel ranges in size from 1mm to 2cm and is mostly well-rounded with some angular pieces.
	54.86	70.10	Wishart Fm (WQTZ)	Weathered white chips with a muddy light red-brown clay coating. Silica grains in white chips show matrix leaching.
	70.10	182.88	Attikamagen Fm (LS)	Over all color is typical greenish-grey of the Attikamagen. Most of recovered material is sand size with some rounded chips. Chips show some bedding coloured from mauve, green, grey and white.
HW-RC15-WE07R	0.0	18.29	Overburden	Grey sand with a mixed with bands of gravel. Gravel ranges in size from 1mm to 2cm and is mostly well-rounded with some angular pieces
	18.29	39.62	Sokoman Fm (BIF)	Reddish-brown coating on 2-10 mm chips of leached IF. Black non-magnatic chips common. White leached chips with yellow limonite staining 20-30%
	39.62	67.06	Sokoman Fm (BIF)	Greyish-brown coating on 2-10 mm chips. Common non-magnetic black chips with minor red band/spots. Some leached white chert and minor yellow limonite staining. Mostly reddish-blue hematite that is largely gravel mixed with sand.
	67.06	97.54	Sokoman Fm (PGC)	Most chips over 10 mm. Chips show PGC weathering with rust/black mineral in the weathered carbonate blebs. Weak magnetics. Red and black colour to the chips. Quartz-rich sand that characterizes the Wishart formation.

Existing Literature

The earliest major reported and recorded work on the Howse Property and deposit was by IOCC from 1950 to 1980. During this period, IOCC completed approximately 110 holes and several trenches, and reported a mineral resource estimate. Between 2005 and 2012, LIM completed ground geophysics survey, and drilled eight holes from 2008 to 2009. IOCC and LIM reported thick overburden of up to 40 m over the deposit. No production has taken place on Howse Property till date.

Structurally, the deposit occurs in a broad syncline with tight second order folds in the hinge area. The hinge area of the first order syncline is faulted by a major reverse fault dipping steeply to the northeast. A major northeast-southwest striking cross fault separates the deposit into two parts. In the southern part, the ore zone has a surface width of about 76 m and the southwest limb of the first order syncline is faulted against lower slate to the northeast. In the northern part, the ore zone has a width averaging about 152 m and both limbs of the syncline in iron formation are preserved.

The 1983 IOCC Inventory of Resources lists the Howse resource at 28,800,000 tonnes at 58% Fe and 5% SiO_2.

Overburden

Some information presented in this section is based on information provided in Section 7.3.7. Depositional evidence of meltwater activity, rare in the region, occurs within the area encompassed by the Howse Property itself. In this area, a relatively uniform cover of till overlies buried glaciofluvial sand and gravel. The landform is interpreted to be a buried kame, more or less centered on the deposit, overridden by a late glacial advance. The kame (dome shape) is deduced on aerial photographs by a distinct, radial drainage pattern centered on the thickest portion of sand and gravel that encompass the Howse Property area. Drilling has shown that the overburden covering the Howse Property varies in thickness from 12 to 52 m in the explored part of the deposit, as shown for some boreholes in Figure 7-13. Silty sand is the most widespread surficial material in the vicinity of the Project. The till is generally moderately-well to well drained, supporting sandy soils. In depressions where the groundwater table is perched on an impervious layer, the till may be imperfectly to poorly drained. The 2013-2014 drilling results (Volume 2 Supporting Study C) indicate that the glaciofluvial material intercepted was mainly a mixture of sand and gravel, with occasional clay content.

Figure 7-13 shows the observed percentage of clay, sand and gravel in the overburden section of some boreholes.

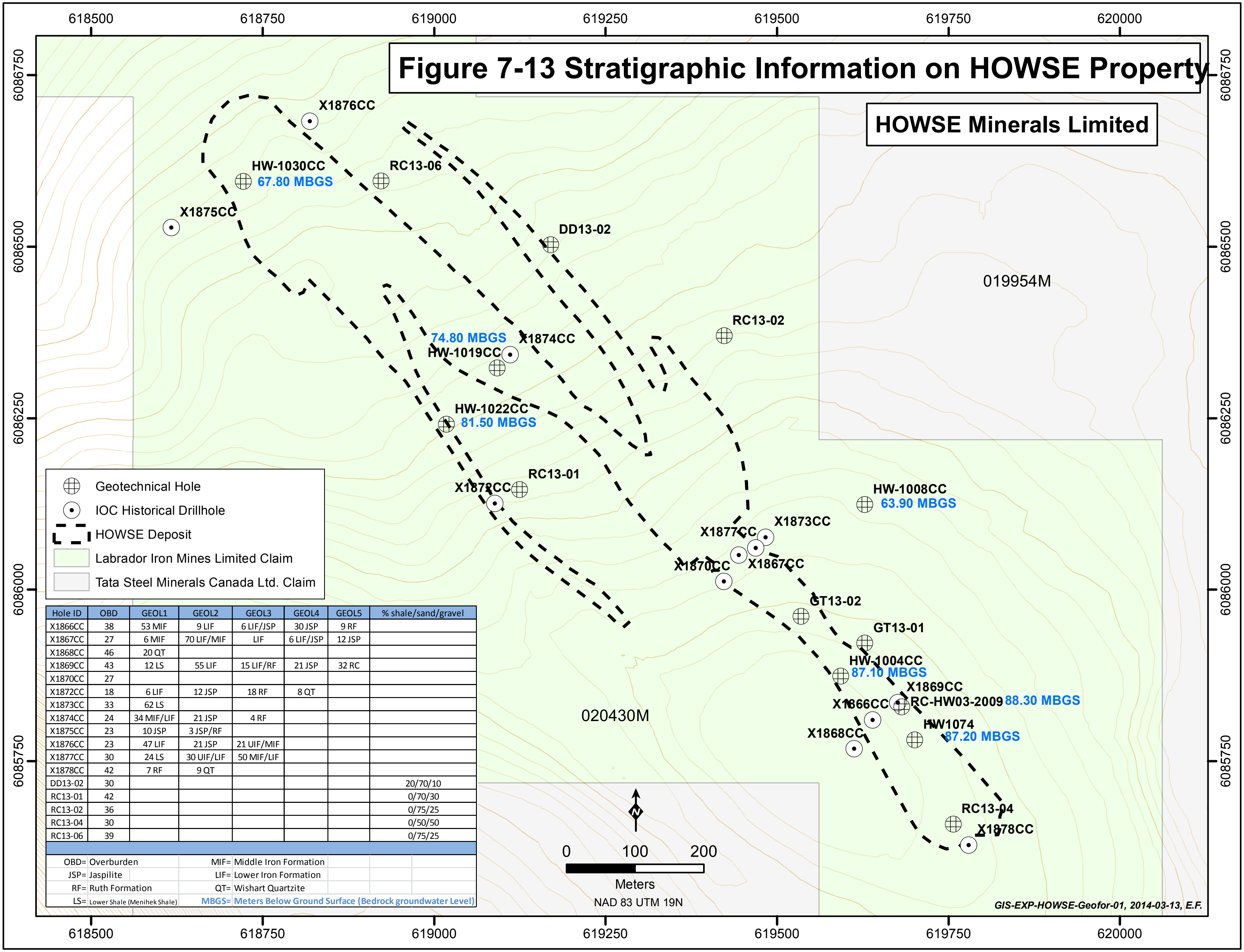
The Howse area is dominated by Irony Mountain, which is a prominent bedrock knob resistant to glacial erosion. Meltwater channels incised through till are seen on the western flank of the mountain.

Bedrock

The bedrock at Figure 7-13 shows the general geology of the spatially close Timmins and Howse deposits. It can be observed that the geological context is very similar for the Howse and Timmins deposits considering the geological trend and bedrock lithological continuity. Exploration work, including drilling conducted by IOCC on the Howse Property, generated stratigraphic sections of the deposit showing a narrow correlation with the Timmins deposits as illustrated by Figure 7-13. The general pattern is the same for both the Timmins and Howse areas, with the obvious exception of some minor local variations. The formations containing the economic iron ore are highlighted in blue. Some stratigraphic sequences established from drilling by IOCC on the Howse Property are shown in Figure 7-13. A surface ore plan produced by IOCC shows that the Howse Property lies in a faulted geological environment.

Figure 7-13 Stratigraphic Information on HOWSE Property

HOWSE Minerals Limited



⊕ Geotechnical Hole

⊙ IOC Historical Drillhole

HOWSE Deposit

🟩 Labrador Iron Mines Limited Claim

▢ Tata Steel Minerals Canada Ltd. Claim

Hole ID	OBD	GEOL1	GEOL2	GEOL3	GEOL4	GEOL5	% shale/sand/gravel
X1866CC	38	53 MIF	9 LIF	6 LIF/JSP	30 JSP	9 RF	
X1867CC	27	6 MIF	70 LIF/MIF	LIF	6 LIF/JSP	12 JSP	
X1868CC	46	20 QT					
X1869CC	43	12 LS	55 LIF	15 LIF/RF	21 JSP	32 RC	
X1870CC	27						
X1872CC	18	6 LIF	12 JSP	18 RF	8 QT		
X1873CC	33	62 LS					
X1874CC	24	34 MIF/LIF	21 JSP	4 RF			
X1875CC	23	10 JSP	3 JSP/RF				
X1876CC	23	47 LIF	21 JSP	21 UIF/MIF			
X1877CC	30	24 LS	30 UIF/LIF	50 MIF/LIF			
X1878CC	42	7 RF	9 QT				
DD13-02	30						20/70/10
RC13-01	42						0/70/30
RC13-02	36						0/75/25
RC13-04	30						0/50/50
RC13-06	39						0/75/25

OBD= Overburden
JSP= Jaspilite
RF= Ruth Formation
LS= Lower Shale (Menihek Shale)

MIF= Middle Iron Formation
LIF= Lower Iron Formation
QT= Wishart Quartzite
MBGS= Meters Below Ground Surface (Bedrock groundwater Level)

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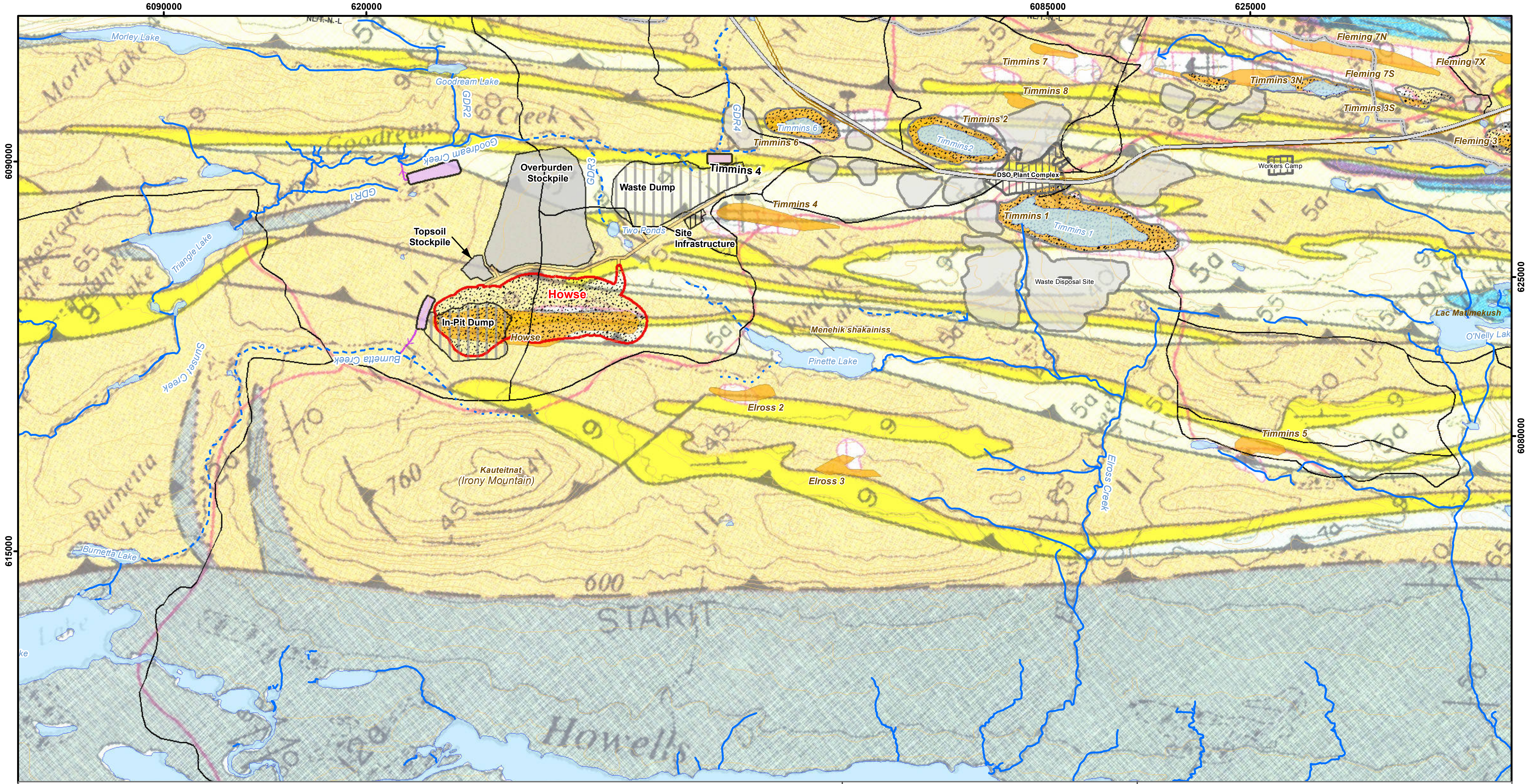

LEGEND

Geological Components

- 5a : Grey Shale, Siltstone And Graywacke
- 6a : Dolomite
- 8 : Brecciated Chert
- 9 : Orthoquartzite, Quartzite And Siltstone
- 11 : Cherty Iron Formation
- ▨ : Mining Area

Infrastructure and Mining Components

- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Site Infrastructure
- Proposed Waste Dump/ In-Pit Dump
- Proposed and Existing Sedimentation Pond
- Proposed Ditch
- DSO Haul Road
- Proposed Mine Haul Road
- Existing Railroad
- Elross Lake Area Iron Ore Mine (ELAIOM) Plant Infrastructure footprint
- Existing Pit
- Existing Dump
- Deposit

Basemap

- Permanent Watercourse
- Intermittent Watercourse
- Storm Runoff
- Disappearing Stream
- Artesian Spring
- Water Body
- Contour Line (50 ft)
- Provincial Border
- Existing Road
- Main Access Road

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0615 , PR185-19-14, 2016-01-26, jtremblay

N

0 500 1 000
Meters

UTM 19N NAD 83

SCALE: 1:30 000

SOURCES:

Basemap
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec, Boundary used for claims
SNC Lavalin, Groupe Hémisphères, Hydrology update, 2013

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
Howse Minerals Limited/
MET-CHEM Howse Deposit Design for General Layout., 2015

Geology layer
Wardle RJ, Geology of the south-central Labrador Trough, scale 1:100,000.

ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Geology

Howse Minerals Limited

GroupeHemispheres

5731, rue Saint-Louis,
Bureau 201, Lévis (QC)
Canada, G6V 4E2

1453, rue Beaubien est,
Bureau 301, Montréal (QC)
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Figure 7-14

Acid Rock Drainage Potential

Comparison data used to understand the Howse Property is mainly from the Timmins area, as the two are physically close and geologically similar. Samples were collected from drill holes in various parts of the Timmins deposits to cover the widest range of volume, extent and relative proportions of ore/waste in relation to the exploration hole. Waste samples around the deposit were also included as part of this program in order to better understand the various formations that will be encountered during mining.

The process of sample selection was based on the following rationale:

- consider the local and regional geological and hydrogeological conditions which could be affected during this process;
- cover all geological formations to be encountered during the service life of the mine;
- cover ore and waste in a proportional way; and
- cover any visible changes in the proportions of minerals in the ore and waste log data.

The Timmins area was well analyzed with respect to the ARD potential because of the mining activity. In addition, several orthodox tests such as Acid Base Accounting (ABA), which includes Total Sulfur (S) and Raw Neutralizing Potential (NP), Acid Potential (AP), Net Neutralization Potential (NNP) and Neutralization Potential Ratio (NPR or NP/AP) tests were conducted. Moreover, a Leaching Potential test, including the Toxicity Characteristic Leaching Procedure (TCLP), was conducted on the samples. Analyses of the resulting sample leachates were performed for concentrations of mercury, arsenic, barium, boron, cadmium, chromium, lead, selenium, uranium, fluoride, nitrates and nitrites. The primary goal for these tests was to monitor the drainage chemistry and acid generating potential of the geological formations of the Timmins area. Some results are shown in Table 7-40 for reference.

Based on the above ARD results and geological similarity between the Timmins area and the Howse Property, it can be assumed that the geological formations that will be encountered in and around the Howse Property do not have acid generating potential. The TSMC geological team will also send samples from all Howse geological formations at various levels to confirm this assumption in the coming months. From the first ABA analysis done for Howse, the maximum acid potential result was 2 kg $CaCO_3$/t, indicating that the samples are not acid generating (Volume 2 Supporting Study H).

Table 7-40 Toxic Element Concentration and Acid Rock Potential of the Timmins Area

ORE/ WASTE	LITHOLOGY	SULFUR (%)	AS	CR	PB	SE	CD	AP	NP	NNP	F	NO_3	NO_2	LEACHATE PH
Ore	MIF	0.02	<0.004	<0.007	<0.01	<0.005	<0.002	0.6	12	11.4	1	<0.2	<0.2	4.94
		0.01	<0.004	<0.007	<0.01	<0.005	<0.002	0.6	12	11.4	<1	<0.2	<0.2	4.93
Ore	MIF	<.01	<0.004	0.083	<0.01	<0.005	<0.002	0.3	12	11.8	<1	<0.2	<0.2	4.94
Waste	MIF	<.01	<0.004	0.023	<0.01	<0.005	<0.002	0.3	12	11.7	<1	<0.2	<0.2	4.94
Waste	MIF	0.02	<0.004	0.007	<0.01	<0.005	<0.002	0.6	12	11.4	<1	<0.2	<0.2	4.94
Ore	MIF	0.02	<0.004	<0.007	<0.01	<0.005	<0.002	0.3	12	11.7	<1	<0.2	<0.2	4.93
Waste	MIF	<.01	<0.004	<0.007	<0.01	<0.005	<0.002	<0.3	12	12	<1	<0.2	<0.2	4.94
Waste	MIF	0.01	<0.004	<0.007	<0.01	<0.005	<0.002	0.3	12	11.7	<1	<0.2	<0.2	4.91
Ore	MIF	0.01	<0.004	<0.007	<0.01	<0.005	<0.002	0.3	12	11.7	<1	<0.2	<0.2	4.94
		0.01	<0.004	<0.007	<0.01	<0.005	<0.002	0.3	12	11.7	<1	<0.2	<0.2	4.94

ORE/ WASTE	LITHOLOGY	SULFUR (%)	AS	CR	PB	SE	CD	AP	NP	NNP	F	NO_3	NO_2	LEACHATE PH
Ore	MIF	0.01	<0.004	<0.007	<0.01	<0.005	<0.002	0.3	12	11.7	<1	<0.2	<0.2	4.91
Ore	MIF	0.01	<0.004	<0.007	<0.01	<0.005	<0.002	0.3	12	11.7	<1	<0.2	<0.2	4.91
Waste	MIF	0.01	<0.004	<0.007	<0.01	<0.005	<0.002	0.3	12	11.7	<1	<0.2	<0.2	4.90
Waste	MIF	0.02	<0.004	<0.007	<0.01	<0.005	<0.002	0.6	12	11.4	<1	<0.2	<0.2	4.90
Ore	MIF	0.01	<0.004	0.008	<0.01	<0.005	<0.002	0.3	25	24.7	<1	<0.2	<0.2	4.94
Waste	MIF	0.01	<0.004	<0.007	<0.01	<0.005	<0.002	0.3	13	12.7	<1	<0.2	<0.2	4.94
Ore	MIF	0.01	<0.004	<0.007	<0.01	<0.005	<0.002	0.3	12	11.7	<1	<0.2	<0.2	4.94
Ore	MIF	0.02	<0.004	<0.007	<0.01	<0.005	<0.002	0.6	12	11.4	<1	<0.2	<0.2	4.94
Waste	MIF	0.02	<0.004	0.091	<0.01	<0.005	<0.002	0.6	12	11.4	<1	<0.2	<0.2	4.94

Seismicity

The Schefferville station of the Federation of Digital Seismograph Networks (FDSN) is located within the Eastern Background seismic zone, in which low-level but occasionally noteworthy seismicity may occur. The region is seismically quiet in all directions from the station for more than 300 km (FDSN, no date). Blasts from the mines near Labrador City are recorded several times weekly. They normally range from $2 < MN < 3$.

Current Study

The concurrent exploration, geotechnical, and hydrogeology work on Howse Deposit comprises both reverse circulation and diamond drilling. In addition to drilling, reconnaissance mapping was done on both licenses (021314M and 021315M).

Some geotechnical and hydrogeological investigations were also completed on the Howse deposit during the same period.

The objective of the exploration program was to validate reported historical resources and carry out further drilling to bring this information to at least the Indicated resource category.

The objective of the geotechnical study was to provide information to an acceptable level for pit-wall design in different strata to ensure stability.

Data Gaps

The geology of the Howse area is well known and there are no data gaps.

7.3.6 Hydrogeology

The Howse hydrogeological field study was initiated by Golder Associates (Golder) in winter 2013 and completed by Geofor Environnement (Geofor) in falls 2014 and 2015. A part of the data collected by Golder Associates was incorporated in the Geofor's hydrogeological report, which is found in Volume 2 Supporting Study C, along with Golder's technical memorandum. The wells drilled under supervision of Geofor in 2015 are presented in Figure 7-15 along with the Golders' boreholes referred in the Geofor's report.

Golder Associates supervised the drilling of five boreholes into bedrock (HW-RC13-001, HW-RC13-002, HW-RC13-003, HW-GT13-001 and HW-GT-13-002), and one into overburden only (HW-BH-13-01). HW-GT13-001 and HW-GT13-002 were submitted to packer tests. HW-GT13-0001 was fitted with a thermistors array distributed along the borehole to check the eventual presence of permafrost. Temperatures were recorded automatically twice a day.

Geofor's hydrogeological program of fall 2014 consisted of the drilling of three wells into the overburden to the rock interface and three wells into the rock at an initially planned depth of 180 m below ground surface. Two wells into rock were submitted to pumping tests. One well was drilled at each extremity of the long axis of the deposit and the third one, which caved in at the end of the drilling, in the middle of it. The field work was completed in September and October 2014.

Five new wells sequentially numbered from HW-RC15-WE05R to HW-RC15-WE09R, were drilled in September 2015. Except for HW-RC15-WE06, which is in the middle of the long axis of the deposit, all wells are outside the deposit. HW-RC15-WE05R, HW-RC15-WE06R, HW-RC15-WE08R and HW-RC15-WE09R are located along the long axis of the iron formation containing the deposit. This axis corresponds to the dominant structural and geological northwest-southeast trend of the Labrador Through. Well HW-RC15-WE07R was drilled in order to obtain information on groundwater on the northeast side of the deposit.

HW-RC15-06R, HW-RC15-07 and HW-RC15-08R were submitted to pumping tests. Well HW-RC14-WE02R, which has caved in in 2014, was cleaned to a certain depth with the drill and equipped as a piezometer to be used as observation well during the pumping of HW-RC15-WE06R.

The 2014 available hydrogeological data was gathered in order to establish a hydrogeological model and to simulate impacts of mine dewatering on groundwater and surface water. The modelling part was subcontracted to SNC-Lavalin which was asked to update the model in 2015 with new data. SNC-Lavalin's report is included in Volume 2 Supporting Study C.

All previous studies concerning the DSO projects were consulted. This section presents the compilation of previous knowledge and findings of the 2013 to 2015 Howse hydrogeological programs. The results of dewatering simulations are also discussed.

7.3.6.1 Component Description

LSA, RSA and Temporal Boundaries

The local study area (LSA) is considered to be limited to the watersheds within which the Project takes place. This corresponds to the Goodream Creek, Pinette Lake and Burnetta Creek watersheds, including Triangle Lake. The LSA is limited to these watersheds because they will be the only ones directly affected by the Project. The Elross Creek watershed is not included in the LSA, since it will not be directly affected by the Project, and since the effects generated by the processing of ore at the DSO plant are discussed in the ELAIOM EIS. The regional study area (RSA) is considered to be the upper portion of the Howells River. The three watersheds included in the LSA drain into Howells River, and other projects in the area also ultimately discharge into the Howells River watershed.

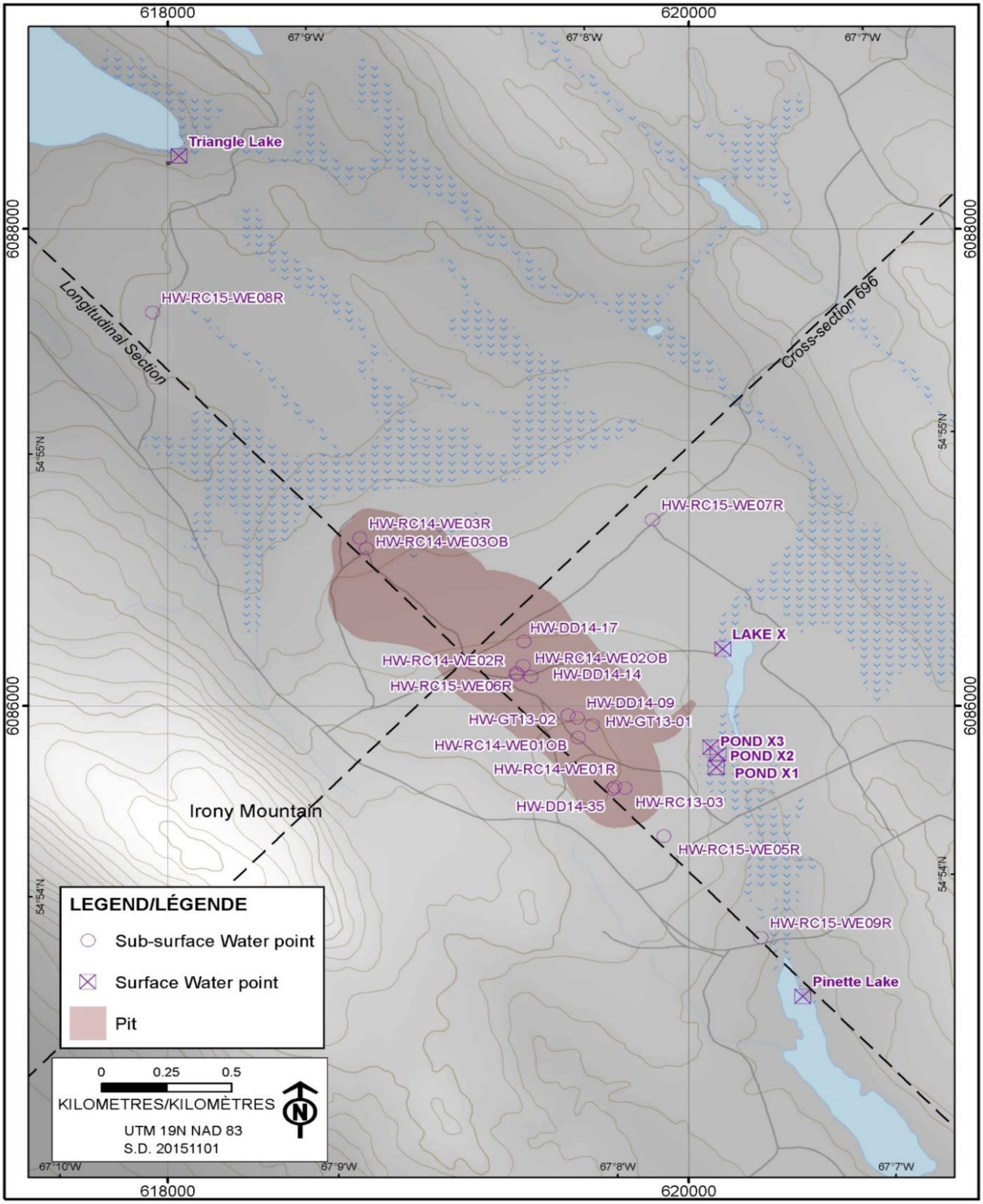


Figure 7-15 Location of Wells, Piezometers and Boreholes in the Howse Project area

Existing Literature

Regional Groundwater Flow

There is no specific literature concerning the hydrogeology of the Howse deposit except the studies carried out by TSMC since 2013. No documentation about the field works done by IOCC on Howse hydrogeology was found. FracFlow (2006) and SNC in collaboration with Geofor (unpublished and confidential report) have conducted some hydrogeological works on Labmag and Kémag taconite deposits. Labmag project is located northwest of Howse just on the other side of Howells River.

Other mining projects in the area were conducted by different companies. A section on hydrogeology in the NI43-101 Joyce Lake DSO deposit Report for Century can be downloaded from the Sedar site. Other information can be available in assessment report of others companies having operated in the region. For example, Labrador Iron Mine which has mined the James Deposit, few kilometers from Schefferville, has done extensive hydrogeological study. Century's Full Moon Taconite and Adriana Otelnuk Taconite NI43-101 studies also likely have some hydrogeology studies related to their specific deposit.

Some articles about hydrogeology of the large area of Schefferville can also be found in the official literature. J.J. Drake, L. Nichols, J.P. Stubbins, P. Monro and F.H. Nicholson are the best known of these authors.

Groundwater Basins

The analysis of the data collected during the mining of a large number of DSO deposits located between the Gagnon pits near Schefferville and the Triangle Lake and information gathered from exploration campaigns by TSMC and former companies allowed defining two main groundwater basins. The groundwater flow in both basins is primarily controlled by the Hudsonian northwest-southeast main fracturing system and to a lesser extent by perpendicular secondary fractures.

The Fleming 7 deposit is located on a groundwater divide which corresponds also to the Québec-Labrador border. To the south-east of Fleming 7, the groundwater is flowing entirely on the Québec side from Fleming 7 area toward the Big Star Lake area (Fleming Basin on the Figure 7-16) which is a sector of discharge for a large part of groundwater of this basin

On the northwest side of Fleming 7, the partial delimitation of the Goodream Basin on Figure 7-16, which is entirely in Labrador, is based on groundwater elevations collected by TSMC during previous and recent hydrogeological studies (Groupe Hémisphères 2010, Groupe Hémisphères and Geofor 2011, 2012a, 2012b, Geofor 2015a, Geofor 2015b). Much information is available in the sector of TSMC/DSO3 which is the mining area circling the TSMC's processing plant and including the Timmins and Fleming deposits (see Figure 7-17). Elsewhere, the information is mainly obtained from water elevations measured in the Howse deposit area from 2013 to 2015. The northwest and a part of the southwest limit of the basin cannot be defined or ascertained without supplementary hydrogeological data.

Groundwater Flow in the Goodream Basin

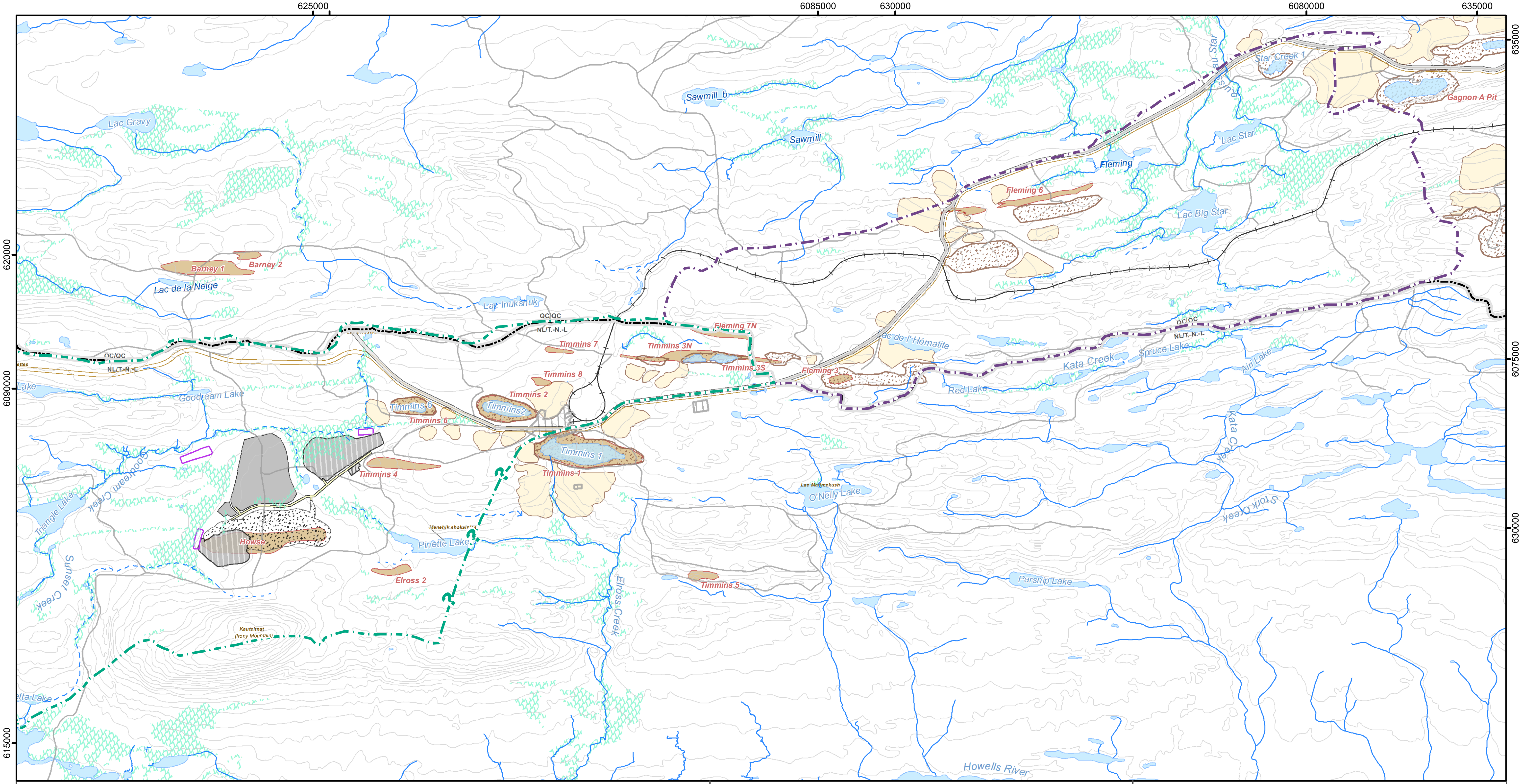
As part of the modelling, SNC-Lavalin has drawn the piezometric map presented in Figure 7-18 from all available groundwater elevations measured in Howse and TSMC/DSO3 areas. Table 7-41 summarizes the main specifications of wells or piezometer used. A map, showing the geology of the Howse area is presented in Figure 7-19. The piezometric maps (Figure 7-18) shows the groundwater flow pattern in the Goodream basin. The groundwater recharge is occurring in the Fleming 7 deposit area where the highest groundwater elevations are found and from the high elevation terrains along the Québec-Labrador boundary for the northeast of the basin and from the groundwater divide on the Irony Mountain on the southwest side of the basin. Groundwater flows in a northwest direction more or less parallel to the geological and structural main trend with a mean gradient of about 0.15 m/m. At the level of Timmins 4, a part of groundwater flow begins to focus toward an area located southwest of the Triangle Lake. The gradient is minimal in the vicinity of the well HW-RC15-WE08R with a value of 0.005 m/m (see Figure 7-18).

No obvious groundwater resurgence was observed in the area surrounding the Howse deposit. This is coherent with the deep water table observed in the large area around the Howse deposit. Without presuming of all mechanisms of discharge of groundwater to the surface network, it can be assumed that the Burnetta Lake area is one of the points of discharge of groundwater in the sector of Howse deposit.

Henry Simpson, an experienced geologist involved in the mapping of the Schefferville area, outlines that the creeks often follows the surficial layout of thrust faults which are zones of soft and erodible material. He also believes that the Burnetta Creek layout can also be controlled by such a structure based on his mapping experience of this sector (personal communication). As can be seen in Figure 7-18, the Burnetta Creek flows, from its origin, along the surficial layout of a thrust fault to a certain point downgradient where it makes a sudden 90 degree turn to flow southwest toward the Burnetta Lake following very likely another thrust fault perpendicular to the structural main trend. The creek finally flows into the Burnetta Lake that discharges into the Howells River.

The area between the Burnetta Lake and the irony mountain is very disturbed from the geological and structural point of view. Two thrust faults oriented northeast-southwest and delimiting a northeast geological Menihek unit are noted on each side of the Burnetta Creek upstream of the Burnetta Lake. In this area, this orientation is unusual for a thrust fault and a geological unit as can be seen on the Figure 7-19. Although incompletely mapped in the northeast direction, it can be supposed that the faults are continuous along the northeast section of the Burnetta Creek and intercept at some point the main northwest-southeast structural faults conveying the groundwater that will then be channelled toward the Burnetta Lake area where it will discharge.

As support to this hypothesis, Groupe Hémisphères has observed a clear increase of the flow of the Burnetta creek close to its discharge into the Howells River (Groupe Hémisphères, 2014). For example, for the same day in August 2013, the specific runoff at the upstream was 4.1 L/s/km^2 while the downstream station near the mouth recorded 147 L/s/km^2. They concluded that the downstream section of the creek was probably largely fed by groundwater.



LEGEND

Hydrogeologic watershed
- Goodream
- Fleming

Infrastructure and Mining Component
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Site Infrastructure
- Proposed In-Pit Dump/ Waste Dump
- Proposed Sedimentation Pond
- DSO Haul Road
- Existing Railroad
- Existing Dump
- Existing Pit
- Deposit
- Elross Lake Area Iron Ore Mine (ELAIOM) Plant Infrastructure Footprint
- Proposed Mine Haul Road

Basemap
- Permanent Watercourse
- Intermittent Watercourse
- Storm Runoff
- Disappearing Stream
- Artesian Spring
- Water Body
- Wetland
- Contour Line (50 ft)
- Provincial Border
- Existing Road
- Main Access Road

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0597 , PR185-19-15, 2016-03-22, edickoum

N

0 500 1 000 1 500 2 000
Meters

UTM 19N NAD 83

SCALE: 1:50 000

SOURCES:
Basemap
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and Government of Quebec,
Boundary used for claims
SLE, AMEC and GHI (October 2012). LabMag and Kémag Iron Ore Projects 2012 Mine Site Aquatic Program Field Report.
Groupe Hémisphères, Hydrology, Wetland, 2013.

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
Howse Minerals Limited/
MET-CHEM, Howse Deposit Design for General Layout, 2015

ENVIRONNEMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Location of the Goodream and Fleming Groundwater Basins

Howse Minerals Limited

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Bureau 301, Montréal (QC)
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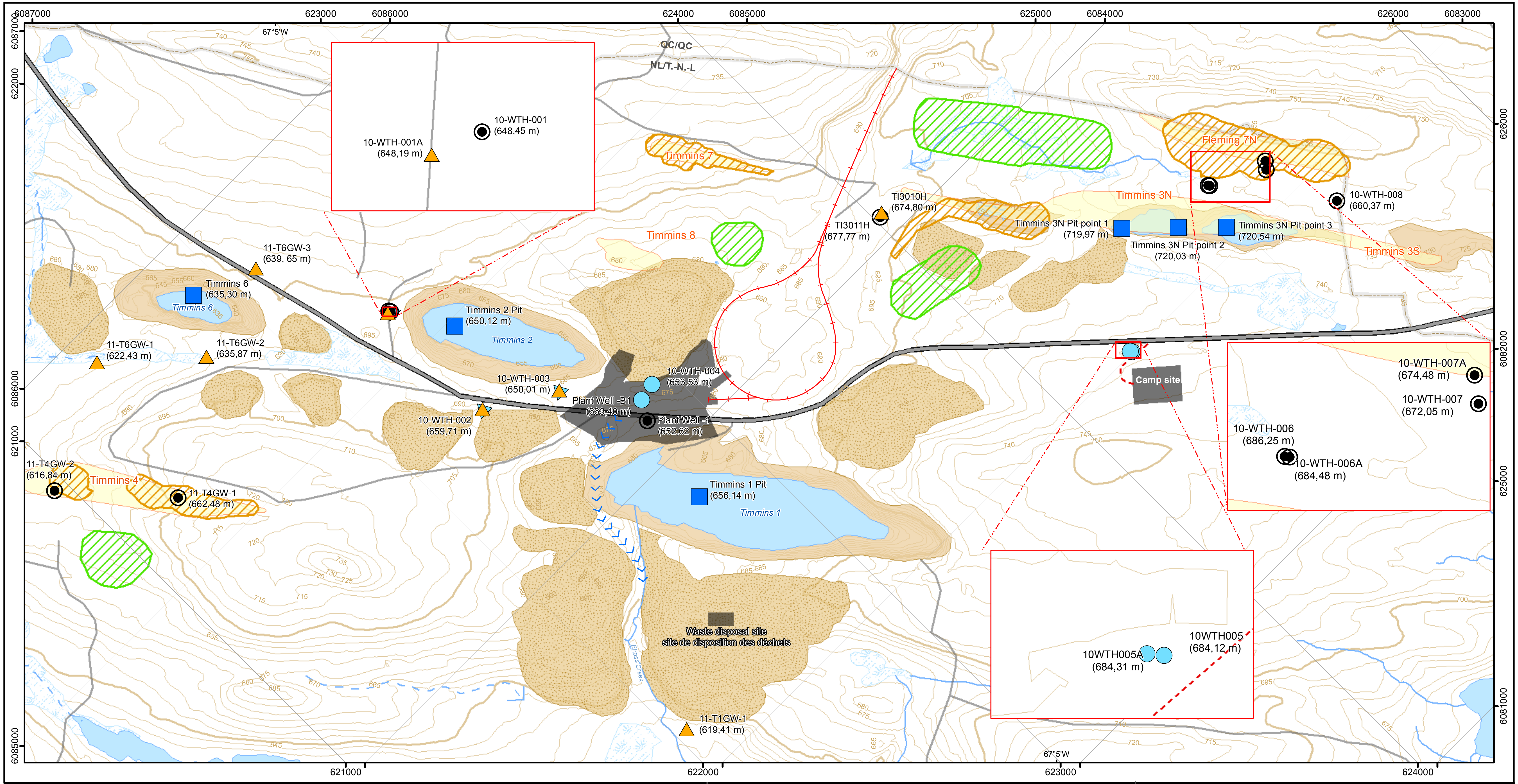
Figure 7-16



LEGEND

Surveys

- ▲ Environmental monitoring well
- ◉ Piezometer
- ■ Unconfined water in relation with watertable
- ● Water supply well
- (649,4 m) Static water elevation asl

Infrastructure and Mining Component

- Deposit
- Proposed road
- Proposed pit
- Proposed waste dump
- Elross Lake Area Iron Ore Mine (ELAIOM) Plant Infrastructure Footprint
- Proposed yard track

Basemap

- Provincial border
- Main access road
- Road/route
- Waterbody
- Disappearing pond
- Wetland
- Watercourse
- Intermittent watercourse
- Disappearing watercourse
- Existing large ditch
- Existing mined-out pit
- Existing waste dump
- Contour interval

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0223 , PR84h, 2016-01-27, jtremblay

N

0 200 400 600 800 1 000 1 200
Meters

UTM 19N NAD 83

SCALE: 1:15 000

SOURCES:
Basemap
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and Government of Quebec,
Boundary used for claims
Geofor and GHI (April 2012). Hydrogeological Drilling Report, Fleming 7N Area - DSOP, Project 1a.
Groupe Hémisphères, Hydrology, Wetland, 2013.
Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads

geofor environnement

ENVIRONNEMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Wells Location in the TSMC/DSO3 Area

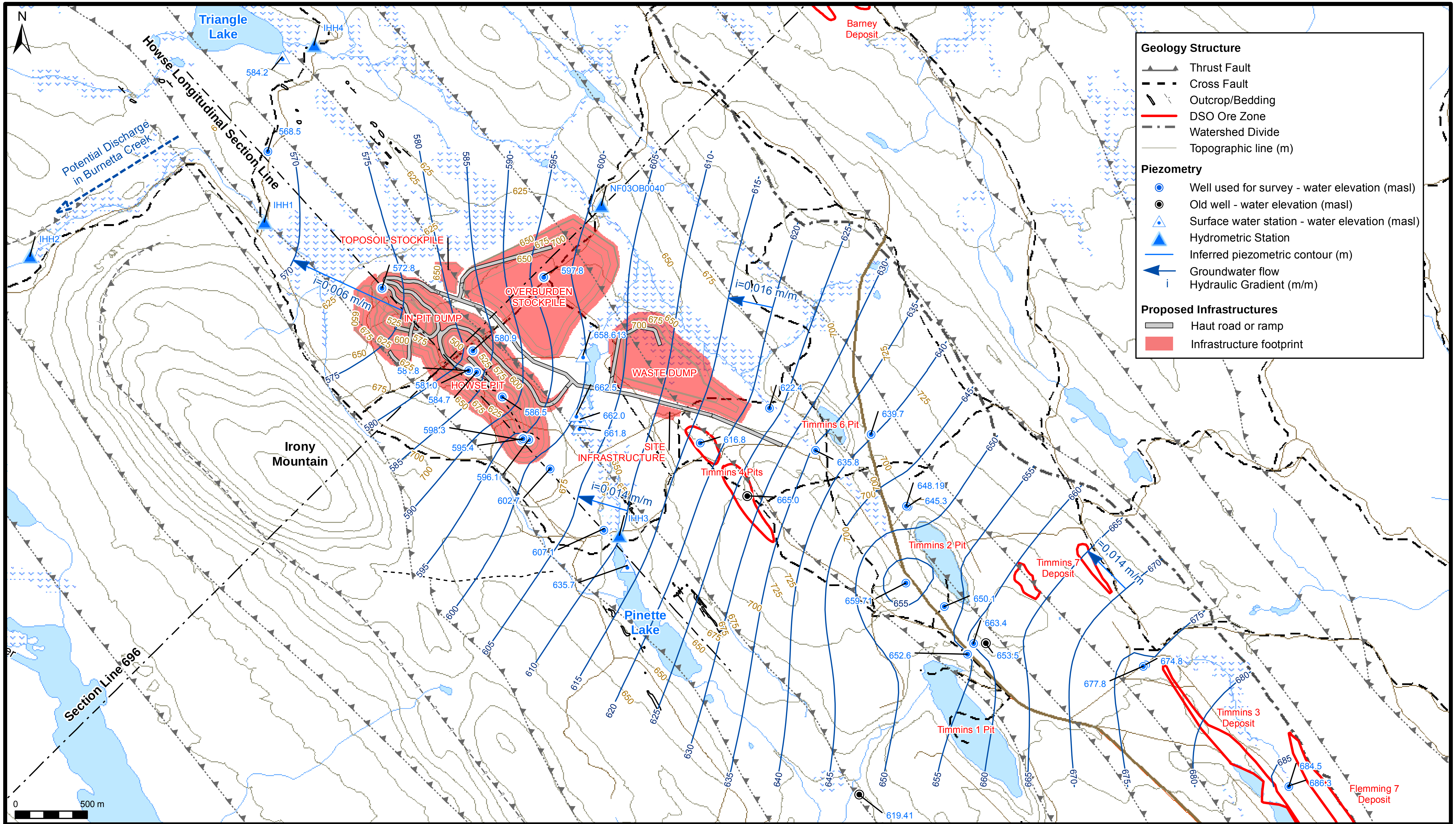
Howse Minerals Limited

GroupeHemispheres

5731, rue Saint-Louis,
Bureau 201, Lévis (QC)
Canada, G6V 4E2

1453, rue Beaubien est,
Bureau 301, Montréal (QC)
Canada, H2G 3C6

Figure 7-17



NO.	DATE	DESCRIPTION	DRAWN	VERIFIED
0	9 nov. 2015	Pour consultation	E. Cazeneuve	A. M. Benlahcen

TITRE

Figure 7-18
Piezometric Map
of the Goodream
Groundwater Basin

PROJET

Hydrogeology Modeling - Howse project

CLIENT

Geofor Environnement

CONSULTANT

SNC·LAVALIN

ÉCHELLE	NUMÉRO	RÉV.
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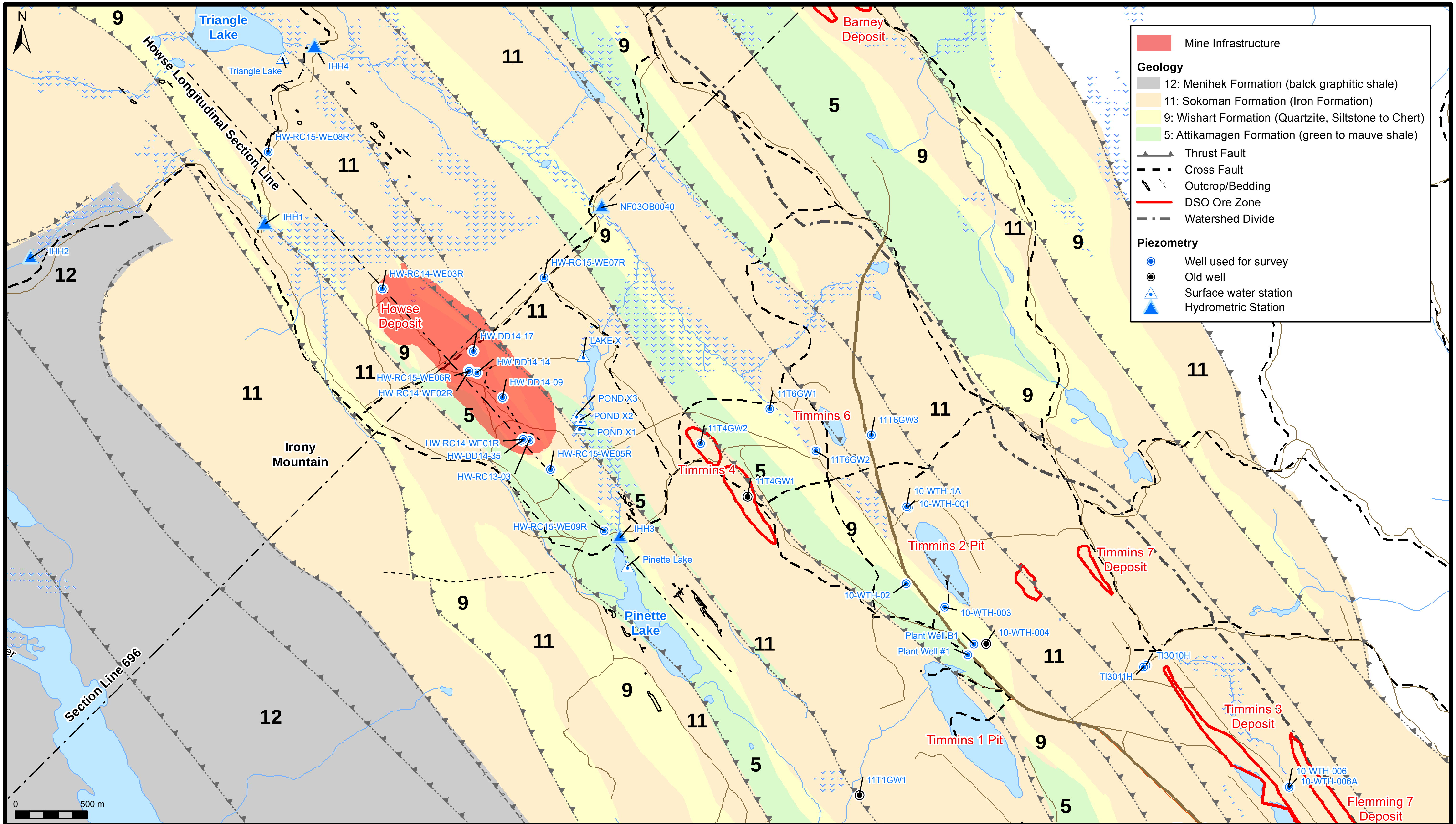

NO.	DATE	DESCRIPTION	DRAWN	VERIFIED
0	5 nov. 2015	Pour consultation	E. Cazeneuve	A. M. Benlahcen

TITRE

Figure 7-19
Surface Geology
of the Howse Area

PROJET

Hydrogeology Modeling - Howse project

CLIENT

Geofor Environnement

CONSULTANT

SNC·LAVALIN

ÉCHELLE	NUMÉRO	RÉV.
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Table 7-41 Wells, Piezometers and Boreholes in the Howse and TSMC/DSO3 Areas

HOLE ID.		Well Ø (mm)	Easting (mE) zone 19	Northing (mN) zone 19	Elevation (TOC) (m)	final depth (m)	water depth (toc) Nov. 4, 2015 (m)	Groundwater Elevation (m)	Final diameter mm	Construction End Date (m)
WELLS AND PIEZOMETERS OF THE HOWSE AREA										
HW-RC14-WE01R	Geofor, 2014	152	619715	6085660	684.173	164.00	88.76	595.41	152	2014-09-13
HW-RC14-WE02R	Geofor, 2014	203	619338	6086138	671.032	182.00	90.05	580.98	178	2014-09-24
HW-RC14-WE03R	Geofor, 2014	152	618737	6086703	640.145	180.00	67.32	572.83	152	2014-10-19
HW-RC15-WE05R	Geofor, 2015	152	619903	6085454	679.07	181.4	76.35	602.72	152	2015-08-28
HW-RC15-WE06R	Geofor, 2015	305	619339	6086132	672.30	168.2	90.48	581.82	305	2015-09-02
HW-RC15-WE07R	Geofor, 2015	203	619859	6086780	656.21	97.6	58.37	597.84	203	2015-09-11
HW-RC15-WE08R	Geofor, 2015	184	617942	6087650	613.07	73.2	44.53	568.54	203	2015-09-10
HW-RC15-WE09R	Geofor, 2015	184	620275	6085028	646.46	97.6	39.39	607.07	203	2105-09-08
HW-RC14-WE01OB	Geofor, 2014	203	619575	6085867	684.368	40	38.89	645.48	203	2014-09-03
HW-RC14-WE02OB	Geofor, 2014	203	619363	6086168	671.051	28.5	dry	dry	203	2014-09-01
HW-RC14-WE03OB	Geofor, 2014	203	618762	6086659	644.937	35	dry	dry	203	2014-08-29
HW-DD14-09	TSMC, 2014	123	619571	6085950	681.599	150.00	95.08	586.52	83	2014-08-20
HW-DD14-14	TSMC, 2014	123	619393	6086123	674.179	102.00	89.5	584.68	83	2014-08-27
HW-DD14-17	TSMC, 2014	123	619367	6086270	665.707	101.00	84.84	580.87	83	2014-08-27
HW-DD14-35	TSMC, 2014	123	619706	6085652	684.722	94.50	86.41	598.31	83	2014-10-09
HW-RC13-03	Golder, 2013	123	619755	6085655	683.449	180.00	87.37	596.08	83	2013-12-07
HW-GT13-01	Golder, 2014	123	619628	6085922		184.40			83	2013-12-03
HW-GT13-02	Golder, 2015	123	619535	6085961		183.90			83	2013-12-12
WELLS AND PIEZOMETERS OF THE TIMMINS AREA										
11T6GW-01	TSMC, 2011	152	621425	6085872	665.130	92.40		622.43	152	2011-10-09
11T6GW-02	TSMC, 2011	152	621746	6085581	684.600	103.70		635.82	152	2011-10-08
11T6GW-03	TSMC, 2011	152	622131	6085690	704.150	103.70		639.65	152	2011-10-06
11T4GW-02	TSMC, 2011	152	620945	6085630	677.97	97.6		616.84	152	2011-10-11
Plant Well #1	TSMC, 2011	152	622800	6084167	680.55	103.7		652.63	152	2011-10-14
Plant Well B1	TSMC, 2011	152	622843	6084242	681.78	97.6		663.40	152	2011-10-30
10-WTH-02	TSMC, 2010	152	622372	6084662	693.04	140.2		659.71	152	2010-10-05
10-WTH-01A	TSMC, 2010	152	622376	6085195	699.29	79.25		648.19	152	2010-10-29
10-WTH-01	TSMC, 2010	152	622387	6085191	699.05	73.15		645.25	152	2010-10-06
10-WTH-03	TSMC, 2010	152	622639	6084499	682.81	94.5		650.10	152	2010-10-07
TI3010H	TSMC, 2009	152	624039	6084096	694.13	74		674.80	152	2009-10-27
TI3011H	TSMC, 2009	152	624021	6084085	694.46	110		677.77	152	2009-10-31
10-WTH-06	TSMC, 2010	152	625028	6083256	739.14	134.1		686.25	152	2010-11-05
10-WTH-06A	TSMC, 2010	152	625032	6083251	739.23	140.2		684.48	152	2010-11-12
SURFACE WATER IN THE HOWSE AREA										
LAKE X			6086239	620132				658.61		
POND X1			6085741	620106				661.82		
POND X2			6085797	620114				661.96		
POND X3			6085827	620085				662.46		
Pinette Lake			6084782	620439				635.73		
Triangle Lake			6088305	618045				584.2		

The Table 7-42 compares the temperatures for Burnetta and Pinette Lakes. The drilling of well HW-RC15-WE08R in 2015 in the vicinity of Pinette Lake shows that the groundwater level is 24 m below the bottom of the lake suggesting that the lake is fed by surface water of its watershed and not by groundwater. The Table 7-42 compares the temperature of both lakes. The lower temperatures of Burnetta Lake suggest that a part of the water is provided by cold groundwater resurgences.

Table 7-42 Lakes Temperatures

	BURNETTA L.	PINETTE L.
Date	**°C**	**°C**
June 2014		8.2
July 2014		13.0
July 2015	6.6	12.5
August 2015	6.9	
Sept. 2015	5.0	7.6

Groundwater Flow under the Howse Deposit

The Figure 7-20 shows the cross-section drawn from the knowledge of the geology of the area and the drilling done along the northwest southeast Iron Formation passing through the deposit. The section illustrates the profile of the deposit and of the planned pit with the geology intercepted by the wells and the position of the main fractured zones. The water table is also represented.

The profile covers 3.5 km between the 2 extreme wells. It shows that the overburden thickness varies from a minimum of 20 m at the northwest limit of the deposit to a maximum of over 50 m at the southeast limit. The groundwater has a constant downward slope passing from an elevation of 607 m at HW-RC15-WE09R to 569 m at HW-RC15-WE08R. The groundwater flow is then from the southeast to the northwest with a mean slope of 0.01 m/m. Under the deposit the depth of the water table is minimum at HW-RC15-WE03R with a value of 67 m below ground surface and maximum of 90 m at HW-RC15-WE06R. The groundwater in the section of the deposit is recharged in the high elevation of the groundwater divide of the Irony Mountain. The groundwater would discharge into the Burnetta Lake area as explained in the previous section.

Based on the depth of the bottom of Pinette Lake above the groundwater elevation, it is not excluded, although unlikely, that Pinette Lake feeds the groundwater flowing toward the deposit. The lake is sitting on the Attikamagen shale which is a more or less impervious geological unit. The bottoms of the lakes of the area are generally naturally lined by impervious sediments. The only possible contact with groundwater would be a thrust fault whose location has been extrapolated to the southwest shore of the lake.

Groundwater Recharge Calculation

The climatic data for the Schefferville area is based on the 1981–2010 monthly climate normals from the Schefferville A weather station (No. 7117825) and evaporation data from Churchill Falls weather station (No. 8501132). A gap in the temperature data was filled using the Fermont station (No. 704BC70).

Schefferville monthly temperature is above freezing point during the months of May to September. July is the warmest month with an average temperature of 12.7 °C and the coldest month is January with an average temperature of -23.3°C.

Table 7-43 summarizes the water budget. The mean total precipitation is 790.8 mm per year, of which 373.5 mm represents snowfall expressed as rainfall equivalent. The water budget uses the evapotranspiration value calculated for a contiguous area by Fracflow (2006) using the Thornwaites equation. Fracflow evaluated the total evapotranspiration value taking place from May to November at 188.4 mm per year.

The sublimation of snow is estimated at 15 % of the total snowfall based on extensive studies conducted in the Wolf Creek Research Basin, Yukon (Pomeroy *et al*., 1998). The actual study area is at similar latitude and experiences equivalent average temperatures throughout the year. The sublimation will therefore represent 56.2 mm, expressed as rainfall equivalent. As shown on water budget of Table 7-43, a total of 109 mm of water is available for groundwater recharge, representing 20 % of the water depth after evapotranspiration and sublimation. The runoff value of 80 % of the total precipitation has been taken from the waste management plan section of SNC-Lavalin.

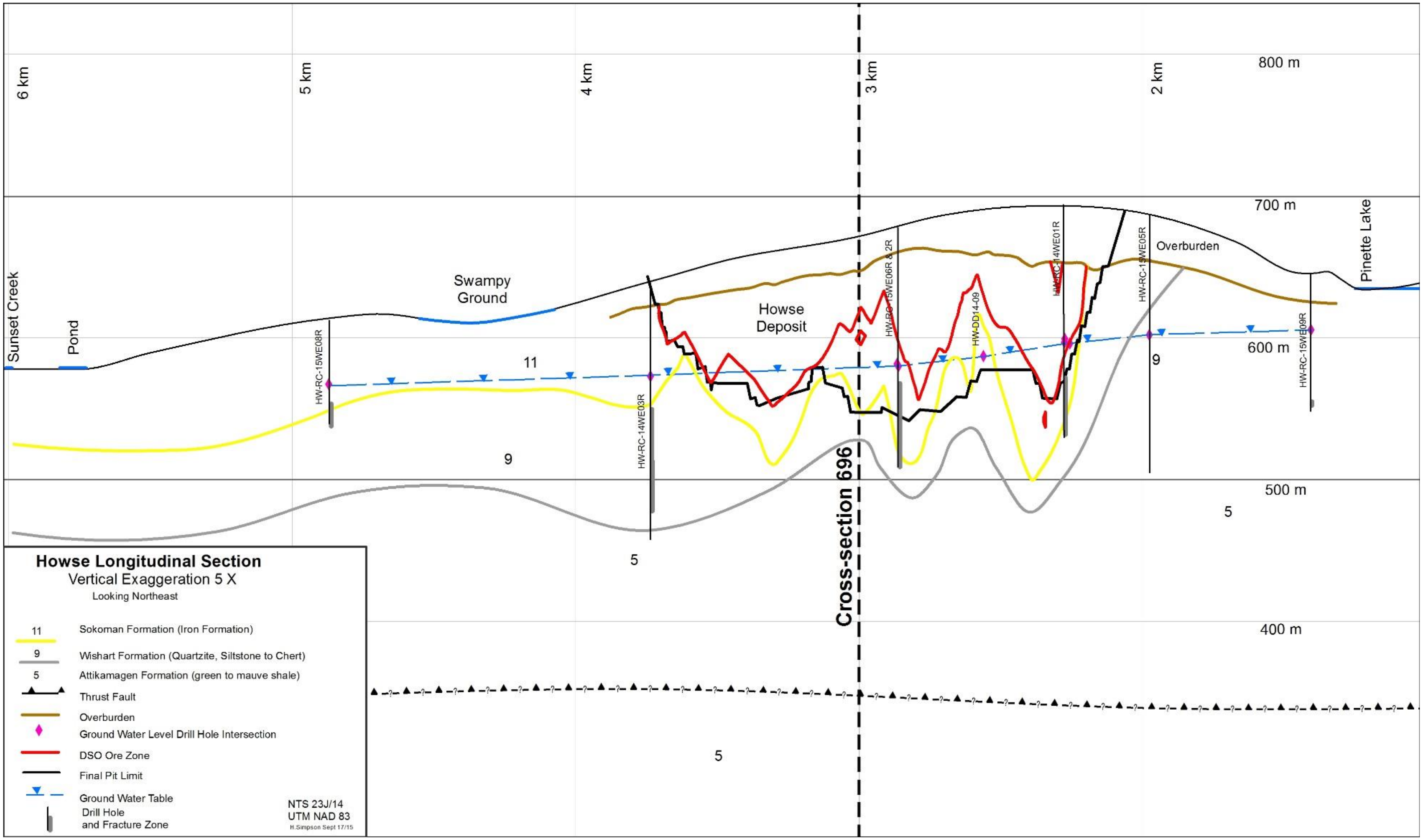


Figure 7-20 Howse Geological Frost Section 696 with the Profile of the Planed Pit

Table 7-43 Annual Water Budget

COMPONENT	DEPTH (MM)
Precipitation	790.8
Evapotranspiration (-)	188.4
Sublimation (-)	56.2
Net Water Depth	**546.2**
Surface flow (80% of Net Water Depth)	437
Infiltration (20% of Net Water Depth)	109

A well supplying the workers camp, a few kilometers from Howse deposit, was equipped by Geofor with a level logger to monitor the variation of the groundwater level along the year. This is actually the only monitoring of the groundwater level covering a one year period. The behavior of the phreatic level of an aquifer varies from a location to another depending, amongst others, of the dimension and nature of the recharge area. This example illustrates the behavior of a specific aquifer of the area.

The graph of Figure 7-21 shows the variation of the phreatic level during the period of observation. A first recharge of the aquifers happens at the snowmelt in spring. At this location, the groundwater rose 14 meters from the end of April to mid-June. The water level stabilized and slightly decreased by few meters in the period from mid-June to around September 20th. From there, a recharge of groundwater begins with the large rainfalls of this season and continues till the end of October, for a total rise of 10 m in groundwater level. With the freezing of the ground and the arrival of solid precipitation, the curve shows that the drawdown of the aquifer is continuous until spring, with the groundwater level reaching 74 m below the surface, with a total drawdown of 25 m at the observed location.

A Groundwater level logger was installed at the end of June 2015 in each of the wells HW-RC13-03 and HW-RC14-WE03R of the Howse deposit. The curve of the water table variation for both loggers shown at Figure 7-22 with the corresponding pluviometry for a part of the observed period is presented for information since it is only covering a short period of the year. For the equivalent period, the behavior of the two Howse monitoring loggers is very different in shape and amplitude compared to the logger at the camp site.

The curves of both loggers (Figure 7-22) at Howse are showing an inverted behavior. HW-RC13-03 has experienced a continuous drawdown of the phreatic level of 1.7 m since the installation of the logger in June 2015 to the last readings available at the beginning of October 2015. For the same period, HW-RC14-WE03R is showing a groundwater level rise of 1.7 m. In our opinion, the drawdown in summer until the beginning of the heavy rains of October is a normal tendency. This pattern was confirmed by periodic manual readings at HW-RC-14-WE01R, HW-DD14-09 and HW-DD14-35 plotted on the Figure 7-22. There are no other wells in the sector to validate the possibly odd but real behavior of HW-RC14-WE03R that can be explained by heterogeneity of the terrain at the location of the well.

The relative stability of water table indicates a good equilibrium between the discharge and the recharge. The level loggers in the wells are still currently recording and the data will be analyzed after a year of recording in order to confirm and explain the behavior of both wells and have a better image of the seasonal variations of the water table.

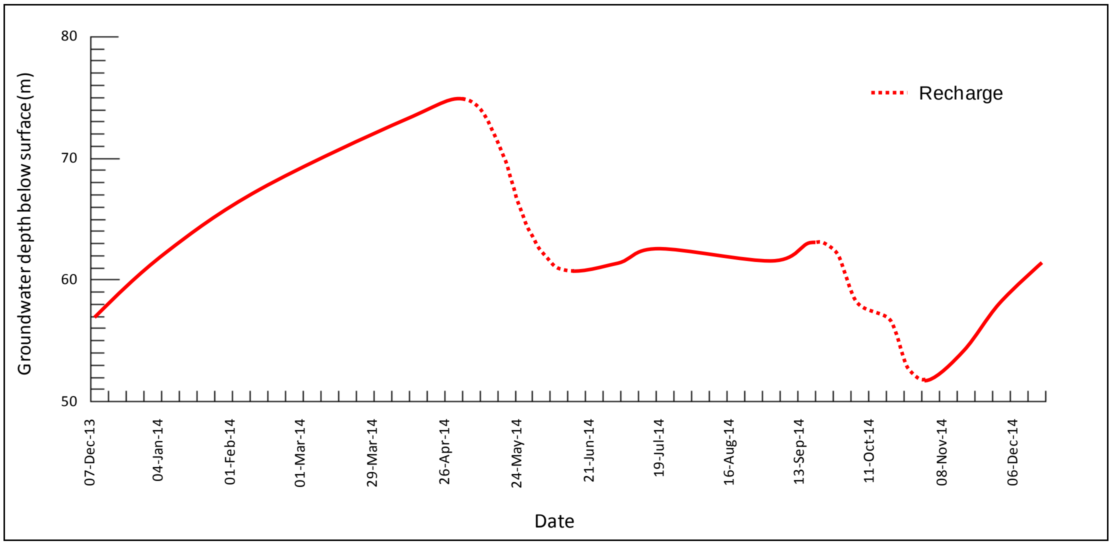


Figure 7-21 Seasonal Variation of the Water Table at Timmins Workers camp

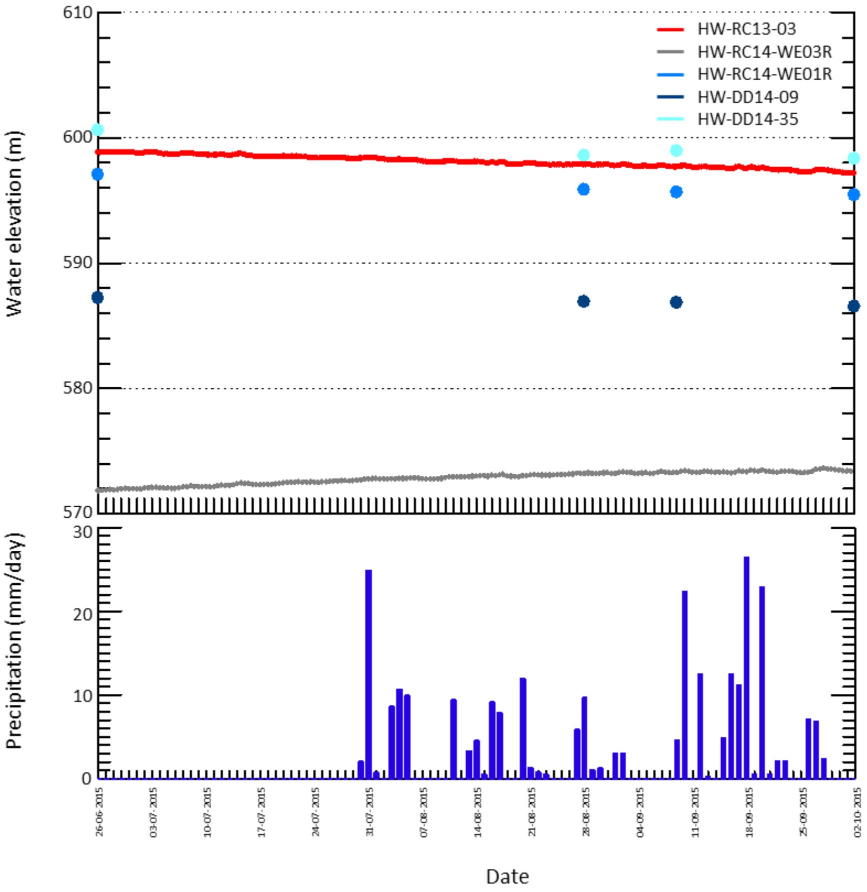


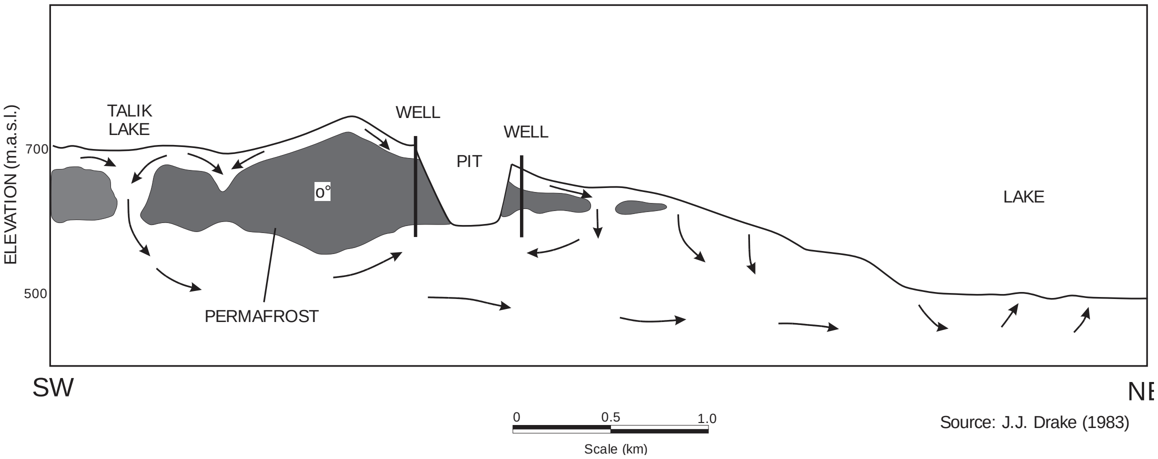
Figure 7-22 Seasonal Variation of the Groundwater Level under the Howse Deposit

Groundwater Flow in an Area of Discontinuous Permafrost

The Howse deposit and its large area are affected by discontinuous permafrost. In this region characterized by series of elongated ridges flanking parallel valleys, permafrost is found at the highest elevations, on tundra sites poorly protected against the wind (IOC, 1974).

Figure 7-22 illustrates the conceptual model of groundwater flow in an area of discontinuous permafrost. Totally and permanently frost-free areas occur within a permafrost zone. Those areas, called taliks, are found principally under some lakes and components of the surface water drainage network. Groundwater flows over the permafrost in the unfrozen superficial layer called the active layer. The groundwater infiltrates into the regional aquifer when the water flowing through active layer reaches a talik. As illustrated in Figure 7-23 a deep mining pit can also feed the groundwater with surface water if it is dug under the regional groundwater level.

A study carried out by Journeaux Ass. (2015) about eventual presence of permafrost in the Howse deposit area has shown that discontinuous permafrost, if any, should occur in erratic and isolated small lenses or pockets but not in any extensive identifiable layers. Based on this study the Howse area will be considered permafrost free.



Source: J.J. Drake (1983)

Figure 7-23 Groundwater Flow in a Region of Discontinuous Permafrost

Howse Overburden Aquifer

The 2013-2014 drilling for the assessment of the deposit was done with minimal drilling water for some overburden wells. The majority of the samples collected were dry. Two of the three holes listed in Table 7-41 and located in Figure 7-15, specifically drilled in the overburden during the hydrogeological study, were dry. A small flow rate of about 12 L/min was observed in well HW-RC14-WE01OB at about 38 m below the surface.

Based on all the available observations and on the 2013 to 2015 programs, it appears that the overburden is generally dry except for the presence of a few perched aquifers of limited extension. This can be explained by the infiltration of the surface water in the overburden and its fast evacuation along the slope of the terrain in permeable layers horizons in the overburden or of at rock interface. A part of the water can also migrate rapidly through the rock fractures.

Howse Rock Aquifer

RC15-WE06R, HW-RC15-WE08R and HW-RC15-WE09R are distributed along the northwest-southeast dominant geological and structural axis of the large area of the Howse deposit. The longitudinal section presented in Figure 7-20 was drawn from the geological knowledge of the area and from the results of the drilling along the northwest-southeast axis.

The section of Figure 7-20 shows the position of the water bearing fractured zones met by the drill in relation to the geology. Water bearing fractures were met deeply below the surface. The ground was dry till the interception of water bearing fractured zones. The observed Groundwater table shown in Figure 7-20 is everywhere over the water bearing fractures indicating a confined aquifer in artesian condition.

All wells, except the HW-RC-15-05R and HW-RC-15-09R, have intercepted the Sokoman Formation (Iron Formation). For all wells into the Iron Formation, the most productive of the fractures shown on the cross-section were met close to or at the interface of the Sokoman and the Wishart Formations. This is the case for HW-RC15-WE07R and also for HW-RC14-WE03R where other productive factures were also met deeper in the Wishart Formation. Well HW-RC15-WE06R was entirely drilled in the Sokoman and was ended not far from the Wishart Formation. An important water bearing zones was met toward the end of the hole probably not far from the Wishart Formation. Productive fractured zones for HW-RC15-WE07R which was drilled into another Iron Formation were met into the Sokoman between 60 and 98 m below ground surface. Any noticeable water bearing fractures were observed at wells HW-RC15-WE05. A small water bearing fracture was intersected at HW-RC15-WE09 toward the end of the hole. HW-RC15-WE05R and HW-RC15-WE09, drilled in the Attikamagen shale and HW-RC15-WE01 in a very muddy section of the Iron Formation show relatively low yield varying between 3 and 60 L/min. The yield of aquifer for all other wells varies from 200 to 800 L/min, the maximum occurring at HW-RC15-WE06R.

Those observations tend to show that the interface between the Sokoman and the Wishart is sometime a fractured sector providing important quantities of water. The Wishart Formation can also convey important quantities of water. The Attikamagen shales will supply minor quantities of groundwater. An important portion of the mining can be done without dewatering due to the deep location of the water table below the ground surface.

Hydraulic Parameters of the Rock Aquifer

Generally, the recent results of hydraulic conductivity testing showed in Table 7-44 indicate that the hydraulic conductivity of the Sokoman Formation, which is the main formation in the area, was relatively higher, and ranging from 1.6E-6 m/s to 1.9E-5 m/s with an average of 9.4E-6 m/s. The shale of Attikamagen have the lowest permeability values with an average of 5E-8 m/s while the Wishart and fault zone recorded an intermediate conductivity values with an average of 1E-7 m/s. The fault zones tested by Golder were coated with mixed and less permeable materials according to borehole logs. This can explain their lower hydraulic conductivities values in comparison to the Sokoman.

The step-drawdown tests conducted by Geofor in 2015 at the three pumping wells (HW-RC15-WEO6R, HW-RC15-WEO7R and HW-RC15-WEO8R) showed a slight decrease in specific capacity of the wells with flow rate increase.

The well HW-RC15-WEO6R located within the proposed open pit was pumped to a maximum of 1.1 m^3/min (291 usgpm) resulting in a 12.4 m final drawdown, and a specific capacity decreasing from 0.2 to 0.1 m3/min per meter.

The wells HW-RC15-WEO7R and HW-RC15-WEO8R located outside the proposed open pit were pumped to a maximum of 0.26 m^3/min (75-85 usgpm) resulting in a 13.6 m final drawdown, and a specific capacity decreasing slightly from 0.04 to 0.02 m^3/min per meter.

Table 7-44 Summary of Calculated Hydraulic Conductivity Results

REFERENCE	TEST	WELL TESTED	K (M/S)	K AVERAGE (M/S)	FORMATION
Golder, 2014	Packer test	HW-GT13-002	2E-07 - 6E-07	4.00E-07	Wishart
			4E-08 - 6E-08	5.00E-08	Attikamagen Shale
		HW-GT13-001	4E-08 - 5E-08		
			1E-07	1.3E-07	Chert/Shale/fault zone
			1E-07		Chert/Shale/fault zone
			2E-07		Shale/fault zone
Geofor, 2014	Pump test	HW-RC14-WE01*	2.13E-06	9.40E-06	Sokoman (Iron ore)/Wishart
		HW-RC14-WE03*	3.34E-05		
Geofor, 2015	Pump test	HW-RC15-WEO6R*	1.1E-05 - 2.4E-05		Sokoman
		HW-RC14-WEO2R**	1.2E-05 - 1.9E-05		
		HW-RC15-WEO7R*	1.6E-06 - 1.1E-05		
		HW-RC15-WEO8R*	1.10E-05		

*Pumping well; ** Observation well

Groundwater Uses and Quality

Actually, groundwater has no specific uses in the Howse area. In the TSMC/DSO3 area groundwater is used for dust control and for some other non-drinking applications. The process plant is taking water from old Timmins 2 pit, which is in fact a mixture of groundwater and surface water. The workers camp, which is about 1 kilometer southeast of the TSMC plant, is supplied by 3 wells which provide drinking water that do not need treatment.

The results of chemical analysis for the wells of Howse submitted to pumping test and, for information, other results from TSMC/DSO3 and TSMC/DSO4 are shown in Table 6. TSMC/DSO4 is another DSO mining sector about 30 km northwest of TSMC/DSO3. Wells K1C009, 11KI2007 and 11TSMC-LBM19 pertains to TSMC/DO4 sector.

Table 7-45 shows the result of the physical property measured in the field in 2015. These parameters indicate that the water is slightly acidic for all wells except for HW-RC14-WE03R which is close to the neutrality. In all cases, the water is very weakly mineralized, as indicated by the electrical conductivity and cold with values around 2 ^{o}C.

The results of analysis of water of the wells of Howse area, presented in Table 7-46, show that, for all wells, except HW-RC14-WE01R, the analysed chemical parameters of this very soft water are generally under the detection limits of the laboratory method or, if not, well below the maximum acceptable concentration of the more stringent regulations, if appropriate. The maximum acceptable concentrations from Canadian *Metal Mining Effluent Regulations* (MMER) are shown the corresponding column of Table 7-46 for the deleterious elements concerned.

In contrast to all other wells drilled in the Howse sector, the physical properties of the water at HW-RC14-WE01R show values of total suspended solids exceeding the authorized limit of 30 mg/L of the MMER and high values of total dissolved solids and turbidity. The turbidity of all other wells is below 2 NTU with a real color below 4 UCV. Some water bearing muddy sections where met during the drilling of HW-RC14-WE01R. The muddy sections were releasing suspended solids in the pumped water causing an increase of the turbidity. The concentration of total suspended solids, as well as the turbidity and coloration, decreased significantly between the two sampling sessions indicating a cleaning of the water bearing structures with time. This decrease may continue in time but it has not been proven that it will go under the MMER limit. The suspended solids must therefore be taken into account in the dewatering process. The classical solution consists to settle the pumped water in ponds before releasing it in the drainage surface network. The Wells can also be designed with gravel pack around a pumping column in order to filter the groundwater at the pumping stage. Finally, the location of the wells can also be carefully chosen by drilling exploration holes prior to drill the dewatering wells.

The wells of the TSMC-DSO3 and TSMC/DSO4 show characteristics close to Howse area as can be seen in Table 7-46. The groundwater is showing low mineral content. Well 10WTH005 has shown concentration of 250 ug/ml that is higher than the very low values of other wells. The water of shows sometimes relatively high concentration of suspended solids associated to turbidity values. This can be explained by the simple construction design of those well which were mainly drilled for hydrogeological exploration purposes.

Table 7-45 Physical Parameters Measured in the Field

WELL	HW-RC14-WE01R			HW-RC14-WE03R			RC15-WE07R	RC15-WE08R
Time from the pump start	24 hours	36 hours	72 hours	24 hours	48 hours	72 hours	24 hours	72 hours
pH	6.05	6.2	6.04	6.9	6.7	6.2	5.92	5.84
Electrical Conductivity (μσ)	11	12.3	14.5	21.2	20.7	21	21.9	22.9
Sp. Electrical Conductivity (μσ)	20	22	26.1	37.5	36.5	37.1	38.6	39.0
Temperature (°C)	2.1	1.8	1.8	2.3	2.3	2.3	2.1	2.0

Table 7-46 Results of Physical and Chemical Analysis Measured in the Laboratory

		HOWSE DEPOSIT							TSMC/DSO3 and TSMC/DSO4								
	Units	**HW-RC14 WE01R (24HRS)**	**HW-RC14 W01R (72H)**	**HW-RC14 WE03R (24HRS)**	**HW-RC14 WE03R (72HRS)**	**HW-RC15 WE06R**	**HW-RC15 WE07R**	**HW-RC15 WE08R**	**TI3011H**	**10WTH00**	**10WTH00**	**10WTH06A**	**11T6GW1**	**11T4GW2**	**KI1C009A**	**KI2007**	**TSMC-LBM-19**
METALS																	
Mercury (Hg)	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001									
METALS																	
P2O5		-	-	-	-	-	0.0	0.0									
Total phosphorous	mg/L	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01									
METALS ICP-MS																	
Aluminum (Al)	ug/L	<30	<30	53	49	<10	<10	<10		<1.0	<0.03	<30	2100	19	<10	<10	<0.03
Antimony (Sb)	ug/L	<3.0	<3.0	<3.0	<3.0	<1.0	<1.0	<1.0		<1.0	<30	<6	<1.0	<1.0	<1.0	<1.0	<0.006
Arsenic (As)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	< 2	<1.0	<0.3	<2	<1.0	<1.0	<1.0	<1.0	<0.002
Barium (Ba)	ug/L	<20	<20	<20	<20	2.6	2.7	<2.0		<2.0	<2	<30	5.9	2.6	<2.0	<2.0	<0.03
Silver (Ag)	ug/L	<0.3	<0.3	0.36	<0.3	<0.10	<0.10	<0.10		<0.10	<6	<0.3	0.18	0.21	<0.10	<0.10	<0.0003
Boron (B)	ug/L	<50	<50	<50	<50	<20	<20	<20		<5.0	12	<50	9.6	<5.0	<5.0	<5.0	<0.05
Cadmium (Cd)	ug/L	<1.0	<1.0	<1.0	<1.0	<0.20	<0.20	<0.20		<0.20	<30		<0.20	<0.20	<0.20	<0.20	<0.001
Beryllium (Be)	ug/L	<2.0	<2.0	<2.0	<2.0	<0.40	<0.40	<0.40				<2	<0.50	<0.50	<0.50	<0.50	<0.002
Bismuth (Bi)	ug/L	<50	<50	<50	<50	<0.25	<0.25	<0.25					<0.25	<0.25	<0.25	<0.25	<0.05
Chromium (Cr)	ug/L	<5.0	<5.0	<5.0	<5.0	<0.50	<0.50	<0.50		<0.50	<1	<30	<0.50	<0.50	<0.50	<0.50	<0.03
Calcium (Ca)	ug/L	1 400	1 600	2 400	2 400	1000	2300	<300	9900	3000	<10	1000	<1000	<1000	2000	<1000	<1000
Cobalt (Co)	ug/L	<20	<20	<20	<20	<0.50	<0.50	<0.50		1.1	<30	<30	<0.50	<0.50	<0.50	<0.50	<0.03
Copper (Cu)	ug/L	<3.0	<3.0	<3.0	<3.0	7.1	<0.50	<0.50	5	<0.50	<30	8	0.81	0.75	<0.50	<0.50	<0.003
Total Hardness (CaCO3)	ug/L	9 900	1100	1500	1500	7200	14000	1600	5800	2800	<1	3000	<1	<1	10	<1	<1
Tin (Sn)	ug/L	<50	<50	<50	<50	<1.0	<1.0	<1.0					<1.0	<1.0	<1.0	<1.0	<0.05
Iron (Fe)	ug/L	<100	<100	<100	<100	<100	<100	<100	< 100	32	<30	<100	1100	100	<100	<100	<0.1
Magnesium (Mg)	ug/L	1 600	1 700	2 200	2 200	1100	2000	220	6600	5000	<1000	<1000	<1000	<1000	<1000	<1000	<1000
Manganese (Mn)	ug/L	<3.0	<3.0	<3.0	<3.0	3.5	9.8	<0.40		250	<3	<3	4.2	7.4	0.51	1.6	0.003
Molybdenum (Mo)	ug/L	<10	<10	<10	<10	<0.50	<0.50	<0.50				<30	<0.50	<0.50	<0.50	<0.50	<0.03
Nickel (Ni)	ug/L	<10	<10	<10	<10	<10	<1.0	<1.0	< 10	<1.0	<3	<10	3.4	<1.0	<1.0	<1.0	<0.01
Lead (Pb)	ug/L	<1.0	<1.0	<1.0	<1.0	0.53	0.31	<0.10	< 1	0.97	<1	<1	0.33	0.22	<0.10	<0.10	<0.001
Potassium (K)	ug/L	290	210	340	360	200	360	<100	500	470	<100	300	1000	140	230	<100	<0.2
Selenium (Se)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0		<1.0	100	<1	<1.0	<1.0	<1.0	<1.0	<0.001
Sodium (Na)	ug/L	2 100	1 900	1 700	1 700	1700	920	<100	920	1800	<10	1100	520	340	410	290	0.5
Strontium (Sr)	ug/L	<50	<50	<50	<50	3.1	5.4	<2.0					3.3	2.4	3.4	4.5	<0.05
Thallium (Tl)	ug/L	<10	<10	<10	<10	<2.0	<2.0	<2.0					<2.0	<2.0	<2.0	<2.0	<0.01
Titanium (Ti)	ug/L	<50	<50	<50	<50	<10	<10	<10					15	<10	<10	<10	<0.05
Uranium (U)	ug/L	<2.0	<2.0	<2.0	<2.0	<1.0	<1.0	<1.0					<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium (V)	ug/L	<10	<10	<10	<10	<2.0	<2.0	<2.0				<10	<2.0	<2.0	<2.0	<2.0	<0.01
Zinc (Zn)	ug/L	30	31	27	19	5.7	<5.0	<5.0	35	6.2	590	19	5.7	<5.0	<5.0	<5.0	0.007
Mercury (Hg)	ug/L	-	-	-	-	1.5	<0.10	-		0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

		HOWSE DEPOSIT							TSMC/DSO3 and TSMC/DSO4								
	Units	HW-RC14 WE01R (24HRS)	HW-RC14 W01R (72H)	HW-RC14 WE03R (24HRS)	HW-RC14 WE03R (72HRS)	HW-RC15 WE06R	HW-RC15 WE07R	HW-RC15 WE08R	TI3011H	.0WTH005	10WTH004	10WTH06A	11T6GW1	11T4GW2	KI1C009A	KI2007	TSMC-LBM-19
CONVENTIONALS																	
Conductivity	mS/cm	0.029	0.028	0.037	0.038	0.022	0.034	0.041		0.073	0.011		0.012	0.008	0.023	0.010	0.011
Inorganic phosphorous	mg/L	0.04	0.03	<0.02	<0.02	-	-	-					<0.03	<0.03	<0.03	<0.03	<0.03
Nitrogen ammonia (N-NH3)	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02		<0.02	<0.02		0.03	<0.02	<0.02	<0.02	0.04
Orthophosphate (P)	mg/L	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		<0.05	<0.05		0.02	0.02	<0.01	<0.01	<0.01
Phenols-4AAP	mg/L	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002					0.002	0.003	<0.002	<0.002	0.002
Reactive silica (SiO2)	mg/L	9.8	11	7.0	7.1	10	6.2	6.7					6.7	4.4	5.5	3.6	6.1
Real Color	UCV	15	4	4	3	<2	<2	<2		<2	4		3	<2	<2	<2	<2
Sulfides (S2-)	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02		<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02
Total Cyanide (CN)	mg/L	<0.01	<0.01	<0.01	<0.01	-	-	-	< 0.01	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Turbidity	NTU	180	99	1.9	1.6	1.8	1.4	0.2		0.5	7.5		51	86	0.6	27	3.7
Absorbance at 254nm	/cm	0.29	0.15	0.008	0.009	-	-	-					0.18	0.072	<0.005	0.023	0.006
Alkalinity Total (as CaCO3)	mg/L	15	15	17	20	21	11	17									
Bromide (Br-)	mg/L	<0.1	<0.1	<0.1	<0.1	-	-	-			<0.1		<0.1	<0.1	<0.1	<0.1	<0.1
Bicarbonates (HCO3 as Ca	mg/L	15	15	17	20	21	11	17	44	13	2	12					
Carbonate (CO3 as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1		<1							
Chloride (Cl)	mg/L	0.14	0.15	0.12	0.12	0.11	1.7	0.14	0.87	0.16	8.1	0.07	0.27	0.17	0.11	0.28	0.21
Nitrites (N-NO2-)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02		<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02
Nitrates (N-NO3-)	mg/L	0.06	0.10	0.11	0.11	0.08	0.76	0.09		0.05	0.33		0.58	0.56	0.09	0.09	1.2
Sulfates (SO4)	mg/L	0.9	0.9	1.0	1.1	<0.5	1.0	0.8	0.9	18	12	0.2	0.6	<0.5	1.3	1.2	<0.5
Total Dissolved Solids	mg/L	37	37	45	39	15	20	28		47	<10		77	<10	14	12	17
Total suspended solids (TS	mg/L	210	180	2	<2	-	-	-	6				15	120	<0.2	110	12
Dissolved organic carbon	mg/L	1.2	0.8	-	-	0.5	0.3	0.3		0.3	0.4						
Total Organic Carbon	mg/L	-	-	<0.2	<0.2	-	-	-		0.4	0.3		0.2	<0.2			
Dissolved oxygen	mg/L	-	-	-	-	12	11	11									
pH	pH	-	-	-	-	7.11	7.00	7.38									
Nitrate (N) and Nitrite(N)	mg/L	-	-	-	-	0.08	0.76	0.09		0.05	0.47		0.58	0.56	0.09	0.09	1.2

Dewatering Simulations

The technical memorandum, describing the methodology, the model and the results of the simulations are provided in Volume 1 Appendix IV.

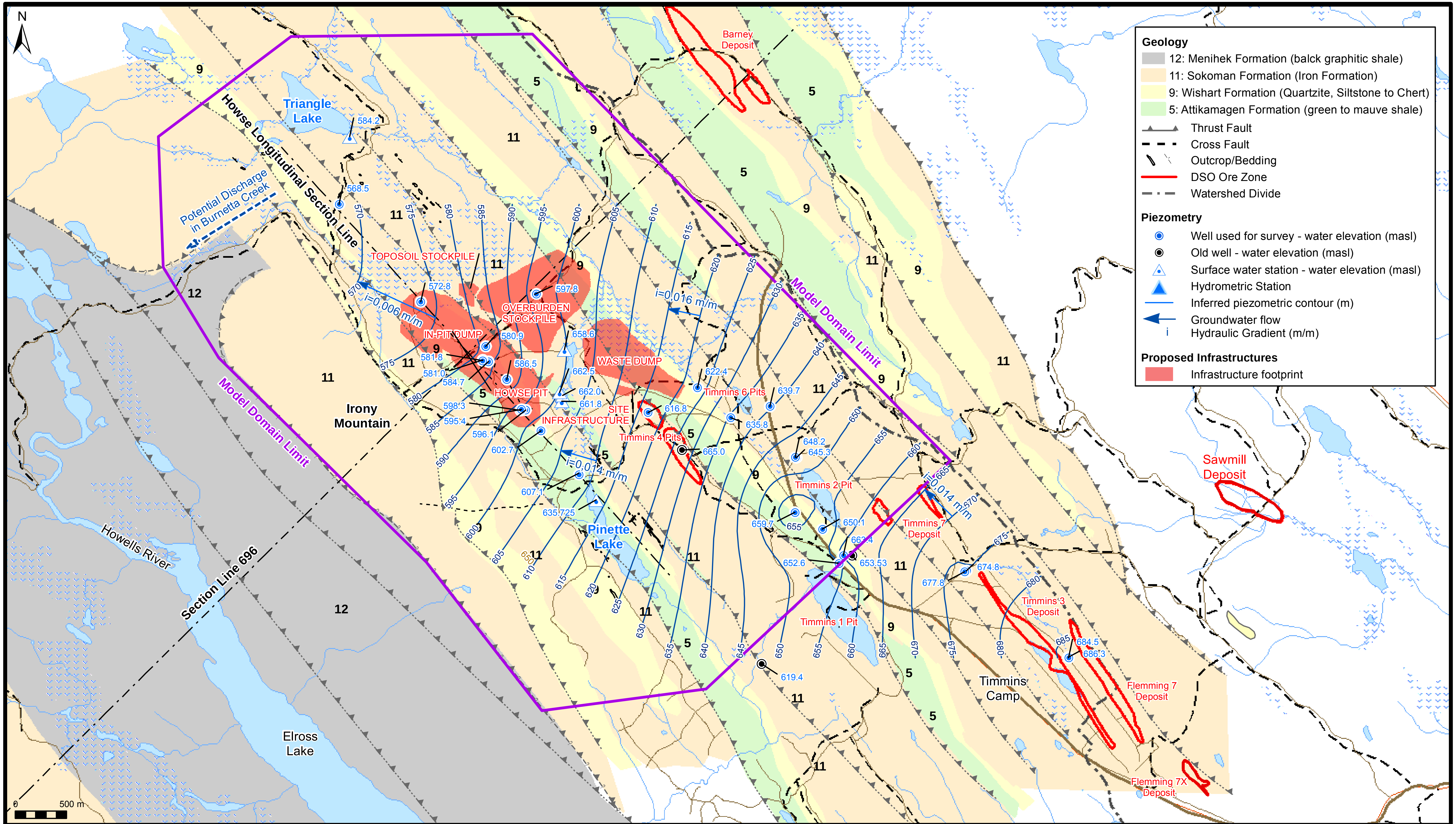
In order to estimate the flow rate resulting from the dewatering of the Howse deposit, a conceptual model of the aquifer flowing through the deposit was built and transposed into a numerical model. The model of the natural groundwater flow of the aquifer was calibrated with hydrogeological parameters determined from field data collected at the site during actual and past campaigns. After the calibration of the natural groundwater flow model, the open pit was introduced into the model to simulate the dewatering of the future mine pit at its final maximum depth of 160 m. The model considers a rectangular domain of about 5 km by 8 km as shown on Figure 7-24.

The model incorporates the basic assumptions of the groundwater flow developed in this report. Simulations were carried out in steady state flow regime with the objective of evaluating the flow rates and extent of the influence of the dewatering activities at the final depth of the pit only. Direct precipitation over the area of the pit was not considered in the model since this water will be collected by sump pumps. The runoff water is considered to be deviated from the pit.

In addition to the base case of the calibrated model, three sensitivity analyses were completed by increasing the hydraulic conductivities of hydrostratigraphic units to emphasize the flow along bedding planes and increasing the recharge rate for one of the scenarios.

A total pumping rate of 9 400 m^3/day was obtained from the simulations for the base case dewatering scenario updated with the supplementary data of 2015. The details of the modelling with all parameters used are shown in Volume 1 Appendix IV.

The base case flow rate may reach higher values ranging from 12,000 to 19,000 m^3/day with slightly higher hydraulic conductivities and increased recharge values. Table 7-47 summarizes the flow rate results taking into account these non-negligible factors, and shows the influence of permeability and recharge rate increase possibly due to the heterogeneity of the formations and geological structures within the study area.



NO.	DATE	DESCRIPTION	DRAWN	VERIFIED
0	9 nov. 2015	Pour consultation	E. Cazeneuve	A. M. Benlahcen

TITRE

Figure 7-24
Model Domain
of the Howse Deposit Area

PROJET

Hydrogeology Modeling - Howse project

CLIENT

Geofor Environnement

CONSULTANT

SNC·LAVALIN

ÉCHELLE	NUMÉRO	RÉV.
1:35 000	623419-000-1005-3-1	0

\\Envir01\public\Proj\623418_Modelisation_projet Howse\4.0_Réalisation\4.5_SIG\ArcGIS\1MXD\Report\623418_Howse_Fig3-1_ModelDomain_v3.mxd

Table 7-47 Dewatering simulation results including sensitivity analysis

SCENARIO	FLOW RATES (M^3/DAY)		ASSUMPTIONS	PUMPING RATE INCREASE
	MODEL	SAFETY FACTOR OF 1.25		
Base case: Calibrated model	9393	11741	Kx, Ky, Kz; Recharge : 100 mm/y	
Sensitivity analysis Case 1	17382	21728	Kx, Ky and Kz multiplied by 2 for OB and Sokoman, Recharge increased to 200 mm/y	1,9
Sensitivity analysis Case 2	18752	23440	Kx, Ky and Kz multiplied by 2 for all five units (OB, Sokoman, Whishart, Shale and Fault zones), Recharge increased to 200 mm/y	2,0
Sensitivity analysis Case 3	11754	14693	Kx, Ky, Kz; Recharge increased to 200 mm/y	1,3

The sensitivity analyses results indicate that the hydraulic conductivity is the more influent parameter in the model. Indeed when the recharge is doubled (case 3) the pumping rate increases by a factor of 1.3 while doubling the hydraulic conductivity and recharge results by a pumping rate increase by a factor of 2.

Groundwater dewatering simulation results are presented in terms of piezometry and drawdown in the Figure 7-25 and Figure 7-26 respectively.

It can be seen in Figure 7-26 that larger drawdowns are observed in the vicinity of the pit. The regional drawdown resulting from the pumping activities is expected to be about 10 m towards the north-west limit of the domain (downgradient of the study area near the Triangle Lake). This result implies that Burnetta Creek and a wetland complex located at the southwest of the Triangle Lake may be affected by the drawdown. In fact, Burnetta Creek is supposed to be a groundwater discharge zone according to the field observations and the structural geology (likely existence of a fault) along Burnetta Creek.

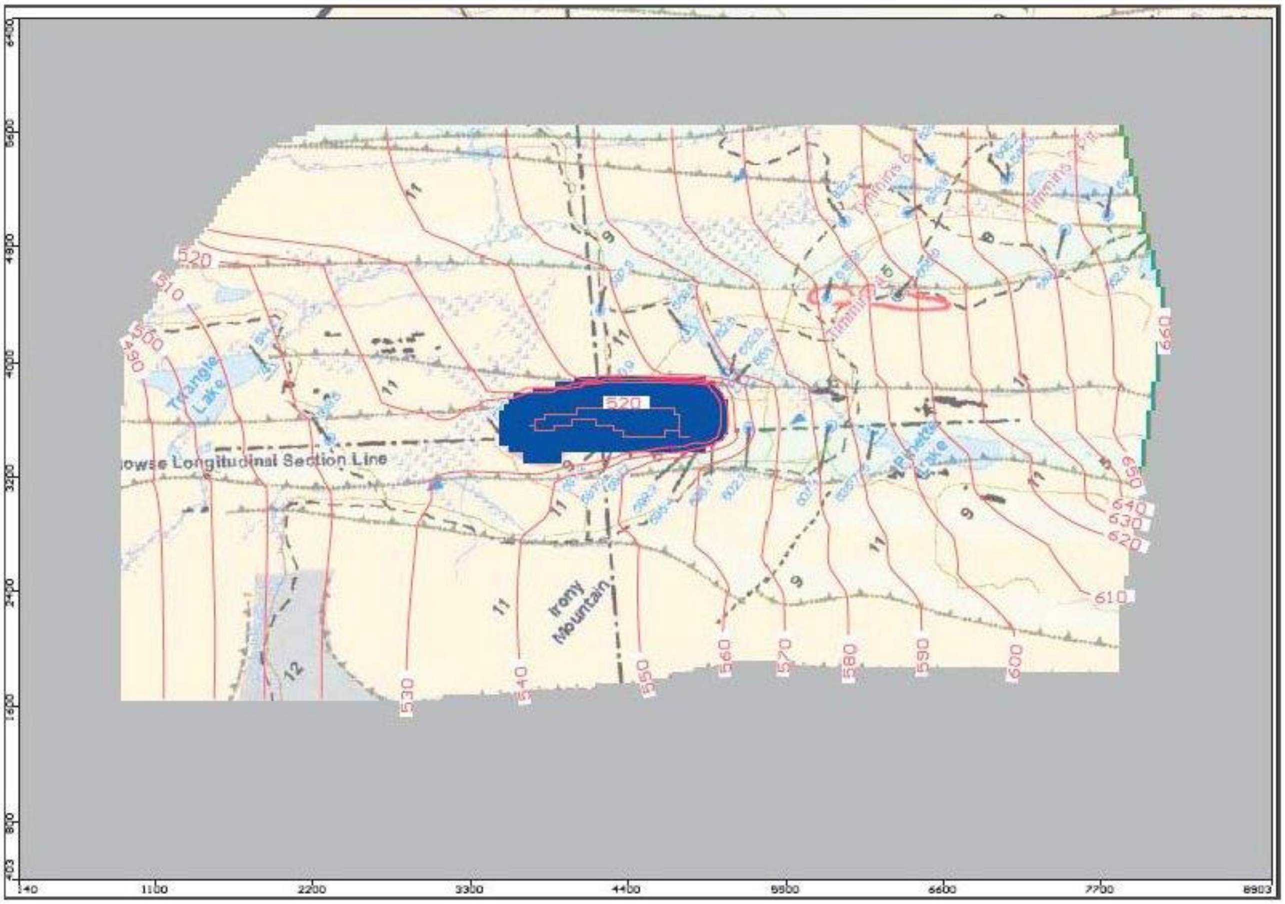


Figure 7-25 Piezometric Map during Dewatering (final depth)

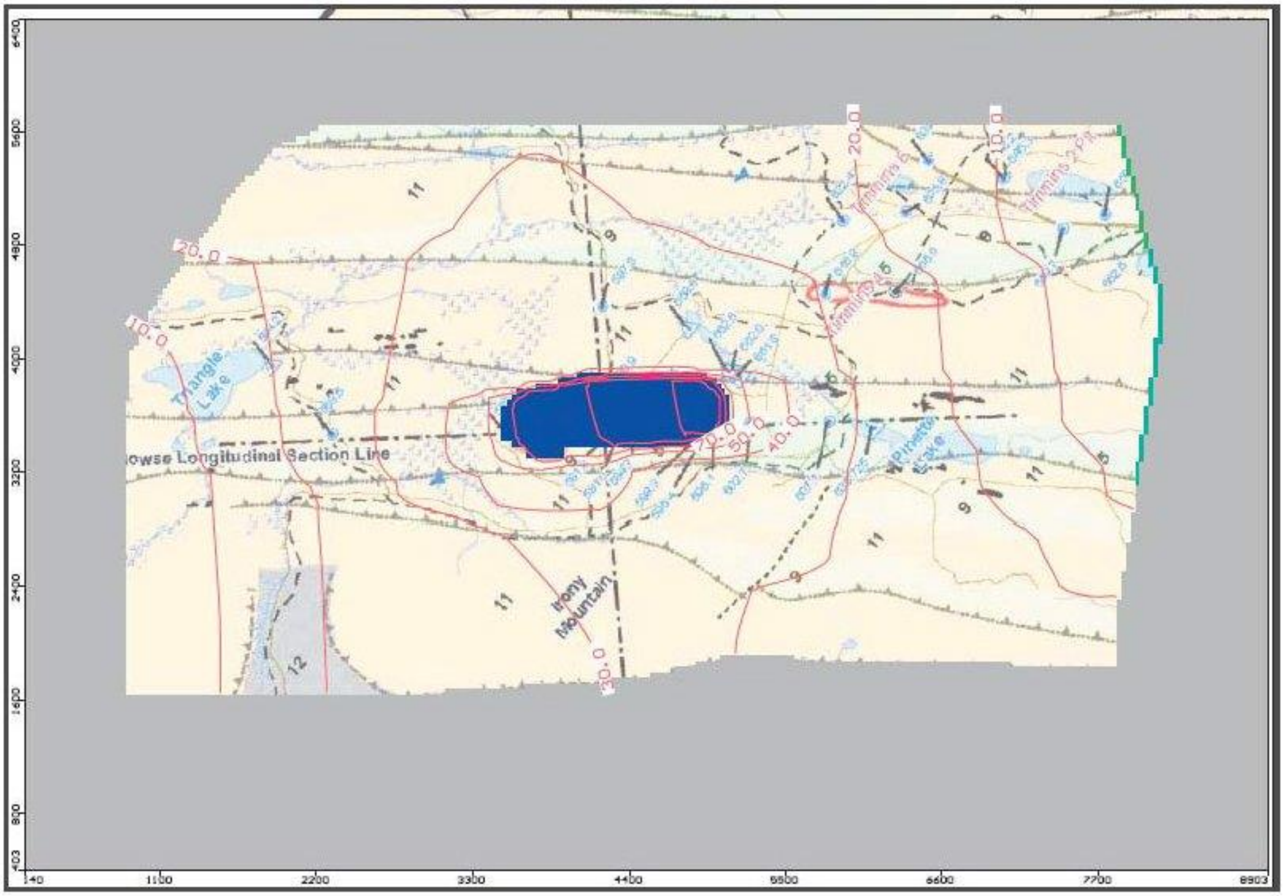


Figure 7-26 Groundwater Drawdown during Pit Dewatering (final depth)

Data Gaps

The groundwater flow model was developed based on up-to-date (2015) hydrogeologic information. The predicted dewatering rates derived from the model have allowed for the completion and sizing the WMP components. The actual results of the modelling give an estimate of the global dewatering rate sufficient for the sizing of the WMP components. Further, the detailed dewatering plan will be adjusted based on the local drilling results, which will be acquired prior to dewatering. The model will then be fine-tuned following new information.

Local monitoring of the groundwater flow of Burnetta Creek is in progress and should be maintained in order to obtain historical data and to assess the impact of dewatering during mining.

7.3.7 Geomorphology

VC Assessment

Site-scale geomorphology will be modified through excavation of the open pit and localized earth works associated with site preparation for stockpiling, waste rock placement and local road upgrading. This could have minor water balance effects in the immediate vicinity. Potential effects would be limited to surficial materials and landforms that are regionally widespread. Furthermore, reclamation of all surface disturbance areas will restore conditions necessary to support re-establishment of terrestrial ecosystems. Geomorphology is thus not retained as a VC.

7.3.7.1 Component Description

Geomorphology refers to the surficial materials and landforms within an area. Its consideration in the Howse Project proposal is relevant because of its role in supporting terrestrial ecosystems and its influence on project layout and site reclamation.

LSA, RSA and Temporal Boundaries

The LSA for geomorphology encompasses the watersheds of Burnetta, Elross and Goodream (western portion) creeks. Potential direct effects on surficial deposits are restricted to the immediate footprints of ground disturbance, whereas potential indirect effects are farther-reaching. A watershed-based definition of the LSA acknowledges that earth works and localized changes in surface drainage patterns could affect site-scale waters balance. Such potential effects on surficial deposits, in turn, could affect local ecosystem function. Geomorphological (terrain) mapping has been completed within the LSA to ensure the distribution and characteristics of surficial materials, and their sensitivities to mine development, are understood.

The RSA for geomorphology encompasses the Labrador Trough of Labrador and northeastern Québec, which exhibits low-relief, valley-and-hill morphology. The distribution of different surficial materials and landforms, overall, is relatively homogeneous within this region. All surficial materials and landforms encountered within the LSA similarly occur within the RSA, providing an important geographic context. Furthermore, this RSA definition encompasses areas of previous and proposed mining-related disturbance (e.g., open pits, waste rock piles, etc.). The full extent of any cumulative effects is included within this region of historic mining operations.

The temporal boundaries for geomorphology include the expected lifespan of the mine (i.e., approximately 10 years) plus an allowance for a period of natural stabilization and restoration following localized disturbance (i.e., another 30 years). A 40-year timeframe is conservative, given that surface instabilities associated with historic mining operations have stabilized since their cessation several decades ago, and that deliberate reclamation will expedite site recovery and vegetation colonization.

Existing Literature

A good understanding of geomorphology in the vicinity of the Howse Project has been gained from government-, university- and industry-led research on the distribution and characteristics of surficial materials and landforms within western Labrador and northeastern Québec. Surficial geology maps to support drift prospecting and permafrost studies in the region provide confidence that the conditions within the Howse Project LSA are generally representative of conditions in the broader RSA. Several publications describing the glacial history and landscape evolution also provide important background information. Studies involving interpretation of large-scale aerial photography and examination of soils at hundreds of locations within the region have been completed by Groupe Hémisphères and its project partners since 2006 in support of mineral exploration projects.

Table 7-48 summarizes key publications that are directly relevant to the characterization of geomorphological conditions within the Howse Project LSA and RSA, and to an effects assessment.

Table 7-48 Summary of Pertinent Information on Geomorphology within the Howse Project Area

TITLE	AUTHOR/YEAR	DESCRIPTION	RELEVANCE
LabMag Iron Ore Project Labrador Study Area Terrestrial Ecosystem Mapping	Gartner Lee Limited and Groupe Hémisphères (2007)	Detailed report with accompanying surficial geology mapping describing terrain units within the Howse Project RSA	Provides local-scale characterization of geomorphology, including distribution of terrain units similar to those in the Howse Project LSA
Surficial Geology of Western Labrador, Schefferville (NTS 23J)	Klassen and Paradis (1998)	1:250,000-scale surficial geology map with polygon, line and point features within the Howse Project RSA	Provides distribution and characteristics of geomorphology at a scale of relevance to regional effects assessment
Glacial landforms and deposits, Labrador, Newfoundland and eastern Québec	Klassen et al. (1992)	1:1,000,000-scale surficial geology map with polygon, line and point features within the Howse Project RSA	Provides a basis for characterizing the regional-scale distribution and characteristics of different surficial materials and landforms
Surficial geology of the Schefferville area (Labrador parts of NTS 23J/10 and 23J/15)	Liverman and Vatcher (1992)	Publication describing local-scale glacial and meltwater processes responsible for the geomorphology within the Schefferville region	Provides photographs and descriptions of different landforms, which also occur within the Howse Project RSA
Ice flow history and glacial dispersal in the Labrador Trough	Klassen and Thompson (1987)	Publication summarizing the glacial history specifically within the Labrador Trough portion of the Howse Project RSA	Provides an understanding of the nature and distribution of landforms within the region
Quaternary correlations in Arctic Canada	Andrews et al. (1986)	Publication outlining the glacial (ice-flow) history across northern regions of Canada, including across the Howse Project RSA	Provides chronology and trajectories of ice flows and deglaciation in the region, which is important for understanding post-glacial landscape evolution
Evolution of the landscape of the Schefferville area	Nicholson (1971)	Overview of the bedrock, glacial and post-glacial processes responsible for the geomorphology present in the Howse Project RSA today	Provides regional context and an integrated understanding of the geomorphological processes that most influence different elements of the landscape

Glacial History and Geomorphology within the RSA

The main landscape elements of the Howse Project RSA, including ridges, valleys and the pattern of the major drainage network, are the result of deformation and erosion of Precambrian (up to 3 billion years old) bedrock. Continental glaciations during the Quaternary Period (<2 million years) have modified areas of the landscape to varying degrees through the erosion of bedrock and the deposition of surficial materials. During the Quaternary Period, continental glaciations repeatedly covered most of Canada, including the Howse Project RSA. The Laurentide Ice Sheet, which extended across mainland Canada from the foothills of the Rocky Mountains to Newfoundland and Labrador, is believed to have had several centers, or ice divides, from which ice flowed outward. One of those ice divides, the Labrador Divide, appears to have been centered just a few tens of kilometres northwest of Schefferville during the most recent, Late Wisconsin glacial advance, which culminated locally about 8,000 years ago (Andrews *et al*., 1986).

Till deposited beneath actively flowing glaciers and through passive let-down by melting ice covers most of the ground surface. Its continuity and thickness are, however, highly variable. Only a thin, discontinuous veneer overlies the bedrock west of the Howells River, whereas comparatively thick (up to several metres) ground moraine blankets the uplands to the east. The till is bouldery, with a silty sand matrix. Large erratics are scattered across the rolling plains. Deglaciation appears to have occurred through gradual concentric retreat of the ice sheet from the margin toward the center, with isolated areas of *in situ* downwasting of ice. Kettles and low-relief, hummocky moraine are typical features of stagnant ice. Sandy to gravelly kames, such as that overlying the Howse Deposit, are scattered throughout the region with various sizes. Meltwater spillways and esker complexes radiate outward from the LSA in regional-scale surficial geology mapping (Klassen *et al*., 1992). Boulder fields in some valley bottoms are probably the result of meltwater erosion of fine-grained sediments. According to radiocarbon dating of peat, the LSA was not ice-free until 5,000 to 6,000 years ago (Nicholson 1971).

Early in the post-glacial period, particularly before vegetation had become established, a variety of processes modified the regional landscape. Periglacial activity was concentrated along windswept ridges and plateaux at high elevations, where snow depth during the long winter was minimal. As a result of glacial debuttressing and weathering, cliffs were particularly susceptible to frost shatter and mass movements. Colluvium accumulated along the bases of prominent hills and knobs. Streams eroded channels through glacial drift and formed small fans and deltas where they flowed into broad valley bottoms and lakes. Strong winds deflated till-covered ridges, leaving behind a gravelly surface lag and redistributing fine sediments into sheltered, low-lying areas. In valley bottoms and depressions within rolling to undulating plains, vegetation began to colonize. Wetlands formed in the most poorly-drained areas, such as along bedrock fractures and at the confluence of headwater streams and shallow subsurface drainage pathways, where high groundwater tables slowed the decomposition of organic material. Permafrost is sporadic (discontinuous) within the region (Heginbottom, 1995), occurring mostly within high-elevation, windswept hills (Journeaux Assoc, 2015), but it is sufficiently deep that it has little to no effect on ground stability or terrestrial ecosystems.

Surficial Materials and Landforms within the LSA

The surficial geology in the vicinity of the Project is based on aerial photograph interpretation (Volume 2 Supporting Study K), field observation reviews and previous terrain mapping for the Taconite Project (Gartner Lee and Groupe Hémisphères, 2007) and for the DSO Project (Groupe Hémisphères, 2011a). Terrestrial ecosystem descriptions highlighted for each type of surficial deposit can be consulted in Section 7.4.2. Terrain in the vicinity of the Project is shown in Figure 7-27. Soils are described in Section 7.4.2 in association with other ecosystem characteristics.

The distribution and characteristics of landforms in Howse Project LSA reflect a combination of ridges and valleys formed by folded, iron-rich, Precambrian metamorphic bedrock; glacial erosion and deposition from a generally northwestward flowing portion of the Laurentide Ice Sheet; deglacial meltwater processes; and post-glacial stream erosion and accumulation of organic matter. Irony Mountain, which is relatively resistant to glacial erosion, projects above the surrounding landscape as a prominent bedrock knob at the western edge of the LSA. Its thin, silty sand soils are well to rapidly drained and support Ecotypes TSS02 and TSS03, and TSS04 to a lesser extent (Section 7.4.2 for details on the ecosystems). Bedrock is also exposed along the crests of lower ridges and in some narrow valleys where meltwater has eroded surficial materials, supporting Ecotype TSS02. Its weathered surface is a patchwork of angular blocks where frost heave has been most severe.

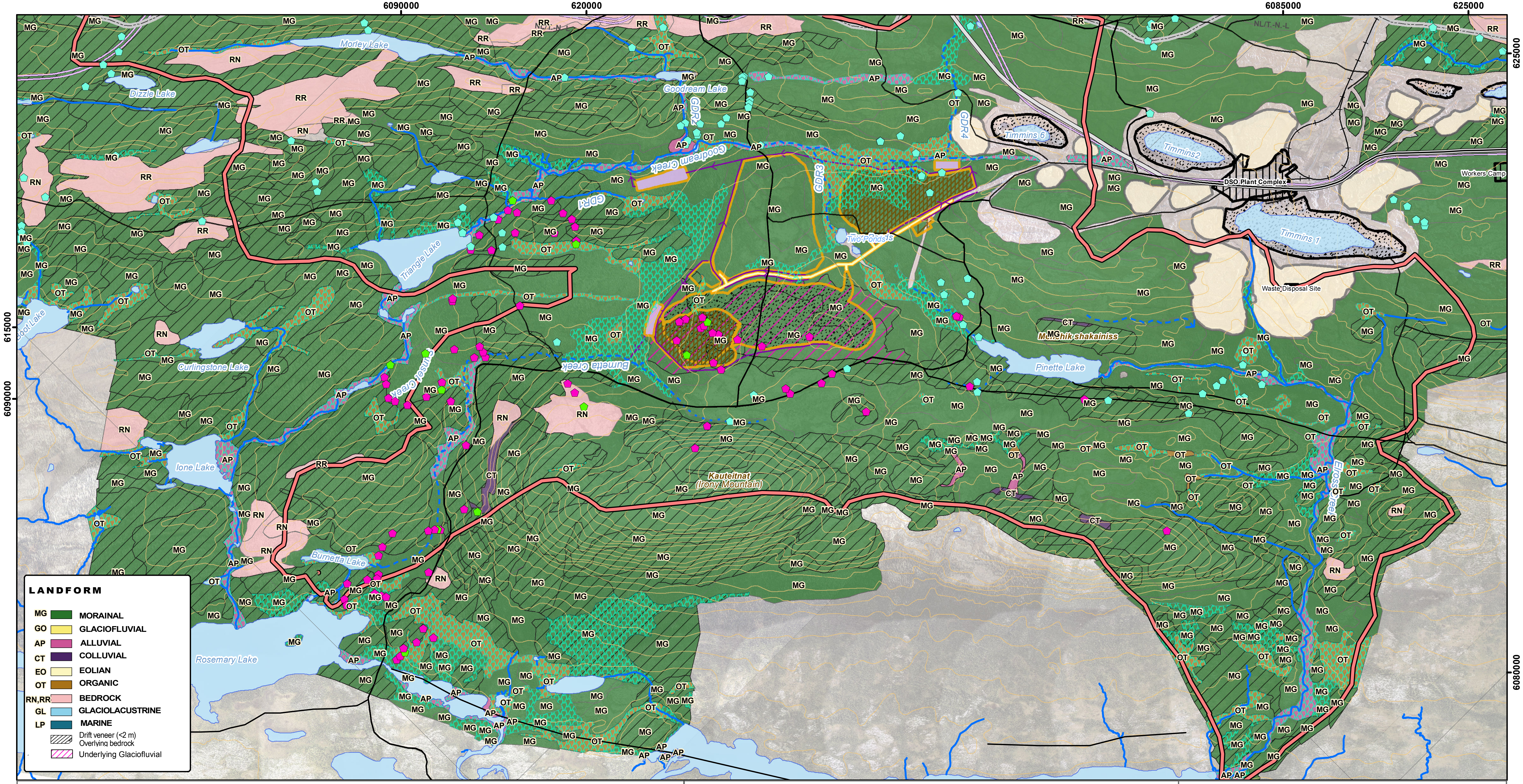
Silty sand till is the most widespread surficial material in the vicinity of the Project. Its thickness ranges from less than one metre in discontinuous veneers to a few metres in blankets and infilled hollows, which were more sheltered from glacial erosion. The till is generally moderately well to well drained, supporting sandy soils and Ecotypes FSM05 and FSM01. In depressions, where the groundwater table is perched on underlying bedrock, the till may be imperfectly to poorly drained. Ecotype FSM08 is more common in such areas.

Conspicuous meltwater channels wrapping around the western flank of Irony Mountain and incised through till provide clear evidence of deglacial meltwater pathways. Depositional evidence of meltwater activity is less common in the region. One noteworthy exception occurs northeast of Irony Mountain, in the vicinity of the Howse Deposit itself. Here, trenching and drilling records indicate that a relatively uniform cover of till overlies an average of 28 m of buried glaciofluvial sand and gravel (Thiagarajan (BK) Balakrishnan, *pers. comm*.). Its presence can only be inferred in aerial photography based on a distinct, radial drainage pattern interpreted to be centered on the thickest portion of sand and gravel. The landform is interpreted to be a buried kame overridden by a late glacial advance. The till cap is sufficiently thick and continuous that soil moisture and nutrient regime are relatively unaffected by the underlying glaciofluvial deposit. As in other areas of well drained till, Ecotypes FSM05 and FSM01 predominate.

Since the deglaciation of the region, organic material has accumulated in poorly to very poorly drained depressions and in areas of groundwater discharge. Organic mesic and fibric soils support Ecotypes FSM10, FSM12 and FSM14. In areas of greater regional slope, contemporary streams have eroded and redistributed glacially derived sediments in alluvial plains. The floodplains, comprising sand and silt, are typically imperfectly drained. Riparian ecosystems in such areas include Ecotypes FSM07 and FSM15. In the LSA, permafrost is restricted to high-elevation, windswept hills above about 660 m (Journeaux Assoc, 2015), at sufficient depth that it has little to no effect on ground stability or terrestrial ecosystems.

Data Gaps

Previous government- and university-led surficial geology projects have produced regional- and local-scale mapping and descriptions of geomorphology within the Howse Project RSA and LSA. Information gained from these original publications has been supplemented by observations made during recent field investigations and aerial photograph-based geomorphological mapping in support of mineral exploration in the area. No significant data gaps are known to exist for geomorphology, and diligent observations during site preparation and mining will further supplement the existing data set.



LEGEND

Data Validation

- ⬟ 2008/2009 Survey
- 2013 Survey
  - ⬟ Ground
  - ⬟ Visual
- ▭ Local Study Area

Infrastructure and Mining Components

- ▤ DSO Haul Road
- ┼ Existing Railroad
- ▨ Elross Lake Area Iron Ore Mine (ELAIOM) Plant Infrastructure footprint
- ▦ Existing Pit
- ▭ Existing Dump
- ▦ Proposed Howse Pit
- ▭ Proposed Topsoil/ Overburden Stockpile
- ▨ Proposed Site Infrastructure
- ▨ Proposed In-Pit Dump/ Waste Dump
- ▭ Existing and Proposed Sedimentation Pond
- → Proposed Ditch
- ═ Proposed Mine Haul Road

Basemap

- ─ Permanent Watercourse
- ‐ ‐ Intermittent Watercourse
- ⋯ Storm Runoff
- → Disappearing Stream
- ●─ Artesian Spring
- ▭ Water Body
- ─ Contour Line (50 ft)
- ─ Existing Road
- ═ Main Access Road
- ▨ Wetland

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0575 , PR185-19-14, 2015-11-10, edickoum

0 500 1 000 1 500
Meters

UTM 19N NAD 83

SCALE: 1:30 000

SOURCES:
Basemap
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and government of Quebec,
Boundary used for claims
SLE, AMEC and GHI (October 2012). LabMag and Kémag Iron Ore Projects 2012 Mine Site Aquatic Program Field Report.
Groupe Hémisphères, Hydrology, Wetland, 2013.

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
Howse Minerals Limited/
MET-CHEM, Howse Deposit Design for General Layout, 2015

SURVEY:
Groupe Hémisphères (2011) Terrestrial Ecosytems and Terrain : Iron Ore Project Direct Shipping.
Technical Report for New Millennium Capital Corp, 2008-2010.

ENVIRONMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Terrain

Howse Minerals Limited

GroupeHemispheres
5731, rue Saint-Louis,
Bureau 201, Lévis (QC)
Canada, G6V 4E2

1453, rue Beaubien est,
Bureau 301, Montréal (QC)
Canada, H2G 3C6

Figure 7-27

7.3.8 Permafrost

7.3.8.1 Component Description

The demonstrated absence or isolated presence of permafrost in the Howse Project LSA makes negligible any potential effects of permafrost on the project, or of the project on permafrost. Assuming a continued trend of climatic warming, permafrost is not expected to aggrade into stockpiles or waste rock piles, and any isolated bodies of permafrost at depth within bedrock will continue to thaw undetected, with no measurable effect on groundwater. In the unlikely event small bodies of frozen ground are encountered during pit excavation, site-specific adjustments or mitigations will address any potential effects. Finally, no comments were raised concerning permafrost during the Howse consultation process. For these particular reasons, permafrost is not retained as a VC.

Permafrost is ground that remains at or below 0°C for more than one year. Its consideration in the Howse Project proposal is relevant because of the potential for permafrost, where present, to influence ground conditions, approaches to project design and support ecosystem function.

LSA, RSA and Temporal Boundaries

The LSA for permafrost is defined by a 500 m buffer around the Howse Project footprint. This is considered to be the maximum potential area of effect for proposed project activities, such as excavations (open pit) and stockpiles. Potential direct effects of ground alteration from the project are localized (typically metres to tens of metres), whereas potential indirect effects through alteration to surface drainage patterns can have farther-reaching effects (in the order of a few hundred metres). A 500 m buffer intentionally excludes Irony Mountain, which has no potential for effects.

The RSA for permafrost is defined by the upper Howells River watershed and its immediate surroundings within the Labrador Trough. This area is entirely within the zone of sporadic discontinuous permafrost; it exhibits relatively uniform valley-and-hill morphology; and it encompasses areas of previous and proposed mining-related disturbance (e.g., open pits, waste rock piles, etc.). The full extent of any cumulative effects is included within this region of historic mining operations.

The temporal boundaries for permafrost include the expected lifespan of the mine (i.e., approximately 15 years) plus an allowance for a period of re-equilibration and restoration of any detectable changes in permafrost and related ground conditions (i.e., another 30 years). A 46-year timeframe is conservative, given that surface expressions of localized changes in permafrost associated with historic mining operations have stabilized since their cessation several decades ago. This timeframe is also based on EBA Engineering Consultants Ltd.'s (2004) experience in permafrost regions of northwestern Canada, where natural processes can reclaim a mine cut in permafrost in four to ten years, depending on site conditions, and "succession toward a closed-canopy spruce forest is well underway about 40 years after disturbance" (p.22).

Existing Literature

A uniquely good understanding of permafrost conditions and distribution in the vicinity of the Howse Project has been gained from a history of Iron Ore Company of Canada (IOCC) mining operations in the area, starting in 1954, through which numerous deep (up to ~100 m) exploration boreholes were instrumented with thermocables. Decades of permafrost-related research ensued, following establishment by the McGill Subarctic Research Station of a permafrost research site in 1967 at the Timmins 4 Deposit, just 2 km southeast of the Howse Deposit (Granberg et al., 1984). Studies involving interpretation of large-scale aerial photography and examination of soils at hundreds of locations within the region have been completed by Groupe Hémisphères and its project partners since 2006 in support of mineral exploration projects. More recent field investigations and desktop analyses, specifically in support of planning for the Howse Project, have supplemented and updated key observations and measurements from the extensive historical data set.

Table 7-49 summarizes key publications, including those containing historical and recent data sets, which are directly relevant to the characterization of permafrost conditions within the Howse Project LSA and to an effects assessment.

Table 7-49 Summary of Pertinent Information on Permafrost Conditions within the Howse Project Area

TITLE	AUTHOR/YEAR	DESCRIPTION	RELEVANCE
Permafrost Condition at TSMC Howse Deposit, Schefferville, Québec	Journeaux Assoc (2015)	Includes new analyses of historical ground temperature and permafrost data from the Howse Project RSA, and reports the results of newly collected ground temperature, air temperature and permafrost data from the Howse Project LSA	Facilitates comparison between historical and current permafrost conditions, and allows updates to be made with respect to expectations for mining
Hydrogeology and MODFLOW Modelling – Howse Property	Geofor Environment (2015)	Reports the results of recent borehole drilling and groundwater monitoring in the Howse Project LSA	Facilitates inference of unfrozen conditions in areas of rapidly responding groundwater levels
Permafrost Map of Canada	Heginbottom, 1995	Provides nation-wide delineation of permafrost continuity, ice content, landforms and temperatures	Establishes regional context for permafrost conditions and limits of discontinuous permafrost
Schefferville Permafrost Research Volume I: Parts 1a and 1b, Summary, Review and Recommendations and Catalogue of Available Materials	Granberg et al. (1984)	Reports results of extensive permafrost research conducted in the Howse Project RSA, including ground temperature records, material properties and ground ice observations, and includes bibliography of related references	Provides comprehensive baseline foundation for characterizing historical permafrost conditions within the Howse RSA
Annotation, Error Analysis and Addenda to Schefferville Permafrost Data File, Vol I, Summary & Index	Granberg et al. (1984)	Provides overview of errors and erratic results from thermocable data in the Howse Project RSA	Provides opportunity to update interpretations of original ground temperature data
Annotation, Error Analysis and Addenda to Schefferville Permafrost Data File, Vol XIII, Graphic Representation of Thermocable Data (b) Howse to Timmins 4 Cable 14E	Granberg et al. (1984)	Identifies errors and erratic results from thermocable data in the Howse Project RSA	Provides opportunity to update interpretations of original ground temperature data
Annotation, Error Analysis and Addenda to Schefferville Permafrost Data File, Vol XV,	Granberg et al. (1984)	Includes comments of erratic readings, sometimes with cause, and permafrost presence	Provides opportunity to better understand where and how groundwater is impacting

TITLE	AUTHOR/YEAR	DESCRIPTION	RELEVANCE
Annotations of Thermocable Data Plots and Permafrost Prediction Maps; Data Corrections		and condition, based on thermocable readings in the Howse Project RSA	ground temperature measurements
Permafrost spatial and temporal variations near Schefferville, Nouveau-Québec	Nicholson (1979)	Provides synthesis and analysis of data from history of IOCC/McGill permafrost research in mine areas within Howse Project RSA, including permafrost distribution (three-dimensionally) and thermal regime	Provides valuable regional summary of historical permafrost data set, to which more modern observations and measurements can be compared
Indirect mapping of the snow cover for permafrost prediction at Schefferville, Québec	Granberg (1973)	Assess the relationship between topography (elevation and surface roughness) on snow accumulation, and relates this to permafrost distribution within the Howse Project RSA	Emphasizes the important role that snow cover and wind exposure have on the occurrence of permafrost and reports particular snow depth thresholds of regional relevance

Distribution

The Howse Project is located within the zone of sporadic discontinuous permafrost, within which permafrost generally underlies 10-50% of the landscape (Heginbottom, 1995). Regionally (i.e., within the RSA), permafrost is more extensive to the north, where tundra dominates the landscape, and less extensive to the south, where woodlands predominate. At a local scale (i.e., within the LSA), the distribution of permafrost relates to elevation, topographic characteristics, vegetation, snow cover, substrates and groundwater movement.

Research centered around the Timmins 4 Deposit determined that "the winter snow cover is the most important single factor affecting the distribution of ground temperatures [and, therefore, permafrost distribution] in the Schefferville area" (p. 148, Granberg et al., 1984). Snow acts as an effective insulator, reducing heat loss from the ground during winter. The average annual snowfall of about 350 cm and 7 to 8 months of snow cover inhibit permafrost development in much of the area (Nicholson, 1979). In order to understand the distribution of permafrost in the vicinity of the Howse Project, local patterns in winter snow cover and spring snow melt must be considered. Through indirect mapping of snow cover for permafrost prediction, Granberg (1973) found that the distribution of snow relates strongly to the dynamics of winter winds and the snow it carries. Minimal snow accumulates in exposed areas, such as high-relief, rocky hill crests, where the absence of trees allows redistribution by wind. Permafrost is common in such areas. Thicker snow cover in sheltered areas, such as forested slopes, valleys and in the lee of hills, promotes the deposition, accumulation and springtime persistence of snow. Permafrost is commonly absent in such areas. Typical woodland snowpacks of 1.5 m are sufficient to prevent the development of permafrost (Nicholson, 1979). Based solely on site exposure and vegetation, permafrost is more likely to underlie Irony Mountain, immediately west of the Howse Deposit, than it is to underlie the Howse Project LSA, which is lower, relatively sheltered and partly forested.

Journeaux Assoc (2015) demonstrated that elevation is a particularly reliable predictor of permafrost distribution within the Howse Project RSA, based on spatial comparisons it made of historical observations and ground temperature data available in Granberg et al.'s (1984) summaries of permafrost research in the area. Journeaux Assoc's (2015) Table 4-1 summarizes occurrences of frozen ground reported by personnel working in the former and existing mining pits in the region. Frozen ground conditions were only reported in pits above 660 m (i.e., based on observations from 11 pits from 660 m at Leroy 1 to 800 m at Sunny 1). Unfrozen conditions were documented at pits from 540 m in elevation (i.e., Ferriman) to 775 m in elevation (i.e., Kivivic 4). The unfrozen conditions at higher elevations are partly attributed to substrate and ore characteristics (e.g., porosity).

Based solely on elevation, permafrost has a low likelihood of occurrence within the Howse Deposit itself, which slopes from a maximum of about 680 m at its southern limit down to almost 580 m at its northern limit. Most of the broader Howse Project LSA is similarly below the 660 m regional low threshold of frozen ground occurrences. Only two small areas within the LSA exceed the 660 m elevation: a gentle slope between the western edge of the Howse Deposit and the base of Irony Mountain, and the crest of a small hill southeast of the southern waste rock dump (Figure 7-28). No mine-related infrastructure is proposed within either of these areas.

Substrate composition also has an important role on permafrost distribution within the Howse Project LSA, seemingly counteracting the effects of elevation and exposure in the upper portion of the Howse Deposit itself, where may otherwise occur. An average of 28 m of highly permeable sands and gravels overlies the Howse Deposit (Granberg et al., 1984), in contrast to the comparatively thin mantle of till prevalent elsewhere. The landform with which these sands and gravels are associated is likely a kame, deposited by glacial meltwater in contact with glacial ice. Much of the kame is unfrozen based on information derived from thermocables installed in boreholes within the deposit (Granberg et al., 1984). Granberg et al. (1984) postulate that the permeable sands and gravels allow "a heat gain by warm water infiltration during summer that outweighs the effects of shallow snow accumulation in winter" (p. 23). Nicholson (1979) also documented a strong dependence of permafrost presence/absence on the proximity to, and catchment areas of, subsurface drainage pathways. Areas with subsurface water flow inhibit permafrost development and, over time, can thaw any relict permafrost that may be present. These statements are corroborated by the recent observations and interpretations of Journeaux Assoc (2015), which found that groundwater levels within the deposit are deep (i.e., approximately 70 to 90 m below ground surface, based on wells drilled recently by Geofor Environment), yet respond notably to major rainstorms. Each year, relatively warm rainwater efficiently infiltrates the granular deposits and porous iron formation, transferring heat and thawing any relict permafrost.

During field reconnaissance in the Schefferville mining region, Journeaux Assoc (2015) attributed observations of shallow, irregular depressions along high-elevation haul roads to localized permafrost degradation. No surface expressions diagnostic of permafrost or thawing frozen ground were observed in the Howse Project area.

Thermal Conditions and Trends in Ground Temperature

The general thermal regime of the permafrost in the Howse Project RSA is well understood from the significant amount of thermocable data and related research. Mean permafrost temperature, regionally, is usually between 0 and -1°C; temperatures lower than -2°C are almost always restricted to the uppermost 20 m (Nicholson, 1979). Nicholson (1979) reports seasonal fluctuations of permafrost temperature of up to 0.1°C are common to depths of 25 m, which is consistent with more recent measurements described below. The magnitude of the temperature variation decreases with depth, and there is a lag time before maximum and minimum temperatures are reached at depth (Granberg et al., 1984). Steep horizontal temperature gradients of up to 1°C per 15 m lateral distance are not exceptional in the region (Nicholson, 1979).

Journeaux Assoc (2015) compiled and reviewed ground temperature records from four sources: 1979 McGill temperature graphs from thermistors installed in the Howse area; Golder Associates' temperature records beginning in December 2013 in a borehole near the southeast limit of the Howse Deposit; New Millennium temperature records from installations in the nearby LabMag and KéMag deposits; and measurements by Nicholson (1979) at Timmins 3 and 4. With the exception of an occasional "erratic reading" (documented as such), Granberg et al. (1984) reported ground temperatures encompassing the Howse Deposit, below the depth of seasonal frost penetration, above 0ºC (i.e., 0.5 to 2ºC) down to 120 m depth below ground surface. Nicholson (1979) presented a cross-section that showed ground temperatures for an area around the Timmins 4 deposit, just 2 km away from the Howse Deposit, with temperatures above 0ºC for terrain lower than 670 m in elevation. Given that the Howse Deposit is lower than 680 m, Nicholson's findings are consistent with the measurements reported by Granberg et al. (1984).

Golder Associates installed a thermistor string in December 2013 to a 40 m depth on the southeast end of the Howse Deposit (elevation approx. 680 m). The temperature profile from December 2013 to August 2014 reveals ground temperatures below the depth of seasonal frost penetration (approx. 5 m) are consistently above freezing. The temperatures decrease from about 3ºC at 666 m (14 m below ground surface (bgs)) to about 1.5ºC at about 644 m (38 m bgs). The temperature profile from August 2014 to February 2015 reveals a similar frost penetration depth of about 5 m, and deeper ground temperatures transitioning from 2.5ºC down to a 24 m depth, to 1ºC by about 38 m depth (64 m bgs). In conjunction with the thermistor installation, Golder Associates installed two water temperature recorders at the same location, one at 89.5 m depth and another at 180 m depth. The readings indicate a temperature of 0.5ºC at the groundwater table and 1ºC at the 180 m depth. Based on this information, Journeaux Assoc. (2015) concludes that ground temperature probably decreases slowly from 1ºC at the 38 m depth noted above, to about 0.5ºC at the water table (80 m bgs).

These recent temperature records confirm unfrozen conditions and the absence of permafrost within this part of the Howse Deposit (Journeaux Assoc, 2015). Of note in the temperature profile is an anomalous rise in ground temperature at 7 m depth during a period when gradual cooling is expected. The infiltration of relatively warm precipitation during a rainstorm likely explains this temporary warming, and is a testament to the warming effect that can occur to greater depth over centuries in such granular deposits as exist at the Howse Deposit (Journeaux Assoc, 2015). Geofor Environment's recent monitoring of groundwater levels in the Howse Deposit confirmed unfrozen conditions with groundwater levels about 70 to 90 m below ground surface, with a gentle 2% slope toward the northwest (as reported by Journeaux Assoc, 2015). Groundwater flow is noted to be mainly controlled by bedding planes, fractures and faults, with no indication of permafrost control.

Thermistors installed by New Millennium in 2012 in the LabMag and KéMag deposits provide another opportunity to assess and compare recent ground temperatures in the area. The two thermistors installed in the LabMag deposit, just a few kilometres west in forested areas at an elevation of 513 and 565 m, exhibit temperature profiles similar to those recorded at the Howse Deposit (Journeaux Assoc, 2015). Temperatures below the 3-5 m thick annual surface freezing layer decreased from about 5ºC at 5 m depth to about 3ºC at 10 m depth. Much farther north, in exposed areas of bedrock at an elevation of 705 m, the KéMag thermistor intercepts the permafrost table at about 8 to 10 m depth, with permafrost temperatures fluctuating between about 0 and -2ºC.

In order to assess the potential for changes in climate to affect permafrost, especially since most of the data were collected by IOCC and McGill researchers, Journeaux Assoc (2015) compiled weather data from Schefferville since the mid-1900s. The tabular and graphical representation of freezing and thawing indices (i.e., the yearly sum of the differences between 0ºC and the daily mean temperature of the days with means below and above 0ºC, respectively) indicate a slight warming trend in an air temperature metric that relates to permafrost condition. This warming trend is likely reflected in ground temperatures as well.

Summary of Permafrost Conditions and Implications for Mining

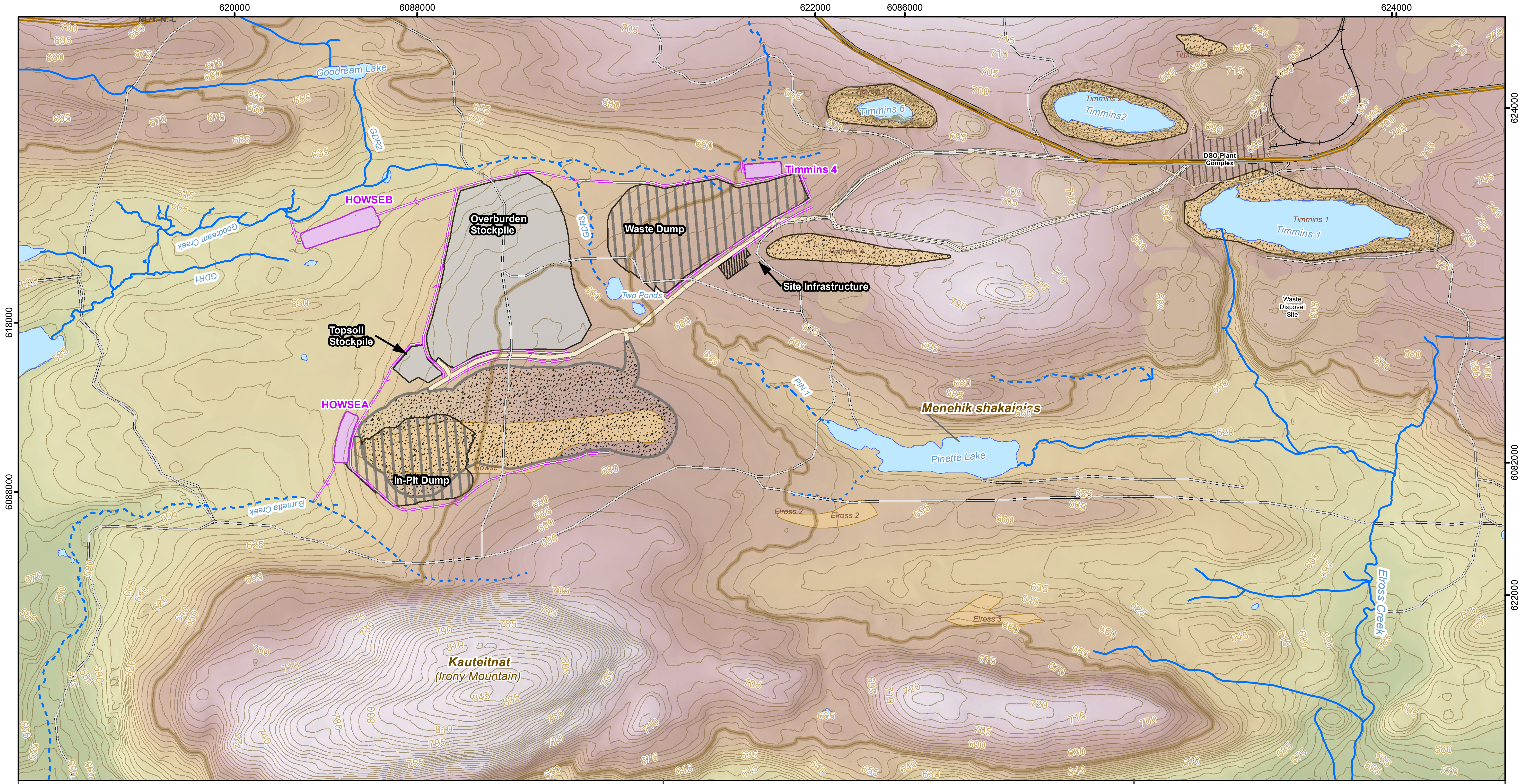
Journeaux Assoc's (2015) recent field investigation and desktop analysis conclude that any notable permafrost historically present in the Howse Project LSA below 660 m in elevation has since thawed and disappeared based on several lines of evidence:

- Thermistor readings reported in and around the Howse Deposit by McGill researchers (Granberg et al., 1984) and by Golder Associates, and in the nearby LabMag Deposit by New Millennium;
- Recent confirmation by Geofor Environment of deep groundwater levels in permeable granular deposits overlying the Howse deposit;
- Absence of any indication of permafrost below an elevation of 660 m in notes from personnel working in old and existing pits in the region; and
- Extrapolation of Nicholson's (1979) ground temperature observations from the nearby Timmins 4 area (i.e., unfrozen ground below 680 m).

Any isolated bodies of permafrost that do exist within the Howse Project LSA are likely restricted to the two higher elevation areas to the west and southeast of the Howse Deposit, where no mine-related infrastructure is proposed. Other areas below the 660 m lower regional limit of permafrost (Journeaux Assoc, 2015) are less exposed and at least partly forested. Even if small remnants of permafrost exist within the area, they would occur deep within the bedrock and have low ice contents. Nicholson's (1979) observation that ice contents in the area are low (commonly around 15% by volume) supports his statement, with application to proposed mine development, that "there is usually no change of rock volume on thawing" (p. 267). With low ice contents, any remnant permafrost exposed in bedrock during pit excavation would have little effect on overall pit stability and could be addressed through site-specific adjustments and mitigations as needed. As noted by Journeaux Assoc (2015), direct detection or modelling of possible remnant patches of permafrost within the Howse Project LSA would be difficult and of limited value.

Data Gaps

Few regions of Canada have such an extensive historical data set on ground temperature and permafrost conditions as is available for the Howse Project LSA and RSA. Recent field investigations, including borehole drilling, thermistor installations and groundwater monitoring, have enabled updates and comparisons to be made of permafrost conditions. These have been supplemented by desktop analyses and interpretations. No significant data gaps are known to exist for permafrost, and diligent observations during site preparation and mining will further supplement the existing data set.



LEGEND

Elevation (m asl)

847

551

660 m asl

Infrastructure and Mining Components

- DSO Haul Road
- Existing Railroad
- Elross Lake Area Iron Ore Mine (ELAIOM) Plant Infrastructure footprint
- Existing Dump
- Other Pit
- Deposit
- Proposed Ditch
- Proposed Howse Pit
- Proposed Topsoil/ Overburden Stockpile
- Proposed Site Infrastructure
- Proposed In-Pit Dump /Waste Dump
- Proposed and Existing Sedimentation Pond
- Proposed Mine Haul Road

Basemap

- Permanent Watercourse
- Intermittent Watercourse
- Storm Runoff
- Disappearing Stream
- Artesian Spring
- Water Body
- Contour Line (16 ft)
- Provincial Border
- Existing Road
- Main Access Road

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0577 , PR185-19-14, 2016-03-22, edickoum

N

0 500 1 000
Meters

UTM 19N NAD 83

SCALE: 1:20 000

SOURCES:
Basemap
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and Government of Quebec, Boundary used for claims
Groupe Hémisphères, Hydrology, 2013.

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
TATA Steel Minerals Canada Limited/ MET-CHEM, Howse Deposit Design for General Layout, 2013

Permafrost
Schefferville Permafrost Research, summary review and recommendations and catalogue of available materials for IOC Permafrost data, 1983.

ENVIRONNEMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Permafrost Potential within the LSA

Howse Minerals Limited

GroupeHemispheres

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Figure 7-28

7.3.9 Hydrography and Hydrology

7.3.9.1 Component Description

Hydrology is considered a VC insofar as it concerns the water budget, which is linked with the available amount of water for fish habitat. Further, the amount and speed of water flowing into creeks can lead to more or less erosion of the natural habitat, thus affecting water quality, which is also a component of fish habitat. As such, due to its effect on water quality and fish habitat, in interest for first nations, water budget is selected as VC.

LSA, RSA and Temporal Boundaries

The LSA is considered to be limited to the watersheds within which the Project takes place and that could potentially be affected by the Project: Triangle Lake, Pinette Lake and Burnetta Lake watersheds. This area includes some watercourses, the largest being Goodream Creek. This LSA also encompasses all sections that could dry out from the operation of the Howse mining activities (Figure 7-29).

In an effort to capture as much data as possible, we include data from well-documented large watersheds as far as 600 km away. Closer stations are used to better understand the local hydrography; the Howells River station at the bridge and others along Elross Creek are among these, but with much shorter time-series, in the order of a few years or less. The RSA also includes the Elross Lake watershed (Figure 7-29).

The temporal boundaries for the hydrology component includes up to 5 years after the end of the Howse Project Decommissioning and Reclamation phase, as based on observations of past IOCC iron ore sites throughout the ELAIOM project. Seasonal variations are also considered: During spring thaw, water flow is at its maximum and more mine water is expected to be discharged according to the WMP (Section 3.2.5), whereas in late summer and winter, streams are at their lowest flow, and sometimes even dry up because of the permeable nature of the surficial deposits and bedrock. In Labrador, dry ups are frequent in winter because of the very long cold period with persistent snow (Rollings, 1997).

Existing Literature

Hydrography

Knowledge of the surface flow pattern in the area was updated through field observations and interpretation of 2008 aerial photographs taken at a 1:10,000 scale. This hydrographic update was described in NML and PFWA (2009) and shows that the National Topographic Data Base (NTDB) was relatively outdated and imprecise. It also indicates that IOCC's mining operations dried out sections of watercourses farther east and thus reduced drainage density. Nevertheless, the most recent LSA update conducted by Groupe Hémisphères (Volume 2 Supporting Study K) currently reveals a terrain that is slightly disturbed by geological exploration paths, but with a drainage density that is still lower than anticipated, i.e., slightly more than 1 km of watercourse per km². With a cumulative length of 36 km in the LSA, the flow is achieved through three main watercourses, namely Goodream Creek to the north, Burnetta Creek (newly recommended hydronym) to the west and PIN1 (Pinette Lake Inflow to the southeast). Ultimately, all the creeks end at Howells River. For Goodream Creek, which ends at Triangle Lake, water is discharged toward two more lakes and then Howells River via Sunset Creek. For Pinette Lake Inflow, water is discharged via Elross Creek.

Combined, the LSA's lakes and ponds cover a total surface area of 50 ha. Triangle Lake is by far the largest water body, followed by Pinette Lake. Small ponds, part of wetlands (labelled as Two Ponds on the maps), are located northeast of the deposit, while other unnamed small lakes and ponds can be found within the LSA.

Hydrology

Brace Centre for Water Resources Management (BCWRM, 2005) conducted the initial hydrology investigation in 2005 with flow measurements at the Howells River Bridge. This station, with a drainage area of 250 km² and named HBL, was recommissioned in 2010 by Groupe Hémisphères (2013a), and provides the first year-round hydrogram in the vicinity of the LSA. Analysis suggests that HBL has hydrological responses that are similar to those of large-scale government hydrometric stations. Also, the transposition method for estimating extreme events seems effective only for the largest stations situated down the valley. High elevation watercourses were found to have a really large freshet, proportionally speaking. In contrast, some watercourses fed by large wetlands may show a particularly regular water regime, where freshets are inconspicuous, as was the case in the RSA (Groupe Hémisphères, 2010).

Reference Hydrometric Stations

Long-term streamflow data in central-west Labrador are sparse, whereas data in Québec are more abundant. Rollings (1997) identified 39 reference stations useful for modelling hydrology in Labrador. McFadyen (near the mouth), Pekan River and Swampy Bay are hydrometric stations that are now out of operation but are close to the study area and meet basic requirements, notably that of the number of years of operation. Baseline information and statistics can be found in Table 7-50.

Table 7-50 Reference Hydrometric Stations

NAME	FEDERAL NO.	COOR-DINATES (NAD83)	DRAINAGE AREA (KM²)	OPERA-TIONAL DATE	MEAN MONTHLY DISCHARGE (M³/S)	LOWER QUARTILE (M³/S)	UPPER Quartile (m³/s)
McFadyen (near the mouth)	03OA003	54°5'52" N 66°33'32" O	3,610	1972–1982	89.1	73.3	109
Pekan River	02UC003	52°11'20" N 66°53'29" O	3,390	1965–1982	75.7	69.7	81.6
Swampy Bay	03LD004	56°38'34" N 68°33'50" O	8,990	1972–1993	165	155	178

Local Hydrometric Stations

Numerous hydrometric stations already exist in the LSA. There are three types of measurements: instantaneous (single or discontinuous records), recording (continuously recording but not transmitting data using a satellite transmitter), and near real-time (continuously recording and transmitting data using a satellite transmitter). As previously discussed, 20 stations were installed in the Howells River Valley for the Taconite Project (SNC-Lavalin, 2013a). Of these, four monitor the water quantity coming from the Howse Project drainage area (Table 7-51). Roughly 20% of the recording stations, left for over a year, recorded that watercourses were completely dry by the end of the winter, when the low flow period occurred. Those were streams with a total drainage area of less than 9 km². Groupe Hémisphères (2013a) reported similar results at the nearby DSO 2a project site.

Two upstream stations were built by TSMC to monitor the TSMC's ELAIOM Project and are now part of the Real Time Streamflow program maintained jointly by Environment Canada – Water Survey of Canada and the Water Resources Management Division, NL Department of Environment and Conservation of Newfoundland and Labrador. Station NF03OB0039 records data on Elross Creek below the Pinette Lake inflow, while station NF03OB0040 records data on Goodream Creek, 2 km northwest of Timmins 6 pit. At the moment, gauging is not fully completed and only water level (or stage) is presented over the Internet (WRE, 2014).

For the current Project, four instantaneous stations were recently installed to collect flow data near the Project footprint, as shown in Figure 7-29. In addition to the location, Table 7-51 shows basic morphometric data and flow rates collected since 2013.

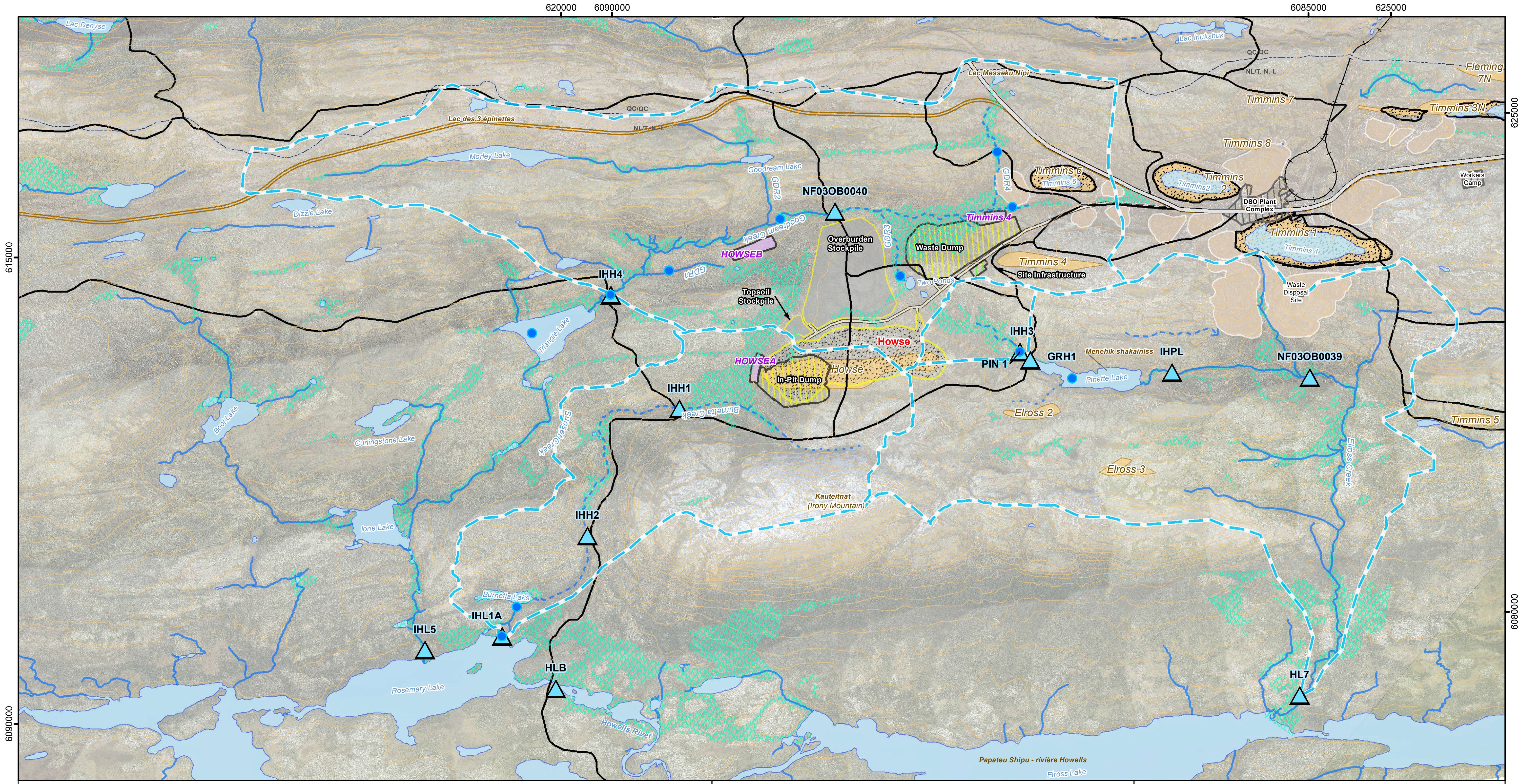
Compared to larger watercourses like Howells River, smaller watercourses like Burnetta Creek or PIN1 dry up in winter or summer.

Table 7-51 Local Hydrometric Stations and Stream Dimensions

STATION (WATER BODY)	TYPE (OPERATIONAL DATE)	COORDINATES (NAD83)		DRAINAGE AREA	WETTED WIDTH*	MEAN WATER DEPTH*	FLOW RATE (M^{3}/S)**	
		LATITUDE	LONGITUDE	(KM^{2})	(M)	(M)	MIN.	MAX.
Current Project (Volume 2 Supporting Study I)								
IHH1 (Burnetta Creek Upstream)	Instantaneous (2013-2014)	54.91743	-67.16064	2.72	2.00	0.097	0	0.011
IHH2 (Burnetta Creek Midcourse)	Instantaneous (2013-2014)	54.91797	-67.17927	4.65	0.97	0.056	0	0.001
IHH3 (Pinette Lake Inflow)	Instantaneous (2013-2014)	54.89796	-67.12312	0.66	0.35	0.031	0	0.003
IHH4 (Goodream Creek)	Instantaneous (2013-2014)	54.92791	-67.15383	13.65	3.13	0.236	0.397	0.703
ELAIOM Project (WRE, 2013)								
NF03OB0039 (Elross Creek)	Near real-time (>2011)	54.87750	-67.09972	n.d.	n.d.	n.d.	Stage	Stage
NF03OB0040 (Goodream Creek)	Near real-time (>2011)	54.91750	-67.12389	n.d.	n.d.	n.d.	Stage	Stage
Taconite Project (SNC-Lavalin, 2013)								
HLB (Howells River bridge)	Recording (2010-2011)	54.91089	-67.20390	250.0	14.50	0.776	1.42	22.5
HL7 (Elross Creek near Mouth)	Recording (2010-2011)	54.86150	-67.13702	16.15	2.75	0.287	0.12	0.26
IHL1A (Burnetta Creek near mouth)	Instantaneous (2011-2014)	54.91717	-67.20282	5.81	9.00	0.158	0.26	0.86
IHL5 (Sunset Creek near mouth)	Instantaneous (2011)	54.92154	-67.21140	28.80	6.20	0.228	1.58	1.69

*: As measured at the higher observed stage when gauging

**: Minimum or maximum flow rate can be instantaneous or mean daily records



LEGEND

Survey

△ Hydrometric Station

● Water Quality Station

Infrastructure and Mining Component

- Proposed Howse Pit
- Proposed Topsoil/Overburden Stockpile
- Proposed Site Infrastructure
- Proposed In-Pit Dump/ Waste Dump
- Proposed and existing Sedimentation Pond
- DSO Haul Road
- Mine Haul Road
- Existing Railroad
- Existing Dump
- Existing Pit
- Deposit
- Elross Lake Area Iron Ore Mine (ELAIOM) Plant Infrastructure Footprint

Basemap

- Permanent Watercourse
- Intermittent Watercourse
- Storm Runoff
- Disappearing Stream
- Artesian Spring
- Water Body
- Wetland
- Watershed Boundary
- Contour Line (50 ft)
- Provincial Border
- Existing Road
- Main Access Road

*Hydronyms are oriented along the direction of water flow

FILE, PROJECT, DATE, AUTHOR:
GH-0576 , PR185-19-14, 2016-03-22, edickoum

N

0 500 1 000 1 500 2 000

Meters

UTM 19N NAD 83

SCALE: 1:35 000

SOURCES:
Basemap
Government of Canada, NTDB, 1:50,000, 1979
Government of NL and Government of Quebec,
Boundary used for claims
SLE, AMEC and GHI (October 2012). LabMag and Kémag Iron Ore
Projects 2012 Mine Site Aquatic Program Field Report.
Groupe Hémisphères, Hydrology, Wetland, 2013.

Infrastructure and Mining Components
New Millennium Capital Corp., Mining sites and roads
Howse Minerals Limited/
MET-CHEM, Howse Deposit Design for General Layout, 2015

Surveys
SNC-Lavalin (May 2013) Taconite Project LabMag
Mine Site 2012 Hydrology Field Report. Final Report
done in collaboration with Groupe Hémisphères and
AMEC for New Millennium Iron/TATA Steel, 25 pages
and 5 appendices.

ENVIRONNEMENTAL IMPACT ASSESSMENT
HOWSE PROPERTY PROJECT

Hydrography and Hydrology
Water Quality

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Figure 7-29

Table 7-52 Goodream Creek Natural Inflow at Junction with Timmins 4 Sedimentation Pond 3 Outflow (316 ha)

MONTH	SNOWFALL [M³]	RAINFALL [M³]	INFILTRATION [M³]	NET RUNOFF [M³]	EVAPO-TRANSPIRATION [M³]	INFLOW [M³]	INFLOW [L/S]
Jan	141,337	0	0	0	0	0	0.0
Feb	116,175	330	0	330	0	330	0.1
Mar	140,404	1,219	0	1,219	0	1,219	0.5
Apr	143,454	15,101	0	15,101	0	15,101	5.8
May	74,514	88,527	0	1,213,971	0	1,213,971	453.2
Jun	11,399	219,038	138,262	92,175	92,175	0	0.0
Jul	0	319,818	191,891	127,927	108,319	19,608	7.3
Aug	1,739	301,660	182,040	121,360	77,371	43,989	16.4
Sep	30,733	255,297	171,618	114,412	50,844	63,568	24.5
Oct	148,195	89,629	0	89,629	0	89,629	33.5
Nov	205,982	8,337	0	8,337	0	8,337	3.2
Dec	155,384	520	0	520	0	520	0.2
Year	**1,169,316**	**1,299,476**	**683,811**	**1,784,981**	**328,709**	**1,456,273**	**46.2**

Table 7-53 Goodream Creek Natural Inflow at Junction with HOWSEB Outflow (1,068 ha)

MONTH	SNOWFALL [M³]	RAINFALL [M³]	INFILTRATION [M³]	NET Runoff [m³]	EVAPO-TRANSPIRATION [M³]	INFLOW [M³]	INFLOW [L/S]
Jan	477,942	0	0	0	0	0	0.0
Feb	392,854	1,117	0	1,117	0	1,117	0.5
Mar	474,787	4,124	0	4,124	0	4,124	1.5
Apr	485,101	51,064	0	51,064	0	51,064	19.7
May	251,973	299,359	0	4,105,130	0	4,105,130	1,532.7
Jun	38,546	740,691	467,542	311,695	311,695	0	0.0
Jul	0	1,081,488	648,893	432,595	366,290	66,305	24.8
Aug	5,882	1,020,086	615,581	410,387	261,636	148,752	55.5
Sep	103,925	863,306	580,339	386,893	171,932	214,961	82.9
Oct	501,130	303,085	0	303,085	0	303,085	113.2
Nov	696,542	28,193	0	28,193	0	28,193	10.9
Dec	525,441	1,758	0	1,758	0	1,758	0.7
Year	**3,954,124**	**4,394,271**	**2,312,354**	**6,036,040**	**1,111,552**	**4,924,488**	**156.2**

Table 7-54 Burnetta Creek Natural Inflow at Junction with HOWSEA Outflow (83 ha)

MONTH	SNOWFALL [M³]	RAINFALL [M³]	INFILTRATION [M³]	NET RUNOFF [M³]	EVAPO-TRANSPIRATION [M³]	INFLOW [M³]	INFLOW [L/S]
Jan	37,192	0	0	0	0	0	0.0
Feb	30,570	87	0	87	0	87	0.0
Mar	36,946	321	0	321	0	321	0.1
Apr	37,749	3,974	0	3,974	0	3,974	1.5
May	19,608	23,295	0	319,446	0	319,446	119.3
Jun	2,999	57,638	36,382	24,255	24,255	0	0.0
Jul	0	84,157	50,494	33,663	28,503	5,160	1.9
Aug	458	79,379	47,902	31,935	20,360	11,575	4.3
Sep	8,087	67,179	45,160	30,107	13,379	16,727	6.5
Oct	38,996	23,585	0	23,585	0	23,585	8.8
Nov	54,202	2,194	0	2,194	0	2,194	0.8
Dec	40,888	137	0	137	0	137	0.1
Year	**307,695**	**341,946**	**179,939**	**469,702**	**86,497**	**383,205**	**12.2**

Table 7-55 Pinette Lake Outlet Natural Inflow (237 ha)

MONTH	SNOWFALL [M³]	RAINFALL [M³]	INFILTRATION [M³]	NET RUNOFF [M³]	EVAPO-TRANSPIRATION [M³]	INFLOW [M³]	INFLOW [L/S]
Jan	106,070	0	0	0	0	0	0.0
Feb	87,186	248	0	248	0	248	0.1
Mar	105,370	915	0	915	0	915	0.3
Apr	107,659	11,333	0	11,333	0	11,333	4.4
May	55,921	66,437	0	911,055	0	911,055	340.1
Jun	8,554	164,382	103,762	69,175	69,175	0	0.0
Jul	0	240,016	144,009	96,006	81,291	14,715	5.5
Aug	1,305	226,389	136,616	91,078	58,065	33,013	12.3
Sep	23,064	191,594	128,795	85,863	38,157	47,706	18.4
Oct	111,216	67,264	0	67,264	0	67,264	25.1
Nov	154,584	6,257	0	6,257	0	6,257	2.4
Dec	116,612	390	0	390	0	390	0.1
Year	**877,542**	**975,225**	**513,183**	**1,339,584**	**246,688**	**1,092,896**	**34.7**

The following tables show the water balance results, after the construction of water management infrastructure, at a time near the end of the mine life.

Table 7-56 Goodream Creek Modified Inflow at Junction with Timmins 4 Sedimentation Pond 3 Outflow (304 ha)

MONTH	SNOWFALL [M^3]	RAINFALL [M^3]	INFILTRATION [M^3]	NET RUNOFF [M^3]	EVAPO-TRANSPIRATION [M^3]	PUMPING FROM PIT [M^3]	INFLOW [M^3]	INFLOW [L/S]
Jan	135,118	0	0	0	0	0	0	0.0
Feb	111,063	316	0	316	0	0	316	0.1
Mar	134,226	1,166	0	1,166	0	0	1,166	0.4
Apr	137,142	14,436	0	14,436	0	0	14,436	5.6
May	71,235	84,631	0	1,160,551	0	210,000	1,370,551	511.7
Jun	10,897	209,399	132,178	88,118	88,118	0	0	0.0
Jul	0	305,745	183,447	122,298	103,553	3,098	21,843	8.2
Aug	1,663	288,386	174,029	116,019	73,966	6,950	49,003	18.3
Sep	29,380	244,063	164,066	109,377	48,606	10,044	70,815	27.3
Oct	141,673	85,685	0	85,685	0	0	85,685	32.0
Nov	196,918	7,970	0	7,970	0	0	7,970	3.1
Dec	148,546	497	0	497	0	0	497	0.2
Year	**1,117,861**	**1,242,294**	**653,720**	**1,706,433**	**314,243**	**230,092**	**1,622,282**	**607**

Table 7-57 Creek Modified Inflow at Junction with HOWSEB Outflow (1162 ha)

MONTH	SNOWFALL [M^3]	RAINFALL [M^3]	INFILTRATION [M^3]	NET RUNOFF [M^3]	EVAPO-TRANSPIRATION [M^3]	PIT DEWATERING [M^3]	INFLOW [M^3]	INFLOW [L/S]
Jan	519,251	0	0	0	0	682,000	682,000	254.6
Feb	426,809	1,214	0	1,214	0	616,000	617,214	255.1
Mar	515,824	4,480	0	4,480	0	682,000	686,480	256.3
Apr	527,029	55,478	0	55,478	0	660,000	715,478	276.0
May	273,752	325,233	0	4,459,942	0	682,000	5,141,942	1 919.8
Jun	41,877	804,710	507,953	338,635	338,635	660,000	660,000	254.6
Jul	0	1,174,962	704,977	469,985	397,949	682,000	754,036	281.5
Aug	6,390	1,108,253	668,786	445,857	284,249	682,000	843,608	315.0
Sep	112,908	937,923	630,498	420,332	186,792	660,000	893,540	344.7
Oct	544,444	329,281	0	329,281	0	682,000	1,011,281	377.6
Nov	756,745	30,629	0	30,629	0	660,000	690,629	266.4
Dec	570,856	1,910	0	1,910	0	682,000	683,910	255.3
Year	**4,295,885**	**4,774,073**	**2,512,214**	**6,557,743**	**1,207,625**	**8,030,000**	**13,380,118**	**3,137**

Table 7-58 Burnetta Creek Modified Inflow at Junction with HOWSEA Outflow (143 ha)

MONTH	SNOWFALL [M³]	RAINFALL [M³]	INFILTRATION [M³]	NET RUNOFF [M³]	EVAPO-TRANSPIRATION [M³]	INFLOW [M³]	INFLOW [L/S]
Jan	64,448	0	0	0	0	0	0.0
Feb	52,974	151	0	151	0	151	0.1
Mar	64,022	556	0	556	0	556	0.2
Apr	65,413	6,886	0	6,886	0	6,886	2.7
May	33,977	40,367	0	553,552	0	553,552	206.7
Jun	5,198	99,878	63,045	42,030	42,030	0	0.0
Jul	0	145,832	87,499	58,333	49,392	8,941	3.3
Aug	793	137,553	83,007	55,338	35,280	20,058	7.5
Sep	14,014	116,412	78,255	52,170	23,184	28,986	11.2
Oct	67,574	40,869	0	40,869	0	40,869	15.3
Nov	93,925	3,802	0	3,802	0	3,802	1.5
Dec	70,853	237	0	237	0	237	0.1
Year							

Table 7-59 Pinette Lake Outlet Modified Inflow (228 ha)

MONTH	SNOWFALL [M³]	RAINFALL [M³]	INFILTRATION [M³]	NET RUNOFF [M³]	EVAPO-TRANSPIRATION [M³]	INFLOW [M³]	INFLOW [L/S]
Jan	102,266	0	0	0	0	0	0.0
Feb	84,059	239	0	239	0	239	0.1
Mar	101,591	882	0	882	0	882	0.3
Apr	103,798	10,926	0	10,926	0	10,926	4.2
May	53,915	64,054	0	878,380	0	878,380	327.9
Jun	8,248	158,487	100,041	66,694	66,694	0	0.0
Jul	0	231,407	138,844	92,563	78,376	14,187	5.3
Aug	1,259	218,269	131,717	87,811	55,983	31,829	11.9
Sep	22,237	184,723	124,176	82,784	36,789	45,995	17.7
Oct	107,228	64,852	0	64,852	0	64,852	24.2
Nov	149,040	6,032	0	6,032	0	6,032	2.3
Dec	112,429	376	0	376	0	376	0.1
Year	846,069	940,248	494,778	1,291,540	237,840	1,053,699	33.4

Dilution factor over the LSA and RSA

Solely based on increasing of drainage area, the effluent is rapidly diluted when progressing downstream. This hydrological phenomena is used to evaluate the effect of the mining effluent on other components such water quality and fish habitat. Table 7-60 show the dilution factor for the effluents for Construction and Operation phases, when the water leaves the LSA or the RSA.

Table 7-60 Dilution factor of the pond effluents over the LSA and RSA

WATERSHED	CONSTRUCTION PHASE	OPERATION PHASE
Burnetta Lake Outlet (LSA)	1 in 8.4	1 in 6.8
Triangle Lake Outlet (LSA)	1 in 8.4	1 in 4.8
Elross Lake (RSA)	1 in 124.7	1 in 96.9

Data Gaps

Water balance computations are based on climatological data from Environment Canada Schefferville A climate station (ID 7117823, 520.90 m asl, 2005-present).

7.3.9.2 Effects Assessment

Project Interaction with Water Budget and Potential Effects

Site Construction Phase

No potential interaction

During the site Construction phase, the following activities have no interaction with water budget:

- transportation and traffic;

At the beginning of mine construction, as the water table is deep, there will be no dewatering, so no effect on water budget is expected.

Potential interaction

- upgrading/construction of the Howse haul road and upgrading of the bypass road;
- pit development.

During the construction of infrastructure such as roads and pit development, some surficial modification might change the runoff path but the general topography will not be changed and the water budget should stay largely unchanged. On the other hand, removal of part of the overburden will likely intercept some runoff and lead to slight modifications of the water balance.

➔ The effect associated with the above potential interaction is the modification of the water budget reporting to specific locations along the creeks and water bodies surrounding the Howse Project.

The nature of the effect is direct and the effect is adverse.

Operation Phase

No potential interaction

The following activities do not have potential interaction with the water budget:

- blasting and ore extraction;
- mineral processing;
- transportation of ore and traffic;
- solid waste disposal;
- hazardous waste disposal;
- treatment of sanitary wastewater; and
- explosives management.

Potential interaction

- removal and storage of remaining overburden and topsoil;
- operation of waste rock dumps;
- pit development;
- dewatering; and
- ongoing site reclamation.

The removal and storage of the remaining overburden and topsoil, as well as the operation of waste rock dumps, have an effect on the water budget because the presence of those big stacks will modify natural site runoff. This will result in a modification of the water budget of the natural creeks and water bodies downstream from the mine site.

Dewatering has an effect on water budget because groundwater is discharged at the surface of the site, adding an important quantity of water to the natural watercourses (Section 3.1). The dewatering water will be discharged at a single point, adding a great amount of water at Burnetta Creek and Goodream Creek. The water budget downstream from this point will be modified through increased flows. On the other hand, the deepening and dewatering the pit will cause drying of the periphery of the pit; the source of creeks or wetlands can be altered by this interaction. The magnitude of this effect can be visualized in the hydrogeological component description (Section 7.3.9). The result is a change of the hydrography, by a reduction in the density of the watercourses. The only potential risk to level changes could have been Pinette Lake, but a water regime analysis reveals a non-significant change in stage over the years of operation, as, based on surface flow changes, the drawdown does not exceed 2 mm. The complete study is available in Volume 2 Supporting Study I). The addition of dewatering water may regulate the water regime of the receiving creek by reducing the magnitude of high and low flows during the year.

Ongoing site reclamation could reverse most of the effect on water budget if the drainage of the restored area can be diverted towards its original drainage path.

- ➔ The effect associated with the above potential interaction is the modification of the water budget reporting to specific locations along the creeks and water bodies surrounding the Howse project.

The nature of the effect is direct and the effect is adverse.

Decommissioning and Reclamation Phase

No potential interaction

The following activities do not have potential interaction with the water budget:

- demobilization of Howse facilities and heavy machinery;
- transportation and traffic.

Potential interaction

- final site reclamation.

With the final site reclamation, dewatering will be stopped. The final site reclamation will then largely reverse the effects on the water budget, which will tend to approach its original state. However, the water budget will never be exactly the same as it was before the Howse Project.

➔ The effect associated with the above potential interaction is the modification of the water budget reporting to specific locations along the creeks and waterbodies to approach its natural state.

The nature of the effect is direct and the effect is adverse.

7.3.9.3 Mitigation Measures

Standard mitigation measure

Table 7-61 presents the standard mitigation measures that will be applied for all phases. Even if water crossing were completely avoided in the footprint, standard mitigation measures are provide in case of necessity, like a possible bypass road.

Table 7-61 Standard Mitigation Measures for the Water Budget

CODE	MEASURE	MITIGATION EFFECT
Erosion and Sedimentation Control (ES)		
ES2	To follow the site's natural topography and prevent erosion, keep stripping, clearing, excavation, backfilling, and grading operations to a strict minimum on the work sites.	Limiting disturbance of the natural land will limit the effect on the natural water creeks, lakes and river
ES14	Along steep slopes bordering rights-of-way, use sediment barriers at the foot of the embankment or install protective material (straw, wood chips or mats) directly on the slope to reduce the volume of sediments that are transported.	This measure will limit erosion and sediment transportation. Furthermore, it will promote infiltration.
Watercourse Crossings (WC)		
WC1	Check whether a permit or authorization is needed for building watercourse crossings.	Proper permitting planification will allow for the regulation to be respected and deadline to be met.
WC6	Accurately assess the watercourse's peak flow in order to choose the appropriate diametre of pipe.	Avoiding overflow reduce the possibility that road material reaches waterbody and reduce erosion in the upstream portion of the culvert.
WC17	Install a culvert at least 45 cm in diameter.	This measure will prevent blockage with miscellaneous debris and flooding of the creek or ditch
WC18	Maximum flow depth must not exceed 85% of the culvert's vertical clearance.	Proper design of the culvert will allow for optimal flow and prevent flooding and erosion in the creek or ditch

CODE	MEASURE	MITIGATION EFFECT
WC21	Do not block the flow of water and respect the slope, natural drainage of the soil and direction of the watercourse when installing a culvert.	Proper installation of culvert will limit disturbance of the natural flow
WC27	Monitor culverts and bridges periodically, especially in the spring or after heavy rains. Pay particular attention to signs of erosion, poor plant regrowth, obstacles blocking water flow and structural integrity.	Good monitoring will prevent damage of the infrastructure and erosion in the ditch or creek
Waste Management (WM)		
WM3	Do not dump any waste into aquatic environments, including waste from cutting vegetation or stripping the soil. All waste accidentally introduced into aquatic environments must be removed as quickly as possible.	In addition to degrading the quality of the water, waste can cause jams in the flow of water, and erosion. This measure will prevent all of these negative environmental effect.
Drilling and Blasting (DB)		
DB4	The manufacturer’s instructions must be followed to ensure that blasting procedures are safe both for humans and the environment.	These measures will preserve the water quality from any deleterious forms of nitrogen contamination in surface or groundwater
DB9	No explosive must be used in or near water.	This measure preserve global water quality of the LSA natural water bodies
DB16	Use multiple detonators in bore holes as per the manufacturer’s recommendations and optimize the arrangement of blasting holes to minimize misfires.	This measure preserves quality of the water for direct or indirect contamination from deleterious form of nitrogen
DB19	Use reliable triggering systems that allow for precise firing of the explosives.	These measures increase blasting efficiency and therefore reduce the explosive residues concentration in sump water
Construction Equipment (CE)		
CE6	No machinery must circulate in the riparian strip unless regulations permit it.	As long as the littoral of the crossing remains intact, erosion cannot begin. Furthermore, it will ensure infiltration of possible run off.
Water Management (H2OM)		
H_2OM2	Re-use of waste water from mining operations will be encouraged.	This measure will limit the use of fresh water and limit the variation of the natural water balance of the LSA.
H_2OM6	At the end of restoration work, implement the surface water and groundwater monitoring programme.	If water quality does not improve after mining operations, find the source of the problem and correct the situation
Rehabilitation (R)		
R1	Follow good practices presented in the rehabilitation plan.	Most of the good practice are already proven methods that help reducing modification of natural water balance
R2	Draw up a rehabilitation plan	A rehabilitation plan will ensure that the final situation is brought back the most possible to initial condition

Specific Mitigation Measures

Table 7-62 presents the specific mitigation measures to which the Proponent is committed and will be applied to reduce the significance of the effects on water budget.

Table 7-62 Specific Mitigation Measures for Water Budget

SPECIFIC MITIGATION MEASURES FOR WATER QUALITY	
Measure	**Mitigation Effect**
Riprap will be installed on both sides of Burnetta Creek from the discharge point to 600 m downstream	Riprap will be installed within Burnetta Creek littoral and lower shore up to where water flow increase is expected to stay below 20%, thereby nearly eliminating erosion risks in that stream (see the next section Methodological Approach used to Assess this Component for more details).

7.3.9.4 Residual Effects Significance Assessment

The overall methodological approach to assess the environmental effects is presented in Section 5. However, in order to apply this methodology to the water budget VC, it is essential to consider assessment criteria applicable specifically to this VC (Table 7-63).

In order to understand the context in which this component is affected, it is important to describe its ecological context and resilience. Ecologically, most of the water bodies potentially affected by water regime changes are of low ecological importance. Indeed, water regime changes will mainly affect adjacent watercourses (Burnetta and Goodream Creeks) Therefore, since Burnetta Creek dose not shelter fish, only Goodream Creek is ecologically sensitive to those water regime changes. Moreover, the scale of water regime changes significantly reduces with increasing distance from the project and insignificant effects are expected once we reach downstream lakes.

Table 7-63 Assessment Criteria Applicable for Water Budget

TIMING		
Inconsequential timing	**Moderate timing**	**Unfavorable timing**
Timing of discharge makes it so that there are insignificant environmental effects	Timing of discharge makes it so that there are low significant environmental effects	Timing of discharge makes it so that there are large significant environmental effects
GEOGRAPHIC EXTENT		
Site specific	**Local**	**Regional**
Howse project footprint	LSA delineated in Section 7.3.9.1	Higher portion of the Howells River potentially disturbed by the Howse Project
DURATION		
Short	**Medium**	**Long**
Less than 12 months. Limited to the Construction and/or Decommissioning and Reclamation phase.	12-24 months. Extends beyond the Construction phase, but shorter than the lifespan of the Project.	More than 24 months Or long as the Project duration
REVERSIBILITY		
Reversible	**Partially reversible**	**Not reversible**

Full restoration of pre-development situation likely.	Partial restoration of pre-development situation likely.	Little/no restoration of pre-development situation likely.
MAGNITUDE		
Low	**Moderate**	**High**
The spring monthly maximum flow will increase less than 20% (Stephens, 2002). The hydrography will not change significantly, only the intermittent character of watercourses will be accentuated	The spring monthly maximum flow will increase more than 20% but less than 50% (Stephens, 2002). The hydrography will change significantly: upstream of watercourses will drying-out but waterbody will remains permanent.	The spring monthly maximum flow will increase more than 50% (Stephens, 2002). The hydrography will change dramatically: upstream of watercourse and waterbody will all dry up.
FREQUENCY		
Once	**Intermittent**	**Continual**
One time	Occasional or intermittent	Year round

Site Construction Phase

Timing

There are two scales to consider for timing. First, there is the annual timing. Discharge will mainly take place in the spring, at snow melt. Therefore, most of the flow increase will occur when the river banks are still frozen, which will considerably reduce erosion stress. Secondly, there is the long time scale in which the dewatering of the pit will occur only throughout the last years of the project as the groundwater table will not be reached before a few years. Since, significant effect on water regime are not expected in the first years, timing is considered **inconsequential** for this phase (Value of 1).

Geographic extent

The water budget modification will be restricted to the creeks and water bodies located directly downstream from the infrastructure construction site (**local**). Farther than that, the difference in water budget will become insignificant. (Value of 2)

Duration of the effect

The area excavated prior to pit development will not be filled, at least for the entire duration of the project (**long**). (Value of 3)

Reversibility of the effect

At the end of construction activities, natural water balance of the streams will not have returned to its original state (**partly reversible**). (Value of 2)

Frequency

Runoff only during the spring and summer period, and no runoff during winter (**intermittent**). (Value of 2)

Magnitude

Changes in water budget during the Construction phase will be limited. There will be no dewatering at this phase, limiting the effect on water budget. During the Construction phase, perceptible effects are not expected on environmental integrity, component quality or human use related to water budget (**low**). (Value of 1)

7.3.9.4.1 Significance

Based on this assessment, the effects of the Howse Project on the Hydrography and Hydrology are expected to be non-significant.

Operation Phase

Timing

Significant effect on water regime are expected as the pit gets deeper. Although ice cover in the spring will lower erosion impact on steam banks, lowering importance of the effects. Also, higher effects are expected in Burnetta Creek, but it is of lower ecological value as it does not shelter fish. Therefore, it is expected that there will be low but significant effect over the course of the project or **moderate timing** (Value of 2).

Geographic extent

The geographic extent of the effect is **local**, since the water budget modification will be restricted to the creeks and water bodies located directly downstream from the mine site. (Value of 2)

Duration of the effect

The duration of the effect is **long**, corresponding to the duration of the Howse project. (Value of 3)

Frequency

The frequency of the effect is **continual**, because the dewatering will be ongoing all year long once the water table depth is reached. As the water table is very deep, there will be intermittent dewatering until the pit reaches a certain depth. Continuous dewatering might start only a few years after the beginning of the operation. (Value of 3)

Reversibility of the effect

The reversibility of the effect is **partial**, because at the end of the operation of the Howse project, diches and sedimentation ponds will remain in place modifying slightly the natural flow path of the water in the footprint of the project. (Value of 2)

Magnitude

The magnitude of the effect is **moderate**, because the WMP will cause an increase of the spring monthly maximum flow more than 50% for Burnetta but less for other water bodies. Specific mitigation measures are planned for Burnetta that can lower down erosion to almost zero. Concerning hydrography, only the upstream watercourses have the possibility to know longer dry up period. (Value of 2)

Based on this assessment, the effects of the Howse Project on the Hydrography and Hydrology are expected to be significant, although the magnitude could be much lower as all scenarios were calculated as worse-case scenarios.

Decommissioning and Reclamation Phase

Timing

Throughout decommissioning, only natural water inputs will flow through the mine site and impact of the modified watersheds is expected only at freshet, but will be negligible. Timing is considered to be **inconsequential** for this phase (value of 1).

Geographic Extent

The geographic extent of the effect is **local**, since the water budget modification will be restricted to the creeks and water bodies located directly downstream from the infrastructure construction site. Farther than that, the difference in water budget will become insignificant. (Value of 2)

Duration of the effect

The duration of the effect is **long**, since the modification occurring during project restoration will be permanent. (Value of 3)

Frequency

The frequency of the effect is **once**, because once the site is rehabilitated, no other modification will affect the site over time. (Value of 1)

Reversibility of the effect

The reversibility of the effect is **partial**, because even after rehabilitation, the stockpiles and ditches will stay in place, continuing to modify slightly the original drainage layout of the site. (Value of 2)

Magnitude

The magnitude of the effect of stopping dewatering will be **low** when compared with the pre-operation state, as the water budget will tend to return to its original state, and there will be no perceptible effect on environmental integrity anymore. (Value of 1)

Based on this assessment, the effects of the Howse Project on the Hydrography and Hydrology are expected to be significant Significance of the Residual Effect

Residual effects are presented for the three watersheds affected by the construction of the Howse project. The water budget modifications represents either a flow increase and possible erosion or a reduction in flow. Erosion is estimated based on the spring monthly maximum flow, considering that an increase of 20% of the spring monthly maximum flow causes a significant hydrological change (Stephens, 2002).

Goodream Creek

The drainage area difference, between the existing (1068 ha) and the modified (1162 ha) Goodream Creek watershed, at the junction with HOWSEB outflow, is 94 ha. This represents an increase of approximately 9 % of the existing drainage area at this point, resulting in additional runoff downstream from sedimentation pond HOWSEB.

Pit dewatering will be treated in sedimentation pond HOWSEB, adding a constant discharge into Goodream Creek downstream from sedimentation pond HOWSEB as well. At this location, Goodream Creek is considered a permanent watercourse with fish habitat (HML, 2014c). The ditch planned on the southeast part of the Howse Project will intercept natural drainage flowing towards Goodream Creek. However, the release of approximately two third of Howse pit runoff into Timmins 4 sedimentation 3 will ensure that some water will be kept in this section of the creek.

Howse deposit water table was found to be between 64 and 90 m deep (Geofor, 2015 and Golder, 2014). Dewatering rate is expected to be lower during the first years of mining operations as, during this time, dewatering will be limited to water from direct precipitation and infiltration through the unsaturated geological units. Later, when pit depth reaches the water table depth, dewatering rate will increase gradually, and reach a maximum value when the pit reaches its final depth. Therefore, there will be no dewatering until the pit reaches a certain depth. Dewatering will be ongoing all year long once the water table depth will be reached. Goodream Creek spring monthly maximum flow, at the junction with sedimentation pond HOWSEB outflow, will increase by approximately 25%, corresponding to a low magnitude effect on erosion. However, Goodream Creek is surrounded by wetlands, which will have a buffering effect on flow. Also, Goodream Creek has a braided system of streams and canals where the water will spread.

Figure 3-7 shows a comparison of Goodream Creek watershed area at the outlet of Triangle Lake with Howse Project (1706 ha) and without Howse Project (1659 ha). There is a 3% (47 ha) increase of Triangle Lake drainage area with Howse. This is a small increase that will not generate any noticeable water level variation for Triangle Lake. Similarly, the average flow increase in Goodream Creek, due to Howse mine pit dewatering, will not effects noticeably Triangle Lake water level as this flow increase is small in comparison with existing natural flow variations during floods.

Burnetta Creek

The drainage area difference, between the existing (83 ha) and the modified (143 ha) Burnetta Creek watershed at the junction with HOWSEA outflow, is 60 ha. This represents an increase in the existing drainage area at this point, resulting in additional runoff downstream from the junction with sedimentation pond HOWSEA outflow.

Burnetta Creek does not host any fish habitat upstream from Burnetta Lake, which is located considerably downstream (>4 km) from this water release point. It is an intermittent creek with a relatively small natural flow. The bed is mainly made up of boulders but downstream, the last reach of 1.2 km before the lake, a proper channel could not even be found in some areas and the water flow is believed to be subterranean (Volume 2 Supporting Study I).

After the construction of sedimentation pond HOWSEA, a relatively large area of the Burnetta Creek watershed will be diverted. Rather than flowing naturally into Burnetta Creek some distance downstream from the junction with HOWSEA outflow, runoff from the diverted area will be collected then released sporadically. Consequently, spring monthly maximum flow will increase by approximately 72%, corresponding to a high effect on erosion.

However, the effects of the Howse project construction on Burnetta Creek is decreasing when the distance downstream from junction with HOWSEA outflow is increasing. When a point located approximately 600 m downstream from the junction with HOWSEA outflow is considered, the drainage area difference between actual and future conditions is only 36 ha. At this point, spring monthly maximum flow will increase by approximately 18 %, which corresponds to a low magnitude effects. Therefore, to keep the effects magnitude of Howse construction on Burnetta Creek low, this creek will be protected against erosion by a riprap on a distance of approximately 600 m downstream from junction with HOWSEA outflow as a specific mitigation measure.

Pinette Lake

Pinette Lake watershed will be reduced by 9 ha following Howse Project construction. This difference represents 4 % of the existing Pinette Lake watershed (237 ha) at the lake outlet.

The decrease in Pinette Lake inflow is very low. An inflow decrease is beneficial from an ecosystemic perspective, because an oligotrophic lake like Pinette Lake could benefit from a longer water renewal time. Concerning the water level change, a dedicated study was realized to simulate the difference in water regime between the natural and modified one. Because the weir at the outlet is very wide, the lake level varies little during a year. At the spring freshet, a drawdown of only 2 mm is expected while in summer and autumn no more than 1 mm is expected (Volume 2 Suppporting Study L).

7.3.10 Water Quality

It is important to the community that young Innu continue to have access the Howells River in the future. Furthermore, water quality - primarily water color - is a sensitive issue for local communities, who will avoid water bodies affected by changes in water quality or color, a statement that was clear during the public consultations, by both elders and younger users of the area. Further, water bodies provide habitat for aquatic life. For these reasons, this component was selected as a VC. Local and regional water quality data are available to properly assess the effects of the Howse Project on water quality, and federal and provincial criteria exists to quantify water quality.

Three lakes and two ponds are located within the LSA. Water quality is a concern for first nations people, namely in relation to overall water quality and fish habitat. This component was raised as an issue by first nations groups 10 times during consultations in the fall of 2014.

7.3.10.1 Component Description

LSA, RSA and Temporal Boundaries

The LSA is limited to the subwatersheds directly in contact with the Howse Project. The limits are the same as for the hydrology component and are shown in Figure 7-29. The LSA is limited to these watersheds because dilution factors are large enough within these limits to ensure the integrity of the surrounding receiving environment, since lakes act as decanters (Section 7.3.9). The Elross Creek watershed is not included in the LSA, since all efforts have been made to have zero effect on Pinette Lake, a tributary to Elross Creek. Therefore, it will not be directly affected by the Project. Further, the effects generated by the processing of ore at the DSO plant, which potentially effects Elross Creek, are covered in the ELAIOM EIS.

The RSA is composed of the larger surrounding watersheds, which encompasses the subwatersheds of the LSA until Elross Lake. This large watershed (335 km²) includes the entire Elross Creek watershed and the Ione Lake watershed, including Sunset and Goodream Creeks. The RSA includes all drainages coming from other projects in the area which could potentially interact and create cumulative effects.

The temporal boundaries for the water quality component includes up to 1 year after the end of the Howse Project Decommissioning and Abandonment phase, as based on observations from Dubreuil (1979) showing that water quality returned to normal after a few months of cessation of pumping at Fleming 3 (a close-by mine site). Additionally, capturing seasonal variations is fundamental to properly assess this component. During spring thaw, water flow is at its maximum and more mine water is expected to be discharged according to the WMP (Section 3.2.5), whereas in late summer and winter, streams are at their lowest flow, and sometimes even dry up because of the permeable nature of the surficial deposits and bedrock. In Labrador, dry ups mainly happen in winter because of the very long cold period with persistent snow (Rollings, 1997).

Existing Literature

Table 7-64 summarizes summertime water quality for 11 water bodies close to Schefferville approximately 25 years after the start of mining in the area. Burnt Lake and Hematite Lake were both receiving water pumped from mines at the time of sampling. Burnt Lake was so severely disrupted by mining that it had virtually no natural catchment, and the stream above it was actively eroding mine wastes that were encroaching on its banks (Drake, 1983). Lake-water concentrations of Ca and Mg ions were similar in each of the water bodies sampled and are consistent with what is expected for lakes with drainage basins associated with the mineral-rich rocks of the Labrador Trough (Penn, 1971). Dissolved oxygen in the lakes surrounding Schefferville ranges from 8 mg/L to 13 mg/L, and lakes are usually near oxygen saturation during the open-water period, even at maximum depth (Penn, 1971). Combined with the transparency that always exceed 5 m, it can be said that all lakes of the RSA are oligotrophic (cold water bodies with low nutrients and trout).

Table 7-64 Water Chemistry in the RSA or Nearby, Means (and SD), 1975-2003

WATER BODY	LOCATION	SAMPLING DATE	TEMPE-RATURE (°C)	PH	CA (mg/L)	MG (mg/L)	HCO_3 (mg/L)	SIO_2 (mg/L)
Knob Lake	Nearby	1975–1978	13.7 (3.7)	6.9 (0.3)	6.6 (0.5)	4.1 (0.8)	24.4 (4.4)	2.1 (0.9)
Burnt Lake*	Nearby	1975–1978	11.6 (1.7)	7.7 (0.3)	14.7 (4.4)	9.4 (0.9)	90.9 (15.5)	5.5 (1.8)
Hematite Lake*	Nearby	1975–1978	13.1 (2.0)	5.1 (0.1)	1.2 (-)	0.7 (-)	1.9 (1.7)	0.6 (0.1)
Hope Lake	Nearby	1975–1978	13.0	5.7	9.8	6.9	59.9	-
Gemini Lake	Nearby	1975–1978	15.6 (2.9)	8.2 (0.7)	11.5 (2.4)	7.3 (2.3)	75.4 (16.3)	4.3 (1.4)
Pinette Lake	LSA	1975–1978	14.0 (3.6)	5.8 (0.4)	1.2 (0.6)	0.7 (0.4)	5.1 (2.6)	2.0 (1.7)
Elross Lake	RSA	1975–1978	15.3 (2.8)	7.0 (0.5)	6.0 (1.6)	2.4 (0.4)	29.8 (8.7)	3.0 (1.1)
Ione	RSA	2003	12.8	7.49	3.65	2.20	-	-
Rosemary	RSA	2003	13.2	7.68	8.37	3.00	-	-
Fleming*	RSA	2003	11.9	7.75	8.34	2.89	-	-
Contact	RSA	2003	-	-	9.03	3.06	-	-

* Downstream of a mining effluent

In 2006, a survey of the Howells River basin was carried out by AMEC Earth & Environmental (2012). Surface water samples were collected from roughly 30 locations along the Howells River Valley, all included in the RSA. Results show that surface temperatures on lakes and ponds in early September ranged from 8.1 to 13.9 °C, pH level between 8.1 and 8.6, conductivity between 43 and 84 µmho/cm and dissolved oxygen 8.34 to 11.38 mg/L. The water was universally non-turbid (<1 NTU) and soft (hardness 20-60 mg/L; alkalinity 10-60 mg/L). Scruton (1984) reports that the dissolved minerals of water bodies on the Lakes Plateau (East of Schefferville area) has a mean value of 6.1 mg/L, placing these freshwater bodies among the purest in the world. Conductivity in Menihek Lake was measured as 31 µS/cm by Duthie and Ostrofsky (1974).

Recent Portrait of Water Bodies within the LSA

More recently, *in situ* surface water quality measurements were taken within the LSA in July and September 2008 for the ELAIOM project (AMEC, 2009). The Project's launch also required the installation of two near Real-Time Water Quality (RTWQ) monitoring stations which are now part of a provincial network partnership between the Water Resources Management Division (from Department of Environment and Conservation of NL Government), Environment Canada and various industries. Data from the RTWQ monitoring station NF03OB0040 extend back to 2012 and consist of around 3000 measurements annually. A 2014 aquatic survey technical report was completed to collect essential complementary water quality data to assess the effects of the Howse Project is presented in Volume 2 Supporting Study M. Also note that TSMC has ongoing monitoring of Goodream Creek and Pinette Lake. Up to date data from those recent studies are summarized in Table 7-65 and Table 7-66 and sampling stations can be located at Figure 7-29.

Table 7-65 Recent *In Situ* Surface Water Quality Measurements from the LSA, Minimum and Maximum Values

REACH/ SITE	WATERBODY LOCATION	DATE	TEMPER-ATURE	CONDUC-TIVITY	PH	TURBIDITY	DISSOLVED OXYGEN
			(°C)	(µS/CM)		(NTU)	(MG/L)
Goodream Creek	Close to Triangle Lake	2013	3.8 – 5.2	41 – 43	5.69 – 7.0	0.21	13.12
Burnetta Creek	At the road crossing	2013	6.4	6	5.39	0.45	10.59
Burnetta Lake	Burnetta Lake outflow	2015	-	50	7.0	0.20	-
GDR1	At the confluence with Goodream Creek	2013	3.8	41	5.7	-	13.12
GDR2	Close to Goodream Lake	2012	12.8	11	6.7	0.65	-
GDR3	Two Ponds outlet	2008*	9.3 – 14.1	1 – 14	5.7 – 7.2	13.10	-
GDR4	Middle of the reach	2009	9.7 – 14.4	0 – 13	5.3 – 5.4	0.19 – 0.36	-
Goodream Creek	Upstream from GDR4	2009	16.5	0 – 13	7.8 – 8.0	0.91 – 9.37	–
IHH4	Goodream Creek before Triangle Lake	2013	3.8	41	5.7	-	13.12
IHH1	Upstream from Burnetta Creek	2013	6.8	6	4.9	-	9.70
IHL1A	Downstream from Burnetta Creek	2013	6.0	5	5.9	0.45	11.50
NF03OB0040	Goodream Creek 2 km NW of Timmins 6	2012-2015	1.1 – 21.5	2 – 20	4.3 – 6.5	0 – 2,779***	5.14 – 13.30
PIN1/IHH3	Pinette Lake inflow	2008* to 2013	8.8 – 16.7	6 – 7	4.7 – 5.9	0.31 – 0.62	6.90 – 10.38
Pinette Lake	Pinette Lake center	2013	12.7	4	6.8	-	10.38
Triangle Lake	Triangle Lake center (RSA)	2013	8.8	34	6.3	-	12.46

*: Two samplings, one in July and one in September

**: Over 3,000 readings

***: values over 1,000 are attributed to biofouling

Source: Volume 2, Appendices I and M; AMEC, 2009, Groupe Hémisphères 2013a, September 2013b and 2009b, RTWQ

Most of the *in situ* parameters measured (including dissolved oxygen, temperature, and conductivity) were consistent with good water quality. Conductivity was exceptionally low; the virtual absence of nutrients, salts or impurities in the water showed no correlation between the location of the sampling sites downstream or upstream from old mining activities. All of the water bodies within the ELAIOM project study area were acidic at one time or another during the sampling periods. The pH was quite low at the RTWQ station along Goodream Creek, as well as in the Pinette Lake inflow (PIN1) and the upstream portion of Burnetta Creek, two small watercourses close to the Howse deposit. The acidic value is likely due to the wetlands which partially cover their drainage area, since acidic forest and fen are the most extensive type of wetland, occupying about 12% of the LSA, as discussed in Section 7.4.2.

According to the RTWQ reports (NLDEC, 2012b; 2013b; 2014d) large turbidity spikes coincide with significant rainfall events and the subsequent rapid flow increases and values surpassing 1000 NTU are attributable to biofouling. Indeed, values reached over 2,700 NTU in 2012 and since 2013, whereas, it never exceeded 131 NTU. Other values are within relatively normal range.

Laboratory surface-water physico-chemical quality results are shown in Table 7-66. Surface water data for Goodream Creek is available from three recent field surveys (Groupe Hémisphères, 2013a; 2013b, and Volume 2 Supporting Study I). Combined, they provide a comprehensive overview of surface water quality in the LSA, and indicate that some parameters exceed CCME guidelines. Aluminium exceedances were detected for all watersheds, for iron in the Goodream and Pinette watersheds and for copper upstream of Goodream Creek. For aluminium, this phenomenon was observed by AMEC (2009) in about half the stations visited for the ELAIOM project, indicating that background values are naturally high for that parameter. However, it is noteworthy that values shown are for total concentration, meaning that water samples are not filtered before analysis. As such, the particulates affect the concentration values, and if the soil is particularly rich in metal, this will transpose to the water quality. The overall quality of the natural water for metals and conventional parameters is considered good. The water was soft (hardness 20-60 mg/L; alkalinity 10-60 mg/L) for most of the sites sampled, but particularly in Burnetta Creek, where the water is less alkaline.

Nevertheless, some RDLs were too high to confirm that the CCME guidelines were not exceeded by any of the parameters. However, if we consider the Metal Mining Effluent Regulation (MMER) guidelines, which are most likely to apply to this Project, the RDLs would be within acceptable limits. The first environmental effect monitoring cycle is currently being carried out (summer 2015) for the ELAIOM project and its report will provide information to improve the predictions of the expected environmental effects.

Table 7-66 Laboratory Surface Water Quality Results for the LSA

SURFACE WATER			CCME		RESULTS					
PARAMETER	UNIT	RDL[1]	GUIDELINES[2] AQUATIC LIFE	GOODREAM CREEK 2011-2014 (N=8)	GDR2 08-08-2012	PIN1/IHH3 2008-2014 (N=8)	BURNETTA CREEK 03-09-2013	GDR3 (TWO PONDS OUTLET) 10-09-2008	TRIANGLE LAKE 02-09-2013	BURNETTA LAKE 16-07-2015
Conventional										
Acidity ($CaCO_3$)	mg/L	10	—	-	41	41	<10	<10	10	-
Ammoniacal Nitrogen ($N\text{-}NH_3$)	mg/L	0.02	2.22[3]	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02
Bicarbonates (HCO_3 as $CaCO_3$)	mg/L	1	—	-	5	5	2	7	15	25
Chlorides (Cl)	mg/L	0.05	120	0.41	0.06	0.06	0.11	0.42	0.22	0.13
Fluorides (F)	mg/L	0.1	0.12	-	<0.1	<0.1	<0.1	<0.1	<0.1	-
Nitrate(NO_3^-) and Nitrite(NO_2^-)	mg/L	0.02	—	0.29	<0.02	<0.02	<0.02	0.28	0.11	<0.02
Sulfates (SO_4)	mg/L	0.5	—	1	1.7	1.7	<0.5	2.5	2.2	2.6
Suspended Solids (TSS)	mg/L	2	Narrative[4]	0.3	<2	<2	5	19	3	<2
Total Alkalinity ($CaCO_3$) at pH 4.5	mg/L	1	—	11	5	5	2	7	15	25
Total Hardness ($CaCO_3$)	mg/L	1	—	12	11	11	1.2	14	1.6	22
Total Phosphorus (P)	mg/L	0.003/0.01	oligotrophic 0.004-0.01	<0.003	<0.01	<0.01	-	<0.01	-	<0.01
True Color (sampled on 06-07-2014)	UCV	2	—	6	-	-	27	3	3	3
Metal (total)										
Aluminum (Al)	µg/L	10/30	100	<10-120	70	12-118	130	57	18	<10
Arsenic (As)	µg/L	1/2	5	<1	<2	-	<1	<1	<1	<1
Cadmium (Cd)	µg/L	0.02/1	$10^{(0.86(\log [CaCO_3])-3.2)}$	<0.2	<1	<0.02-0.129	<0.2	0.129	<0.2	<0.2
Calcium (Ca)	µg/L	300/500	—	300-2,300	1,900	300-569	<500	685	2,700	4,000
Copper (Cu)	µg/L	0.5/3	2	<0.5-1	<3.0	<0.5-1.9	<1.0	4	<1.0	<1.0
Iron (Fe)	µg/L	60/100	300	<60-310	100	60-1,080	220	1,640	75	<60

SURFACE WATER			CCME		RESULTS					
PARAMETER	**UNIT**	**RDL[1]**	**GUIDELINES[2]** **AQUATIC LIFE**	**GOODREAM CREEK 2011-2014 (N=8)**	**GDR2 08-08-2012**	**PIN1/IHH3 2008-2014 (N=8)**	**BURNETTA CREEK 03-09-2013**	**GDR3 (TWO PONDS OUTLET) 10-09-2008**	**TRIANGLE LAKE 02-09-2013**	**BURNETTA LAKE 16-07-2015**
Lead (Pb)	µg/L	0.1/1	1	<0.1	<1.0	<0.1	<0.50	<1.0	<0.50	<0.50
Magnesium (Mg)	µg/L	100/200	—	2.0-1300	1,400	180-291	290	195	2,300	3,000
Manganese (Mn)	µg/L	0.4/3	—	1-33	12	2.3-104	23	64	6.5	2.6
Mercury (Hg)	µg/L	0.02/0.1	0.026	<0.001-<0.1	<0.1	<0.01-<0.1	<0.10	<0.02	<0.10	<0.10
Molybdenum (Mo)	µg/L	0.05/30	73	<0.5-1	<30	<0.05-<2	<1.0	<2	<1.0	<1.0
Nickel (Ni)	µg/L	1/10	25	<1-<3.5	<10	<1-<2	<2.0	<1	<2.0	<2.0
Potassium (K)	µg/L	100/500	—	<100-330	<200	56-<100	<500	20	<500	<500
Radium (RA 226)	Becquerel/L	0.002	—	0.002	-	-	-	-	-	-
Selenium (Se)	µg/L	1/3	1	<1-<3	<1	<1-<3	<3.0	<1	<3.0	<3.0
Sodium (Na)	µg/L	100/500	—	610-820	300	390-820	<500	<500	580	740
Uranium (U)	µg/L	1/20	15	<1-<20	<20	<1-24	<1.0	<1.0	<1.0	<1.0
Zinc (Zn)	µg/L	5/7	30	<5-25	<5	<5	<7.0	8	<7.0	<7.0

[1] RDL, Reported Detection Limit; (RDL for Goodream/RDL for other stations when different)

[2] CCME (2007), Surface Water Quality Guidelines for the Protection of Aquatic Life

[3] The criteria for total ammoniacal nitrogen varies with temperature and pH; the most conservative value from the parameters measured in the field was used

[4] Clear flow: Maximum increase of 25 mg/L from background levels for any short-term exposure (e.g., 24-h period). Maximum average increase of 5 mg/L from background levels for longer term exposures (e.g., inputs lasting between 24 h and 30 d)

Aboriginal Traditional Knowledge

As identified in the summary of first nation concerns (Table 7-2), contamination of lakes and watercourses is a real preoccupation.

For local peoples, the red color of the water is associated with water bodies affected by the mining activities and that have a bad quality. Peoples will avoid exploiting the aquatic habitat were this phenomena occurs. It as to be said here that the red color in the RSA is mainly a consequence of the colloidal TSS, and not a dissolved substance that affect the true color of the water. Therefore, it has to be understood that assessment of the effect of TSS and associated mitigation measures are one and the same that would be applied to alleviate the red color problematic highlighted by first nations.

Data Gap

The extensive literature on water quality on the local and regional scale along with the detailed water quality information collected in the recent years provide a good portrait of the physico-chemical characteristics of the surface water of the LSA, and no significant data gap is believed to exist for this component.

7.3.10.2 Effects Assessment

Literature review and Current Studies Data Used to Assess the Potential Effect

The following water quality standards were used to assess environmental effect on water quality:

- CCME (2014)
- MMER (2002)

In addition to data collected in 2013 and 2014 (Table 7-65) for the Howse Project, the MMER environmental effect monitoring and the Newfoundland and Labrador monitoring, as per the certificate of approval for the ELAIOM project, provides information on the dynamics between water quality and mining operations. The Water Management Strategy (Section 3.2.5) also provides useful information on effluent quality and types of effluent treatments developed for the Howse Project. The ELAIOM project is adjacent to the LSA and composed of a similar iron deposit and was extracted by TSMC in the same manner as the Howse Project. Effluent quality measurements from ELAIOM are therefore very useful to assess the effect of Howse Project on water quality.

At a national scale, Environment Canada performed an assessment of the environmental effects monitoring data coming from all metal mines subjected to the MMER (Environment Canada, 2012). This metadata study summarized essential effluent and water quality data for the iron ore sector. A complementary metadata study was performed by Hatch for the Mine Environment Neutral Drainage (MEND) Program (Pouw *et al.*, 2014) This study identify best available technologies economically achievable (BATEA) to manage and control effluent from various types of metal mines in Canada, including for iron ore.

These standards, data and studies were selected because they are commonly used by the scientific community to assess the effects of metal mining projects on water quality and because they are recognised as reliable to protect the ecological and human health across Canada.

Project Interaction with Water Quality and Potential Effects Assessment

Site Construction Phase

During the site Construction phase, all project activities will have potential interaction with water quality.

Potential interaction

- upgrading/construction of the Howse haul road, bypass road and water management infrastructures;
- pit development; and
- transportation and traffic.

Construction will begin by setting up facilities dedicated to the management of drainage water as described previously in the WMP (Section 3.2.5). These water management facilities will intercept and treat runoff water from the entire Howse footprint. Further, basin dimensioning will allow particles as fine as 0.01 mm to settle for a design flood return period of 25 years.

Land clearing will induce runoff and has the potential to contaminate the nearby water bodies of all three watersheds of the LSA with TSS.

Potential water contamination may also occur at watercourse crossings during the excavation and installation of culverts and other structures. The road network will be upgraded according to rigorous design criteria which minimize the effects on watercourse crossings and manage suspended solids. These criteria are specified by DFO and are related to the sizing and position of the culvert.

Transportation and traffic will create dust that may reach nearby water bodies (Section 7.3.2), and hence increase the TSS concentrations in the water. However, the roads are at least 100 m from the closest watercourse, lowering contamination risks from this source. Furthermore, no lakes are included in the Air Quality Modelling Perimeter, where TPM (24 hours) may exceeds air quality standards. Outside this perimeter, neither TPM nor other parameters will exceeds quality standards in NL. It is, however, anticipated that the roads will be sprayed in dry weather to reduce dust. In evaluating the emission rates of particulates, it was estimated that spraying the roads regularly would reduce the production of dust emissions by 75% (Section 7.3.2).

Accidents and malfunctions can also potentially have an effect on water quality and it is treated in Section 6.4.

➔ The effect associated with the above potential interaction are due to water contamination by total suspended solids and accidental spills.

The nature of the effect is direct and the effect is adverse.

Operation Phase

No potential interaction

During the operation phase, all project activities will have potential interaction with water quality.

Potential interaction

- removal and storage of remaining overburden and topsoil;
- blasting and ore extraction;
- mineral processing;
- dewatering;

- operation of waste rock dumps;
- transportation of ore and other traffic;
- solid waste disposal;
- hazardous waste management;
- explosives waste management;
- sanitary waste management; and
- ongoing site restoration.

Although water bodies are located near the overburden stockpile and waste rock dumps (minimum distance being 60 m), the ditches of the WMP will intercept the runoff before reaching them. Further, the erodibility of waste rock from iron ore mines in Québec/Labrador is in the order of 30 t soil/ha per year (Ripley *et al.* 1996), as compared to more than 400 t soil/ha per year for most other kinds of waste rock generated by Canadian mines, thus reducing the risk of contamination by suspended solids and other contaminants (blasting residues, fuel/oil). The available geological knowledge (Section 7.3.5) indicates that the ore and waste rock generated by the Howse Project are already naturally leached and should therefore not leach further in the local environment. As discussed in Section 7.3.5.1, acid rock drainage issues are not expected, but water quality monitoring will be done by HML to tests for PH changes. Further, regular testing will be done on the waste rock and waste stockpile to monitor for acid in rocks. As a result of this monitoring (full details provided in Sections 9.1.3-9.1.5), HML will stockpile any problematic rock material separately. Moreover, according to Pouw *et al.* (2014), the Labrador Trough iron ore mine operations are non-acid generating and non-metal leaching, which is in accordance with a focused study completed for the Howse Project (Volume 2 Supporting Study H). Risks associated with acid rock drainage issues are therefore considered to be non-existent.

Hydrological changes caused by Howse operations will affect water quality as such: increase flow induces erosion and hence cause more TSS contamination. It is expected that the spring monthly maximum flow at Burnetta Creek will increase by 72% (Section 7.3.9.2). As for Goodream Creek, increases are more modest: 12% at the Timmins 4 Sedimentation Pond 3 discharge and 25% at Sedimentation Pond HOWSEB (Section 7.3.9.2). All sump and dewatering water will be discharged into Sedimentation Pond HOWSEB and ultimately into Goodream Creek. Fortunately, the water quality from peripheral wells at the Howse site is expected to be of very good quality (Volume 2 Supporting Study B), mixing with sump water before it is discharged in the environment.

Pouw *et al.* (2014) reviewed effluent quality control metadata (MMER data) coming from different iron ore mines operation and concluded that "the sole contaminant that is considered to be typical for iron ore operations based on the information reviewed is total suspended solids". Based on 10 years of data accumulated on iron ore mines through MMER, concentrations of TSS after settling treatment is always lower than 62 mg/L. The operation of the Howse Project is similar to the iron ore mining operation described in the Pouw *et al.* (2014) study. Additionally, it does not include the use of a concentrator, minimizing the risk of generating a large amount of colloidal TSS that could be problematic to remove using settling alone. Indeed, the water quality survey of the ELAIOM mining operation meets legislative requirements based on MMER (2002), except for TSS, which will therefore be the main parameter of concern as demonstrated in Section 3.2.5. The ELAIOM effluent TSS concentration in the water tested was above MMER criteria at spring freshets since 2013, although ongoing work in the sedimentation ponds might be to blame.

A study of the IOCC Fleming 3 mining area has shown that water pumped from mine pits is red and muddy, which affects sump water quality. Concentration of TSS in water pumped from the bottom of the pit varied from 8 to 2,100 mg/L (Mansikkaniemi, 1980). However, at approximately 5 m from the mouth of the water pipe, the mean grain size of bottom material was found to be 0.27 mm. From the foregoing that include the bottom of Red Lake, the deposits are medium and fine silt. The establishment of a WMP for the Howse Project comprising a large network of ditches and three sedimentation ponds will treat water for suspended sediments. However, TSS smaller than 0.01 mm are not expected to settle in sedimentation ponds and are still expected to flow in the receiving environment. The fact that Howse project effluent does not include processed water charged with very fine suspended solids coming from a concentrator (see above for more details), as it is the case for many other iron ore operations in the Labrador Trough Region, greatly reduces the risk of finding an important portion of TSS smaller than 0.01 mm.

Due to the type of erodible surficial deposits present within the Howse Project footprint, road runoff will be another source of water contamination to the water bodies during rain events and snow melt. However, the WMP is designed to intercept all this runoff.

The use of emulsion for explosives and machinery during ore extraction will leave nitrogen compounds (blasting residue), fine particulates and fuel/oil in the open pit. Once mixed with the sump water, these contaminants will be pumped to the surface. However, since the beginning of ELAIOM project, neither nitrates, nitrites nor hydrocarbons exceed CCME and MMER criteria. Therefore, no exceedance is expected for those parameters.

The Howse operations will generate dust that could reach nearby water bodies and increase TSS concentrations. Because dust concentration will be concentrated around pit and road (Section 7.3.2), and that the WMP will capture all runoff, the effects are expected to be negligible compared to other TSS sources (runoff and sump water).

All types of dangerous and domestic wastes will be transported to the DSO complex facilities, where they will be treated as described in Section 3.3.2.

Finally, ongoing restoration will have a positive effect by reducing runoff on waste dump and overburden stockpile.

- ➔ The effect associated with the above potential interaction derives from water contamination by total suspended solids and accidental spills.

The nature of the effect is direct and the effect is adverse.

Decommissioning and Reclamation Phase

No potential interaction

During the decommissioning and reclamation phase, all project activities will have potential interaction with water quality.

Potential interaction

- demobilization of Howse facilities and heavy machinery;
- transportation and traffic;
- final site restoration.

Runoff will continue to be generated throughout this phase, but effect will decrease substantially after cessation of pumping and will further decrease with revegetation of Howse footprint. Water quality has been shown to return to normal after a few months of cessation of pumping at Fleming 3 mine site in old IOCC Schefferville operations (Dubreuil, 1979).

Facility demobilization, transportation and traffic will continue to generate dust in the same way as presented in the operation phase subsection.

As stated in Section 7.3.9.2, water regime should nearly return to previous levels and erosion associated with spring flow will decrease accordingly.

- ➔ The effect associated with the above potential interaction derives from water quality contamination by total suspended solids and accidental spills, although improved water quality is expected following final site restoration.

The nature of the effect is direct and the effect is adverse.

7.3.10.3 Mitigation Measures

Standard Mitigation Measures

Table 7-67 presents the standard mitigation measures that will be applied during all project phases. Please note that no water crossings are planned in the Howse project selected alternative, but that standard mitigation measures for water crossings are included in Table 7-67, in case of a unpredictable change.

Table 7-67 Standard Mitigation Measures for Water Quality

CODE	MEASURE	MITIGATION EFFECT
Watercourse Crossings (WC)		
WC2	Arched culverts must be installed at all watercourse crossings where potential or confirmed fish habitat is present.	This will prevent erosion as the littoral of the crossing will remain intact.
WC3	Keep the scale and duration of work in the water to a minimum and confine the work to minimum-flow or low-water periods.	This measure will limit the amount of erosion generated during water crossing construction activities.
WC5	Build bridges and install culverts on narrow, straight sections without reducing the width of the watercourse, choosing ground with adequate load-bearing capacity and gentle slopes. Build them as far as possible from watercourse mouths or confluences.	Reducing imprint on shoreline maintains a natural protection from erosion.
WC6	Accurately assess the watercourse's peak flow in order to choose the appropriate diameter of pipe.	Avoiding overflow reduce the possibility that road material reaches waterbody and reduce erosion in the upstream portion of the culvert.
WC9	Build crossings perpendicular to the watercourse.	Reducing imprint on shoreline maintains a natural protection from erosion.
WC10	Use existing road crossings, cleared strips or paths as far as possible to avoid disturbing riparian vegetation.	
WC12	Preserve plant cover and stumps in road rights-of-way.	
WC14	Before starting work, confine the work area with a silt or filter fence	This measure avoid sediment transport into water and ensure that work methods and materials used do not generate excessive turbidity.
WC16	When building a bridge or installing a culvert in an area without fish habitat, do not reduce the width of the watercourse more than 20% (measured from the natural high-water mark).	These measures will prevent road material from reaching the river.

CODE	MEASURE	MITIGATION EFFECT
WC19	Ensure the stability of soil, shorelines, banks, fill and structures during the construction of watercourse crossings (geotextile liner, rip-rap on embankments and watercourse bed, etc.)	
WC21	Do not block the flow of water and respect the slope, natural drainage of the soil and direction of the watercourse when installing a culvert.	These measures will ensure that erosion will not occur downstream the culvert.
WC22	Backfill around the culvert and stabilize the fill. The end of the culvert must extend at least 30 cm beyond the base of the fill.	
WC23	The base of the culvert must be buried beneath the natural bed of the watercourse to a depth equivalent to 10% of the culvert's height. Maximum burial depth must not exceed 30 cm, however, or a bottomless arched culvert must be used.	
WC25	All temporary structures must be stabilized upstream and downstream and demolished when the work is finished.	These measures will reduce sediment transport into water and ensure that erosion not begin downstream of working zones.
WC26	Once work is finished, restore the bed of the watercourse to its natural profile, stabilize the banks and revegetate as needed with native species.	
WC27	Monitor culverts and bridges periodically, especially in the spring or after heavy rains. Pay particular attention to signs of erosion, poor plant regrowth, obstacles blocking water flow and structural integrity.	This measure made sure to prevent the road material from reaching the river.
Waste Management (WM)		
WM3	Do not dump any waste into aquatic environments, including waste from cutting vegetation or stripping the soil. All waste accidentally introduced into aquatic environments must be removed as quickly as possible.	In addition to degrading the quality of the water, waste can cause jams in the flow of water, and erosion. This measure will prevent all of these negative environmental effects.
Hazardous Materials Management (HM)		
HM1	Implement a hazardous waste management plan in the event that fuel or other hazardous substances are spilled.	These measures will preserve water quality from direct or indirect hydrocarbons or other hazardous substances contamination.
HM3	Spill kits for recovering oil products and hazardous materials must be present on the worksite at all times.	
HM4	Each vehicle and piece of machinery on the site must contain enough absorbent materials to intervene rapidly in the event of a spill. A list of materials and intervention methods to be used in the event of a spill must be approved by the supervisor.	
HM5	All accidental spills must be reported immediately to the person in charge of the emergency response plan, which will have been drawn up and approved before work start-up.	These measures will ensure that swift action done by trained individuals is taken in case of accidental spills.
HM6	If harmful substances are spilled, the responsible authority must be contacted.	
HM9	If hazardous materials are spilled, the contaminated areas must be marked and the surface layer removed for disposal in accordance with regulations in effect in order to limit contamination of waterbodies by runoff. Contaminated areas must be backfilled and stabilized to permit revegetation.	These measures will preserve water quality from direct or indirect hydrocarbons or other hazardous substances contamination.

CODE	MEASURE	MITIGATION EFFECT
HM12	When a site is closed, ensure that all tires have been removed and properly disposed of.	
Drilling and Blasting (DB)		
DB1	An explosives management plan must be drawn up to minimize the amount of ammonia and nitrates released into the natural environment.	These measures will preserve the water quality from any deleterious forms of nitrogen contamination in surface or groundwater.
DB4	The manufacturer's instructions must be followed to ensure that blasting procedures are safe both for humans and the environment.	
DB9	No explosive must be used in or near water.	This measure preserve the global water quality of the LSA natural water bodies.
DB13	Water left after drilling must be blown out using compressed air before the pneumatic loading of the ANFO.	These measures increase blasting efficiency and therefore reduce the explosive residues concentration in sump water.
DB14	Depending on blasting conditions, the explosives used can greatly affect the overall quantity of explosives waste, so it is important to choose the appropriate type of explosive.	
DB15	Explosives waste must be recovered and disposed of in an appropriate manner after each blast.	This measure preserve the quality of the water for direct or indirect from deleterious form of nitrogen.
DB16	Use multiple detonators in bore holes as per the manufacturer's recommendations and optimize the arrangement of blasting holes to minimize misfires.	These measures increase blasting efficiency and therefore reduce the explosive residues concentration in sump water.
DB17	To minimize explosives waste, minimum distances between collars and charges must be determined for all underground blasting charges, based on geological conditions and the application.	
DB18	Prevent misfires by establishing time delay blasting cycles as per the explosives manufacturer's recommendations.	
DB19	Use reliable triggering systems that allow for precise firing of the explosives.	
Construction Equipment (CE)		
CE1	Store all equipment and machinery in areas specifically designed for this purpose, particularly parking, washing and maintenance areas. These zones must be located 60 m or more from watercourses and waterbodies.	These measures will preserve water quality from direct or indirect hydrocarbons contamination.
CE2	Washing of equipment in aquatic environments is prohibited.	This measure preserve the global water quality for all LSA natural water bodies.
CE4	Construction equipment must be delivered to the site in good working order, without leaks and equipped with all emissions filters required to comply with emissions regulations and reduce noise disturbance. The equipment must be regularly inspected to detect any leaks or mechanical defects that could lead to fuel, lubricant or hazardous material spills.	These measures will preserve water quality from direct or indirect hydrocarbons contamination.
CE5	Fuel-related operations (storage, transportation and handling) must comply with the relevant standards and guidelines. All equipment must be refuelled more than 15 m from a waterbody.	

CODE	MEASURE	MITIGATION EFFECT
CE6	No machinery must circulate in the riparian strip unless regulations permit it.	As the littoral of the crossing remains intact, erosion cannot begin.
CE9	All pumps and generators near waterbodies must be equipped with a drip pan.	These measures will preserve water quality from direct or indirect hydrocarbons contamination.
CE10	Inspect equipment at each use to detect leaks and drips. Any leaks must be repaired and reported immediately to the field supervisor.	
CE15	The dust-control liquid used must comply with GNL regulations.	This measure preserve the global quality of the water for natural water body.
Water Management (H$_2$OM)		
H$_2$OM5	Once mining operations are finished, but before restoration work begins, establish a surface water and groundwater monitoring programme approved by the competent authority and proceed with required sampling.	This method will ensure that if water quality does not improve after mining operations, the source and solution to the problem will be identified quickly.
H$_2$OM6	At the end of restoration work, implement the surface water and groundwater monitoring programme.	If water quality do not improve after mining operations, find the source of the problem and correct the situation
Rehabilitation (R)		
R1	Follow good practices presented in the rehabilitation plan.	Most of the good practices are already proven methods that help reducing water contamination
R2	Draw up a rehabilitation plan	
R3	Produce post-mining and post-rehabilitation monitoring reports.	This method will ensure that if water quality does not improve after mining operations, the source and solution to the problem will be identified quickly.

Specific Mitigation Measures

Table 7-68 present all specific mitigation measures applied to reduce the effects on water quality.

Table 7-68 Specific Mitigation Measures for Water Quality

SPECIFIC MITIGATION MEASURES FOR WATER QUALITY	
Measure	**Mitigation Effect**
Riprap will be installed on both sides of Burnetta Creek from the discharge point to 600 m downstream	Riprap will be installed within Burnetta Creek littoral and lower shore up to where water flow increase is expected to stay below 20%, thereby nearly eliminating erosion risks in that stream (Section 3.2.5 of the WMP for more details).
Divert sedimentation pond HOWSEA into the pit	This will avoid contamination of Burnetta Creek surface water from TSS generated by the peripheral ditches.

Note that at this stage, most of the design included in the WMP (Section 3.1.6) are also practices and measures carefully adapted to mitigate the environment concerns. This plan essentially target TSS to settle out before reaching the environment. Since smaller particles do not settle out fast enough, there will probably be some suspended solids discharged into the environment, but the Proponent has committed to applying chemical treatment if necessary. The complete description of this optional treatment is in the WMP (Section 3.1.5).

7.3.10.4 Significance of the Residual Effects

In order to assess the effects properly, a little ecological context is necessary. Hardness is extremely low in all water bodies of the LSA as shown in the component description, increasing bioavailability of contaminants for aquatic fauna. Buffer capacity is also low based on low alkalinity values in the water bodies of the area. However, water bodies are very far from their carrying capacity since they are all oligotrophic as indicated by very low nutrient concentrations and low primary productivity. Also, several other components depend on the integrity of the water quality such as aquatic fauna and herpetofauna. Based on limited knowledge of the effect of neighboring mining operations on water quality, the Howse Project is likely to increase TSS in the water bodies of the LSA. On the other hand, the water quality of the surface water in contact or flowing from IOCC past mining sites is largely good. Analysis of differences in metal concentration between sites upstream and downstream from the former IOCC DSO mine sites show no significant difference (NML and PFWA, 2009). All other parameters analyzed comply with the applicable requirements of the CCME.

Table 7-69 Assessment Criteria Applicable for Water Quality

TIMING		
Inconsequential timing	**Moderate timing**	**Unfavorable timing**
Timing of discharge makes it so that there are insignificant environmental effects	Timing of discharge makes it so that there are low significant environmental effects	Timing of discharge makes it so that there are large significant environmental effects
SPATIAL EXTENT		
Site specific	**Local**	**Regional**
Howse project footprint	LSA delineated in Section 7.3.10.1	RSA delineated in Section 7.3.10.1
DURATION		
Short	**Medium**	**Long**
Less than 12 months. Limited to the Construction and/or decommissioning and reclamation phase	12-24 months. Extends beyond Construction phase, but shorter than the lifespan of the Project	More than 24 months As long as the Project duration or even longer
REVERSIBILITY		
Reversible	**Partially reversible**	**Not reversible**
Water quality returns to pre-project levels	Surface water contamination persist after source of effect ceases, but its magnitude is significantly lower	Surface water contamination persist after source of effect ceases
MAGNITUDE		
Low	**Moderate**	**High**
Water quality in water bodies located within the LSA is barely or not affected by the Howse Project (all parameter below CCME guidelines)	Water quality in water bodies located within the LSA is affected by the Howse Project because results are sometimes above MMER authorized concentrations in the effluent but below CCME guidelines in the receiving environment	Water quality in water bodies located within the LSA is severely affected by the Howse Project because results are often above MMER authorized concentrations and sometimes above CCME guidelines in the environment

FREQUENCY		
Once	**Intermittent**	**Continual**
One time	Occasional or intermittent	Year round

Timing

There are two scales to take into account when considering timing. First, there is the annual timing. Discharge will mainly take place in the spring, at snow melt. Therefore, most of the discharge will occur while background water quality is at its worse due to natural erosion deriving from the extreme flow increase. Secondly, there is the long time scale in which the dewatering of the pit will occur only throughout the last years of the project, when the groundwater table will be reached. Since the main contaminant is TSS and it is expected to be naturally high in the spring, the importance of this impact is lowered. As for the long term timing, even if more mine water is discharged, the contaminant charge will stay the same and will therefore be more diluted.

As such, timing of the effect on water quality is considered to have a **moderate** effect on water quality (Value of 2).

Spatial Extent

TSS should sometime exceed the MMER criteria at the outfall of the sedimentation ponds (Section 3.2.5), and dilution will lower concentration under CCME criteria before exiting into the LSA. Using only the proportion of watersheds, dilution reach 1 in 8 at Burnetta Lake while it approach 1 in 5 at Triangle Lake (Section Hydrology 7.3.9). When further considering deposition and filtration by substrate and vegetation along the watercourses, no notifiable effects of the project on surface water quality is expected outside the LSA.

As such, the spatial extend of the Howse Project on water quality is not expected to extend to the RSA, and is therefore considered to be **local** (Value of 2).

Duration

Water quality will be negatively impacted from the beginning of the Construction phase up to the end of the Howse Project, and even after. TSS will be generated during construction and site preparation and are likely to reach WMP infrastructures. The effluent will flow periodically during the operation and decommissioning and reclamation phases. It will also flow after the Project ends but will eventually not be charged anymore with TSS. For this reason, the duration is considered to be **long** (Value of 3).

Reversibility

Water quality has been shown to return to normal after a few months of cessation of pumping at the Fleming 3 mine site in old IOCC Schefferville operations (Dubreuil, 1979), a similar mine site close to the LSA. Surface water quality contamination is therefore considered **reversible** (Value of 1).

Magnitude

Water quality in water bodies located within the LSA has high probability to be impacted by the Howse Project because similar conditions encountered for ELAIOM give effluent quality results above MMER criteria's for TSS. As discussed above, the TSS is a water quality parameter know to be difficult to control. However, the presence of wetlands in Goodream Creek will act as a filter, reducing the water contamination risk in Triangle Lake located downstream of the wetland complex. Burnetta Creek does not host a wetland complex, but most of the TSS reaching it will have time to settle before reaching Burnetta Lake located more than 4 km downstream. Water infiltration is also expected along watercourses, which represents the best water treatment for TSS in the absence of other contaminants.

Based on the maximum value of 62 mg/L after treatment providing by Pouw et al. (2014) and only considering dilution, maximum concentrations are not expected to exceed 7.4 mg/L in Burnetta Lake, well below MMER authorized monthly mean concentration (15 mg/L) and, most of the time, respecting the 5 mg/L increase allowed by CCME guidelines. Indeed, background levels of TSS are <2 mg/L in Burnetta Lake (Section WQ), but the value used for this calculation is the maximum concentration observed and will actually probably be lower. Additionally, the filtrating action of substrate and aquatic vegetation along the 4 km of intermittent streams will most certainly further reduce TSS content and make TSS exceedance sporadic or non-existent in Burnetta Lake.

Sump water will probably be heavily charged with TSS and some effects on fish and fish habitat are possible in that stream as well as in Triangle Lake. Indeed, using the same rationale as above, TSS concentrations in Triangle Lake are not expected to be above 12,9 mg/L, still under the MMER's authorized monthly mean concentration (15 mg/L), but sometimes above the CCME guidelines, when considering a natural TSS concentration of 3 mg/L. Nevertheless, concentrations should generally be lower than CCME guidelines. Then again, concentrations in Goodream Creek will often be higher than the MMER and CCME guidelines when there is an effluent flow (during spring freshet or heavy rain events).

For that reasons, the magnitude is considered to be **moderate** (Value of 2).

Frequency

The frequency is **intermittent**, since no contamination will occur during the winter months, as deep freeze prevents water runoff. Moreover, the effluent flows only during spring or during heavy rain events. The associated value is 2.

7.3.10.4.1 Significance

The great majority of the above assessment criteria's are of moderate order (most of the values are of 1 or 2, except for duration). When using the aggregation matrix presented in the methodology**, the overall effect of the Howse Project on water quality is expected to be non-significant (value of 12)**. The ELAIOM Project effluent TSS is known to be above MMER criteria for a short period of time in spring. No other ELAIOM Project MMER effluent parameters are above the criteria. Similar effluent quality should be expected for the Howse Project as the WMP uses similar water treatment techniques. As the dilution factor is very high when the effluent reach the Howells River (>1 in 50), the effect of the Howse Project on water quality is limited to the LSA. When comparing with Elross creek that has been a receiving environment for more than 40 years due to past IOCC and present ELAIOM Projects, the effect of the Howse Project effluent is not likely to cause the demise of the actual aquatic life in Goodream or Burnetta Creeks. For all these reasons, the effect of the Howse Project on water quality is considered **non-significant**.

Likelihood

Likelihood determination is not needed as the effect was determined non-significant.