Joyce Lake Direct Shipping Iron Ore Project:

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Chapter 12:

Groundwater Resources

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12.0 ENVIRONMENTAL ASSESSMENT – GROUNDWATER RESOURCES

As detailed in chapter 1, Joyce Direct Iron Inc. succeeded Labec Century Iron Ore Inc. ("Labec Century") as the Project Proponent on February 18, 2021 following an internal reorganization. All references to Labec Century as the Project proponent may be interpreted as now referring to Joyce Direct Iron Inc.

12.1 VC Definition and Rationale for Selection

Groundwater Resources include domestic, commercial, and industrial groundwater-source water supplies, and the groundwater component of freshwater ecosystems.

Groundwater is defined as the water held beneath the Earth's surface in the pores, fractures, crevasses, and seams of bedrock and overlying surficial materials. Groundwater originates from the percolation of rain, snowmelt, or surface water into the ground, flowing from areas of high elevation (i.e., recharge areas) to areas of low elevation (i.e., discharge areas), where it exits the sub-surface as springs, streams, lakes, and wetlands. The infiltrating water fills voids between individual grains in unconsolidated materials (collectively referred to as "overburden"), and fills fractures, pores, and voids developed in consolidated materials such as bedrock. The upper surface of the saturated zone is called the water table. An aquifer is defined as a saturated formation or group of formations that can store or transmit useable volumes of groundwater to wells or springs. .

Groundwater Resources refer specifically to the value and function of groundwater in supplying freshwater for human and light industrial or commercial uses and in maintaining stream flow for ecological habitat. Groundwater availability for ecological and human uses and its susceptibility to chemical degradation or depletion by human activities is determined by the hydrogeological and hydrochemical properties of the surficial and bedrock geology in which it is found.

Groundwater is an integral component of the hydrologic cycle that can interact with and indirectly affect freshwater resources and freshwater ecosystems at points of discharge. There is a dynamic interaction between Groundwater Resources and Water Resources (Chapter 11). Groundwater generally sustains the base flow of springs, streams, and wetlands during the frozen winter months and during dry periods of the year. More rarely, surface water bodies and perched wetlands can seasonally contribute to groundwater recharge and storage under specific hydrogeological conditions.

Groundwater Resources has been selected as a VC for environmental assessment to satisfy requirements under Section 4.22 of the Newfoundland and Labrador EIS Guidelines for the Joyce Lake Direct Shipping Iron Ore Project (the Project) because:

- Groundwater Resources can be an important concern for rural residents who might use groundwater from springs, dug wells or drilled wells as their potable water supply. Potential quantity or quality effects to Groundwater Resources, and specifically damage to domestic water supply wells, are common stakeholder concerns.

- Groundwater Resources are expected to provide potable water supply to specific components of the Project and rural un-serviced residences adjacent to the Project components. The potential for the disruption to or contamination of the groundwater drinking supply for both the mine operations and any nearby residents therefore requires assessment.

- Groundwater is an integral component of the hydrologic cycle, and an effect on Groundwater Resources can influence other VCs, including Water Resources (Chapter 11), Wetlands (Chapter 14), and Fish and Fish Habitat (Chapter 15); the effect of groundwater base flow on surface water flow rates and quality will be accounted for in the Water Resources VC (Chapter 11).

- Groundwater can be a critical seepage and contaminant transport pathway between the various Project components and adjacent surface water resources (e.g., waste rock, ore storage, petroleum, or chemical storage facilities, wastewater, and solid waste management sites). Conversely, water from surface water sources and permeable aquifers can be transmitted as groundwater towards Project components such as the open pit mine.

- The dewatering required for the operation of the open pit mine will be measurable in groundwater flows over a large radius from the mine, and can affect the yield of water supply wells, groundwater flow pathways, and surface water baseflow within the zone of influence.

- There are linkages between this VC and Chapter 19: Current Use of Lands and Resources for Traditional Purposes by Indigenous Persons, and Chapter 18: Historic and Cultural Resources

12.1.1 Approach to Assessment of Effects

The aim of the groundwater investigation is to develop a site-wide characterization of both the quality and quantity of the groundwater in the vicinity of the Project. The water levels, topographically-inferred flow directions and patterns, and the hydraulic properties of overburden and bedrock have been considered for an understanding of groundwater interactions with the Project (i.e. the pit dewatering), and how the Project might interact with the natural hydrogeological-hydrologic cycle.

A preliminary assessment of groundwater resources in the Local Study Area was undertaken by Stassinu Stantec in 2012. This assessment included a desktop review of available exploration drilling information provided by Labec Century (2011, 2012), and a week-long field program in October, 2012, that consisted of water-level monitoring at existing exploration boreholes and completion of three hydraulic tests and collection of three water chemistry samples from selected boreholes (Stassinu Stantec 2013).

Detailed hydrogeological investigations were carried out in 2014 by WESA concurrent with geotechnical investigations by LVM at the various mine components. A three-dimensional groundwater flow model (MODFLOW-Surfact) of the open pit mine area was created by WESA and calibrated to the available hydrogeological data. This model was then used to evaluate various design alternatives for the open pit mine dewatering and to assess groundwater interactions with local water bodies. Further information respecting the overburden and shallow bedrock in the vicinity of the various mine components was provided by the 2014 geotechnical program (LVM 2014a and LVM 2014b). The scope and results of these studies are summarized in Section 12.6.

Stassinu Stantec's approach to the assessment of environmental effects on Groundwater Resources is based on the observation that there are no Groundwater Resources users either within the mine PDA or within several kilometres of the open pit mine. Based on the interpreted hydrology, it is also anticipated that groundwater pathways from Project components to points of discharge will be relatively short (i.e., less than one or two kilometres) and that all potentially contaminated seepages originating from the various mine components will be locally confined within the overall wastewater and surface water management systems.

12.2 Scope of the Assessment

12.2.1 Regulatory Setting

The *Water Resources Act* SNL 2002 cW-4.01 gives the Water Resources Management Division of NLDOECC the responsibility and legislative power for the management and protection of water resources in the province, including groundwater. Groundwater use authorizations are required from NLDOECC under the *Water Resources Act*.

Water supply well construction for various Project components is regulated under the Well Drilling Regulations, 2003, Newfoundland and Labrador Regulation 63/03 under the *Water Resources Act* (O.C. 2003-221) (NLDOECC 2003). New water supply wells for the various mine components must be constructed by licensed well drilling contractors in compliance with the Regulation. Water well abandonment is regulated under Section 18 (3) of the Well Drilling Regulations.

Groundwater resources for potable usage are generally regulated by NLDOECC with respect to the Guidelines for Canadian Drinking Water Quality (Health Canada 2020), which specifies maximum acceptable concentrations for health-based parameters and Interim Maximum Acceptable Guidelines for non-health or aesthetic parameters. Other guidelines respecting groundwater quality, specifically from a discharge perspective, include the MDMER Schedule 4 (MDMER 2002); The CCME CWQG-PAL (CCME 2012); and Newfoundland and Labrador

Regulation 65/03 *Environmental Control Water and Sewage Regulations*, Schedule A (Newfoundland and Labrador 2003, amended 2009).

12.2.2 Influence of Consultation and Engagement on the Assessment

Few specific issues or concerns regarding Groundwater Resources were raised during consultation and engagement activities with NLDOECC, Indigenous groups, stakeholder groups, and the general public (Table 12.1). These specific concerns informed baseline data collection and are addressed through the Groundwater Resources environmental assessment.

Table 12.1 Issues Raised by Indigenous Groups and Stakeholders

Question / Issue	Community/ Organization	Summary of Comments	Response
Waste Management	Naskapi of Kawawachikamach	Will the water quality be affected by mining, i.e. tailings? Surface runoff?	The Project ore processing during operations will comprise “dry” crushing and screening only. Tailings will not be created. Mine contact water will be controlled to regulatory effluent criteria in sediment ponds prior to release to the environment.
Water Quality	Naskapi of Kawawachikamach	Weather changes a lot in that area, how are they planning to secure the waste so that it will not leak into the lake, the soil, the groundwater, etc.?	Overburden, waste rock and low grade ore stock piles will be graded (sloped at 18-22º) to avoid issues with erosion and gullying. These stockpiles will also have perimeter ditches to collect runoff and groundwater seepage and direct it to sedimentation ponds before release to the environment..
Dewatering	Naskapi of Kawawachikamach	How will they drain the open pit (Joyce Lake)? Where will the water drain? How will drainage of Joyce Lake affect Iron Arm Lake water levels? How will ‘filling-up’ Joyce Lake affect water levels?	Joyce Lake dewatering will take place during the first year of operations. Water from the lake will be pumped to perimeter ditches where it will gravity drain to the Joyce Lake outlet system, currently in place at the east end of Joyce Lake. The open pit will be dewatered in two ways: using a series of drawdown wells around the pit perimeter drilled to intercept clean groundwater; and drained by pumping water directly to the Joyce Lake perimeter ditches and also if necessary by using pumps in sumps within the pit to pump mine contact water out to a sediment pond before release to the environment. The dewatering of Joyce Lake and pumping from the open pit are not expected to increase water levels in Attikamagen Lake. When the mine is closed, Joyce Lake and the open pit will refill with water from precipitation and ground water recharge to the same level that Joyce Lake is today.

Table 12.1 Issues Raised by Indigenous Groups and Stakeholders

Question / Issue	Community/ Organization	Summary of Comments	Response
Dewatering	Naskapi of Kawawachikamach	How will you prevent flooding from occurring once the mine is closed?	To prevent flooding once the mine is closed Joyce Lake and the open pit will refill with water naturally from precipitation and ground water recharge. When water levels reach the current elevation of Joyce Lake today, water in the lake and open pit will spill out through the existing outlet system, mitigating potential flooding, as it is doing today. To prevent flooding on other areas of the Project site including the haul road and rail loop after closure, mine features will be removed/rehabilitated to eliminate potential barriers to water flow (e.g., culverts and bridges) and to maintain flooding conditions that currently exist.
Closure and Decommissioning	Naskapi of Kawawachikamach	What will happen with the mine once you are done mining the iron ore?	A detailed Closure and Reclamation Plan will be prepared for the Project, as required by the Newfoundland and Labrador Mining Act. The Plan will provide a final closure strategy for the open pit, waste piles, mine roads, and other mine facilities, and will incorporate progressive rehabilitation during all stages of the Project. to limit the work required after cessation of Operations and to limit the environmental effects during the Project life. A preliminary plan for the closure of the mine includes erosion control by revegetation wherever possible, stabilized slopes, and barricades around the open pit.
Effects on water and aquatic environment	Naskapi of Kawawachikamach	What are the impacts on water and on the environment?	Overburden, waste rock and low grade ore piles will be graded (sloped and stable) to avoid issues with erosion and gullying. The overburden, waste rock and low grade ore stockpiles will also have perimeter ditches to collect runoff and groundwater seepage and direct it to sedimentation ponds before release to the environment. The primary potential effects of the quarried rock for causeway construction on Iron Arm water will arise from some explosives residue on the surface of the blasted rock. The explosives residue may cause elevated ammonia or nitrogen concentration for a short and temporary period, however the concentrations are not expected to exceed the long term exposure limits of the CWQG-PAL

No issues with respect to groundwater resources have been noted in the stakeholder consultation.

12.2.3 Temporal and Spatial Boundaries

The temporal boundaries for the environmental assessment include the Project phases of Construction, Operation and Maintenance, and Closure and Decommissioning. The temporal boundary for Construction is one year (pre-operation), for Operation and Maintenance is approximately seven years, and for Closure and Decommissioning is approximately one year.

The spatial boundaries for the environmental effects assessment of Groundwater Resources are defined below. Based on conventional understanding of natural groundwater flow systems, the spatial boundaries for the Project are considered to be small, as the open pit mine area is situated within a bedrock synclinal structure on a bedrock-dominated peninsula. The mine and processing and accommodations areas are located on a bedrock peninsula bounded on all sides by major surface water boundaries associated with Attikamagen Lake (i.e., Iron Arm, Hollinger Lake, Timmins Bay). These lakes and associated streams and wetlands are expected to be the discharge boundaries for any Project-driven groundwater seepages or open pit mine water level dewatering.

Project Development Area (PDA): The PDA is the area represented by the Project footprint as defined in the Project Description (Chapter 2) (Figure 12.1).

Local Study Area (LSA): The LSA is the maximum area within which Project-related environmental effects can be predicted or measured with a reasonable degree of accuracy and confidence (Figure 12.2). The Groundwater Resources LSA includes the PDA and any adjacent and intervening areas where Project-related environmental effects may reasonably be expected to occur, including a 100 m buffer adjacent to the haulage and access roads east of Iron Arm and the Astray Lake rail yard site (Figure 1.1, Chapter 1). In consideration of expected groundwater flow directions, the LSA would include the PDA and those areas between the PDA and expected discharge boundaries for groundwater flow (i.e., Iron Arm, Timmins Bay, remnants of Joyce Lake and Attikamagen Lake for the Mine Site, and Gilling River estuary and Astray Lake for the rail yards).

Based on available topography maps, the Groundwater Resources LSA is contained within several local sub-watersheds of Attikamagen Lake that overlap with the Project. These topography-controlled watersheds would result in relatively short run-off and groundwater travel paths between the various Project components and the closest receiving water discharge environment. Based on expected groundwater flow pathways, the LSA would generally include (Figure 1.1, Chapter 1):

- the north part of the peninsula east of Iron Arm bounded by various inlets of Attikamagen Lake (Timmins and Montreal Bays on the east, Iron Arm on the west and Hollinger Lake on the south); this area hosts the mine site and associated infrastructure where water quantity and quality effects could occur due to pit dewatering, accident and malfunction;

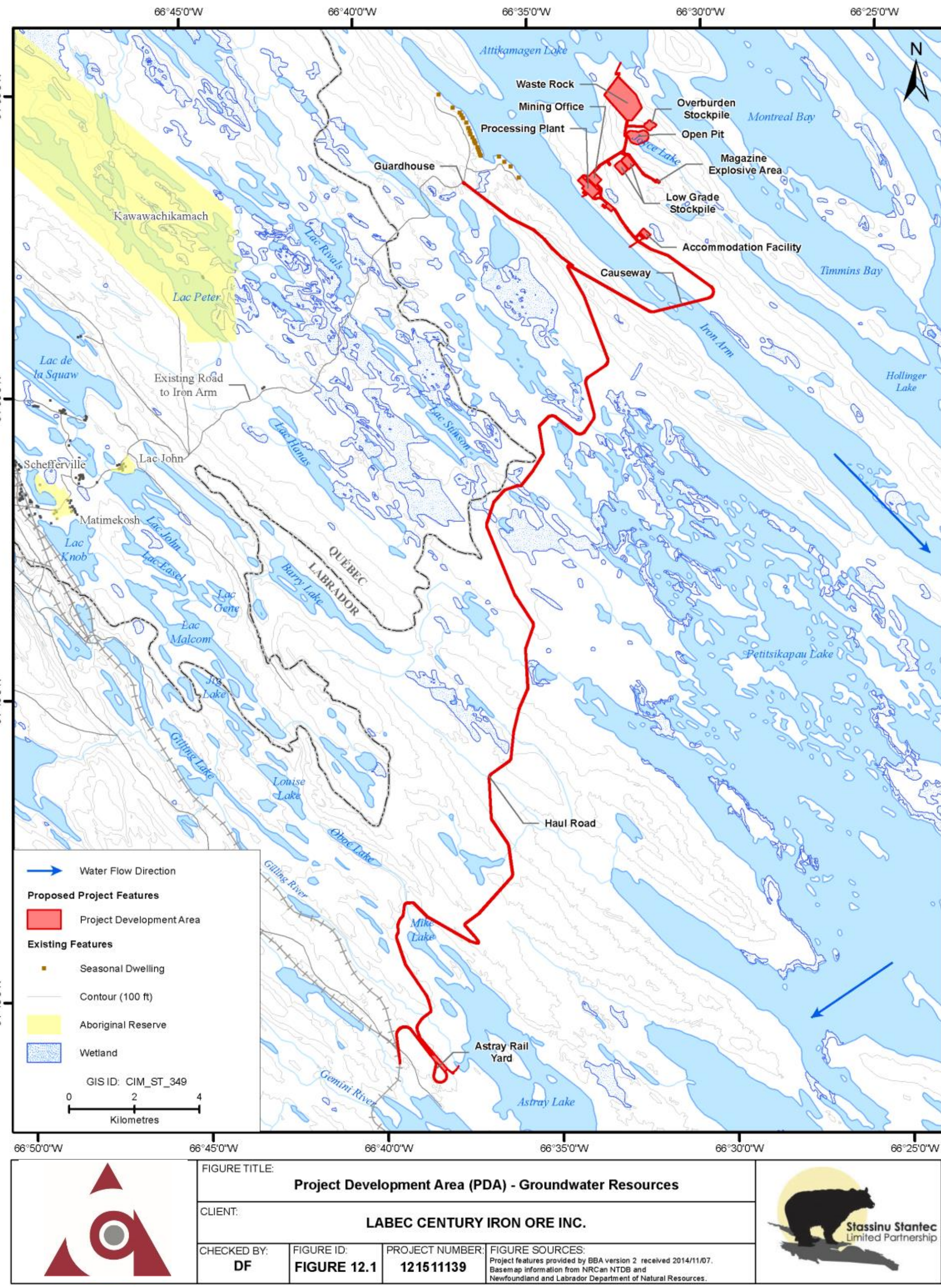

Figure 12.1 Project Development Area

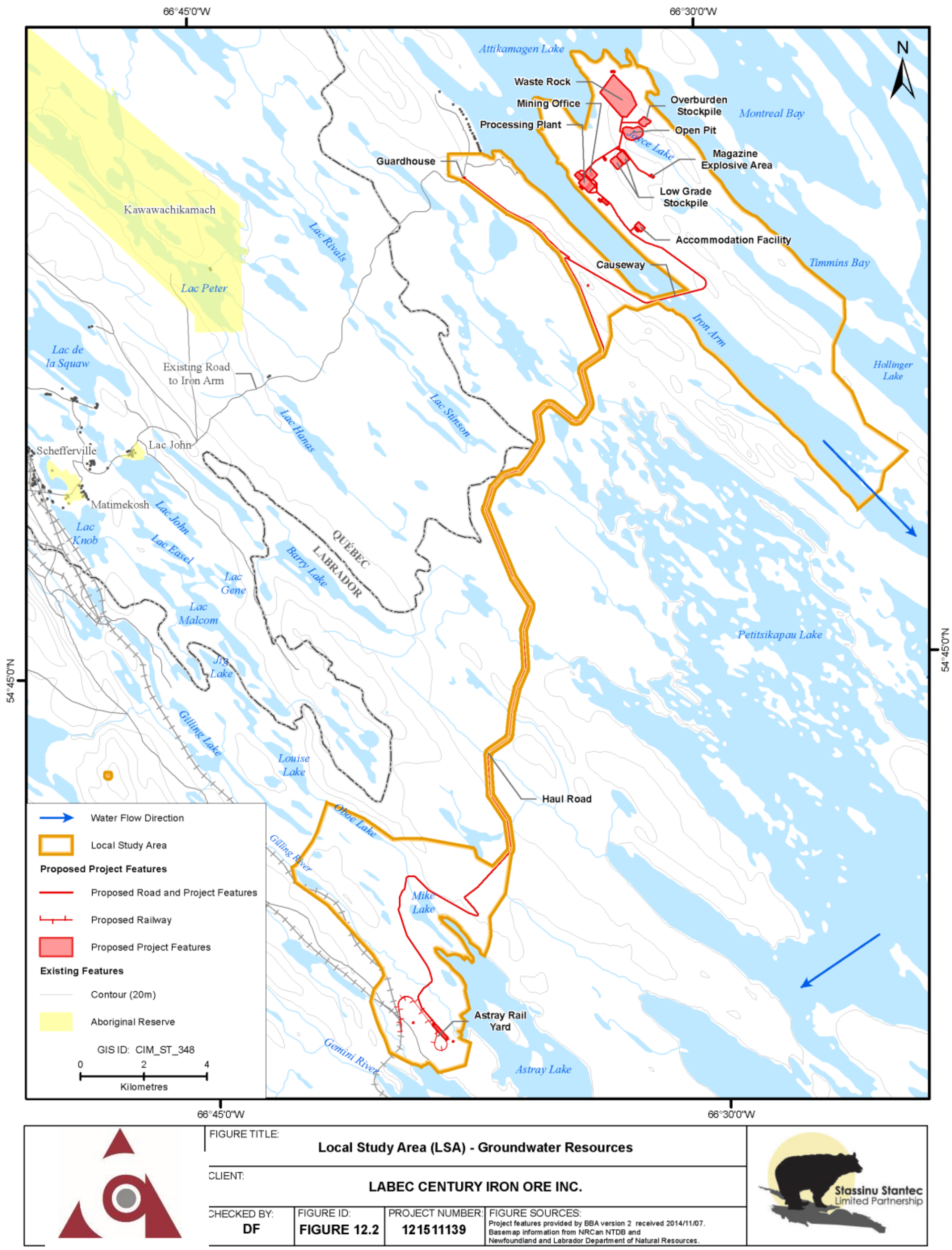

Figure 12.2 Local Study Area

- the Astray Lake rail yard between the various loading facilities and the shores of Astray Lake where predominantly water quality effects could occur due to accident and malfunction; and to a lesser extent,

- limited areas hydraulically down-gradient of the main haulage road and access road where accidents and malfunction could theoretically effect local groundwater quality.

Regional Study Area (RSA): The RSA is the area within which cumulative environmental effects and the significance of those effects on Groundwater Resources may occur. The RSA is the area within which the significance of Project effects is predicted. Because the Project is situated within the headwaters of the much larger Churchill River watershed, the RSA is considered to be those areas located hydraulically downstream of the Project (Figure 12.3).

Because of the defined drainage patterns and the expected short groundwater travel distances between points of recharge and points of discharge in this hydrogeological environment, any groundwater resources effects associated with the Project are anticipated to be limited to the PDA and LSA, and not extend out into the RSA. With respect to groundwater quantity, effects to residential water supply wells are not expected to occur, because of the remote location of the various Project activities, the general absence of stakeholders with wells near Project components, and the presence of intervening water bodies such as Iron Arm and Attikamagen Lake, which should act as barriers to horizontal groundwater interactions. The effect of water table lowering by the open pit mine dewatering is not expected to extend substantially beyond the major lake boundaries surrounding the mine site. No groundwater resource users are identified within the PDA or the LSA within 13 km of the mine site. With respect to groundwater quality, groundwater seepage from potential contaminant sources (e.g., waste rock storage, oil storage, and other mine-related activities) is expected to discharge to the surface water environment within a short distance of travel.

The significance of cumulative Project effects on the environment will therefore be assessed at the receiving water (RSA) level (Chapter 11: Water Resources and Chapter 14: Wetlands).

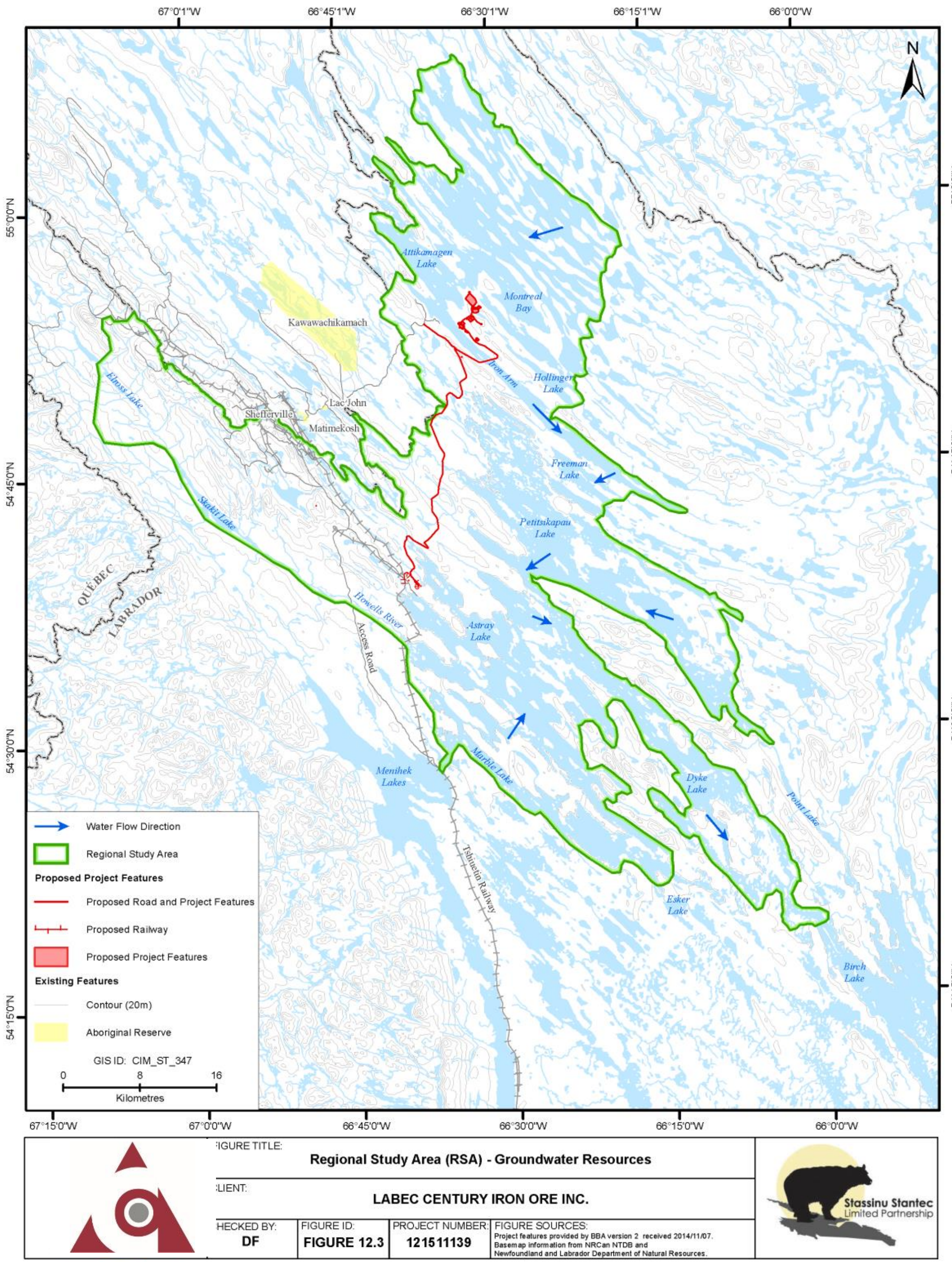

Figure 12.3 Regional Study Area

12.2.4 Selection of Environmental Effects and Measurable Parameters

The selected potential environmental effects and the associated measurable parameters for Groundwater Resources, with rationale, are summarized in Table 12.2.

Table 12.2 Measurable Parameters for Groundwater Resources

Environmental Effect	Measurable Parameter	Rationale for Selection of the Measurable Parameter
Changes in Groundwater Level	Changes in shallow (phreatic) and deep (piezometric pressure) water table elevation measured in monitoring wells adjacent to and at distance from the open pit mine.	• The excavation and dewatering of the open pit mine will divert the natural groundwater flow directions inward towards the pit, and lower groundwater levels in overburden and bedrock between the open pit mine and the adjacent lakes. • Substantial decline in shallow water table elevations can result in loss of yield to dug or drilled wells, or reduction in drought-period baseflow to nearby surface water bodies. • Changes in bedrock water levels at distance may occur due to long-term open pit mine dewatering. • Changes in groundwater pressures at depth in bedrock fractures can result in a reversal of the vertical hydraulic gradient from positive (i.e., naturally-occurring discharge into a lake or stream) to negative (i.e., seepage loss from a lake or stream), with possible effect on stream flows and pit inflow rates.
	Changes in water levels in materials storage areas measured in monitoring well(s); measured in standpipes in material, if necessary.	• An increase in water level (e.g., mounding) within the overburden, waste rock and ore storage areas can result in increased discharge of potentially contaminated seepage, and/or reduction in containment stability.
Change in Groundwater Quality	Changes in concentrations of major ions (Na, K, Ca, Mg, Cl, SO_4, HCO_3), nutrients (NO_3, NO_2, NH_4, organic carbon, OPO_4, P), physical parameters (pH, dissolved solids, hardness, colour), metals (Al, Sb, As, Ba, Be, Bi, Bo, Cd, Cr, Cu, Cy, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Sr, Ta, Sn, Ti, U, V, Zn) analyzed during routine monitoring.	• Changes in groundwater chemistry substantially deviating from baseline pre-mining conditions can be indicative of an effect.
	Petroleum hydrocarbons, volatile and semi-volatile organic compounds detected during routine monitoring.	• Not present naturally. • Detection indicative of fuel oil releases and need for immediate mitigative action.

12.3 Standards or Thresholds for Determining the Significance of Residual Environmental Effects

Terms that will be used to characterize residual environmental effects for Groundwater Resources are:

- Direction:
  - Adverse: In general, a decrease in static water level, well yield or water quality in comparison to baseline conditions and trends
  - Positive: In general, an increase in static water level, well yield or water quality improvement in comparison to baseline conditions and trends
  - Neutral: no net change in annual water levels, well yields or water chemistry in comparison to baseline conditions and trends
- Magnitude:
  - Negligible: no measurable adverse effect anticipated
  - Low: effect occurs that is detectable, but is within normal variability of baseline conditions
  - Moderate: effect occurs that would cause an increase (or decrease) with regard to baseline, but is within regulatory limits and objectives
  - High: effect occurs that would singly or as a substantial contribution in combination with other sources cause exceedances of objectives or standards within the Project boundaries
- Geographic Extent:
  - Site-specific: effects are restricted to the PDA
  - Local: effects extend into the LSA
  - Regional: effects extend into the RSA
- Frequency:
  - Unlikely: Not likely to occur
  - Once: Effect occurs once during the life of the Project (e.g., clearing)
  - Sporadic: Effect occurs sporadically, at irregular intervals, without any predictable pattern during the life of the Project
  - Rarely: Effect occurs infrequently

  - Frequently: Effect occurs on a regular basis and at regular intervals
  - Continuous: Effect occurs continuously throughout the Project life
- Duration:
  - Short-Term: Effect restricted to construction phase
  - Medium-Term: Effect extends through construction and operation phases
  - Long-Term: Effect extends beyond closure
  - Permanent: Effect is persistent and the measurable parameter(s) unlikely to recover to baseline
- Reversibility:
  - Reversible: Will recover after Project closure and reclamation
  - Irreversible: Permanent
- Ecological/Socio-economic Context:
  - Undisturbed: Area relatively or not adversely affected by human activity
  - Disturbed: Area has been substantially previously disturbed by human development or human development is still present
- Prediction Confidence:
  - Low – Insufficient data or information to reliably predict effect
  - Moderate – Sufficient site-specific information or experience in similar hydrogeology to predict possible effect
  - High – Sufficient site-specific information or experience in similar hydrogeology to reliably determine an effect

A significant residual adverse environmental effect is a persistent degradation in the quantity or quality of groundwater after application of mitigative and remedial measures that could persist long after completion of the Closure and Decommissioning Phase. This will consider the following thresholds:

- Changes in groundwater quantity: such that the yield from an otherwise adequate water supply well or spring decreases to the point where it is inadequate for intended use;

- Changes in groundwater quality: such that the quality of groundwater from an otherwise adequate water supply well or spring that meets guidelines deteriorates to the point where it becomes non-potable or cannot meet the *Guidelines for Canadian Drinking Water Quality* (Health Canada 2020); or,

- Physically or chemically altering the aquifer to the extent that interaction with local surface water results in stream flow or surface water chemistry changes that adversely affect aquatic life or a down-stream surface water supply.

12.4 Potential Project-VC Interactions

The environmental assessment of the Groundwater Resources VC is focused on the following potential environmental effects:

- Changes in Groundwater Level, and

- Changes in Groundwater Quality.

No environmental effects to existing groundwater users are anticipated from the development of this mine. Cabins and hunting camps identified along the west shores of Iron Arm are reported to use surface water only as water supply. The nearest potential water well users (e.g., First Nations communities) are expected to be greater than 13 km from the open pit mine excavation, and separated from the open pit mine by large surface water bodies that provide a high degree of hydraulic isolation.

The primary Project-related effects on Groundwater Resources will include: large scale pumping and dewatering during operation of the open pit mine resulting in substantial changes in PDA, and possibly LSA, to water levels and flow directions predominantly during the Operation phase; and localized changes to groundwater quality in the vicinity of waste rock disposal area, ore stockpiles, landfills and septic disposal fields during the Operational and Decommissioning phases. Accidental releases of hazardous substances during Construction and Operation can locally affect groundwater quality.

Based on historical data and site-specific information from the Joyce Lake site, the ARD/ML potential of overburden, waste rock, ore, and iron ore product is expected to be low. ARD/ML is discussed in detail in Chapter 13: Terrain and Acid Rock Drainage/Metal Leaching. No adverse environmental effects on Groundwater Resources related to ARD/ML are expected. Groundwater quality effects are not expected to be an issue during the Construction, Operation or Decommissioning phases of the open pit mine. All groundwater movement in the vicinity of the mine site will be inward towards the open pit mine during the Construction and Operation and Maintenance phases due to active dewatering, as well as during Decommissioning as the mine is allowed to flood. Groundwater inflow into the open pit mine will mix with the rainfall and will be collected and discharged to the mine wastewater handling systems (see Water Resources VC - Chapter 11).

Each Project activity and physical work for the Project is listed in Table 12.3, and rated as 0, 1, or 2 based on the level of interaction associated with each activity on Groundwater Resources. A key to these ratings can be found at the bottom of the table.

The rating takes a precautionary approach, whereby interactions with a meaningful degree of uncertainty are assigned a rate of 2 requiring a more detailed environmental effects assessment. Project interactions with ratings of 2 are assessed in detail in Section 12.6.

Table 12.3 Potential Project Environmental Effects to Groundwater Resources

Project Activities and Physical Works	Potential Environmental Effects	
	Change in Groundwater Level	Change in Groundwater Quality
Construction		
Site Preparation (including clearing, grubbing, excavation, material haulage, grading, removal of overburden, ditching, and stockpiling)	1	1
Construction of Roads	0	0
Construction of Causeway	0	0
Construction of Site Buildings and Associated Infrastructure	1	1
Construction of Rail loop and Associated Infrastructure	0	0
Construction of Stream Crossings	0	0
Installation of Water Supply Infrastructure (wells, pumps, pipes)	0	0
On-site Vehicle / Equipment Operation	0	0
Waste Management	0	0
Transportation of Personnel and Goods to Site	0	0
Expenditures	0	0
Employment	0	0
Operation and Maintenance		
Maintenance of Causeway	0	0
Dewatering Joyce Lake	2	0
Open Pit Mining (including drilling, blasting, ore and waste haulage, stockpiling, dewatering)	2	0
Ore Processing (including crushing, conveying, storage, grinding, screening) –	0	0
Waste Rock Disposal on Surface	0	1
Water Treatment (including mine water and surface run-off) and Discharge	0	0
Water Supply Well Operation	1	0
Rail Load-Out and Transport	0	0
On-site Vehicle / Equipment Operation and Maintenance	0	0
Waste Management (domestic sewerage; landfill)	0	1
Transportation of Personnel and Goods to Site	0	0
Fuel Transport	0	1
Fuel Storage and Dispensing	0	1
Progressive Rehabilitation	0	0
Expenditures	0	0
Employment	0	0

Table 12.3 Potential Project Environmental Effects to Groundwater Resources

Project Activities and Physical Works	Potential Environmental Effects	
	Change in Groundwater Level	Change in Groundwater Quality
Closure and Decommissioning		
Site Decommissioning	0	0
Site Reclamation (building demolition, grading, scarifying)	0	0
Accidents and Malfunctions		
Hydrocarbon Spill	0	2
Train Derailment	0	2
Forest Fire	0	0
Settling / Sedimentation Pond Overflow	0	0
Premature or Permanent Shutdown	0	0

Key:
0 No interaction
1 Interaction occurs; however, based on past experience and professional judgment, the resulting environmental effect can be managed to acceptable levels through standard operating practices and/or through the application of best management or codified practices. No further assessment is warranted.
2 Interaction occurs, and resulting effect may exceed acceptable levels without implementation of specific mitigation. Further assessment is warranted.

A discussion of significance is provided below for interactions rated as 0 or 1, which are not considered further in the environmental effects assessment. Interactions rated as 2 on Table 12.3 are assessed in more detail in Section 12.6.

12.4.1 Interactions Rated as 0 (No Interaction)

Activities that are rated as “0” are not expected to adversely or permanently interact with or affect the quantity or quality of Groundwater Resources. These activities include those associated with the construction and operation of the roads, rail and load-out facilities, causeway, stream crossings, on-site vehicle operation, transportation of personnel and goods, employment and expenditure, ore processing, and water treatment. Site preparation for the construction of these facilities and infrastructure are discussed in 12.5.2 because of the potential for interaction with groundwater during these activities.

Water demands for the Project will be low due to the proposed dry ore processing procedure. During operation, all groundwater flows will be directed towards the open pit mine as a result of dewatering. All process waters for dust control and other uses will originate from surface water, and all site water and wastewater streams, including drainage and seepages from various Project facilities will be contained within the wastewater control system. These activities are localized near the open pit mine on the east side of Iron Arm, and do not involve substantial excavations or hazardous chemical storage. The potential for water quality changes resulting from blast residue (ammonium nitrate) in the open pit mine water is addressed in Chapter 11 (Water Resources). Groundwater quality is not expected to be affected during operation of the open pit mine. Site decommissioning operations are expected to have little or no effects on Groundwater Resources. Any effects would likely be temporary and localized.

There are no groundwater supply users identified in the area of expected groundwater influence from open pit mine dewatering, or along the haulage road and rail components.

12.4.2 Interactions Rated as 1 (No Further Assessment is Warranted)

Activities that are rated as “1” could potentially interact with local Groundwater Resources (e.g., future on-site water supply wells or local streams); however, the resulting effects are expected to be local (e.g., contained within the PDA), temporary and can be managed with the application of standard operating procedures and/or codified BMP.

12.4.2.1 Groundwater Quantity Effects

Minor and localized groundwater quantity effects that could occur during site preparation (i.e., road construction, component construction, installation of buried infrastructure, pipelines, and water supply wells), and the operation of water supply wells for specific site locations, have been rated as “1”. These potential effects are likely to be temporary during the Construction phase if excavation is below the water table, and are limited to active on-site well pumping during the Operations and Maintenance phase. There is potential for temporary diversion of shallow groundwater flow and lowering of the water table near major excavations for buildings, sub-surface infrastructure, roads, rail lines; and the operation of water supply pumping wells. The expected water table levels in the Project area range from 0 to 36.4 m below ground surface (mbgs; mean 17.1 mbgs, Table 12.6). Excavation and dewatering during site preparation has the potential to interact with groundwater in some areas of the PDA near wetlands, adjacent to surface water bodies, and in areas of low elevation where groundwater may be close to surface. The effects will be temporary in nature and the water levels will return to normal after completion of the excavation or construction.

The water level drawdown effects from the operation of future on-site water supply wells (if any wells are installed) are expected to be limited to a few hundred metres from a pumping well in local bedrock (for intermittent on/off pumping); and the maximum extent of drawdown effects would be limited to the shores of Iron Arm, Attikamagen Lake or Hollinger Lake (continuous pumping), which would typically act as a barrier to further horizontal drawdown. Water level effects on off-site water wells are therefore considered to be unlikely.

12.4.2.2 Groundwater Quality Effects

The groundwater quality changes associated with the site preparation, open pit mine dewatering, ore storage, and waste rock stockpiles are expected to be measurable. However, because seepages will be intercepted by the wastewater control system, and in consideration of the expected seepage chemistry from iron ore, the short groundwater flow pathways and the hydrological isolation of the site from existing groundwater users, effects are rated as “1”. These effects are likely to be limited in area and can be managed through application of standard mitigative measures.

The following points provide additional justification for the rating of "1" for groundwater quality effects:

- Changes to groundwater quality during the Construction phase (turbidity from excavation and accidental fuel releases) are expected to be negligible, local and manageable through application of standard practices.
- Local changes in shallow groundwater chemistry are expected downgradient of the various waste and materials handling facilities including: the overburden stockpile (turbidity); the waste rock stockpile (turbidity, iron, manganese, low grade ARD and other metals), ROM ore stockpiles (turbidity, iron and other metals) and domestic waste disposal facilities (nutrients, metals). These seepages will be intercepted by the wastewater control system.
- The overburden stockpile will contain topsoil, glacial till and organic wetland soils removed from the mine site, open pit mine footprint, and Joyce Lake during site preparation. The overburden stockpile is not expected to present a substantial effect on shallow groundwater quality due to the expected inert nature of the glacial materials. Run-off and seepages containing turbidity, iron and manganese and possible organic carbon from the root mat and wetland soils would be collected in the wastewater control system.
- All groundwater flow is expected to be diverted towards the open pit mine as a result of drawdown during dewatering. Seepages from the waste rock and ore storage piles accumulated in or transiting through the stored materials, either horizontally through the containment dams into overburden and shallow fractured bedrock, or through the bottom of the storage facility into deeper groundwater pathways, could affect shallow groundwater chemistry. The seepage chemistry could include components from the waste rock, iron ore and reaction products (e.g., ion exchange or redox reactions) along the flow path through glacial till and bedrock. Little mounding from rainfall is anticipated in the waste rock or ore storage sites due to the expected high permeability of the coarse grained stored materials. Assuming that the waste rock and ore storage pads are constructed with low permeability bases (using liners or compacted glacial till of low hydraulic conductivity), the majority of the effluent would be expected to exit as toe seepage, which would be collected in the wastewater control system. The effect on groundwater users from potential seepage is anticipated to be negligible, due to the large distance to potential off-site well users, and the presence of numerous intervening surface water boundaries.
- The ARD assessment in the Terrain and Acid Rock Drainage / Metal Leaching VC (Chapter 13) suggests that the waste rock could be classified as non-acid generating based on NPR screening criteria. The overburden was designated non-Potentially Acid Generating (non-PAG); (see Chapter 13 for details on the ARD/ML risk evaluation). All groundwater flow is expected to be diverted towards the open pit mine as a result of drawdown during dewatering, where it will become surface water that is managed in the wastewater management system. Effluent from the waste rock and ore storage areas is considered for purposes of this assessment to be a surface water effect, and is addressed further in the Water Resources VC (Chapter 11).

- Other sources of groundwater seepage effects include chemical storage sites (e.g., ANFO), solid waste landfill, on-site sewerage disposal facilities, vehicle parking and repair facilities. Potential sub-surface effluents from these sources will be monitored and managed using standard procedures.

The above interactions have been rated as "1" because the related effects are typically localized and can be mitigated with BMP, including:

- The location and operation of water supply wells will be implemented in accordance with the sustainability of the host aquifer, as determined by individual constant rate pumping tests performed on each new supply well. Monitoring of supply wells for water quality, water level, and nearby aquifer water level (observation wells), will promote safe abstraction rates that do not adversely affect aquifer water levels at adjacent wells or stream base flows.

- Domestic solid waste from office, accommodations, and lunchroom activities, and construction wastes will be disposed on site in compliance with the applicable NLDOECC regulations. The landfill areas(s) will be located and constructed to prevent for leaching or seepage to Groundwater Resources or Surface Water Resources. Groundwater monitoring will be undertaken to detect non-compliance and guide any remedial action deemed necessary (see contingency plan).

- On-site sewage from the mine facilities will be disposed by the wastewater collection/treatment system, and/or on-site septic disposal systems. If required, septic fields will be constructed in accordance with relevant provincial regulations to reduce interaction between the system and Groundwater Resources.

- There are no domestic water supply wells identified within 13 km of the mine site. In the event that any water supply wells are identified within 200 m of a Project component (i.e., haulage road, rail terminal, accommodations area), the following steps will be taken for the identification, inspection, and monitoring of such supply wells or springs:

  - Conduct a water supply survey to identify any well or spring water users.

  - Where practical, use mechanical excavation methods instead of blasting near water supply wells.

  - In the unlikely event that a well is affected, mitigative measures may include: provision of temporary water supply (bottled or tank); water treatment (particulate filter, iron treatment); well deepening (in event of major excavations); and well replacement (in rare event of total well collapse or loss of supply).

- The waste rock, overburden, and run-of-mill stockpiles are not expected to result in a substantial effect on groundwater. Due to the expected high permeability and porosity of the coarse waste rock, no substantial mounding of groundwater is expected (i.e., limited driving head), and most seepages can be managed by perimeter drainage. Runoff and subsurface seepage from the waste rock and ore stockpile areas will be collected in perimeter ditching, and directed through a settling pond to meet regulated limits prior to release.

- Groundwater monitoring will be carried out in the open pit mine, downgradient of the waste rock and ore stockpiles to detect changes in groundwater chemistry and inform any mitigative measures. Mitigative measures for effects associated with the waste rock storage piles include:

  - Prevention of groundwater mounding within the waste rock piles;

  - Perimeter groundwater monitoring wells;

  - Toe seepage and run-off collection, and direction to treatment system (settling pond); and

  - Monitoring of run-off, seepage, and groundwater chemistry.

- Substantial sulfide mineralization is not expected in the ore or host rocks. However, regular inspection and analysis of waste rock, ore, and overburden materials will be carried out to detect sulfide mineralization in excess of guidelines, and a contingency plan will be developed for the safe disposal of such materials. Groundwater monitoring will be carried out downgradient of potential ARD sources, the waste rock storage, and other materials storage sites. Effluents from the open pit mine will also be monitored at the sump and specific areas of seepage, including: inspection of rock excavations for sulfide mineralization and implementation of ARD abatement measures, if required, and management of sulfide waste rock, if required; and,

- The routine handling of fuel and chemicals during Construction and Operation phases can locally affect Groundwater Resources; however, these events can be mitigated with standard emergency response and clean up protocols. Employee training and a contingency plan for immediate clean-up of small fuel and chemical spills will be implemented. The environmental effects on groundwater quality associated with accidental releases of petroleum hydrocarbons during the life of the Project are addressed in Section 12.8.

The potential for effects on Groundwater Resources is low as a result of the absence of tailings management facilities, the dry ore processing method proposed, and the absence of any identified groundwater supply well users in the area or along the haulage road and rail components. The main receptors of Groundwater Resources effects would be water supply wells installed for the mine operation itself.

Given the nature of the Project, the absence of existing groundwater users and the proposed mitigation options, including collection of most seepages within the wastewater control system, the potential environmental effects of Project-related activities that were rated as 0 or 1 in Table 12.3 are rated as not significant with a high level of confidence, and are not considered further in this EA.

12.4.3 Interactions Rated as 2 (Further Assessment Warranted)

The primary Groundwater Resources-related activity rated as 2 involves the possible effects of regional water table lowering during the Operation and Maintenance phases of the open pit mine, and the possible effects on groundwater quality from accidental releases of petroleum hydrocarbons during a major rail or truck accident or tank failure during the life of the Project. Due to the absence of existing groundwater users, effects are limited to the PDA (mine) and LSA (shipping routes), and would be more associated with on-site Project facilities than to off-site groundwater resource users.

The environmental effects of Project-related activities rated as "2" are addressed further in Section 12.6. The environmental effects on groundwater quality associated with accidental releases of petroleum hydrocarbons during the life of the Project are addressed further in Section 12.9.

12.5 Existing Environment

This Section provides a description of baseline, pre-mining groundwater flow and quality conditions expected in the vicinity of the Project. This baseline hydrogeological characterization is based on review of existing hydrogeological information relevant to the PDA and LSA, a field program conducted in October 2012 to collect preliminary hydrogeological data in the vicinity of the proposed open pit mine using existing mineral exploration boreholes (Stassinu Stantec 2013), and detailed geotechnical and hydrogeological investigation of the mine site in 2014 (WESA 2014; LVM 2014a, b).

12.5.1 Information Sources

The following sources of information have been used for the assessment of Groundwater Resources:

- *Information Review*: including review of previous Proponent-supplied geology, exploration drilling and geophysical reports relevant to the site, climate records, and overburden and bedrock geological maps;

- *Preliminary Site Investigations* (Stassinu Stantec 2013): including inspection of existing mineral exploration boreholes, measurement of static water levels in accessible boreholes, hydraulic testing of three suitable boreholes, collection of three groundwater chemistry samples, and installation of 14 automated groundwater level dataloggers for future evaluation;

- *Detailed Hydrogeological Investigations* (WESA 2014): including lithology, hydraulic conductivity and water chemistry analysis from six 160 to 171 m deep test wells, groundwater level survey, water chemistry sampling and a three-dimensional groundwater flow model to assess drawdown effects at the open pit mine;

- *Detailed Geotechnical Investigations* (LVM 2014a, b): including lithology, materials testing of 25 boreholes in the surrounding areas (LVM 2014b), and detailed engineering geology model, pit slope stability assessment, and recommendations for pit dewatering (LVM 2014a);

- *Consultations:* with Labec Century and the Study Team to review the locations of the mine components; define the boundaries of the area of assessment and review of consultations with local Indigenous groups respecting traditional and local knowledge. No local and Indigenous traditional knowledge pertaining to Groundwater Resources has been made available to the Study Team.

While traditional knowledge pertaining specifically to Groundwater Resources was not identified, the traditional knowledge results identified in Chapter 3: Engagement and Traditional Knowledge have been considered and integrated throughout the assessment.

12.5.2 Method for Characterization of Baseline Conditions

The groundwater baseline conditions were based on a review of relevant reports and information, a limited field program in October 2012 *(*Stassinu Stantec, 2013*)*, and detailed hydrogeological investigations performed in 2014 by WESA and LVM (WESA, 2014; LVM, 2014a, b).

The 2012 field investigations were limited to the inspection, hydraulic testing, and sampling of existing exploration boreholes where conditions warranted (e.g., boreholes were not completed with monitoring wells). Two field visits were performed in 2012 including a reconnaissance fly-over by helicopter in August, and a one-week site visit in October. The 2012 field work focused on the open pit mine area. The information review was also used to infer conditions in the Project Area. Information collected during the October visit included:

- Inspection of 106 existing un-cased, reverse circulation exploration boreholes and measurement of static water levels in 42 boreholes.

- Installation of electronic water level dataloggers in 14 boreholes to monitor seasonal water level fluctuations. It was anticipated that these would become part of the baseline monitoring program and would be downloaded during future inspections.

- Hydraulic response testing (slug testing) was conducted on three boreholes; further testing was hampered by extreme cold temperature and excessive sediment in the uncased boreholes.

- Baseline groundwater chemistry samples were collected from three pumped boreholes to characterize in-situ groundwater quality.

This information was compiled into electronic databases, geographic information system (GIS) mapping, figures, and tables, and used to generate a conceptual understanding of the groundwater flow conditions and baseline groundwater chemistry throughout the PDA and LSA. The reader is referred to the "Baseline Hydrogeology Scoping Study Report" (Stassinu Stantec 2013) for further details. An overview of baseline conditions is provided below.

The 2014 field investigations carried out by WESA in September and October of 2014 (WESA 2014, Appendix O) included:

- Diamond drilling of four vertical, approximately 171 m deep, hydrogeological test wells (i.e., (JGW-01, JGW-02, JGW-03, JGW-04);
- Detailed borehole logging (lithology, RQD, core recovery, fracture frequency);
- Hydraulic testing, including 35 packer injection tests, nine pumping/injection tests;
- Installation and development of six 51 mm diameter PVC screened monitoring wells within the four hydrogeological holes (JGW-01, JGW-02, JGW-03, JGW-04), as well as two of the inclined geotechnical holes installed by LVM (BH-P-03, BH-P-04);
- Water level measurements;
- Collection of six water chemistry samples; and,
- Creation of a 3D (MODFLOW/Surfact) groundwater flow model.

The geotechnical investigations carried out by LVM (LVM 2014b, Appendix D) in the surrounding areas and haulage road between September 24 and October 15, 2014 included:

- 25 diamond drill boreholes drilled to depths 2.39 to 20.9m;
- Collection of soil samples and NQ cores Laboratory materials testing (23 grain size sieve analysis, four hydrometer tests, two Atterberg Limits tests, nine water content tests);
- Installation of 21 mm diameter piezometers in all completed geotechnical boreholes;
- Water level measurements; and,
- Interpretation of overburden and bedrock (open pit mine area) geotechnical properties.

The detailed geotechnical investigations carried out by LVM (LVM 2014a, Appendix C) in the vicinity of the open pit mine in 2014 included:

- Diamond drilling of four inclined geotechnical holes (BH-P-01, BH-P-02, BH-P-03, BH-P-04) in the open pit mine area to vertical depth of 150 m;
- Core logging and analysis;

- Development of an engineering geology model;
- Open pit rock slope stability assessment, and,
- Recommendations for pit water management, slope geometry (bench height and width), rock fall protection and geotechnical and groundwater monitoring.

12.5.3 Baseline Conditions

The hydrogeological setting for the Project is described with respect to physiography and drainage, overburden, bedrock, and expected groundwater flow patterns. On a regional scale, the Project is situated within the Attikamagen Lake system, a series of northwesterly-trending lakes and fjord-like waterways that cover an estimated 1,000 km^2 in northwestern Labrador. The area is relatively pristine, with no other mining activities in the immediate area. Based on satellite imagery and available air photos (Stassinu Stantec 2013), the area is sparsely vegetated, with numerous areas of apparent exposed bedrock or bog lands.

A separate description is provided below for each of the main Project components (i.e., open pit mine, processing plant, accommodations camp facility, haulage road, and the Astray Lake rail yard). Most of the site-specific hydrogeology data are available for the open pit mine area where the majority of the effects on Groundwater Resources are likely to occur (Stassinu Stantec 2013, WESA 2014). Assessment of likely hydrogeological conditions in the other Project areas is provided based on the available bedrock, overburden, and topographical maps and site-specific geotechnical information (LVM 2014a,b).

12.5.3.1 Joyce Lake Open Pit Mine Site

Topography and Drainage

The mine site is located on a 4 km wide northwest oriented peninsula in Attikamagen Lake. The open pit mine is located within a relatively rugged physiography with rolling hills and valleys reflecting the northwest trending structure of the underlying bedrock. Elevation in the mine site area can vary over 92 m, ranging from 504 m on the shores of Iron Arm and Attikamagen Lake up to 584 m at the high point approximately 350 m north of Joyce Lake.

Based on topography and drainage patterns, surface drainage in the vicinity of open pit mine is contained within a defined sub-watershed containing Joyce Lake, an elongate upland lake that drains to the south via an unnamed brook to Hollister Lake. The Joyce Lake sub-watershed forms a bowl-shaped feature between bedrock ridges (elevations 535 to 560 m) located to the east, west, and northwest. Two smaller unnamed bedrock-controlled elongate lakes are identified to the southeast of Joyce Lake. Outside of this hydrologic feature lies Iron Arm to the west, Attikamagen Lake to the north and Timmins Bay on the east (Figure 1.1, Chapter 1).

Run-off intersecting the open pit mine site will be intercepted with a series of ditches and settling ponds. Drainage collected from the open pit mine, and waste rock and overburden stockpiles is expected to be directed to the north through a sedimentation structure near the shoreline of Attikamagen Lake adjacent to the Waste Rock Area. An additional wastewater control and sedimentation pond will be located near Iron Arm associated with the ore stockpiles and processing plant (Figure 2.1). Chapter 11 - Water Resources details the wastewater control process.

Surficial Geology

The surficial geology is described in Chapter 13: Terrain and Acid Rock Drainage/Metal Leaching. No hydraulic testing data are currently available to assess the hydraulic properties of the overburden materials. In general, sandy to silty glacial till can typically be expected to have a low to moderate hydraulic conductivity (K) in the range of 1×10^{-5} to 1×10^{-7} m/s. Glacial outwash deposits (kame, esker structures) dominated by meltwater-washed sand and gravel can have higher K values of 1×10^{-3} to 1×10^{-4} m/s.

The overburden is not considered to be a viable groundwater resource, primarily due to the expected limited saturated thickness in the PDA. Overburden thicknesses range from nil in the vicinity of bedrock ridges, to over 16 m near Joyce Lake and the Waste Rock area, with a median thickness of about 3 m. The best overburden groundwater resource potential for dug wells or shallow screened wells would be in an area that will be disrupted by the proposed open pit mine and dewatering of Joyce Lake.

Bedrock Geology

The bedrock geology is described in Chapter 13: Terrain and Acid Rock Drainage/Metal Leaching. The open pit mine mine area bedrock is comprised of the highly weathered and jointed iron oxide bedrock of the ore zones, including the UMH, RC, LMH, and Lower Red Chert (LRC)/Lower Iron Formation (LIF). The ore zones were reported by WESA (2014) to have moderate to highly fractured water-producing zones with frequent zones of granulated, disintegrated altered rock. The Ruth Shale and Wishart Quartzite units, also located in the open pit mine area, are typically harder, less fractured, and of lower permeability.

Table 12.4 summarizes the available hydraulic testing at Joyce Lake, including three response tests performed by Stassinu Stantec in 2012 and a series of packer tests, pumping tests and injection tests performed on six 150 m to 171 m deep boreholes near the open pit mine in 2014 (WESA 2014). No hydraulic testing was performed on the shallow geotechnical holes by LVM 2014b. Detailed results for the 2014 WESA program are provided in the WESA 2014 Report (Appendix O) and in Table 1 in Appendix P, along with detailed results from Stassinu Stantec 2012 program.

Table 12.4 Statistical Summary of Hydraulic Testing – Joyce Lake Open Pit Mine

Test Type	Unit		K (m/s)	N	Source
Packer	Red Chert	Geomean	7 x10^{-07}	4	WESA 2014
Packer	Lr. Massive Hematite/Red Chert	Geomean	2 x 10^{-06}	5	WESA 2014
Packer	Lr. Iron Fm./Lr. Red Chert	Geomean	7 x 10^{-07}	9	WESA 2014
Packer	Wishart Quartzite	Geomean	3 x10^{-07}	7	WESA 2014
Packer	Ruth Shale	Geomean	2 x 10^{-06}	1	WESA 2014
Packer	All Units	Min	1.1 x 10^{-08}	26	WESA 2014
Packer	All Units	Max	3.7 x 10^{-06}	26	WESA 2014
Packer	All Units	Geomean	6.9 x 10^{-07}	26	WESA 2014
Packer	All Units	Median	9.2 x 10^{-07}	26	WESA 2014
Packer	All Units	Standard Deviation	8.9 x 10^{-07}	26	WESA 2014
Pumping/Injection Tests	All	Geomean	3.1 x 10^{-07}	9	WESA 2014
Slug Tests	All	Geomean	1.2 x 10^{-05}	7	Stassinu Stantec 2013
All pump Tests	All	Geomean	1.5 x 10^{-06}	16	WESA 2014
All hydraulic data	All	Geomean	5.6 x 10^{-07}	34	All

Notes:
Packer testing performed by WESA, 2014; Slug testing performed by Stassinu-Stantec, 2013
K = hydraulic conductivity in m^3/m^2/second (m/s)

Groundwater Conditions

A preliminary assessment of probable groundwater depth, gradients, and flow velocity was presented in the baseline hydrogeology study report (Stassinu Stantec 2013). Figure 12.4 illustrates the relative groundwater level and interpreted groundwater flow directions across the Joyce Lake open pit mine site based on water level measurements in the six 2014 test wells (measured by WESA October 13-18, 2014) and the accessible open exploration boreholes (measured by Stassinu Stantec, October 2012). Figure 12.5 further illustrates the groundwater flow regime across the Project area showing the inferred groundwater flow divides and areas of recharge and discharge associated with the groundwater system.

Groundwater depths vary with topography, with higher groundwater elevations and greater depth to water table in wells located at higher topographic elevations, and lower elevations and shallower depth to water near the lake shore (Stassinu Stantec 2013). Table 12.5 summarizes the measured water table depth below ground and groundwater elevations. Measured groundwater levels varied from artesian flow (i.e., water level was above ground surface) to 36.4 m below ground (mbg), and averaged 17.1 mbg across the site. Corresponding static groundwater elevations varied 42.2 m across the PDA, ranging 482.7 to 524.8 m and averaged 510.1 m.

Based on its upland location on a bedrock peninsula in Attikamagen Lake, local groundwater recharge is likely entirely from precipitation, and would be locally variable based on topography, overburden thickness and permeability, bedrock permeability, and seasonal thaw periods. Based on experience elsewhere in Labrador, groundwater recharge and evapotranspiration would be expected to occur during the summer months of June through September; groundwater outflow to streams could continue to occur during the remaining periods of the year.

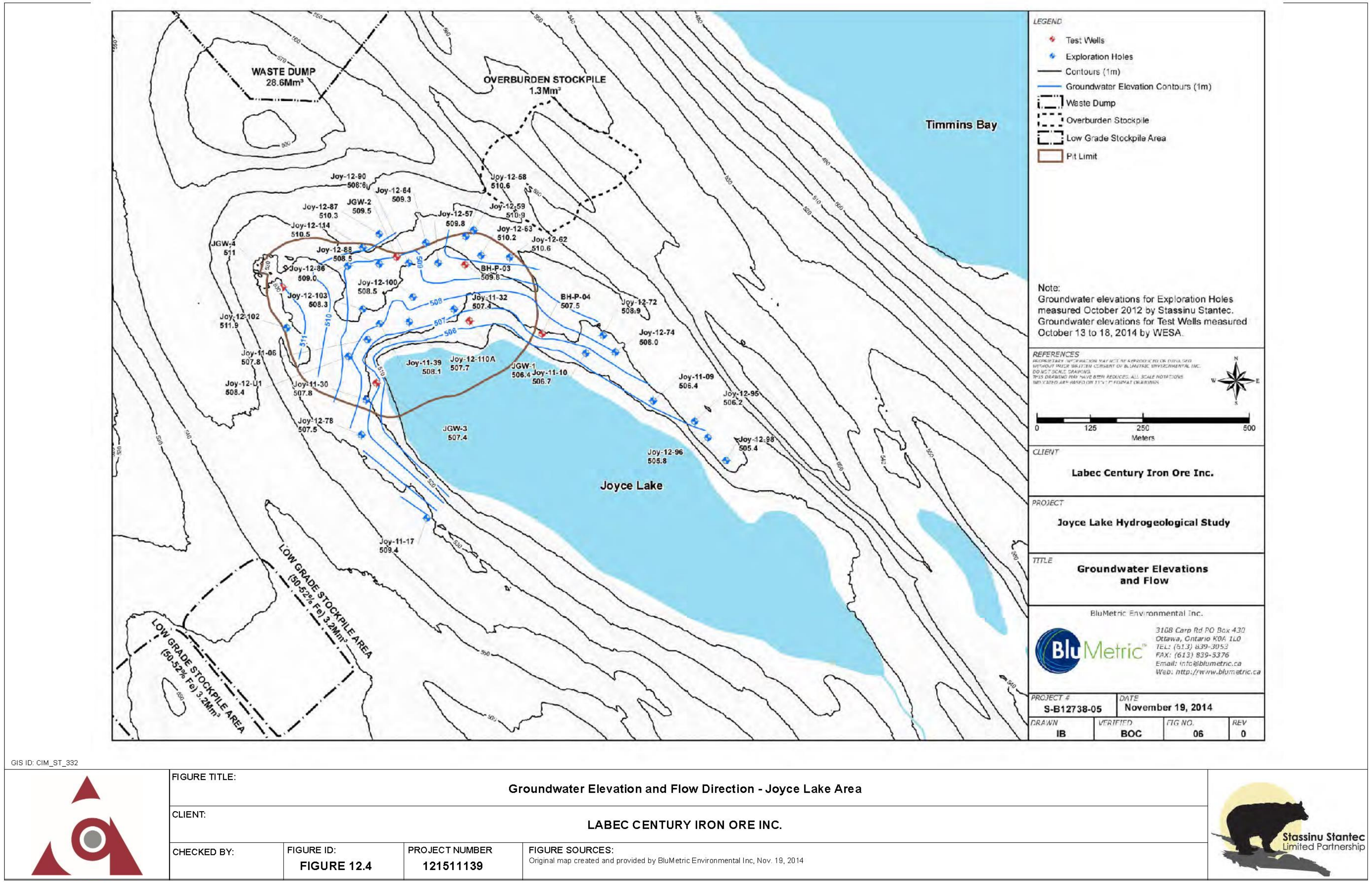

Figure 12.4 Groundwater Elevation and Flow Direction – Joyce Lake Area

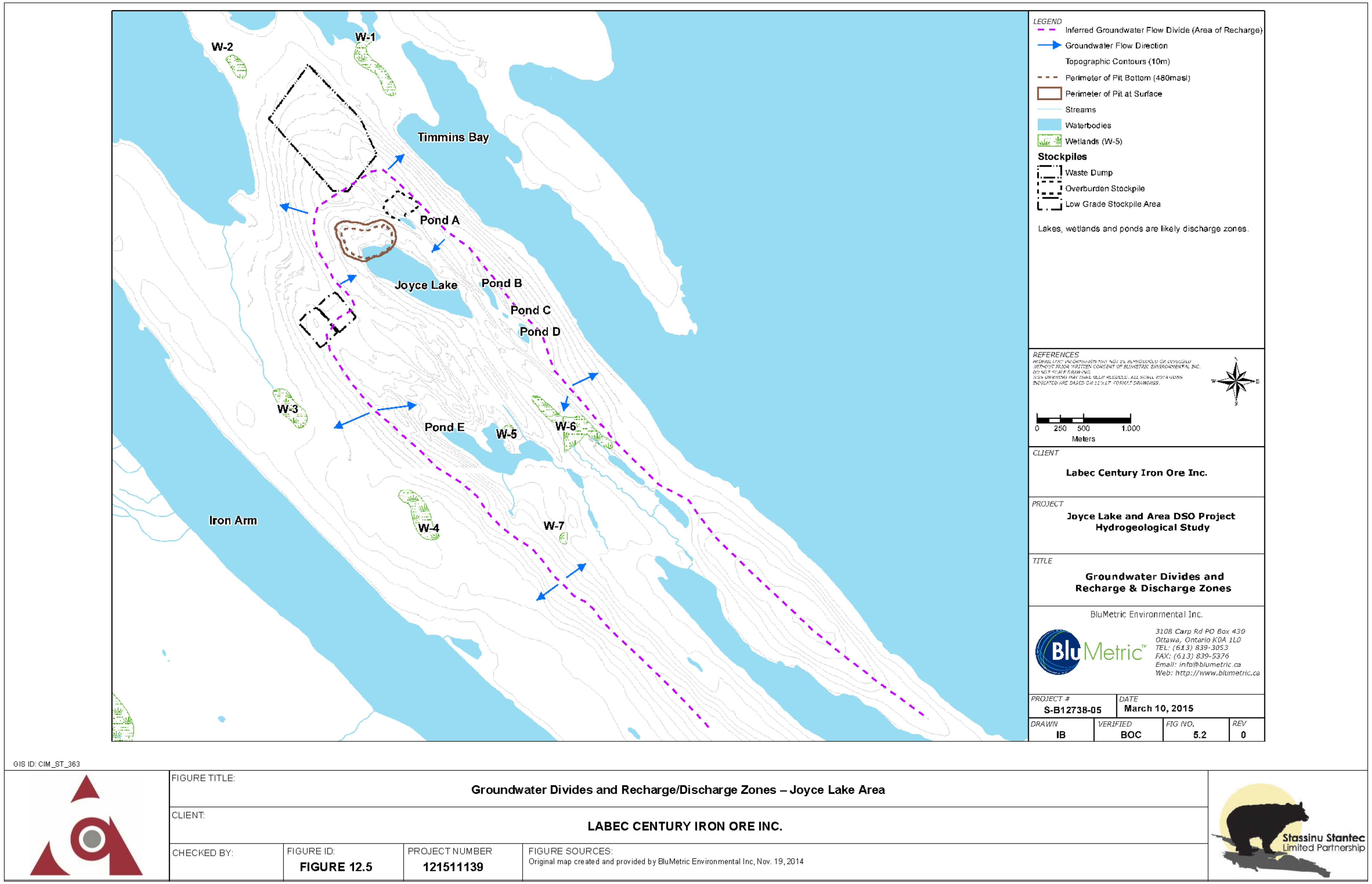

Figure 12.5 Groundwater Divides and Recharge/Discharge Zones – Joyce Lake Area

Table 12.5 Summary of Groundwater Level Monitoring Data – Joyce Lake Open Pit Mine Site

Borehole ID	Borehole Location	Borehole Depth (m)	Borehole Diameter (mm)	Ground Elevation (m)	Water Level (mbg)	Water Elevation (m)	K Test Completed	Chemistry Sample Taken	Data Source
JGW-01	Open Pit Mine	171.0	100	517.31	11.05	506.04	Y	Y	2
JGW-02	Open Pit Mine	171.3	100	532.78	23.38	509.52	Y	Y	2
JGW-03	Open Pit Mine	171.0	100	517.01	9.61	507.39	Y	Y	2
JGW-04	Open Pit Mine	171.3	100	529.49	18.55	511.02	Y	Y	2
BH-P-03	Open Pit Mine	160.7	100	526.33	16.54	509.79	Y	Y	2, 4
BH-P-04	Open Pit Mine	160.0	100	518.84	11.35	507.49	Y	Y	2, 4
Joy-11-06	Open Pit Mine	143.0	75	526.74	18.92	507.82			1
Joy-11-09	Open Pit Mine	140.0	75	514.65	8.21	506.44			1
Joy-11-10	Open Pit Mine	123.0	75	517.09	10.42	506.67			1
Joy-11-15	Open Pit Mine	147.0	75	521.50	0.55	520.95			1
Joy-11-17	Open Pit Mine	99.0	75	530.48	21.10	509.38			1
Joy-11-19	Open Pit Mine	146.0	75	541.53	36.40	505.13			1
Joy-11-30	Open Pit Mine	174.0	75	520.03	12.20	507.83			1
Joy-11-32	Open Pit Mine	174.0	75	521.53	14.15	507.38			1
Joy-11-39	Open Pit Mine	168.0	75	527.57	19.50	508.07			1
Joy-11-41	Open Pit Mine	171.0	75	524.12	7.03	517.09			1
Joy-12-57	Open Pit Mine	128.0	90	526.78	17.00	509.78			1
Joy-12-58	Open Pit Mine	60.0	90	535.42	24.87	510.55			1
Joy-12-59	Open Pit Mine	66.0	90	536.66	25.75	510.91			1
Joy-12-62	Open Pit Mine	69.0	90	532.05	21.50	510.55			1
Joy-12-63	Open Pit Mine	91.5	90	532.18	22.00	510.18			1
Joy-12-64	Open Pit Mine	69.0	90	536.42	27.10	509.32			1
Joy-12-67	Open Pit Mine	90.0	90	525.05	0.20	524.85			1
Joy-12-69	Open Pit Mine	118.5	90	524.83	2.55	522.28			1
Joy-12-71A	Open Pit Mine	90.0	90	524.73	0.10	524.63			1
Joy-12-72	Open Pit Mine	84.0	90	519.08	10.17	508.91			1

Table 12.5 Summary of Groundwater Level Monitoring Data – Joyce Lake Open Pit Mine Site

Borehole ID	Borehole Location	Borehole Depth (m)	Borehole Diameter (mm)	Ground Elevation (m)	Water Level (mbg)	Water Elevation (m)	K Test Completed	Chemistry Sample Taken	Data Source
Joy-12-74	Open Pit Mine	90.0	90	516.40	8.40	508.00			1
Joy-12-78	Open Pit Mine	30.0	90	524.08	16.55	507.53			1
Joy-12-82	Open Pit Mine	42.0	90	532.98	29.85	503.13			1
Joy-12-86	Open Pit Mine	79.5	90	533.20	24.20	509.00			1
Joy-12-87	Open Pit Mine	48.0	90	544.09	33.75	510.34	Y	Y	1
Joy-12-88	Open Pit Mine	69.0	90	534.06	25.55	508.51			1
Joy-12-90	Open Pit Mine	78.0	90	530.16	21.55	508.61			1
Joy-12-92	Open Pit Mine	42.0	90	521.36	16.50	504.86			1
Joy-12-93	Open Pit Mine	76.5	90	512.20	29.50	482.70			1
Joy-12-95	Open Pit Mine	129.0	90	527.73	21.53	506.20			1
Joy-12-96	Open Pit Mine	103.5	90	527.86	22.10	505.76			1
Joy-12-98	Open Pit Mine	45.0	90	525.92	20.48	505.44			1
Joy-12-100	Open Pit Mine	141.0	75	528.57	20.10	508.47			1
Joy-12-102	Open Pit Mine	49.5	90	530.67	18.80	511.87	Y	Y	1
Joy-12-103	Open Pit Mine	153.0	75	530.04	21.70	508.34	Y	Y	1
Joy-12-105	Open Pit Mine	135.0	75	523.59	0.05	523.54			1
Joy-12-106	Open Pit Mine	117.0	75	524.43	0.25	524.18			1
Joy-12-110A	Open Pit Mine	171.0	75	524.76	17.10	507.66			1
Joy-12-112A	Open Pit Mine	98.0	75	519.80					1
Joy-12-114	Open Pit Mine	117.0	90	541.46	31.00	510.46			1
Joy-12-116	Open Pit Mine	100.5	90	536.00	16.70	519.30			1
Joy-12-U1	Open Pit Mine	159.0	86	525.22	16.85	508.37			1
BH-01-14	Borrow Pit near Rail Loop	20.9	73	473.99	0.47	473.52			3
BH-02-14	Borrow Pit near rail loop	16.1	73	474.24	0.72	473.52			3
BH-03-14	Rail Loop	4.0	73	508.03	>4.04	<504.0			3
BH-04-14	Rail Loop	14.0	73	502.25	7.80	494.45			3

Table 12.5 Summary of Groundwater Level Monitoring Data – Joyce Lake Open Pit Mine Site

Borehole ID	Borehole Location	Borehole Depth (m)	Borehole Diameter (mm)	Ground Elevation (m)	Water Level (mbg)	Water Elevation (m)	K Test Completed	Chemistry Sample Taken	Data Source
BH-05-14	Borrow Pit near rail loop	6.5	73	475.55	1.00	474.55			3
BH-06-14	Borrow Pit	7.2	73	477.17	5.03	472.14			3
BH-07-14	Borrow Pit	12.5	73	475.99	0.25	475.74			3
BH-08-14	Borrow Pit	11.5	73	476.19	0.00	476.19			3
BH-09-14	Mine Haul Road at Telecom Tower	3.1	73	548.17	0.25	547.92			3
BH-10-14	Causeway West	5.6	73	475.81	0.70	475.11			3
BH-11-14	Causeway East	5.8	73	470.45	0.40	470.05			3
BH-12-14	Accommodations	3.8	73	506.90	0.00	506.90			3
BH-13-14	Processing Plant	2.4	73	489.75	>1.28	<488.5			3
BH-14-14	Low Grade Ore	2.7	73	533.86	1.25	532.61			3
BH-15-14	Overburden	4.5	73	542.02	4.23	537.79			3
BH-16-14	Waste Rock	17.9	73	531.57	0.27	531.30			3
BH-17-14	Mine Haul Road (Rail Loop)	2.4	73	516.45	1.68	514.77			3
BH-18-14	Mine Haul Road (Telecom Tower	3.1	73	472.00	0.50	471.50			3

Notes:
m – metre; mm – millimetres, mbg – metres below ground; K – hydraulic conductivity
Data source: 1 – Stassinu Stantec 2012; 2 – WESA 2014; 3 – LVM 2014b; 4 - LVM 2014a

Figure 12.4 (after WESA 2014) shows that the pre-mining groundwater flow directions in the vicinity of the open pit mine are predominantly towards Joyce Lake. Groundwater flow directions are expected to closely follow topography, flowing from local recharge areas at topographic highs at local watershed divides towards local topographic lows around Joyce Lake, Hollinger Lake, and other smaller lakes and streams in the area. Conceptually, the local groundwater flow directions can be expected to be relatively short (1 to 2 km) from the local bedrock ridge-dominated upland areas (average elevation 560 to 580 m) located north, east and west of Joyce Lake, flowing inwards towards Joyce Lake (estimated elevation 503 m) and associated local low lands that host lakes, streams, and wetlands. Outside of these local topographic highs forming the Joyce Lake sub-watershed, groundwater flow would be expected to be towards Attikamagen Lake on the north, Iron Arm on the west, Timmins Bay on the east, and Hollinger Lake on the south.

In consideration of the thin overburden characteristic of the area, the primary mode of shallow groundwater flow likely occurs as interflow through the thin permeable overburden and shallow fractured bedrock from elevated areas towards low areas, streams and wetlands. Table 12.6 summarizes pre-mining horizontal hydraulic gradients in the vicinity of the open pit mine (Stassinu Stantec, 2013). Inferred horizontal groundwater gradients range from 1.2% (i.e., 0.012 m/m near the lake) to 6.4% (from north highland area) throughout the site, averaging 3% towards the lake shores, and averaging 1.6% southward in the low area of the proposed open pit mine immediately north of the lake. These gradients are similar to estimates provided by WESA 2014 (0.014 to 0.039 m/m in the open pit mine area north of Joyce Lake).

Table 12.6 Estimated Horizontal Groundwater Gradients

Borehole 1	Borehole 2	Elev. 1 (m)	Elev. 2 (m)	Distance (m)	Gradient (%)	Flow Direction
East and West of Joyce Lake						
JOY-11-17	Lake	509.38	503	100.0	6.4%	east
Joy-12-78	Lake	507.53	503	102.9	4.4%	east
Joy-12-72	Lake	508.90	503	123.0	4.8%	west
Joy-11-32	Lake	507.38	503	114.3	3.8%	south
Joy-12-82	Lake	510.55	503	182.9	4.1%	southwest
South from the Open Pit Mine towards Joyce Lake						
JGW-2	Lake	509.5	503.0	229	2.8%	south
JGW-4	JGW-3	511.0	507.4	310	1.2%	southeast
JGW-2	JGW-1	509.5	506.4	194	1.6%	south
Joy-12-57	Joy-11-32	509.78	507.38	157	1.5%	south
Joy-12-87	Joy-12-90	510.34	508.61	77	2.2%	south
Joy-12-87	Joy-11-32	510.34	507.38	247	1.2%	south
Joy-12-102	Joy-12-103	511.87	508.34	183	1.9%	east
Joy-12-114	Joy-12-100	510.46	508.47	163	1.2%	Southeast
Notes: m – metres; % -%; Joyce Lake elevation assumed to be 505 m geodetic						

No multi-level monitoring wells are available to assess vertical gradients at the Joyce Lake site. Based on topography and observed water levels in boreholes, a downward vertical hydraulic gradient from overburden to bedrock is expected in the sub-watershed divide areas, and upward vertical hydraulic gradient would be expected close to the lake shores. Based on the available water level data in the vicinity of the open pit mine (observed horizontal gradients and updated bedrock K values from WESA 2014, Table 12.4), the average linear groundwater flow velocity is estimated to be in the order of <0.1 to 1 m/day (mean 0.16 m/day) in the open pit mine area north of Joyce Lake, and <0.1 to 0.4 m/day (mean 0.45 m/day) near the east and west shores of Joyce Lake. WESA 2014 estimates average linear groundwater velocities ranging from 9 m/yr to 200 m/yr. (<0.1 to 0.5 m/d) in the vicinity of the open pit mine.

While there are no site-specific groundwater monitoring data at the other sites, the above observations can generally be applied to the other mine components by pro-rating the grade elevations. Table 12.5 provides measured water levels for geotechnical boreholes established in the other mine components; these are described in Section 12.6.1.

Water Balance

A preliminary estimation of groundwater recharge is provided as part of water balance analysis in Chapter 11. In the cold climate characteristic of Labrador, groundwater recharge is limited to the short summer months when evapotranspiration is less than the sum of total rainfall less total run-off. Recharge may also be limited in areas of discontinuous permafrost. Some localized recharge may occur during the winter (October through April) during short periods of thaw. Discharge to receiving waters could occur year-round below the frost line, with resulting lowering of water table elevation, and is an important component of stream baseflow in the winter when direct overland flow is limited. A regional groundwater recharge (Infiltration) coefficient of 270 mm/yr. has been used for water balance and groundwater modeling at this site.

No data were retrieved from the automated water level dataloggers installed by Stassinu-Stantec in late 2012. Further details on seasonal recharge and water table fluctuation will be available after collection of two years of water level data.

Groundwater Chemistry

Table 12.7 presents a statistical summary of groundwater chemistry collected to date at the Joyce Lake site. The full general and metals chemistry results for the 2012 and 2014 samples are provided in Table 2 and Table 3 respectively, in Appendix P.

Table 12.7 Statistical Summary of Groundwater Chemistry, Joyce Lake

Parameter	Units[1]	MDMER[2] Sch. 4	CWQG-PAL[3]	NLR 65/03[4] Sch. A	Min	Max	Mean	N
Sodium	mg/L	-	-	-	0.4	19.9	4.3	10
Potassium	mg/L	-	-	-	0.2	2.0	0.7	10
Calcium	mg/L	-	-	-	1.1	9.6	4.4	10
Magnesium	mg/L	-	-	-	1.2	9.9	4.9	10
Alkalinity	mg/L	-	-	-	9.3	53.1	33.2	9
Acidity	mg/L	-	-	-	11.6	15.0	13.4	6
Sulfate	mg/L	-	-	-	2.1	40.0	12.2	9
Chloride	mg/L	-	120.0	-	0.2	31.0	4.0	9
Fluoride	mg/L	-	-	-	<0.1	<0.1	<0.1	3
Silicate	mg/L	-	-	-	4.4	7.5	6.2	3
Ortho Phosphorus	mg/L	-	-	-	<0.01	<0.01	<0.01	3
Total Phosphorus	mg/L	-	-	-	0.2	0.6	0.4	3
Dissolved Phosphorus (P)	mg/L	-	-	-	<0.1	<0.1	<0.1	3
Nitrate + Nitrite	mg/L	-	-	-	<0.1	0.45	0.29	9
Nitrate	mg/L	-	3.00	13.00	<0.1	0.45	0.29	9
Nitrite	mg/L	-	-	-	<0.05	<0.03	<0.03	9
Ammonia	mg/L	-	-	-	<0.03	0.14	0.05	9
Total Kjeldahl Nitrogen (TKN)	mg/L	-	-	-	0.05	0.87	0.37	3
Diss. Organic Carbon (C)	mg/L	-	-	-	<0.5	<0.5	<0.5	3
Total Organic Carbon (C)	mg/L	-	-	-	<0.5	0.5	0.34	3
Colour	TCU	-	-	-	<5	<5	<5	3
Turbidity	NTU	-	-	-	1.7	>1000	386.0	2
Conductance	uS/cm	-	-	-	24	221	101.5	10
pH	units	-	6.5-9.0	-	6.7	7.8	7.2	10
Hardness	mg/L	-	-	-	7.9	61.8	33.4	9
TDS	mg/L	-	-	1000	21	130	80	9
TSS	mg/L	-	-	-	5	6,600	3,300	4
Sum Anions	me/L	-	-	-	0.25	1.82	0.86	3
Sum Cations	me/L	-	-	-	0.26	1.37	0.63	3

Table 12.7 Statistical Summary of Groundwater Chemistry, Joyce Lake

Parameter	Units[1]	MDMER[2] Sch. 4	CWQG-PAL[3]	NLR 65/03[4] Sch. A	Min	Max	Mean	N
% Difference	-	-	-	-	1.96	30.80	15.62	3
Bicarbonate	mg/L	-	-	-	9.3	48.0	26.4	3
Carbonate	mg/L	-	-	-	<1	<1	<1	3
Langelier Index (@ 4C)	-	-	-	-	-3.53	-1.95	-2.86	3
Langelier Index (@ 20C)	-	-	-	-	-3.27	-1.70	-2.61	3
Saturation pH (@ 4C)	-	-	-	-	9.08	10.30	9.79	3
Saturation pH (@ 20C)	-	-	-	-	8.83	10.00	9.54	3
Metals:								
Aluminum	µg/L	-	100	-	<5	51.3	20.7	10
Antimony	µg/L	-	-	-	<1	<1	<1	10
Arsenic	µg/L	1,000	5	500	<1	<1	<1	10
Barium	µg/L	-	-	5,000	<1	36.0	6.6	10
Beryllium	µg/L	-	-	-	<1	<1	<1	10
Bismuth	µg/L	-	-	-	<1	<1	<1	10
Boron	µg/L	-	1,500	5,000	<2	<50	<50	10
Cadmium	µg/L	-	-	50	<1	0.15	0.041	10
Cerium	µg/L	-	-	-	<1	<1	<1	6
Cesium	µg/L	-	-	-	<1	<1	<1	6
Chromium	µg/L	-	-	1,000	<1	1.6	<1	10
Cobalt	µg/L	-	-	-	0.22	7.4	2.6	10
Copper	µg/L	600	2	300	<1	**9.9**	**3.6**	10
Europium	µg/L	-	-	-	<1	<1	<1	6
Gallium	µg/L	-	-	-	<1	<1	<1	6
Iron	µg/L	-	-	10,000	<20	4,510	728	10
Lanthanum	µg/L	-	-	-	<1	<1	<1	6
Lead	µg/L	400	1	200	<0.1	<0.1	<0.1	10
Lithium	µg/L	-	-	-	<5	5.5	3.5	6
Manganese	µg/L	-	-	-	42	16,400	4,170	10
Mercury	µg/L	-	0.026	5	<0.1	0.037	<0.1	10

Table 12.7 Statistical Summary of Groundwater Chemistry, Joyce Lake

Parameter	Units[1]	MDMER[2] Sch. 4	CWQG-PAL[3]	NLR 65/03[4] Sch. A	Min	Max	Mean	N
Molybdenum	µg/L	1,000	73	500	<1	7.7	1.8	10
Nickel	µg/L	-	25	-	<2	39	11.4	10
Niobium	µg/L	-	-	-	<0.1	<0.1	<0.1	6
Rubidium	µg/L	-	-	-	1	1.9	1.575	6
Scandium	µg/L	-	-	-	<0.1	<0.1	<0.1	6
Selenium	µg/L	-	1	10	<1	11.2	5.2	10
Silicon	µg/L	-	-	-	<600	<600	<600	6
Silver	µg/L	-	0.1	50	<1	<1	<1	10
Strontium	µg/L	-	-	-	5	64.0	17.5	10
Sulfur	µg/L	-	-	-	<800	620.0	516.0	6
Tellurium	µg/L	-	-	-	<1	<1	<1	6
Thallium	µg/L	-	0.8	-	<1	<1	<1	10
Thorium	µg/L	-	-	-	<1	<1	<1	6
Tin	µg/L	-	-	-	<1	<1	<1	10
Titanium	µg/L	-	-	-	<1	<1	<1	10
Tungsten	µg/L	-	-	-	2	80.8	26.7	6
Uranium	µg/L	-	15	-	<1	<1	<1	10
Vanadium	µg/L	-	-	-	<1	<1	<1	10
Yttrium	µg/L	-	-	-	<1	3.2	1.2	6
Zinc	µg/L	1,000	30	500	<5	**69.2**	11.5	10
Zirconium	µg/L	-	-	-	<1	<1	<1	6

Notes:
1. TCU-True Colour Unit; NTU-Nephelometric Turbidity Unit; mg/L-milligrams per litre; µg/L–micrograms per litre; me/L–milliequivalents per litre; µS/cm-microseimens/centimeter; "-" = no criteria; "<" - not detected above RDL (Reportable Detection Limit)
2. MDMER Schedule 4- Metal and Diamond Mining Effluent Regulations
3. CWQG-PAL Guidelines (CCME Canadian Environmental Quality Guidelines Online; https://ccme.ca/en/summary-table (bold-shaded exceeds)
4. NLR 65/03 Schedule A - Newfoundland and Labrador Regulation 65/03.

The shallow groundwater at Joyce Lake is characterized by low concentrations of chloride, major ions, nutrients, metals, and dissolved solids. Based on nine groundwater chemistry samples (three collected in 2012 by Stassinu-Stantec and six collected in 2014 by WESA), the pre-mining bedrock groundwater chemistry in the vicinity of the open pit mine is generally characterized as a clear (colour <5 TCU), very soft (hardness 8 to 62 mg/L, mean 33 mg/L), neutral to slightly acidic (pH 6.7 to 7.8, mean 7.2; alkalinity 9.3 to 53 mg/L, mean 32 mg/L; calcite saturation index -3.5 to -2.0, mean -2.9), calcium bicarbonate water type of low TDS (21 to 130 mg/L, mean 80 mg/L).

The analyzed parameters meet the MDMER Schedule 4 Regulations and the Newfoundland and Labrador Regulation 65/03 Schedule A Guidelines. The CCME-PAL guidelines are exceeded for copper at JGW-1 (7.5 µg/L), JGW-3 (9.9 µg/L) and BH4 (4.7 µg/L); and zinc at JGW-1 (69.2 µg/L).

With respect to water supply well development in this area, concentrations of iron (<20 to 4,510, mean 728 µg/L) and manganese (42 to 16,400, mean 4,170 µg/L) exceed respective Guidelines for Canadian Drinking Water Quality, Health Canada 2020. This is likely associated with the iron ore materials, and/or nearby wetlands (e.g., the 2012 uncased well samples).

Based on their experience in Schefferville area, WESA 2014 suggests that the proposed open pit mine dewatering wells should provide an overall water quality that can be directly discharged to local lakes and streams without treatment other than sediment removal.

12.5.3.2 Modular Processing Plant and Ore Stockpiles

The modular processing plant and associated fine and lump ore stock piles, the ROM mixing area and associated water management systems are located on a small ridge west of the open pit mine near Iron Arm (Figures 1.1 and 2.2 in Chapter 1 and Chapter 2, respectively). Drainage from the processing plant area will be directed southwest through a sedimentation control pond that discharges into Iron Arm (Figure 2.2 in Chapter 2). Groundwater flow is expected to follow topography from inferred recharge areas along the bedrock ridge either eastward towards a wetland and un-named brook that flows north to Attikamagen Lake, or west towards Iron Arm; based on available mapping, the majority of flow from the plant is expected to move towards the west.

Based on the surficial geology mapping (Figure 13.6, Chapter 13), the processing plant area is underlain by a thin glacial till veneer over the southern portion of the site, with slightly thicker glacial till expected to the north of the ridge and along the un-named brook. Based on one 2.4 m deep geotechnical borehole (BH-13-14, LVM 2014b), the site is overlain by 0.15 m of compact brown silt with some sand and gravel till, and underlain by highly weathered gray shale and siltstone of the Dolly Formation (Figure 13.2, Chapter 13). Structurally, this area is situated on a major northwest-striking synclinorium, which implies that older rocks of the Sokoman, Wishart and Dolly Formations could occur at depth. The water table is measured to be greater than the borehole depth (> 1.3 m below grade).

12.5.3.3 Accommodations Camp Facility

The accommodations camp facility is located on the access road on a bedrock ridge south of the open pit mine and the modular processing plant. Drainage is to the west towards Iron Arm through a water control sedimentation pond (Figures 1.1 and 2.3 in Chapter 1 and Chapter 2, respectively). The site is situated on a minor ridge between Iron Arm on the west and an apparent wetland to the east, and local groundwater flow would be expected to flow west towards Iron Arm and east towards an un-named lake.

The proposed accommodations facility is underlain by thin glacial till (Figure 13.6, Chapter 13) and is underlain predominantly by gray shale and siltstone of the Dolly Formation; outcrops of massive dolomite of the Denault Formation may occur on the north, and ridges comprised of Wishart Formation quartzite are noted on the west (Figure 13.2, Chapter 13). Based on one 3.8 m deep geotechnical borehole (BH-12-14, LVM 2014b) this area is overlain by 0.76 m of loose brown sandy gravelly silt and underlain by weathered gray siltstone bedrock. The static water level is observed to be near grade.

12.5.3.4 Low Grade Ore Stockpile

The low grade ore stockpile is situated in an elevated area between Joyce Lake and the modular processing plant (Figures 1.1 and 2.3 in Chapter 1 and Chapter 2, respectively). Based on the overburden and geology mapping, this area is overlain by a thin veneer of glacial till (Liverman et al. 2010), and underlain by a complexly folded bedrock comprised of ortho-quartzite (Wishart Fm.), siltstone/shale (Dolly Fm.) and cherty iron ore (Sokoman Formation), (Wardle 1982a, 1982b). Pending further detailed investigation of local topography, groundwater in this area is expected to flow northeast towards Joyce Lake (pre-mining), and would flow towards the open pit mine in the later phases of development. Based on one 2.7 m deep geotechnical borehole (BH-14-14, LVM 2014b) this area is underlain by 0.46 m of loose brown sandy gravelly silt followed by weathered gray siltstone bedrock with thin bands of white chert. The static water table is indicated to be 1.25 m below grade in this area.

12.5.3.5 Astray Lake Rail Yard

The Astray Lake rail yard facility is located on flat-lying lands west of Astray Lake; drainage is east to the lake through a settling pond (Figure 2.4, Chapter 2). The area is overlain by variable thickness of glacial till. A zone of glacio-fluvial silt, sand, and gravel with groundwater supply development potential is delineated immediately northeast of the rail yard site along the south flowing Gilling River. A zone of rocky till veneer is noted southeast of the site and south of the confluence of Gilling River and Astray Lake (Liverman, et al. 2007).

The underlying bedrock consists of predominantly easterly-dipping gray shale, siltstone, and graywacke of the Le Fer Formation on the west, and dolomite of the Denault Formation on the east. A northeast-trending thrust fault and a narrow band of younger quartzite, siltstone, and minor chert of the Wishart Formation is noted to the east along Gilling River (Wardle 1982a, 1982b).

Geotechnical investigations by LVM, 2014b (BH-03-14 and BH-04-14) near the rail loop indicate 0.5 m to 4.3 m of compact to dense brown silty sandy sand till overlying grey siltstone bedrock. No groundwater resource users are identified in this area. Thick deposits of glacial material are identified northeast of the Rail Loop (BH-01, 02, 05, 06, 07 and 08 and BP-02-01, BH-02-02 and BP-03-01, LVM 2014b) in a proposed borrow pit area near Gilling River. The groundwater table is indicated to be >4.0 to 7.8 m below grade (BH-03 and 04). Based on topography, the dominant groundwater flow direction would be expected to be east and southeast towards Astray Lake and Gilling River.

12.5.3.6 Haulage Road

The haulage road extends approximately 43 km southeast from the mine site to the Astray Lake rail yard loop (Figure 1.1 and 2.4 in Chapter 1 and Chapter 2, respectively). A roadway corridor has been established for planning purposes and the final alignment will be in agreement with surface rights and other title holders. Sediment control measures (e.g., sediment traps) will be implemented to control sediment from entering adjacent watercourses. The route crosses several southeast-flowing streams of the Attikamagen, Petitsikapau and Astray Lake watersheds. Overburden is expected to consist of variable thicknesses of predominantly glacial till deposited between bedrock ridges characteristic of the area; the ridges are likely covered by thin veneers of till and regolith (Liverman et al. 2007). The route crosses the northwest-trending Petitsikapau Synclinorium, and the majority of the route is underlain by gray and black shale and sandstone of the Menihek Formation (Wardle 2007). The bedrock-dominated ridges appear to be underlain by harder quartzite rocks of the Wishart Formation.

A number of geotechnical boreholes are located along the haulage road (BH-12-09, 10, 11, 17 and 19, LVM 2014b). Static water levels ranging from 0.25 m to 1.7 m are reported by LVM 2014b. No groundwater resource users are identified along this route. LVM 2014 has mapped the entire Haulage road area for surficial materials and landforms (LVM 2014b, Appendix D). The majority of the route is overlain by thin glacial till, exposed bedrock, and isolated areas of sand and gravel that have been identified as possible materials borrow pits.

12.5.3.7 Waste Rock Storage Area

The waste rock storage area is located north of the proposed open pit mine on the watershed divide between Joyce Lake and the open pit mine on the south and Attikamagen Lake to the north (Figures 1.1 and 2.4 in Chapter 1 and Chapter 2, respectively). This site is overlain by predominantly glacial till (Liverman et al. 2010) and underlain by gray, black and red shale of the Dolly Formation (Wardle 1982a, 1982b). The presence of meltwater channels to the northeast suggests that overburden thickness may increase in a northerly direction from the ridge. Drainage from the waste rock pile will be to the north to Attikamagen Lake via a sedimentation control pond (Figures 1.1 and 2.4 in Chapter 1 and Chapter 2, respectively). Based on topography and water table elevations (Table 12.5), the water table is expected to be deep under the waste rock pile (>30 m), and the dominant direction of groundwater flow should be north towards Attikamagen Lake.

Based on one 17.9 m deep geotechnical borehole (BH-16-14, LVM 2014b) this area is underlain by greater than 18 m of compact to dense brown silt with sand and gravel glacial till. A static water level of 0.27 m below grade is indicated (LVM 2014b).

12.5.3.8 Overburden Stockpile

The overburden storage area is located east of the proposed open pit mine on the watershed divide between Joyce Lake on the west and Timmins Bay on the east (Figures 1.1 and 2.4 in Chapter 1 and Chapter 2, respectively). This site is underlain by discontinuous till veneer with some exposed bedrock with (Liverman, et al. 2010) followed by gray, black and red shale of the Dolly Formation (Wardle 1982a, 1982b). Based on topography, drainage from the overburden pile will be to the west towards the open pit mine. Based on topography and water table elevations (Table 12.5), the water table is expected to be deep under the waste rock pile (> 22 m), and the dominant direction of groundwater flow is expected to be west towards the open pit mine.

Based on one 4.4 m deep geotechnical borehole (BH-15-14, LVM 2014b) this area is underlain by 0.9 m of brown silt with some sand and gravel followed by broken, fine to medium grained grey sandstone bedrock. A static water level of 4.2 m below grade is indicated (LVM 2014b).

12.5.3.9 Existing Groundwater Resource Users

There are no known permanent dwellings that rely on groundwater as a drinking water source within the immediate vicinity of the Project. The nearest municipal area is the Town of Schefferville in Quebec, located 20 km to the southwest of the site. The nearest Indigenous communities (Kawawachikamach, Lac John, and Matimekush) are located 13 to 21 km to the west in Québec (Stassinu Stantec 2013). Because of distance and the numerous intervening lakes, interaction between the Project and existing groundwater supply wells possibly located at these communities is considered to be highly unlikely.

There are cabins or hunting camps in the area that may have drinking water wells; however, it would be necessary to conduct a visual inspection of these locations to confirm presence or absence of a supply. Seasonal camps are identified on Figure 1.1 in Chapter 1, approximately 4 km west of the open pit mine on the western shores of Iron Arm; 8 km northeast of the Astray Lake rail yard loop on the opposite shore of Astray Lake (East Bay); and 1.5 km south of the Astray Lake rail yard loop on the shore of Astray Lake (West Bay). No camps or cabins are identified on the peninsula where the open pit mine will be located. It is suspected that these seasonal camps and cabins would use surface water or local springs for potable supply. No issues were reported with respect to groundwater resources at these identified properties (Tables 11.2 and 11.4). The groundwater modeling work (WESA 2014, Appendix O) has predicted that no drawdown would be detected at the identified hunting camps west of Iron Arm.

12.5.4 Groundwater Development Potential

Water supply wells are proposed to be developed near the modular processing plant, the open pit mine site, Astray Lake rail yard loop and accommodations facility areas to use for both potable and non-potable (e.g., toilet) purposes. Water quality treatment equipment will be installed at the accommodations facility to treat groundwater from wells or surface water for the potable water supply. Other locations at the site will rely on bottled water.

In consideration of its relatively limited thickness (median 3 m) and expected thin till veneer on upland bedrock dominated areas proposed for these sites, groundwater supply development in overburden deposits from dug or screened wells is considered to be poor in the mine area; the presence of possible esker structures to the north of the mine site may offer limited groundwater development potential in overburden.

Ancient metasedimentary and crystalline bedrock is typically considered to be a poor aquifer, with a generally low to moderate bulk conductivity value of 1×10^{-5} m/s or lower, and poor municipal or industrial-scale well development potential (typically less than 100 L/min). However, this bedrock can locally provide sufficient yield for small commercial and individual domestic users, and possibly domestic uses for on-site Project facilities.

Based on the limited hydraulic testing data and experience elsewhere in similar geology, low- to moderate-yield groundwater supply drilled wells could be developed on this site. Pending confirmation by future on-site groundwater exploration and testing, and based on the range and mean hydraulic conductivity from packer tests at the open pit mine (WESA 2014), these wells are likely to exhibit low to moderate yields of 2.5 to 823 L/day, mean 154 L/min, assuming a saturated thickness of 100 m. With on-site storage, these yields could meet specific potable demands.

Groundwater exploration at a specific location would involve proper location of the well with respect to potential groundwater quality risks and water table depression (i.e., from the open pit mine) and the drilling of a test well and an observation well, followed by hydraulic testing (step drawdown test and constant rate pumping test), and water chemistry analysis. The test data would be analyzed by a hydrogeologist to determine the sustainable yield of the well, well interference parameters, and recommended pump setting and pumping rates. Assessment of water chemistry samples taken during the testing would determine water treatment measures, if needed.

12.6 Assessment of Project-Related Environmental Effects

Activities identified on Table 12.2 with a rating of 2 are considered to have the potential to significantly affect local or regional Groundwater Resources either temporarily or permanently and are further assessed in detail below. In particular widespread water table drawdown and changes in local groundwater flow pathways associated with dewatering of the open pit mine during the operational phase have been rated as a “2” and is addressed below. Accidental releases of petroleum hydrocarbons during a major rail or truck accident or tank failure during the life of the Project is also rated “2” and are addressed in Section 12.8.1.

This section describes the potential effects of Project activities on Groundwater Resources, with emphasis on groundwater levels (i.e., groundwater quantity). Because there is no user of Groundwater Resources (i.e., domestic, commercial, municipal, or industrial groundwater supply wells) identified within several kilometres of the Project, the following assessment is more relevant to local Groundwater Resources that may be used by future groundwater supply wells to be developed for Project components, and hydrological interactions with the surface water and wetland VCs.

12.6.1 Assessment of Change in Groundwater Quantity

A summary of potential Project interactions with Groundwater Resources is presented in Table 12.3.

12.6.1.1 Construction

As indicated in Table 12.2, there are no Project activities during Construction rated as a 2 for Groundwater Resources; therefore, no further assessment of Groundwater Resources effects associated with the construction of the Project is warranted. Short-term interactions between overburden groundwater levels and Joyce Lake may occur during initial grubbing and site preparation for the open pit mine and as Joyce Lake is dewatered; however, the effects are likely to be local and limited to the immediate vicinity of the open pit mine footprint and the north end of Joyce Lake. Similarly, shallow groundwater disruption during clearing and construction at the other components is likely to be localized, and will not affect existing Groundwater Resources. No existing or planned groundwater wells will be affected during this phase of the development. These effects rated as “0” or “1” were discussed in Section 12.4.

12.6.1.2 Operation and Maintenance

As indicated in Table 12.2, the only Project activity during Operation and Maintenance rated as a 2 for Groundwater Resources, and therefore requiring further assessment, is associated with the operation of the open pit mine at the north end of Joyce Lake. Operation of the open pit mine and dewatering of Joyce Lake, will involve major ground disturbance, with the potential to cause local changes in groundwater recharge, water table elevation and flow directions. The effects of the open pit mine operation and maintenance on Groundwater Resources include the potential for lowering of the water table in overburden and bedrock due to mine dewatering, blasting effects on any nearby drilled water wells, and interactions with nearby surface water sources.

Groundwater quantity effects can include lowering of local water levels, with consequent reduction in water levels and yield capacity in water supply wells within the drawdown radius of influence of the open pit mine, reduction in domestic well yield in proximity to Project activities due to blasting, and reduction in local stream flows during the summer and winter due to shallow groundwater diversion caused by excavation and associated mine dewatering. A related concern is the potential for diversion of surface water from the Attikamagen Lake system towards the open pit mine in the event that intervening permeable overburden or bedrock structures are encountered, with consequent increase in dewatering requirements.

The initial stages of the open pit mine excavation will include the removal and stockpiling of substantial volumes of glacial till overburden and lake bottom sediment, with consequent dewatering of the overburden and shallow bedrock in the immediate vicinity of the open pit mine. During the operation of the open pit mine, there will be a requirement for the gradual lowering of water levels in fractured bedrock as the excavation of the open pit mine proceeds. As the mining progresses, the degree of groundwater table decline within several hundred metres of the open pit mine will gradually increase in both overburden and bedrock.

At the onset of the work, the groundwater levels in the vicinity of the open pit mine will be in hydraulic equilibrium with Joyce Lake. As Joyce Lake is isolated and dewatered prior to initiation of mining, the groundwater levels surrounding the former lake shore will begin to decline to the new base level (e.g., the lake bottom initially, or the mine pit sump later during operation) once the water is removed. Subsequent to this, the lake bottom sediments and the overburden in the vicinity of the open pit mine footprint will then be removed, resulting in groundwater seepages entering the excavation from the adjacent overburden along the former shorelines and from the perimeter of the landward portions of the open pit mine. The volumes of inflow from the overburden are presently not determined, but would eventually reach equilibrium proportional to the hydraulic conductivity of the overburden materials once the excavation reaches bedrock.

It is likely that the water table in overburden and bedrock will be lowered substantively in the immediate vicinity of the open pit mine, declining with distance from the open pit mine. Preliminary assessment suggests that the effects of mine dewatering will be limited to the watershed in which the open pit mine will be located. The groundwater modelling carried out by WESA (2014) suggests a maximum drawdown influence of up to 5 m at the shores of Timmins Lake (800m to 1,000 m from the open pit mine) at the maximum drawdown. Drawdown effects are not expected to extend beyond Iron Arm or Attikamagen Lake. It is expected that the large lakes surrounding the Project will act as hydrologic boundaries for open pit mine dewatering effects. Because of distance (greater than 13 km to nearest rural settlement), no existing well users are likely to be affected by the open pit mine.

Modeling assumptions were based on the Project PEA published May 8, 2013. The Project description was modified in 2014 to match the FS published April 14, 2015. Project characteristics used as inputs for this assessment may have since changed as a result of the updated description.

Blasting will be a necessary component of the open pit mining operation. As no domestic supply wells are known to be located within several kilometres of the pit, no blasting related effects on wells are likely. Effects, if any, are more likely to be experienced by on-site wells, which can be readily remediated by the Proponent through provision of particulate filters, monitoring, maintenance, rehabilitation, or replacement, as applicable.

Open Pit Mine Groundwater Inflow Prediction

Water entering the open pit mine that will require collection and discharge in the wastewater control system would originate from rainfall, direct overland run-off and groundwater seepages from overburden and bedrock. There is potential for local streams and lakes to positively affect the groundwater inflow to the open pit mine. The overburden and upper few metres of broken bedrock could be the primary pathway between the open pit mine and the remnants of Joyce

Lake to the south (e.g., the baseline assessment suggested a possible north-south oriented bedrock depression through Joyce Lake), and bedrock is expected to be the primary source of groundwater seepage once mining begins.

Based on other similar mining operations, it is expected that most of the direct overland run-off and overburden component of groundwater inflow will be intercepted at the overburden-bedrock interface with an interceptor trench, and then pumped out of the open pit mine footprint to the water management system; therefore, the majority of inflow to the open pit mine should be derived from a combination of groundwater seepage and rainfall over the open pit mine footprint.

The development of the Joyce Lake open pit mine will result in a gradual lowering of local water levels over the life of the mine. Dewatering is anticipated to begin within one year of the start of pit construction and will likely continue throughout the life of the Project. Pit dewatering will be carried out using a minimum of 7 to 10, 170 m to 290 m deep, high capacity (513 to 1,052 m^3/d (94 to 193 US gallons per minute)) dewatering wells distributed around the perimeter of the open pit mine; the actual numbers and depths of wells will be confirmed based on hydraulic testing of the initial dewatering wells (WESA 2014). The groundwater modeling (WESA 2014, Appendix O) predicts maximum pit seepage rates at the maximum 220 m excavation depth to be 5,714 m^3/d (1,050 USgpm) for the base case (Joyce Lake completely dewatered); 5,410 m^3/d (1,190 USgpm) for Option 1 (Partial dewatering of Joyce Lake assuming a silty bottom) and 7,680 m^3/d (1,410 USgpm) for option 2 (Partial dewatering of Joyce Lake assuming a sandy bottom). These estimates will be refined through final design.

Effects of Water Level Lowering on Groundwater Resources

Figures 6.5 -6.9 (found in Appendix O) illustrate the predicted water table configuration at the end of Phase 4 dewatering (elevation 380 m mining depth). Most groundwater flow on the PDA will be towards the open pit mine after Phase 3 (pit bottom elevation 430 m) development is complete.

The potential effects of open pit mine dewatering on local groundwater levels, baseflow to streams and wetlands were addressed through the development of a three-dimensional groundwater flow model. Modelling details are presented in Appendix O (WESA 2014 Hydrogeology report).

The model was run in three scenarios: Base case - complete dewatering of Joyce Lake, Option 1 - partial dewatering of Joyce lake with a silty bottom (assume $K = 1.2 \times 10^{-7}$ m/s) and Option 2 - partial dewatering of Joyce Lake with a sandy bottom ($K = 1.2 \times 10^{-4}$ m/s); no field data respecting lake bottom sediment permeability were available. Water levels and changes in baseflow to local streams and wetlands were estimated for four phases of dewatering (480, 460, 420, and 380 m pit bottom elevations).

The groundwater modeling predicts that the maximum radius of drawdown interaction at the 150 m maximum pit depth will be limited to the Joyce Lake Peninsula, with no drawdown interaction expected west of Iron Arm or east of Attikamagen Lake (Appendix O). In consideration of the distances to the closest likely groundwater resource users (e.g., 13 km to nearest Indigenous community, and 20 km to Schefferville), no effects on bedrock groundwater resources from the open pit mine dewatering is anticipated. Similarly, no effects would be expected at possible shallow wells at camps located on the west side of Iron Arm about 3.5 km west of the open pit mine.

The modeling shows that the bedrock water table levels will decline substantially in the vicinity of the open pit mine (up to 165 m below static), sufficient to maintain a 25 m buffer between bedrock water levels and the open pit mine walls, with a “cone” of drawdown decreasing rapidly with distance from the pit. Potential maximum drawdowns of less than 0.1 m are predicted at the shores of Iron Arm to the west, and from less than 0.1 m to 5.0 m at the shores of Timmins Lake and an inlet of Attikamagen Lake located approximately 800 m to 1,000 m northeast and north of the open pit mine (Appendix O) at the maximum pit depth. Groundwater levels are predicted to decline by 65 m to 5 m (decreasing with distance north from the open pit mine) under the Waste Rock area; 65 m to 35 m under the overburden storage pile; 50 m to 25 m under the low grade stockpiles (WESA 2014, Appendix O).

A comparison of the predicted groundwater levels at various phases of pit dewatering at the various mine components shows the degree of possible drawdown interaction in those locations. For example, a supply well placed in the vicinity of the accommodations facility or the processing plant would realize a 1.5 m to 2.0 m reduction in bedrock water levels at maximum pit depth (WESA 2014); this degree of interaction is not considered to be adverse to the operation of a typical domestic scale supply well, but would need to be considered in the development of any on-site wells (if any) and in the prediction of sustainable yields.

Groundwater baseflow to some water bodies and wetlands in the PDA/LSA is predicted to decrease by 7% to 62% of pre-mining conditions (WESA 2014) depending on distance from the open pit mine and whether or not the water bodies are influence (wetlands) or effluent (lakes, streams) respecting groundwater. While water levels and out flows from water bodies in proximity to the open pit mine may potentially decline, some of this predicted loss will be mitigated by additional freeboard for rain storage. The net effect on the much larger Attikamagen Lake system should be negligible, because groundwater seepage removed from the pit will ultimately return to the lake via the wastewater control system (See Chapters 11 –Water Resources VC and 14 – Wetlands VC for further assessment of interactions between groundwater and surface water features).

A program of water level monitoring of bedrock and overburden surrounding the open pit mine will be implemented to confirm the predicted water levels. Higher inflows may locally occur in the event that permeable bedrock fractures, lineaments or faults in hydraulic continuity with the surrounding lakes are encountered.

12.6.1.3 Closure and Decommissioning

As indicated in Table 12.2, there is no Project activity during Closure and Decommissioning rated as a “2” for Groundwater Resources, and therefore no further assessment of Groundwater Resources effects associated with the closing and decommissioning of the Project is warranted.

Immediately upon the cessation of open pit mining operations, the open pit mine would begin to flood with a combination of rainwater and groundwater seepage. During this period, the local groundwater movement would continue to be towards the open pit mine; however, as the water level rises in the open pit mine, the magnitude of drawdown at points distant from the open pit mine will gradually recover to pre-mining levels. Once the open pit mine has flooded to equilibrium, the local groundwater flow system should return to approximate pre-mining conditions. No further effects on groundwater levels or water quality are anticipated.

It is anticipated that the groundwater model prepared by WESA (Appendix O) can be used to predict the rate of open pit mine flooding after cessation of operations. Assuming typical low hydraulic conductivity for the fracture bedrock, many years to decades are anticipated, unless supplemented by inflow from the Joyce Lake system. The natural infill rate by groundwater and direct precipitation will depend on the final groundwater seepage rates (to be determined as mining progresses), seasonal precipitation within the estimated 181,425 m^2 open pit mine capture area, the volumes of waste rock, and stockpiled overburden returned to the open pit mine, and whether or not other options, such as seasonal diversion of surface water into the open pit mine from Joyce Lake, are used. The flooded pit would ultimately become part of the local surface water environment, draining naturally southward to Hollinger Lake.

12.6.1.4 Mitigation of Project Environmental Effects

The following mitigation measures are proposed to avoid or reduce Project-related effects on Groundwater Resources quantity during the Project Construction phase:

- Management of surface run-off and drainage will include construction of diversion ditches;
- Run-off from stockpiled material areas (i.e., overburden, waste rock, and ore) will be managed and captured through the use of diversion ditches and local appropriately-sized settling ponds, to control discharge to meet regulated limits prior to discharge;
- Ditches, culverts and settling ponds will be designed, as a minimum, for a 1-in-25 year storm event;
- Excavation drainage water control using settling pond; and
- The pit wall rock, excavated waste rock, and ore will be inspected on a regular basis for sulfide mineralization. Standard ARD abatement procedures will be implemented if warranted.

The following mitigation measures are proposed to avoid or reduce Project-related effects on Groundwater Resources quantity during the Project Operation and Maintenance Phase:

- The pit walls will be regularly monitored for measurable groundwater inflows; with a contingency plan for management of anomalous joint-related groundwater inflows from pit walls using interception, depressurization techniques and/or other groundwater inflow management strategies;
- Precipitation will be monitored as an aid in differentiating the proportions of rainfall and groundwater seepage in the total Open Pit discharge;

- Results of groundwater monitoring (Section 12.10.5) will be reported to authorities as required; and
- In the unlikely event that an on-site water supply well is adversely affected by drawdown from the mine operation, it will be inspected, assessed, and if warranted, remediated to the requirements of the user. Options include:
  - Provision of bottled water (temporary) due to effects from equipment, vibration or blasting during road, mine or infrastructure development;
  - Provision of particulate filters (temporary to permanent);
  - Well deepening (in case of water level lowering leading to substantial yield loss); and
  - Well replacement (in case of total well collapse, loss of yield).

A Water Management Plan will be developed to deal with the major components of water inflow, namely: rainfall, overland run-off, and groundwater seepage (See Chapter 11 –Water Resources). This plan will outline water management in and around the major Project component areas (i.e., ore stockpiles and overburden/waste rock disposal areas, open pit, and roads, rail yards, and water crossings).

12.6.1.5 Characterization of Residual Effects

A summary of potential adverse residual environmental effects for Groundwater Resources quality is provided in Table 12.8.

Operation and Maintenance Phase

The dewatering of the open pit mine and Joyce Lake during mine operations will cause a gradual decrease in the groundwater levels in the area immediately surrounding the open pit mine and Joyce Lake during the Operation and Maintenance phase of the Project, followed by a gradual recovery in water levels as the mine floods during Decommissioning. The risk of ARD is low and will be further reduced by interception of groundwater seepage prior to discharge to the open pit mine by the perimeter dewatering wells. Any groundwater seepage to the open pit mine will be managed in the waste water management system and will not migrate off-site. The potential for infiltration of surface water affected by the chemistry of waste rock and overburden stockpiles and subsequent contamination of groundwater will be reduced by drainage management and direction of affected surface water to a waste water treatment system. Since there are no known Groundwater Resources users located within 13 km of the mine, no residual adverse effects on Groundwater Resources are anticipated.

12.6.2 Summary of Residual Environmental Effects

A summary of adverse residual environmental effects is provided in Table 12.8. The Project will result in large changes in local groundwater levels and groundwater gradients during the Operation and Maintenance Phase; the effects will be limited to the PDA and nearby LSA bounded by the major lakes; are likely to be measurable over 6 to 10 years; water level drawdown effects will occur throughout the life of the mine, but will not affect off-site groundwater users; the effects are reversible once active dewatering ends and water levels are allowed to rise; and will occur in an undisturbed area (e.g., no existing groundwater resources users). Adverse residual effects on Groundwater Resources during Project Operation and Maintenance are predicted to be not significant with a high degree of confidence.

Table 12.8 Summary of Residual Environmental Effects – Groundwater Resources

Project Phase	Mitigation/Compensation Measures	Direction	Residual Environmental Characteristics						Significance	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental/Socio-economic Context			
Changes in Groundwater Quantity and Quality											

Operation and Maintenance	• BMP
	• Continuous monitoring of shallow and deep aquifer water levels to track the distance drawdown of groundwater around open pit mine dewatering
	• Reduce pumped water from the open pit mine through
	  ○ Control of runoff through perimeter drainage trenches around open pit mine and Joyce Lake
	  ○ Control of groundwater seepage to open pit mine by a perimeter of deep dewatering wells
	• Water management around waste rock storage to reduce seepage of affected runoff to groundwater
	• See monitoring
		A	L	L	MT	C	R	U	N	H	• Perimeter and off-site water level monitoring (open pit mine, waste rock stockpiles)
											• Open pit mine sump elevation and discharge monitoring
											• Water quality monitoring, open pit mine inflows and discharge, waste rock stockpiles, Above Grade Storage Tanks

Project Phase	Mitigation/Compensation Measures	Direction	Residual Environmental Characteristics						Significance	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental/Socio-economic Context			

Key:

Direction:
P Positive
N Neutral
A Adverse

Magnitude:
N Negligible: no measurable adverse effect anticipated
L Low: effect occurs that is detectable, but is within normal variability of baseline conditions
M Moderate: effect occurs that would cause an increase (or decrease) with regard to baseline, but is within regulatory limits and objectives
H High: effect occurs that would singly or as a substantial contribution in combination with other sources cause exceedances of objectives or standards within the Project boundaries

Geographic Extent:
S Site: effects are restricted to the PDA
L Local: effects extend to the LSA
R Regional: effects extend into the RSA

Duration:
ST Short term: effect restricted to the construction phase
MT Medium term: effect extends through construction and operation phases
LT Long term: effect extends beyond closure
P Permanent: effect is persistent and the measurable parameter(s) unlikely to recover to baseline

Frequency:
O Once per month or less.
S Occurs sporadically at irregular intervals.
R Occurs on a regular basis and at regular intervals.
C Continuous.
U Unlikely to occur

Reversibility:
R Reversible: will recover after Project closure and reclamation
I Irreversible: permanent

Environmental or Socio-economic Context:
U Undisturbed: area has been relatively or not adversely affected by human activity
D Developed: area has been substantially previously disturbed by human development or human development is still present

Significance:
S Significant:
N Not Significant.

Prediction Confidence:
Based on scientific information and statistical analysis, and effectiveness of mitigation or effects management measure
L Low level of confidence.
M Moderate level of confidence.
H High level of confidence.

12.7 Assessment of Cumulative Environmental Effects

A summary of interactions with the Project resulting from other existing projects and activities on Groundwater Resources is presented in Table 12.9. Further detail regarding these projects is provided in Table 5.4, Chapter 5.

Table 12.9 Potential Cumulative Environmental Effects

Other Projects and Activities with the Potential for Cumulative Environmental Effects	Distance from Joyce Lake (km)	Location	Potential Cumulative Environmental Effects	
			Groundwater Quantity	Groundwater Quality
LIM - Schefferville Iron Ore Mine and Houston 1&2	25	Schefferville	0	0
Tata Steel Minerals Canada - DSO Iron Ore Project	35	NL, QC	0	0
IOC Labrador operation	220	Labrador City	0	0
Champion Iron Ltd. - Bloom Lake Mine and Rail Spur	221	Quebec (400 km north of Sept Iles)	0	0
Tacora Resources Ltd. – Scully Mine	225	Wabush	0	0
Champion Iron Ltd. – Kami Iron Ore Project	230	Wabush, Labrador City	0	0
ArcelorMittal - Mont-Wright Mine	245	Fermont, QC	0	0
Champion Iron Mines Ltd. - Fire Lake North Iron Ore Project	245	Fermont, QC	0	0
Nalcor - Lower Churchill Hydroelectric Generation Project	420	Muskrat Falls	0	0
Nova Scotia Power Maritime Link Inc. – Maritime Transmission Link Project	>500	Newfoundland, NS	0	0

Key:
0 Project environmental effects do not act cumulatively with those of other projects and activities.
1 Project environmental effects act cumulatively with those of other projects and activities, but the resulting cumulative effects are unlikely to exceed acceptable levels with the application of best management or codified practices.
2 Project environmental effects act cumulatively with those of other projects and activities and the resulting cumulative effects may exceed acceptable levels without implementation of project-specific or regional mitigation.

12.7.1 Interactions Rated as 0, 1, or 2

No interactions are expected between the other projects or activities identified on Table 12.9. All potential interactions between identified activities on groundwater are rated as “0”.

The primary mitigating conditions are the large distances (greater than 25 km) between the Project and other projects and activities, and the presence of numerous intervening major surface water bodies that would limit overlapping effects to Groundwater Resources. The predicted water level effects during open pit mine operation will be reduced or eliminated when the open pit mine is flooded during decommissioning.

12.8 Accidents and Malfunctions

Major accidents and malfunctions of Project components could affect the quality of local Groundwater Resources and result in residual environmental effects after remediation has been implemented. For this reason, the potential interactions between Groundwater Resources and a potential spill or train derailment has been rated as “2”. The main accidents and malfunctions scenarios that could affect Groundwater Resources include:

- Hydrocarbon spill; and
- Train Derailment.

Forest fires are unlikely to substantially affect Groundwater Resources and are rated as “0”. While there could be a minor and temporary change in shallow groundwater chemistry due to recharge through burned over areas, or a minor change in recharge component due to changes in run-off and evapotranspiration, the long-term effect is predicted to be negligible.

A major breach of the water control containment could result in substantial flooding and inundation of downstream areas with treated water and sediment. While surface water and Groundwater Resources are interactive, the effect to Groundwater Resources (e.g., well users) should be minimal, due to absence of well users near the site and adherence to proper water well construction criteria intended to prevent interaction with surface water. A contingency plan for the containment and clean-up of the affected areas is described in Chapters 11 and 14.

The following Sections discuss each accidental event scenario and the mitigation and contingency measures that will be implemented during these events to reduce the effects to Groundwater Resources.

12.8.1 Hydrocarbon Spill

Fuel storage on the site will include diesel and fuel oil tanks located at the rail unloading area, near the diesel generators at the mine site, and the process plant area. The maximum total storage capacity for diesel fuel will be 250,000 L. The fuel storage tanks will be located in secondary containment to control spills and will comply with requirements of the applicable provincial and federal acts and regulations, as well as the conditions of the permit and authorizations. The control measures will be able to contain the maximum capacity of all tanks in a storage area.

12.8.1.1 Emergency Response/Mitigation of Environmental Effects

Diesel fuel storage tanks will be designed to mitigate and reduce the probability of accidents and malfunctions. The fuel storage tanks will be located in secondary containment to control spills and will comply with requirements of the applicable provincial and federal acts and regulations, and the conditions of the permit and authorizations.

As part of the Emergency Response and Spill Response Plan, spill prevention and response protocols will include the daily inspection of vehicles and hydraulics for leaks or damage that could cause minor spills and rapid spill response. Vehicles and equipment will be stored in controlled areas where containment of spills can be provided. Staff will be trained in the handling of emergency response and spill scenarios.

Spill response equipment stored on site will include containment and absorbent booms, pads, barriers, sand bags, and skimmers, as well as natural and synthetic sorbent materials. The Emergency Response and Spill Response Plan will include the identification of persons responsible for managing spill response efforts, including their authority, role, and contact details, and a description of steps to take to immediately contain and recover spills. In the event of a spill, hydrocarbon-saturated soil will be removed for temporary storage and eventual treatment / disposal.

12.8.1.2 Characterization of Residual Environmental Effects

Groundwater quality may be adversely affected by a fuel tank failure and the consequent releases of petroleum hydrocarbons. A major fuel spill could result in the movement of free phase petroleum hydrocarbons across the surface towards receiving waters and drainage features, as well as movement of free petroleum hydrocarbon product into the subsurface, thereby affecting the quality of the underlying groundwater. When petroleum hydrocarbon-affected groundwater is intercepted by a water supply well, complaints of odour, iron fouling, and vapours can render the well unusable. When petroleum hydrocarbon-affected groundwater discharges into the surface water environment, the aquatic habitat can be affected by metals, reduced DO, iron flocculation, and discolouration. The effect of fuel spills on surface water resources is addressed further in Chapter 11.

The environmental effects of a fuel spill on Groundwater Resources are predicted to be adverse, but localized and reversible through remediation and restoration. The magnitude and duration of any environmental effect depends on a number of factors including the nature of material spilled, the quantity spilled, the hydrogeologic properties of the underlying aquifer materials, and the effectiveness of remediation. Substantial fuel spills are unlikely to occur, and with appropriate mitigation, the magnitude of the environmental effects is likely to be moderate, or under potentially worst case scenarios, high magnitude. Spill prevention and response protocols included in the Emergency Response and Spill Response Plan will further reduce the likelihood of a fuel spill. Assuming that spills are detected and remediated immediately through effective initiation of the Emergency Response and Spill Response Plans, the effects are reversible and would be anticipated to occur over a number of years. Because there are no known Groundwater Resources users near the proposed mine or along the various rail or trucking routes, an accidental spill is not expected to affect human use of groundwater. Because a persistent measurable or adverse effect is anticipated, adverse residual effects incurred from a worst case scenario, defined as large fuel spill in an area with a shallow aquifer or high-permeability surficial material, the effect to Groundwater Resources may be significant with a moderate degree of confidence. The significance prediction confidence is not high because of the number of variables with respect to size of spills, pathways to groundwater and ultimate receptors.

12.8.2 Train Derailment

Iron ore product will be transported by truck from the Project site to the Astray rail loop which connects directly to the Tshiuetin/QNS&L railway for transport to Sept-Îles. Diesel fuel will be transported by rail to Schefferville and then by contracted trucker to site. On average, iron ore will be transported on approximately four trains each week during summer months between the Astray rail loop and the Sept-Îles port. Each train set will carry approximately 24,000 t of ore in 240 gondola cars. Based on the speed the train will be travelling in the rail loop (5 miles per hour or 8 km/h), the reasonable worst case is the derailment of a maximum of four to five cars. This could result in the iron ore being spilled onto the ground or at stream crossings. Such an event is highly unlikely.

It is estimated that diesel fuel transport frequency will be a maximum of six 96,000 L tank cars per week for all site purposes.

Fuel tank car numbers are based on shipment in standard 96,000 L tank cars similar to those already in fuel haulage service between Sept-Îles and Labrador City. In a reasonable worst case scenario (i.e., where six tanks of diesel fuel are de-railed), approximately 576,000 L (127,000 Imperial gallons) of diesel fuel could be released.

12.8.2.1 Emergency Response/Mitigation of Environmental Effects

The trains will be operated under current QNS&L and TSH Environmental and safety procedures. A detailed Emergency Response and Spill Response Plan will also be developed by Labec Century. This plan will include measures such as:

- Immediate response through the use of absorbent booms and pads;
- Liquid clean up using a vacuum truck (both fuel and groundwater); and
- Reclamation of contaminated soils, removal of contaminated soils and replacement with clean soil.

Additional mitigation measures to be implemented to limit the potential for a train derailment include:

- Manual inspection of rolling stock to confirm there are no problems with the wheels, couplers, carbody or brakes;
- Track inspections in accordance with Transport Canada regulations;
- Properly maintained equipment; and
- Fuel transport amounts will be limited to the amounts required by the Project.

To reduce the likelihood of such an event, emphasis will be placed on safety and accident prevention

12.8.2.2 Characterization of Residual Environmental Effects

A train derailment may occur during any phase of the Project resulting in the deposition of hazardous materials and/or iron ore product into surrounding lands. Iron ore spills are usually highly localized and can be effectively cleaned up by on-site crews using standard equipment and spill response materials. The release of hazardous materials or contaminants into surrounding lands could result in contamination of water and infiltration to groundwater. The magnitude and duration of any environmental effect depends on a number of factors including the nature of material spilled, the quantity spilled, the location of the spill, and the time of year in which the incident occurs. In a worst case scenario, defined as large fuel spill in an area with a shallow aquifer or high-permeability surficial material, the effect to Groundwater Resources may be significant.

Based on spill response actions that will be implemented if a derailment occurs, the low potential for a large spill to occur, the limited geographic extent of the potential interactions following remediation and restoration, and in consideration of the planned and effective mitigation to reduce environmental effects (e.g., Emergency Response and Spill Response Plan measures and provincial / federal regulatory spill response system), effects of a Project-related train derailment on Groundwater resources is considered adverse, moderate in magnitude and rare in occurrence. The effects are expected to be local in extent, persistent over long time periods in cold climates, reversible after application of remediation, and could occur in both populated and unpopulated areas depending on the transportation route. Because persistent measurable or adverse effect is anticipated, adverse residual effects incurred from a train derailment are predicted to be significant with a moderate degree of confidence. The significance prediction confidence is not high because of the number of variables with respect to size of spills, pathways to groundwater and ultimate receptors.

12.8.3 Summary of Residual Effects Resulting from Accidents and Malfunctions

A summary of residual environmental effects resulting from accidents and malfunctions is provided in Table 12.10.

Table 12.10 Summary of Residual Environmental Effects – Accidents and Malfunctions

Project Phase	Emergency Response/Contingency Measures	Direction	Residual Environmental Characteristics						Significance	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental/Socio-economic Context			
Fuel oil spill	• Emergency Response and Spill Response Plan	A	M/H	L	LT	R	R	U	S	M	Standard groundwater monitoring to confirm effectiveness of clean-up.
Train derailment	• Emergency Response and Spill Response Plan	A	M/H	L	LT	R	R	D/U	S	M	Standard groundwater monitoring to confirm effectiveness of clean-up

Key:

Direction:
P Positive
N Neutral
A Adverse

Magnitude:
N Negligible: no measurable adverse effect anticipated
L Low: effect occurs that is detectable, but is within normal variability of baseline conditions
M Moderate: effect occurs that would cause an increase (or decrease) with regard to baseline, but is within regulatory limits and objectives
H High: effect occurs that would singly or as a substantial contribution in combination with other sources cause exceedances of objectives or standards within the Project boundaries

Geographic Extent:
S Site: effects are restricted to the PDA
L Local: effects extend to the LSA
R Regional: effects extend into the RSA

Duration:
ST Short term: effect restricted to the construction phase
MT Medium term: effect extends through construction and operation phases
LT Long term: effect extends beyond closure
P Permanent: effect is persistent and the measurable parameter(s) unlikely to recover to baseline

Frequency:
O Once: effect occurs once.
S Sporadic: effect occurs sporadically, at irregular intervals, without any predictable pattern during the life of the Project
R Rarely: effect occurs infrequently
F Frequently: effect occurs on a regular basis and at regular intervals
C effect occurs continuously throughout the Project life

Reversibility:
R Reversible: will recover after Project closure and reclamation
I Irreversible: permanent

Environmental or Socio-economic Context:
U Undisturbed: area has been relatively or not adversely affected by human activity
D Developed: area has been substantially previously disturbed by human development or human development is still present

Significance:
S Significant:
N Not Significant.

Prediction Confidence:
Based on scientific information and statistical analysis, and effectiveness of mitigation or effects management measure
L Low level of confidence.
M Moderate level of confidence.
H High level of confidence.

12.9 Determination of Significance of Residual Adverse Environmental Effect

A significant residual adverse environmental effect is a persistent degradation in the quantity or quality of groundwater after application of mitigative and remedial measures that could persist long after completion of the Closure and Decommissioning Phase (Section 12.4).

12.9.1 Project Residual Environmental Effects

The main environmental effect on the quantity of Groundwater Resources identified in this assessment is water table lowering as a consequence of the excavation and operation of the open pit mine. This effect is limited to the Construction, and Operation and Maintenance phases. The extent of the effect is expected to be limited to the peninsula hosting the mine site because of the local hydrogeology and the presence of major lakes surrounding the site that are expected to act as hydraulic barriers to regional groundwater level lowering. The effects of water level decline are unlikely to extend beyond the adjacent major water bodies. No water supply well users are identified within the expected area of drawdown influence of the open pit mine. The condition is predicted to be reversible. After decommissioning (i.e., natural flooding) of the open pit mine, this environmental effect will be reversed to near baseline conditions.

With the proposed mitigation and environmental protection measures, the adverse residual environmental effects of the Project on Groundwater Resources from routine activities. are considered to be not significant.

12.9.2 Project Cumulative Effects

The potential environmental effects of the Project on Groundwater Resources will not overlap nor affect the water supply or discharge potential of other known projects within the RSA (see Table 12.10) and thus cumulative environmental effects on Groundwater Resources are not expected.

12.9.3 Accidents and Malfunctions

The potential residual adverse environmental effects of accidents and malfunctions on Groundwater Resources are, for the most part, likely to be not significant after application of appropriate remedial measures. An exception is the extremely unlikely case of a large (i.e., greater than 34 to 114 m^3 for typical tanker truck and rail tanker) accidental release of petroleum hydrocarbons or process chemicals from a major tank rupture, a rail accident involving fuel oil tanker cars, or a fuel transport tanker truck accident. Depending on location, adverse residual environmental effects on Groundwater Resources (and indirectly on surface water resources), the effects could be persistent and measurable beyond the life of the mine operation, and such accidents could indirectly affect the Water Resources and Wetland VCs through the groundwater pathway, and are considered significant with a moderate degree of confidence.

12.10 Follow-up and Monitoring

- Monitoring of groundwater levels and groundwater chemistry will be required during the baseline, Construction, Operation and Maintenance, and Closure and Decommissioning phases of the Project.
- It is anticipated that baseline monitoring would proceed during the baseline and construction phases of Project development. Statistical evaluation of the adequacy of the baseline data will be done to provide a benchmark against which to test for Project effects and the need for any additional pre-construction or pre-operational monitoring to augment the baseline data.
- Regular sampling of selected strategically-located monitoring wells and water supply wells (if installed) would be done over the operation and maintenance phase. Select wells located adjacent to specific components (e.g., open pit mine, bulk fuel storage, waste rock storage) would be monitored following decommissioning to confirm effectiveness of mitigation or decommissioning, and/or declining trends in established seepage plumes.
- Specific monitoring locations, chemistry parameters, and sampling frequencies would be developed as part of an Environmental Protection Program (EPP) for the Project. The proposed minimum monitoring components to be implemented for the Groundwater Resources are discussed in the following Sections.

12.10.1 Open Pit Mine

Proposed groundwater monitoring at the open pit mine will include:

- Blast monitoring as needed.
- Installation of groundwater monitoring wells around the perimeter and at varying distances out from the open pit mine to observe the extent of groundwater level decline around the open pit mine during Construction and Operations and Maintenance phases, and to determine whether or not there is any effect on Project water supply wells, or nearby surface water features.
- Carry out regular groundwater level monitoring at the open pit mine during Construction and Operation and Maintenance phases to track drawdown and recovery and determine whether long term (post closure) monitoring is required.
- If required, regular monitoring of the volume and chemistry of the Open Pit sump discharge for general chemistry and metals on a scheduled as deemed appropriate, based on consultation with provincial and federal regulators as part of development of the Project's EPP.
- Precipitation monitoring at the mine site as an aid in differentiating the proportions of rainfall and groundwater seepage in the total open pit mine discharge.

- Monitoring select wells for groundwater levels and groundwater quality following decommissioning for a period of time, as deemed appropriate based on consultation with provincial and federal regulators as part of development of the Project's EPP. Post-closure groundwater monitoring will be carried out to confirm effectiveness of mitigation or decommissioning.

12.10.2 Waste Rock and Ore Storage Stockpiles

Proposed groundwater monitoring at the waste rock and ore storage stockpiles will include:

- Installation of groundwater monitoring wells in the waste rock and ore stockpile areas to detect and characterize chemistry of seepage leaving the waste rock stockpile area during Operations and Maintenance phase.

- Regular groundwater level monitoring in installed wells in the waste rock and ore stockpile areas during Operations and Maintenance phases.

- Monitoring select wells for groundwater levels and groundwater quality following decommissioning for a period of time, as deemed appropriate based on consultation with provincial and federal regulators as part of development of the Project's EPP. Post-closure groundwater monitoring will be carried out to confirm effectiveness of mitigation or decommissioning.

12.10.3 Joyce Lake Dewatering

It is proposed to dewater Joyce Lake prior to initiation of mining. Part of the dewatering process will require an understanding of the seepage rates of groundwater from surrounding overburden and bedrock so that appropriate seepage and overland drainage collection and diversion measures can be designed. Monitoring during Joyce Lake dewatering will include:

- Installation of groundwater monitoring wells adjacent to the northeast and southwest shores of Joyce Lake, and along the watershed divide between Joyce Lake and the other water bodies to monitor groundwater levels and hydraulic gradients during and after the lake dewatering operations.

12.10.4 Selected Site-specific Monitoring Wells

Groundwater quality monitoring may be warranted at site-specific sources of contamination, such as the above-ground storage tanks, generator fuel tanks, hazardous chemical storage compounds, and solid waste landfill (accommodations camp facility area).

Groundwater quality sampling will be carried out of any water supply wells installed at the mine site over the Operation and Maintenance phase. Water supply wells will be sampled for groundwater quality following a regular schedule, as deemed appropriate based on consultation with provincial and federal regulators as part of development of the Project's EPP.

Groundwater quality monitoring is unlikely necessary but may be warranted at site-specific sources of contaminations, such as the ASTs, generator fuel tanks, hazardous chemical storage compounds, and any solid waste landfill.

12.10.5 Monitoring Management and Reporting

For optimum reliability and statistical relevance, all groundwater level and water chemistry monitoring data must be collected in a consistent manner using defined Standard Operations Procedures relevant for this Project, and archived in a secure database management system, so that results can be regularly reviewed, updated, and assessed by qualified persons. The results of the groundwater monitoring program will be interpreted by a qualified hydrogeologist and reported to the client and relevant regulatory agency on an annual basis.

12.11 Summary

The key conclusions from the assessment of Project related effects on Groundwater Resources are:

- Because of the remote location of the Project, and the interpreted hydrologic / hydrogeologic regime, effects on Groundwater Resources are likely to be limited to the PDA and possibly to the LSA in extent during the Operation and Maintenance Phase.

- There are no known existing Groundwater Resource users within 13 km of the Project facilities, and no Groundwater Resource users (e.g., seasonal camps that likely use surface water) are known to be present along the haulage road or site access roads.

- The main groundwater-related effect during the Operation and Maintenance is water table lowering around the open pit mine. The maximum extent of water level declines is expected to 5 m at the shores of Timmins Lake (800 m to 1,000 m from the open pit mine) at the maximum drawdown. The effects of mine dewatering will be limited to the watershed in which the open pit mine will be located due to the presence of major lakes surrounding the open pit mine that would act as hydrologic boundaries.

- The effects of operational water table lowering will be reversed to baseline conditions after decommissioning. The changes in water levels and water quality in the vicinity of the various Project components will be monitored throughout the life of the Project.

- Water quality effects to groundwater associated with seepage of surface water from the waste rock, ore stockpiles and any solid waste management disposal sites are expected to be not significant due to the inert nature of the materials, the expected absence of ARD and expected short transport distances, where the affected groundwater would be expected to discharge to the local wastewater collection systems and/or local surface waters. The residual and regional effect of these seepages is addressed under the Water Resources VC (Section 12.6).

- Accidental releases of diesel and other petroleum hydrocarbon products from AST or train/ truck transport accidents or malfunctions are expected to be local in extent, and can be remediated by standard remediation techniques. While residual environmental effects from large spills are possible, this is mitigated by the absence of Groundwater Resource users in the likely areas of a potential spill.

- After application of appropriate mitigative measures, no significant adverse residual environmental effects on Groundwater Resources are expected from routine Project activities. In the extremely unlikely event of a large fuel spill, significant effects to groundwater are possible.

- Because of its remote location and hydrological isolation from other activities in the watershed, no cumulative overlap with effects from other projects or activities that could affect Groundwater resources is anticipated.

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Joyce Lake Direct Shipping Iron Ore Project:

Chapter 13:

Terrain and Acid Rock Drainage/Metal Leaching

File No. 121416571

Date: May 2021

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13.0 TERRAIN AND ACID ROCK DRAINAGE/METAL LEACHING

As detailed in chapter 1, Joyce Direct Iron Inc. succeeded Labec Century Iron Ore Inc. ("Labec Century") as the Project Proponent on February 18, 2021 following an internal reorganization. All references to Labec Century as the Project proponent may be interpreted as now referring to Joyce Direct Iron Inc.

13.1 VC Definition and Rationale for Selection

Terrain and ARD/ML has been chosen as a VC because of its importance to the Project planning and potential interactions with Project activities. It specifically addresses the requirement within IAAC EIS Guidelines to assess: Terrestrial Environment-Geology and Geochemistry; ARD/ML; and Surficial Geology (i.e., Terrain and Soil). It also addresses the requirements within the NLDOECC EIS Guidelines to assess Landforms, Soils, Snow and Ice, and ARD/ML. Other related aspects of the terrestrial environment (e.g., wetlands, birds, wildlife and their habitat, other contemporary use of lands and resources) are assessed in Chapter 14, Chapter 16, and Chapter 20, respectively.

As required by IAAC EIS Guidelines, potential Project effects on permafrost have also been considered in this section. The presence of permafrost was assessed as part of the Geotechnical Feasibility Study (Appendix D); based on borehole information obtained throughout the PDA, no evidence of permafrost was observed. Permafrost is therefore discussed with respect to baseline conditions but is not assessed further in this chapter.

The provincial Final Guidelines also require consideration of sensitive landforms and include wetlands as an example of a sensitive landform that should be assessed. For the purposes of this assessment, potential Project effects on wetlands are assessed in Section 14 and are not considered further in this chapter. IAAC EIS Guidelines also require consideration of paleontological resources; these are addressed in Chapter 18: Historic and Cultural Resources and not considered further in this chapter.

13.2 Scope of the Assessment

13.2.1 Regulatory Setting

General regulatory requirements associated with the Project are described in Chapter 2: Project Description. The MDMER under the federal *Fisheries Act* prescribes discharge parameters and their limits from metal mines. There are no other applicable IAAC EIS or NLDOECC EIS regulatory requirements specifically addressing the components of this VC.

13.2.2 Influence of Consultation and Engagement on the Assessment

Specific issues or concerns regarding Terrain and ARD/ML raised during consultation and engagement activities with regulatory agencies (i.e., ECCC, NLDOECC), Indigenous groups, stakeholder groups, are provided in Table 13.1.

Table 13.1 Issues Raised by Indigenous Groups and Stakeholders

Question / Issue	Community/ Organization	Summary of Comments	Response
Mine Waste	Naskapi of Kawawachikamach	How high will the waste pile be?	The maximum height of any of the waste stockpiles will be 90m above ground level measured from the base of the stockpile. Waste stockpiles will be geotechnically designed for stability and the design will include the impact of precipitation and ground water sources that may accumulate on or around the stockpile (Chapter 11). Stockpile side slopes will also be designed to slope at 22º such that water flows will not cause gulleys or erosion of the stockpile. The stockpiles will also have perimeter ditches to collect runoff and groundwater seepage and direct it to sedimentation ponds before release to the environment.

13.2.3 Temporal and Spatial Boundaries

The temporal boundaries for the environmental assessment include the Project phases of Construction, Operation and Maintenance, and Closure and Decommissioning. The temporal boundary for Construction is one year (pre-operation), Operation and Maintenance is approximately seven years, and Closure and Decommissioning is approximately one year.

The spatial boundaries for the environmental effects assessment of Terrain and ARD/ML are defined below.

Project Development Area (PDA): The PDA is the area represented by the Project footprint as defined in the Project Description (Chapter 2).

Local Study Area (LSA): The LSA is the maximum area within which Project-related environmental effects can be predicted or measured with a reasonable degree of accuracy and confidence. The LSA includes the PDA plus a 300 m buffer around the Project footprint where Project-related environmental effects may reasonably be expected to occur (see Figure 13.1). This is a conservative estimate based on the likely maximum extent of deposition from dust generation.

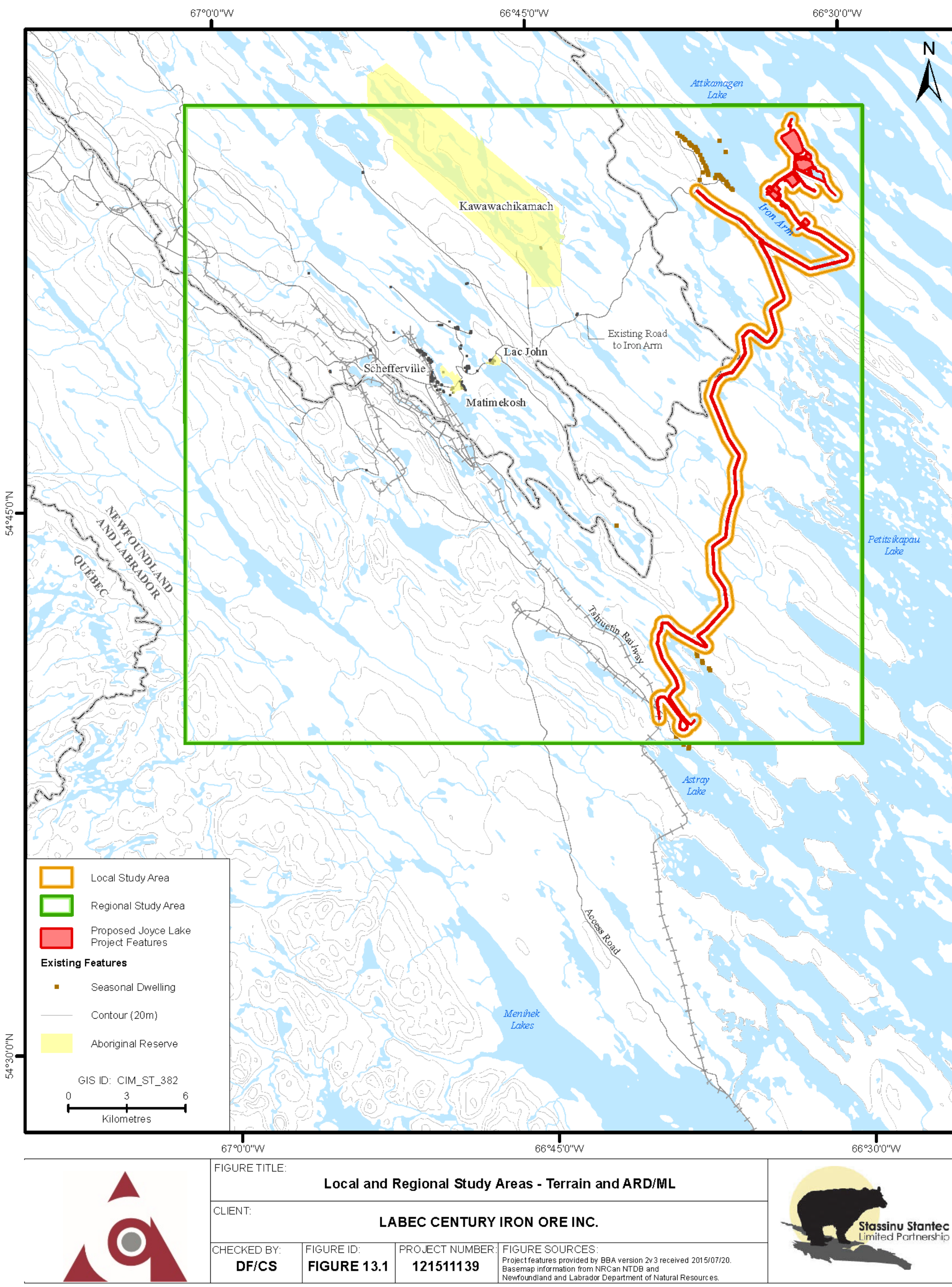

Figure 13.1 Local Study and Regional Study Areas - Terrain and ARD/ML

Regional Study Area (RSA): The RSA provides regional context for the VC assessment and is also the area within which cumulative environmental effects for Terrain and ARD/ML are considered, depending on environmental conditions and the type and location of other past, present, and reasonably foreseeable projects. The RSA includes the areas of the DSO Iron Ore Project (Tata Steel Minerals Canada), and Houston 1 & 2 (Labrador Iron Mines) (Figure 13.1).

13.2.4 Selection of Environmental Effects and Measurable Parameters

The selected potential environmental effects and associated measurable parameters for the assessment of Terrain and ARD/ML are summarized in Table 13.2.

Table 13.2 Environmental Effects and Measurable Parameters for Terrain and ARD/ML

Environmental Effect	Measurable Parameter	Rationale for Selection of the Measurable Parameter
Effect on Landforms and Terrain Stability (terrain integrity)	Loss of significant or sensitive landforms	Wetlands are addressed in Chapter 14. Esker features have the potential to provide valuable habitat. Eskers are also valuable from a historical and cultural perspective and are important for aggregate resources.
	Increase in terrain instability	Terrain instability has implications for health and safety of Project personnel and for the structural integrity and soundness of Project infrastructure and equipment. May be affected by Project activities (e.g., the disturbance of sensitive slopes has the potential to negatively affect natural slope stability potentially resulting in erosion and mass movements).
Change in Soil Quality and Quantity	Soil quality, as measured by reclamation suitability	The suitability of soil for reclamation purposes will determine in part the success of the reclamation effort. Reclamation suitability, wind and water erosion, and soil moisture status can be altered by storage.
	Change in soil quantity, as measured by soil available for reclamation purposes	Storage and maintenance of soil stockpiles is an important component of reclamation activities. Erosion can result in soil loss.
	Contamination of soil	Fugitive dusts from emissions or other sources could cause contamination of soils near the facility. Spills of hazardous materials could also cause contamination.
Change in Snow and Ice	Loss of snow and ice	Snow and ice are important for recreational activities (e.g., snowmobiling). Alteration of the land surface either by removal or placement of materials or construction of structures can result in changes to snow drifting. Dust from the roads, mine sites and waste rock disposal areas will land on the snow and ice surfaces immediately adjacent to these features and has the potential to alter natural albedo levels, resulting in earlier snow and ice melt in areas close to these features.
	Break up of ice	Iron ore will be transported from the open pit haul road and rail loop via a causeway constructed across Iron Arm. The introduction of the causeway to Iron Arm has the potential to result in changes to water flow and level, and subsequent changes to ice formation and break-up.

Table 13.2 Environmental Effects and Measurable Parameters for Terrain and ARD/ML

Environmental Effect	Measurable Parameter	Rationale for Selection of the Measurable Parameter
	Contamination of snow	Runoff from emissions and other sources could cause contamination of snow, which would result in contamination of soils after melting. Spills of hazardous materials could also result in contamination of snow and ice and subsequent effects to soil and water.
ARD/ML	pH, and concentrations of metals, TDS, and sulfate in contact water	Decrease in pH below 4.5 and increase in sulfate and metals in contact water may indicate ARD/ML.
	NPR in the rock	NPR is used for classification of geologic materials and potential for acid generation.

13.3 Standards or Thresholds for Determining the Significance of Residual Environmental Effects

The environmental effects of the Project on Terrain and ARD/ML are defined in terms of the following characteristics:

- Direction:
  - Adverse - Measurable changes negatively affect terrain integrity, soil quality and quantity, and snow and ice; increased exposure of potentially ARD/ML generating material;
  - Neutral - No measurable change; or
  - Positive - Measurable effects benefit terrain integrity, soil quality and quantity and snow and ice; potentially ARD/ML generating material is neutralized.
- Magnitude:
  - Negligible – No measurable adverse effect anticipated;
  - Low - For terrain and landforms, minor changes to shape and stability in the RSA. For soil quality or quantity, a change of 1% to 5% in areal extent or volumetric extent relative to baseline conditions in the RSA. For ARD/ML and for change in snow and ice, effect is detectable but within normal variability of current baseline conditions;
  - Moderate – For terrain and landforms, moderate changes to shape and stability in RSA. For soil quality or quantity, a change of 6% to 10% in area or volumetric extent relative to baseline conditions in the RSA. For ARD/ML, effect is measurable but does not exceed regulatory thresholds. For change in snow and ice, effect is measurable and beyond the normal variability of baseline conditions, but does not affect land and resource use.

    - High – For terrain and landforms, major changes in shape and stability in the RSA. For soil quality or quantity, a change greater than 10% in area or volumetric extent relative to baseline conditions in the RSA. For ARD/ML, effect would independently or cumulatively with other sources cause an exceedance of regulatory standards or guidelines. For change in snow and ice, effect is measurable and beyond the normal variability of baseline conditions and affects land and resource use.

- Geographic Extent:
    - Site-specific - Effect confined to the PDA;
    - Local - Effect confined to the LSA;
    - Regional - Effect extends beyond the LSA but within the RSA.
- Frequency:
    - Once - Effect occurs once;
    - Sporadic - Effect occurs sporadically, at irregular intervals, without any predictable pattern during the life of the Project;
    - Rarely – Effect occurs infrequently, or uncommonly, but may occur at regular long intervals during the life of the Project;
    - Frequently - Effect occurs on a regular basis and at regular intervals during the life of the Project.
- Duration:
    - Short term – Effect does not extend beyond one year;
    - Medium term – Effect does not extend beyond seven years;
    - Long term - Effects are measurable and extend beyond seven years;
    - Permanent – Effects persistent and measurable parameter unlikely to recover to baseline conditions.
- Reversibility:
    - Reversible - Will likely recover to baseline conditions after the end of Project decommissioning;
    - Irreversible - Unlikely to recover to baseline conditions after the end of Project decommissioning (i.e., permanent).

- Ecological Context:
  - Undisturbed – Area has been relatively or not adversely affected by human activity;
  - Disturbed - Area has been substantially disturbed previously by human development or human development is still present.
- Prediction Confidence:
  - Low - physiographic processes not well understood, limited baseline data, quantitative metrics limited, and/or mitigation measure effectiveness unknown.
  - Moderate - regional physiographic processes understood, adequate baseline, quantitative metrics available, and/or proven mitigation measures.
  - High - physiographic process well understood and predictable, adequate baseline and regional data, and/or mitigation measures proven successful.

A significant adverse residual environmental effect on Terrain and ARD/ML is defined as:

- An alteration of ecologically and/or culturally important landforms such that their function for wildlife or social uses within the RSA is no longer sustainable; or where the stability of landforms is compromised to such an extent that it represents an unacceptable risk to ecological or human receptors and infrastructure.
- One where site soils are altered in quality or quantity by the Project to the extent that they are no longer suitable or available for reclamation.
- An alteration in snow and ice cover such that ecological and cultural uses that depend on the snow and ice regime within the RSA are substantially compromised.
- One where effluent pH or metal concentrations exceed MDMER compliance criteria and result in successive acute lethality testing failures in accordance with MDMER compliance monitoring requirements.

13.4 Potential Project-VEC Interactions

The environmental assessment of the Terrain and ARD/ML VC is focused on the following potential environmental effects:

- Effects on landforms and terrain stability (terrain integrity);
- Change in soil quality and quantity;
- Change in snow and ice; and
- ARD/ML.

Potential Project-VC interactions are identified in Table 13.3 with each interaction rated as 0, 1, or 2 based on the level of interaction.

Table 13.3 Potential Project Environmental Effects on Terrain and ARD/ML

Project Activities and Physical Works	Potential Environmental Effects			
	Effects on Landforms and Terrain Stability	Change in Soil Quality and Quantity	Change in Snow and Ice	ARD/ML
Construction				
Site Preparation (including clearing, grubbing, excavation, material haulage, grading, removal of overburden, ditching, and stockpiling)	2	2	2	2
Construction of Roads	2	2	2	1
Construction of Causeway	2	0	2	0
Construction of Site Buildings and Associated Infrastructure	1	1	1	1
Construction of Rail Loop and Associated Infrastructure	1	1	2	1
Construction of Stream Crossings	2	0	2	1
Installation of Water Supply Infrastructure (wells, pumps, pipes)	1	0	0	0
Onsite Vehicle/Equipment Operation	0	1	1	0
Waste Management	0	0	0	0
Transportation of Personnel and Goods to Site	0	0	0	0
Expenditures	0	0	0	0
Employment	0	0	0	0
Operation and Maintenance				
Maintenance of Causeway	1	0	2	0
Dewatering Joyce Lake	2	0	2	2
Open Pit Mining (including drilling, blasting, ore and waste haulage, stockpiling, dewatering)	2	1	2	2
Ore Processing (including crushing, conveying, storage, grinding, screening)	0	1	2	2
Waste Rock Disposal on Surface	2	2	2	2
Water Treatment (including mine water and surface runoff) and Discharge	0	0	0	2
Rail Load-Out and Transport	0	0	2	0
Onsite Vehicle/Equipment Operation and Maintenance	0	1	1	0
Waste Management	0	0	0	0
Transportation of Personnel and Goods to Site	0	0	0	0
Fuel Transport	0	0	0	0
Fuel Storage and Dispensing	0	0	0	0
Progressive Rehabilitation	1	1	1	0
Expenditures	0	0	0	0
Employment	0	0	0	0
Closure and Decommissioning				
Site Decommissioning	1	2	1	2
Site Reclamation (building demolition, grading, scarifying)	1	2	1	2

Table 13.3 Potential Project Environmental Effects on Terrain and ARD/ML

Project Activities and Physical Works	Potential Environmental Effects			
	Effects on Landforms and Terrain Stability	Change in Soil Quality and Quantity	Change in Snow and Ice	ARD/ML
Accidents and Malfunctions				
Hydrocarbon Spill	0	2	1	0
Train Derailment	0	2	1	2
Forest Fire	1	2	0	0
Settling/Sedimentation Pond Overflow	1	2	1	0
Premature or Permanent Shutdown	0	0	0	0

Key:
0 No interaction (i.e., no potential for activity to result in the effect).
1 Interaction may occur; however, based on past experience and professional judgment, the resulting effect is well understood and can be managed to negligible or acceptable levels through standard operating procedures or through the application of management or codified practices. No further assessment is warranted.
2 Interaction may occur and the resulting effect may exceed negligible or acceptable levels without implementation of project-specific mitigation. Further assessment is warranted.

A discussion of significance is provided in the following sections for interactions rated as 0 or 1; these are not considered further in the environmental effects assessment. Interactions rated as 2 are assessed in more detail in Section 13.6.

13.4.1 Effects on Landforms and Terrain Stability

Effects on landforms and terrain stability specifically considers loss of significant or sensitive landforms, such as esker features and increase in terrain instability which could occur if Project activities were to negatively affect existing sensitive slopes, potentially resulting in erosion and mass movements. Eskers are valuable for human and wildlife uses. Historical, archaeological and paleontological sites are often found on eskers close to water as they represent a height of land to view the surrounding landscape, and also as dry area for encampments. They act as ecological connectors in the landscape providing dry ridges for wildlife movement and are often denning sites for wolves, coyotes, foxes, and black bears.

Construction

Site preparation, construction of roads, the causeway and stream crossings are rated as 2 and further assessed in Section 13.6.1. A number of interactions have been rated as 0 as having no interaction with the Project, including onsite vehicle/equipment operation, waste management, transportation of personnel and goods to site, expenditures and employment, as these activities do not require any ground disturbance.

Construction of site buildings and associated infrastructure, construction of rail loop and associated infrastructure, and installation of water supply infrastructure are rated 1 as interactions that can be managed to acceptable levels through standard operating practices or best management practices. Project structures, such as the accommodation camp, processing plant and storage facilities will all be temporary, constructed from materials brought in by rail and truck, and assembled on-site. Any ground disturbance resulting from these activities is captured within the activity of "site preparation" which is rated as 2 and further assessed below. Through the implementation of mitigation that may include maintenance of natural drainage patterns, erosion control, engineering for stability, surface water management (Chapter 11: Water Resources) and wildlife habitat management (Chapter 16: Birds, Wildlife and their Habitats), the effects on landforms and terrain stability from the construction of these structures and other Project infrastructure are anticipated to be minor, site-specific, medium-term (i.e., lasting until decommissioning occurs) and reversible. Through mitigation with standard operating practices, residual adverse environmental effects are predicted to be not significant, with a high level of confidence.

Operation and Maintenance

During Operation and Maintenance, open pit mining, dewatering of Joyce Lake, and waste rock disposal on surface have been rated as 2 due to their potential effects on terrain stability in the area.

Those activities determined to have no interaction with potential effects on landforms and terrain stability include ore processing, water treatment, rail load-out and transport, onsite vehicle/equipment operation and maintenance, waste management, transportation of personnel and goods to site, fuel transport, fuel storage and dispensing, expenditures and employment. These activities have no potential to interact with landforms and terrain stability as they will not entail any further ground disturbance and rail transport and vehicles will be operated within designated areas.

During Operation and Maintenance, those activities that require ongoing earthworks including maintenance of causeway and progressive rehabilitation were rated as 1 as activities in which the interactions with landforms and terrain stability can be managed through standard operating practices. Maintenance of the causeway and progressive rehabilitation will be designed and implemented following standard geotechnical engineering practices, such that impact to existing landforms will be reduced and terrain instability will be addressed. Progressive rehabilitation, in particular, will be intended to stabilize areas. Residual adverse effects are anticipated to be minor, site specific, and permanent and irreversible (with respect to dewatering of Joyce Lake and waste rock storage in particular); with proper planning and mitigation in place, these effects are predicted to be not significant with a high degree to confidence.

Closure and Decommissioning

Closure and Decommissioning activities, including site decommissioning and site reclamation, have been rated as 1 as all earthworks related to this phase may interact with existing landforms and terrain stability, but will be managed with best practices and standard operating procedures. Surface water management, grading, and re-vegetation will all contribute to reducing potential for terrain instability post-decommissioning and closure, such as erosion or local slides.

Accidents and Malfunctions

Hydrocarbon spills, train derailments and premature or permanent shutdown malfunctions have been rated 0 for this effect as none of the identified scenarios would result in ground disturbance or alteration of sensitive landforms or unstable slopes. In the event of a premature shutdown, regulatory requirements include provision for financial assurance from Labec Century.

Rehabilitative measures may be implemented by the Newfoundland and Labrador Minister of Natural Resources, in which case, costs incurred by the Crown in implementing these measures may be recovered by drawing on the financial assurance provided by the proponent. Any required cost expenditures over and above the financial assurance provided would be considered debt by Labec Century to the Crown.

Forest fires have been rated as 1 as the burning of vegetation along steeper slopes can result in the increased risk for erosion of soil and subsequent slope instability. A plan for preventing and combating forest fires will be incorporated into the Emergency Response and Spill Response Plan (refer to Chapter 7: Environmental Management) and soil erosion is assessed as part of change in soil quality and quantity (Section 13.4.2). Burn areas would naturally grow back over time, although the composition would change to early successional species. Areas recently burned over are likely to be avoided by any land and resource users until revegetation occurs, thus limiting any public safety issues associated with slope instability. Any worker health and safety issues associated with slope instability in the vicinity of Project infrastructure would be identified and addressed through mitigation measures, such as stabilization and revegetation. The resulting potential effect would be adverse in direction, potentially regional in geographic extent although isolated to specific areas, and due to the years required for natural regrowth of vegetation in affected areas, is considered long-term. Given that these areas are unlikely to be used by resource users during the time before regrowth, the residual effect is predicted to be not significant, with a high degree of confidence.

Overflow of the settling/sedimentation pond could interact with landforms and slope instability if the path of the overflow were to result in erosion or damage to any structures in place to stabilize any slopes in the vicinity of the ponds. Following the event, the site would be inspected and any remedial work required to restore ditches and erosion control structures would be identified and carried out. While residual effects would be adverse, they would also be localized, short-term and predicted to be not significant with a high degree of confidence.

13.4.2 Change in Soil Quality and Quantity

Construction

Site preparation (e.g., clearing, grubbing, excavation) and construction of roads are rated as 2 due to the potential for admixing, erosion, compaction and changes to the moisture and nutrient status of soils, and the need to properly stockpile soil for reclamation and manage these stockpiles. These activities are further assessed in Section 13.6.2.

Construction activities rated as 0 for having no interaction or ability to affect change in soil quality or quantity include: construction of causeway and stream crossings which will not require disturbance or use of soils (note that any construction activities affecting nearby terrestrial terrain and soils is considered as part of construction of roads); installation of water supply infrastructure; waste management; transportation of personnel and goods to site (includes travel along existing road and rail transportation networks); expenditures and employment.

Other Construction activities that have been rated as 1 include construction of site buildings and associated infrastructure, construction of rail loop and associated infrastructure and onsite vehicle and equipment operation. The ground disturbance required as part of construction of site buildings and construction of the rail loop is assessed under site preparation which was rated as a 2 and assessed further in Section 13.6.2. The assembly of infrastructure has potential to generate dust, and onsite vehicle equipment and operation has the potential to generate dust and result in soil compaction and erosion, particularly where equipment is required to work in unprepared areas during the early stages of construction. However, any dust generated during construction would be native soils, which limits potential for soil contamination. Work areas will be flagged and disturbed areas limited to the extent possible. Best construction practices will be in place to limit dust generation, avoid contamination of soil from materials, such as leaking fuel, lubricants or oil, and reduce the Project footprint. Therefore, adverse environmental effects (i.e., site soils are not suitable for reclamation due to either quality or quantity) are likely to be low, site-specific, short-term and reversible. Residual effects are predicted to be not significant with a high degree of confidence.

Operations and Maintenance

The only activity rated as 2 during Operation and Maintenance is waste rock disposal on the surface as this interaction will have the potential to adversely affect soil quality and quantity and requires further assessment in Section 13.6.2.

Maintenance of the causeway, dewatering of Joyce Lake, water treatment and discharge, rail load-out and transport, waste management, transportation of personnel and goods to site, fuel transport, fuel storage and dispensing, expenditures and employment have all been rated as 0 with no potential to interact with and affect change in soil quality and quantity. Note that for water treatment and discharge, which includes collection and treatment of mine water and surface runoff, systems and infrastructure will be designed to prevent uncontrolled and unplanned releases. Fuel transport, storage and dispensing will also be highly controlled activities. If releases were to occur, soil quality could be affected through contamination or soil quantity could be affected through erosion. These unplanned events are considered and assessed as part of Accidents and Malfunctions.

Open pit mining, ore processing, on-site vehicle/equipment operation and maintenance, and progressive rehabilitation activities have been rated as 1 as they could affect soil quality and quantity. Mining, processing and vehicle/equipment operation will generate dust; however, best practices such as separation and stockpiling of organics during mining for use during rehabilitation will reduce the effects of these activities. While airborne deposition of dust particles associated with these activities has the potential to change soil quality, the deposition of dust composed of iron particulates should not adversely affect the quality of upland soils, because the parent geological material contains substantial amounts of iron. Project environmental effects on air quality (e.g., dust) are addressed in Chapter 10: Atmospheric Environment and Climate. Traffic plans will be followed to reduce soil pulverization and compaction.

Soils suitable for reclamation will be removed and stockpiled for future use during site preparation. Progressive rehabilitation will include use of these soils, but will not result in any adverse interactions with previously undisturbed soils. Overall, residual adverse effects are expected to be low, site-specific, medium-term and reversible; with mitigation and standard practices in places, residual effects are predicted to be not significant with a high degree of certainty.

Closure and Decommissioning

Closure and Decommissioning activities have all been rated as 2 as soils stockpiled during the life of the Project will be used in the reclamation effort. Interactions with the soils during this Project phase will require specific mitigation measures to ensure that all soils are handled and replaced for site reclamation. These activities are further assessed in Section 13.6.2.

Accidents and Malfunctions

Hydrocarbon spills, train derailment, forest fire and settling/sedimentation pond overflow have all been rated as 2 for change in soil quality and quantity and are further assessed in Section 13.8.

Premature or permanent shutdown was rated as a 0 for change in soil quality and quantity. While Closure and Decommissioning will affect soil quality and quantity (in a mostly positive way as a result of reclamation activities) as assessed under that phase, the nature and extent of these effects will not be altered by closure occurring prematurely or permanently. In the event of a premature shutdown, regulatory requirements include provision for financial assurance from Labec Century. Rehabilitative measures may be implemented by the Newfoundland and Labrador Minister of Natural Resources, in which case, costs incurred by the Crown in implementing these measures may be recovered by drawing on the financial assurance provided by the proponent. Any required cost expenditures over and above the financial assurance provided would be considered debt by Labec Century to the Crown.

13.4.3 Change in Snow and Ice

Construction

During Construction, site preparation, construction of roads, construction of causeway, construction of site buildings and associated infrastructure, construction of rail loop and associated infrastructure, and construction of stream crossings have been rated as 2 for potential effects to change in ice and snow and are further assessed in Section 13.6.3. These activities and the presence of this infrastructure may impact the distribution of snow and drifting during winter months and may also result in fugitive dust that could affect snowmelt and changes in lake ice conditions in winter. In general, the potential for dust from any construction activities occurring during the winter months would be less than during non-winter months, as the ground would be wet and/or frozen.

Installation of water supply infrastructure, waste management, transportation of personnel and goods to site, expenditures and employment are not predicted to interact with change in ice and snow. These activities will not contribute to loss of snow and ice, break-up of ice or contamination of snow. Further discussion on surface water and associated water supply infrastructure is provided in Chapter 11: Water Resources. Discussions on ice formation in the RSA can be found in the Lacustrine Ice Environment in the Regional Study Area Memo (Stassinu Stantec 2013).

Onsite vehicle/equipment operation have been rated as 1 as vehicle and equipment movements may require snow clearing and traction control through spreading of sand. These effects will be limited though to the immediate construction area and travel routes and will not contribute to overall loss of snow and ice, break-up of ice or contamination of snow. Residual adverse effects are expected to be low, site-specific, medium-term and reversible and with mitigation and standard practices in places, residual effects are predicted to be not significant with a high degree of certainty.

Operation and Maintenance

Maintenance of the causeway, open pit mining, dewatering Joyce Lake, ore processing, waste rock disposal on surface, and rail load out and transport have been rated as 2 for change in snow and ice and are further assessed in Section 13.6.3.

Water treatment and discharge, waste management, transportation of personnel and goods to site, fuel transport, fuel storage and dispensing, expenditures and employment have all been rated as 0 as there is no expected interaction with change in snow and ice. For water treatment and discharge and for fuel transport, storage and dispensing, systems and infrastructure will be designed to prevent uncontrolled and unplanned releases. If these releases were to occur, snow and ice contamination could occur. These unplanned events are considered and assessed as part of Accidents and Malfunctions.

Onsite vehicle/equipment operation and maintenance and progressive rehabilitation both have the potential to affect change in snow and ice, but based on past experience and limited nature of the interactions, these activities have been rated as 1. As with construction, vehicle operation will require snow clearing and traction control during winter months, which will create localized changes in snow presence, but is not expected to contribute to overall loss of snow and ice, break-up of ice or contamination of snow. Progressive rehabilitation may also have limited interaction with snow and ice and could generate some localized dust, although most rehabilitation activities would be conducted during non-winter months when the ground is not frozen. The potential for dust generation during winter conditions is limited and would be localized. Snow drift patterns in areas that have been rehabilitated are also likely to be locally altered and in some cases, return to pre-Project conditions. Residual adverse effects are expected to be low, site-specific, medium-term and reversible; with mitigation and standard practices in places, residual effects are predicted to be not significant with a high degree of certainty.

Closure and Decommissioning

Decommissioning and reclamation activities are rated as a 1. While dust generation can affect snow and ice conditions, rehabilitation activities conducted during the winter months would be limited due to frozen ground conditions and dust generation is also a lesser concern during this season. Changes in drifting patterns will mostly return to pre-construction conditions as site infrastructure is dismantled and removed and areas are reclaimed. Residual environmental effects are therefore predicted to be not significant with a high level of confidence.

Accidents and Malfunctions

Forest fires and premature or permanent shutdown have both been rated as 0. While a fire could result in early melting of snow and ice or deposition of ash on snow, a Project-related fire that occurred during winter conditions would be unlikely to spread from the Project site to nearby forests, so the potential for a forest fire to interact with snow and ice is considered negligible. Any melting or ash deposition from a fire on site would be localized and short-term (i.e., a few hours).

Premature or permanent shutdown was rated as a 0 for change in snow and ice. While Closure and Decommissioning will affect snow and ice (in a mostly positive way as a result of reclamation activities) as assessed under that phase, the nature and extent of these effects will not be altered by closure occurring prematurely or permanently.

Hydrocarbon spills, train derailment and settling/sedimentation pond overflow are rated as 1. If any of these events occurred during winter conditions, there is potential for localized contamination of snow and ice. However, this would be of most concern due to the subsequent contamination of soils, which is assessed as a change in soil quality and quantity. Any early melting of snow and ice due to any of these events would be infrequent, localized and temporary and are predicted to be not significant, with a high degree of confidence.

13.4.4 ARD/ML

Construction

During Construction, site preparation (e.g., excavation, material haulage, grading) may result in the disturbance and exposure of potential ARD/ML material and has been rated as 2 for further assessment in Section 13.6.4.

Installation of water supply infrastructure, onsite vehicle/equipment operation, waste management, transportation of personnel and goods to site, expenditures and employment are rated as 0. These activities do not require any earthworks or physical construction processes and therefore do not result in any potential disturbance or exposure of potential ARD/ML material.

All other activities related to Construction have been rated as 1, including construction of roads, construction of site buildings and associated infrastructure, construction of the causeway, construction of rail loop and associated infrastructure and construction of stream crossings. These facilities at the Project site will not require excavation for deep foundations or significant subsurface disturbance, although some cuts could be required for road construction. To mitigate these potential effects, standard mitigation will be used including testing for ARD, avoidance if possible, and management of ARD/ML material according to best practices (e.g., subaqueous disposal, capping). Therefore, significant adverse environmental effects (i.e., effluent pH or metal concentrations that exceed MDMER compliance criteria and result in successive acute lethality testing failures in accordance with MDMER compliance monitoring requirements) are not likely.

Operation and Maintenance

Open pit mining, ore processing, waste rock disposal, and water treatment and discharge have been rated as 2 as they involve the disturbance, handling and disposal of material that may be potentially ARD/ML generating. Construction of dykes for dewatering Joyce Lake is rated as 2 because dykes will contain significant amount of waste rock in contact with surface water. Assessment of these activities is presented in Section 13.6.4. All other Operation and Maintenance activities have been rated as 0 as they do not require earthworks and will have no interaction with the potential generation of ARD/ML. These activities include dewatering of Joyce Lake, rail load-out and transport, onsite vehicle/equipment operation and maintenance, waste management, transportation of personnel and goods to site, fuel transport, fuel storage and dispensing, progressive rehabilitation, expenditures and employment.

Closure and Decommissioning

Site decommissioning and reclamation have been rated a 2 as they involve the permanent disposal, stabilization and/or monitoring of material that may be potentially ARD/ML generating. Assessment of these activities is presented in Section 13.6.4.

Accidents and Malfunctions

Train derailment has been rated a 2 due to the potential for rail cars to be transporting ore which could potentially be ARD/ML generating material. This accidental event is assessed in Section 13.8.

Hydrocarbon spills, forest fires, and settling/sedimentation pond overflow have been rated 0 as they have no potential to interact with or disturb material that may be potentially ARD/ML generating.

Premature or permanent shutdown was also rated as a 0 for ARD/ML. While Closure and Decommissioning activities have been rated as a 2 for ARD/ML and are assessed in Section 13.6.4, the nature and extent of these effects will not be altered by closure occurring prematurely or permanently. If a premature shutdown occurred, regulatory requirements include provision for financial assurance from Labec Century.

13.5 Existing Environment

This Section describes the existing terrain and subsurface conditions in the LSA and RSA. The descriptions are based on the Geotechnical Feasibility Study (Appendix D) conducted to determine the nature and properties of subsurface materials and groundwater conditions; existing background data; provincial mapping; and examination of aerial imagery of the LSA. Borehole data assessed in support of this document include boreholes drilled as part of LVM's 2014 geotechnical program and exploration boreholes advanced in the area of the proposed open pit.

The ARD/ML methodology is consistent with the approach recommended by the EIS guidelines outlined in the Mine Environment Neutral Drainage (MEND) Report 1.20.1 and the Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, Version 0 – December 2009, produced by the MEND (Price 2009). In addition to these methods, the assessment of potential ARD/ML effects is based on the testing of the geological materials collected from the site and on historical data from similar mines (LIM 2009). The site geology and mining plans were partly based on the PEA Report of the Joyce Lake Direct Shipping Iron Ore Project (CIMA+ 2013), the Joyce Lake and Area DSO Project Geotechnical Feasibility Study – Surrounding Areas (Appendix D), and the Joyce Lake Hydrogeological Study (Appendix O).

13.5.1 Information Sources

The sources of information for this Section include:

- Geological Resources
  - Existing bedrock and surficial geological mapping conducted by the Province of Newfoundland and Labrador (Wardle 1982; Liverman et al. 2010).
  - Exploration data (e.g. assessment reports), provided by Labec Century (Gan et al. 2012).
- Baseline Studies
  - Stassinu Stantec Limited Partnership. 2013. Joyce Lake Direct Shipping Iron Ore Project: Baseline Hydrogeology Scoping Study. Report prepared for Labec Century Iron Ore.
  - Stantec. 2013. Joyce Lake Direct Shipping Iron Ore Project: Phase 1 Assessment for Acid Rock Drainage and Metal Leaching (ARD/ML). Report prepared for Century Iron Mines Corp. May 2013.
  - Stantec. 2021. Stantec, 2021. Joyce Lake Direct Shipping Ore Project ARD/ML Assessment Update. Memorandum prepared for Century Iron Mines Corp. May 2021.
  - Stassinu Stantec Limited Partnership. 2012. Construction Aggregate Borrow Search, DSO Haul Road to Rail Loop, Joyce Lake Project, NL.
  - GENIVAR. 2013. Joyce Lake Direct Shipping Iron Ore Project. Vegetation Baseline Study. Report prepared for Labec Century Iron Ore.
  - LVM. 2014. Joyce Lake and Area DSO Project Geotechnical Feasibility Study – Surrounding Areas. Report prepared for Labec Century Iron Ore.
  - WESA. 2015. Joyce Lake and Area DSO Project – Hydrogeological Study. Report Prepared for Labec Century Iron Ore.

- Site Imagery:
  - Aerial Photographs: acquired June 5, 2012, resolution 20 cm x 20 cm, coverage only within vicinity of PDA.
  - Satellite Imagery: acquired August 31, 2012, resolution 5 m x 5 m, coverage approximately 25 km radial distance from centre point of PDA.
- National Snow and Ice Data Center, University of Colorado, Boulder (http://nsidc.org/).
- Climatic data from ECCC (2013).

Reference material is appended where noted. The understanding of the existing ARD/ML condition in the LSA is generally based on the Phase 1 Assessment for ARD/ML provided in Appendix Q1 and referenced in the list above. Water quality data sources include field data collected by Stantec and WSP Global team members and the Canada-Newfoundland WQMA data.

While traditional knowledge pertaining specifically to Terrain/ARD ML was not identified, the traditional knowledge results identified in Chapter 3: Engagement and Traditional Knowledge have been considered and integrated throughout the assessment.

13.5.2 Method for Characterization of Baseline Conditions

The method of characterization of baseline conditions for geology, geochemistry, terrain and soils was completed through the analysis and summary of field programs, baseline studies, and existing information, outlined in Section 13.5.1. The specific methods and procedures used for the Geotechnical Feasibility Study are outlined in LVM's report dated 2014 (Appendix D).

Stantec conducted a preliminary reconnaissance assessment of the construction aggregate potential along the proposed haul road route and rail loop from the processing plant to the existing Tshiuetin rail line (Stassinu Stantec 2012). The field work consisted of a one-day helicopter reconnaissance survey from the Joyce Lake property to the proposed rail loop.

The ARD/ML program involved the testing of 234 samples representing waste rock, ore and overburden, and 19 samples of tailings and iron ore product for static tests such as Acid-Base Accounting, Shake Flask Extraction (SFE) and total metals. The processing planned for the Project (i.e., dry processing rather than wet), means there will be no requirement for tailings management. Labec Century's geochemical database, containing over a thousand analyses of total sulfur and carbon, was also used for classification and delineation of waste rock and ore. Based on results of static tests, representative samples of waste rock and ore have being selected for detailed characterization kinetic testing. Characterization included: Acid-Base Accounting, total metals, mineralogy and particle-size distribution. Eight laboratory (humidity cells) and three field (bins) kinetic tests were conducted.

Generic criteria for ARD classification are based on NPRs recommended by the MEND Report 1.20.1 (Price 2009, Table 13.4). Because median values are less sensitive to outliers, classification of geological units is based on the median NPR in this assessment. Carbonate NPR values are generally lower than Sobek NPR. Therefore, Carbonate NPR median values were used for the classification of geological units in an effort to provide a conservative analysis.

Table 13.4 Material Classification Based on NPR Criteria

NPR Criteria	Material Classification
NPR > 2	Non-Potentially Acid Generating (Non-PAG)
2 > NPR > 1	Uncertain Rock Type
NPR < 1	Potentially Acid Generating (PAG)

The method used to characterize baseline conditions for ML included comparison of metal concentrations and pH in leachates from SFE and kinetic tests to respective parameters prescribed by MDMER (2002) to identify potential parameters of concern. Comparison of the leachates to the MDMER limits represents only a qualitative comparison screening), because the rock to solution ratio used in the tests is different from the project ratio. A more accurate evaluation of metal leaching will be assessed with water-quality modelling, which includes water balance and element loadings from kinetic tests.

13.5.3 Baseline Conditions

13.5.3.1 Bedrock Geology

Figure 13.2 illustrates the bedrock geology in the LSA. Two different sources of bedrock geology was required to cover the full length of the LSA and the information for the southern portion of the LSA is not as detailed as for the northern portion.

Regional Geology and Structure

The Project regional geology is similar to that described for the Attikamagen Iron Project (SRK 2011), which geographically encompasses the Joyce Lake deposit. The Project is located on the western margin of the Labrador Trough, a Proterozoic volcano-sedimentary sequence wedged between Archean basement gneisses. The Labrador Trough, also known as the Labrador-Québec Fold Belt, extends for more than 1,000 km along the eastern margin of the Superior craton from the Ungava Bay in the north to Lake Pletipi, Québec. The belt is about 100 km wide in its central part and narrows considerably to the north and south.

The Labrador Trough consists of a sequence of Proterozoic sedimentary rocks, including iron formations, volcanic rocks and mafic intrusions, which together form the Kaniapiskau Supergroup. The Kaniapiskau Supergroup includes the Knob Lake Group in the western part, and the Doublet Group, which is primarily volcanic in the eastern part. To the west of Schefferville, rocks of the Knob Lake Group lie unconformably on Archean gneiss basement rock and, to the east, they pass into the eugeosynclinal facies of the Labrador Trough. The Kaniapiskau Supergroup has been intruded by numerous diabase dikes known as the Montagnais Intrusive Suite.

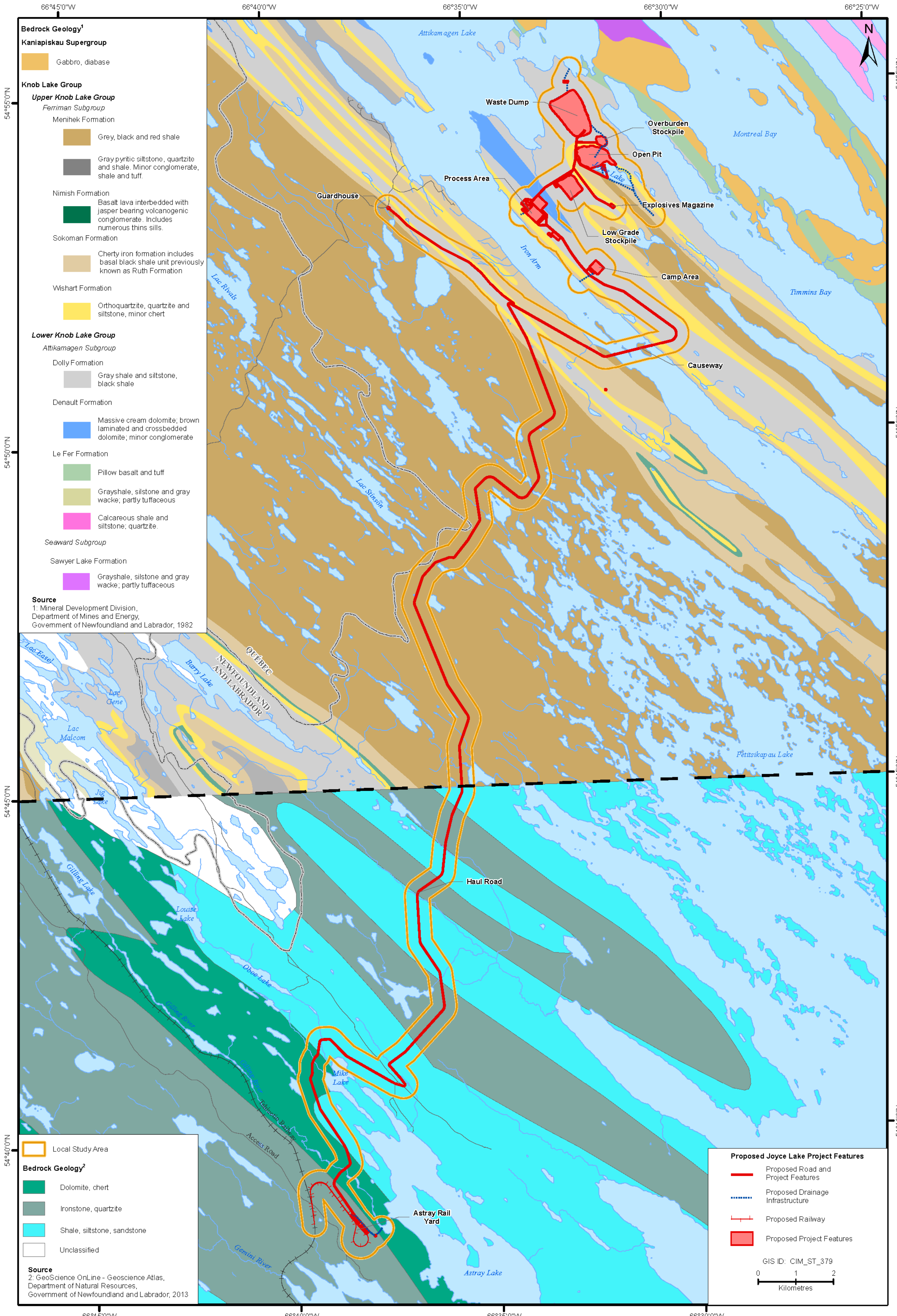

FIGURE TITLE: Bedrock Geology in the Terrain and Acid Rock Drainage/Metal Leaching Local Study Area			
CLIENT: LABEC CENTURY IRON ORE INC.			
CHECKED BY: DF/CS	FIGURE ID: FIGURE 13.2	PROJECT NUMBER: 121511139	FIGURE SOURCES: Project features provided by BBA version 2v3 received 2015/07/20. Basemap information from NRCan CanVec database and Newfoundland and Labrador Department of Natural Resources.

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Figure 13.2 Bedrock Geology in the Terrain and Acid Rock Drainage/Metal Leaching Local Study Area

The metamorphic grade increases from sub-greenschist assemblages in the west, to upper amphibolite to granulite assemblages in the eastern part of the Labrador Trough (Dimroth and Dressler 1978; Hoffman 1988). Thrusting and metamorphism occurred between 1,840 and 1,829 million years ago (Hoffman 1988).

The Joyce Lake LSA is situated on a northwesterly trending series of tight anticlines and synclines, with the Joyce Lake deposit (Sokoman Formation) being located within a local southeasterly plunging synclinal structure in which Joyce Lake is situated. Bedrock outcrops are visible in the immediate area. A southeast trending fault is noted along the east side of Joyce Lake (Wardle 1982).

Stratigraphy

Figure 13.2 illustrates the relative stratigraphy of the Knob Lake bedrock units present in the Joyce Lake LSA. In the vicinity of the mine area, the Knob Lake Group is subdivided into eight formal geological units. The lowermost unit (Sawyer Lake) rests unconformably over Archean-aged gneiss of the Ashuanipi Complex, and is not present at the Project site.

The Knob Lake Group consists of two sedimentary cycles: The older Cycle 1 or Lower Knob Lake Group (the Attikamagen Subgroup) is a shallow marine shelf depositional sequence which includes, in order of decreasing age, gray shale, siltstone, wacke, tuff and basalt of the Le Fer formation; massive dolomite and minor conglomerate of the Denault formation, and gray and black shale and siltstone of the Dolly Formation. Cycle 2 or the Upper Knob Lake Group (the Ferriman Subgroup) was deposited in a deeper water slope-rise environment beginning with a transgressive quartz arenite (Wishart Formation) followed by basal black shale and a cherty iron-formation of the Sokoman Formation, and conformably overlain by clastic shale, slate and siltstone of the Menihek Formation.

Ore Occurrence

The Upper Knob Lake Group includes the Sokoman Formation which is the main exploration target of the Attikamagen Iron Project. The Sokoman Formation forms a continuous stratigraphic unit varying in thickness as a result of folding and fault repetition. The iron formations of the Sokoman Formation are classified as Lake Superior type. They consist of a banded sedimentary unit composed principally of bands of magnetite and hematite within chert-rich rock and variable amounts of silicate-carbonate-sulphide. Such iron formations have been the principal sources of iron throughout the world.

The iron formation occurring on the Attikamagen Iron Project consists mostly of subunits of the Sokoman Formation characterized by recrystallized chert and jasper with bands and disseminations of magnetite, hematite and martite; a type of hematite pseudomorph after magnetite and specularite. Other gangue minerals are a series of iron silicates including minnesotaite, pyrolusite and stilpnomelane and iron carbonate (mainly siderite).

The iron mineralization of the Sokoman Formation is classified as Lake Superior type. It occurs in a sedimentary unit composed of bands of magnetite and hematite within chert-rich rock and variable amounts of silicate-carbonate-sulphide. The high-grade iron ore is thought to have formed in-situ along bedding planes and fractures with hydrothermal or meteoric fluids circulation causing hematite to crystallize and other gangue minerals to leach resulting in iron enrichment (Gan et al. 2012).

Five lithological units were locally defined within the Sokoman Formation from the bottom upwards, according to SGS (2013):

- Ruth Shale, black colored shale and sometimes defined as Ruth Formation.
- Lower Red Chert, blue grey shale-chert mixed with less than 40% of hematite.
- Lower Massive Hematite, generally 40-70% hematite and blue grey shale.
- Red Chert, dominated by <40% hematite, and chert and blue grey shale mixture.
- Upper Massive Hematite, generally 40-70% hematite and blue grey shale.

Based on a mineralogical analysis of 13 samples conducted by Corem for Labec Century in 2012, the hematite is the main source of iron ore whereas the magnetite content in the ore is low. The hematite is fine grained and closely associated with quartz. Significant iron enrichment also occurs as iron carbonates (siderite), iron silicates (minnesotite) and manganese carbonates (rhodocrosite, kutnahorite) altered to iron oxides, goethite, limonite and manganese oxides. Other minerals identified by X-Ray Diffraction in the samples include chlorite, pyrite and calcite (Corem 2012).

Local Geology and Structure

Figure 13.2 illustrates the interpreted geology of the Project area (after Wardle 1982). The Project is located in the south eastern part of the Attikamagen property on a sequence of property-scale synclinal and anticlinal folds, which was offset by a west to northwest striking fault. These hinges are historically reported to be the most enriched iron formation found in the area.

The proposed mine site near Joyce Lake is developed in a synclinal basin, consisting of the Sokoman formation (cherty iron formation) underlain in turn by progressively older beds of the Wishart formation (quartzite, siltstone and minor chert) and Dolly formation (gray shale and siltstone). A sub-crop of younger Menihek formation (gray and black shale and siltstone) is noted immediately west of Joyce Lake, and may underlie portions of Joyce Lake.

The processing plant and ore stockpiles are underlain predominantly by grey shale/siltstone and black shale of the Dolly Formation (Figure 13.2). Structurally, this area is situated on a major northwest striking synclinorium, which implies that rocks of the Wishart and Denault formations may occur at depth.

The accommodation area is situated on the grey shale/siltstone and black shale of the Dolly Formation.

In the area of the open pit, the most refined bedrock geology interpretation of the Sokoman Formation occurrence is available from Labec Century exploration programs. Figure 13.3 illustrates the relative stratigraphy of the Joyce Lake Deposit overlain with exploration borehole locations and the proposed pit shell. Figure 13.4 and Figure 13.5 illustrate a longitudinal and a cross-section, respectively, of the deposit stratigraphy. Structurally, two fault lineaments (the Ferrum River Fault and an un-named fault) are situated about 1,100 m and 300 m respectively to the east of the proposed open pit (Wardle 1982).

13.5.3.2 Overburden Geology

Stratigraphy

Figure 13.6 illustrates the surficial geology in the area surrounding the LSA (Liverman et al. 2010). The natural overburden material in the immediate vicinity of Joyce Lake and the proposed mine area is mapped as predominantly undifferentiated till (e.g., moraine) with frequent areas of exposed bedrock. The waste rock pile and settling ponds located north of the proposed mine area are underlain by thicker deposits of till. Some esker structures have been identified radially from the height of the land (refer to Section 13.5.3.3 for further discussion of eskers).

The processing plant and ore stockpile east of Iron Arm are underlain by variable thicknesses of hummocky ablation till associated with glacial melting (e.g., kame deposits). A potential esker feature was identified in the study conducted by Stantec (Stassinu Stantec 2012) as existing in the location of the low grade ore stockpile. The proposed accommodation camp is underlain by organics.

Overburden Thickness

A review of 36 on-land exploration borehole logs completed in 2011 in the vicinity of the proposed open pit (Appendix T) indicates that the overburden thickness in the pit area (Joyce Lake Peninsula) ranges from nil to 13.7 m, with an average of 4.5 m and a median of 3.0 m.

Based on the borehole data from the Geotechnical Feasibility Study (Appendix D) (Figure 13.7), the overburden thicknesses ranged from 0.15 to 20.90+ m thick with an average of 4.99 m and a median of 2.43 m. Overburden materials are primarily represented by veneers of organic soils (consisting of topsoil and peat) overlying sequences of granular soils and till overlying bedrock. Based on information obtained from the geotechnical investigation, overburden materials on the Project property are expected to primarily contain a broad range of surficial materials including sands and gravels with varying proportions of silt, cobbles and boulders. Investigations have also uncovered regions containing occasional clay deposits (cohesive soils). Overburden materials are also represented by surficial glacial expressions in the form of eskers. These glacio-fluvial landforms are generally composed of poorly sorted sands and gravels; however studies completed to date have indicated high silt (fines) content in the esker materials in the area (Stassinu Stantec 2012; refer to Section 13.5.3.3).

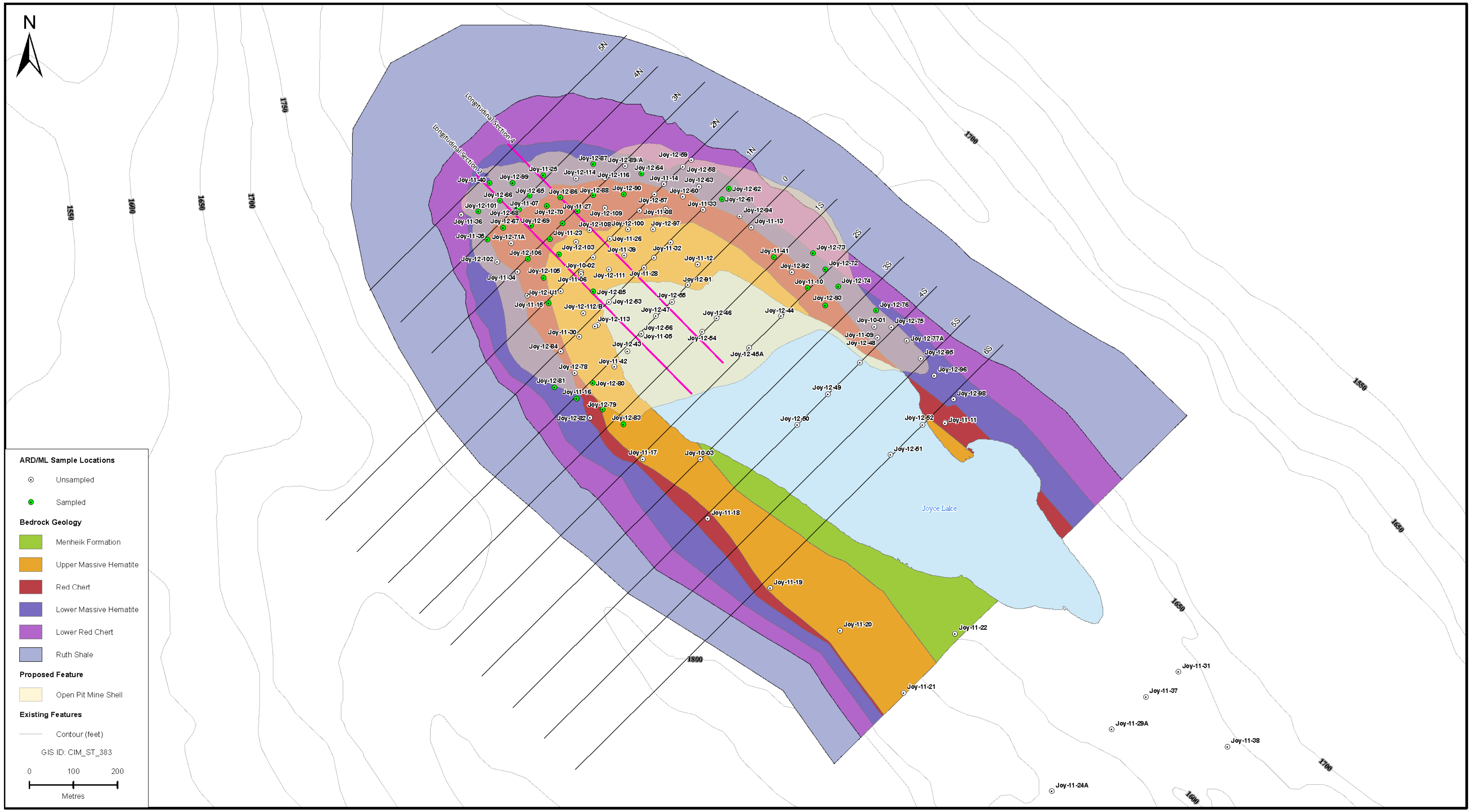

FIGURE TITLE:			
Bedrock Geology and ARD/ML Sample Locations, Joyce Lake Open Pit Mine			
CLIENT: **LABEC CENTURY IRON ORE INC.**			
CHECKED BY: **DF/CS**	FIGURE ID: **FIGURE 13.3**	PROJECT NUMBER **121511139**	FIGURE SOURCES: Data provided by BBA received 2015/07/20.

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Figure 13.3 Bedrock Geology and ARD/ML Sample Locations, Joyce Lake Open Pit Mine

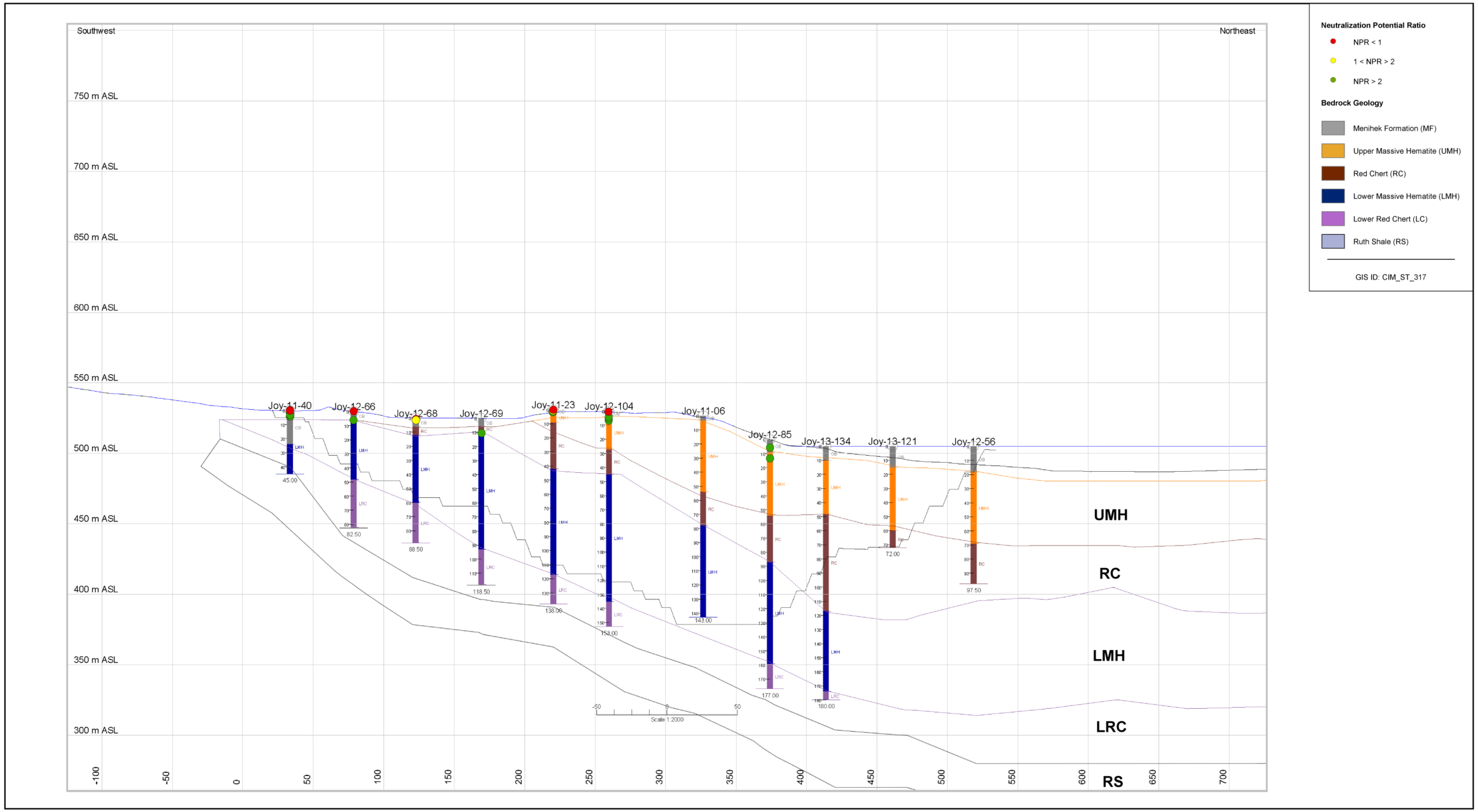

FIGURE TITLE: **Longitudinal Section (Section 2) of Bedrock Geology and Structure and ARD/ML Test Results, Joyce Lake Open Pit Mine**			
CLIENT: **LABEC CENTURY IRON ORE INC.**			
CHECKED BY: **DF**	FIGURE ID: **FIGURE 13.4**	PROJECT NUMBER **121511139**	FIGURE SOURCES: Century, June 25/13

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Figure 13.4 Longitudinal Section (Section 2) of Bedrock Geology and Structure and ARD/ML Results, Joyce Lake Open Pit Mine

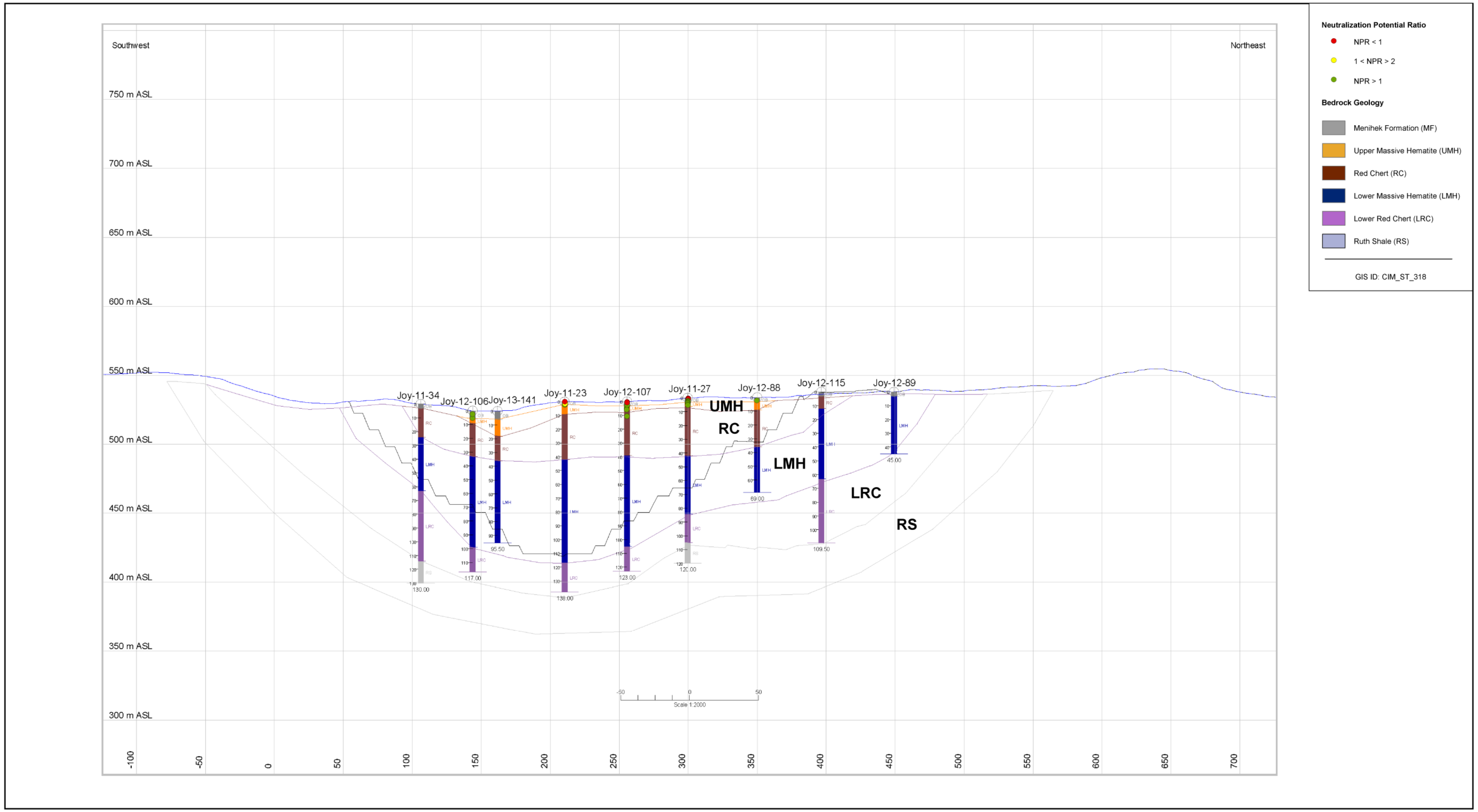

FIGURE TITLE:
Typical Section (Section 3.0N) of Bedrock Geology and Structure and ARD/ML Test Results, Joyce Lake Open Pit Mine

CLIENT:
LABEC CENTURY IRON ORE INC.

CHECKED BY:	FIGURE ID:	PROJECT NUMBER	FIGURE SOURCES:
DF	**FIGURE 13.5**	**121511139**	Data provided by Century June 25, 2013

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Figure 13.5 Typical Section (Section 3.0N) of Bedrock Geology and Structure and ARD/ML Results, Joyce Lake Open Pit Mine

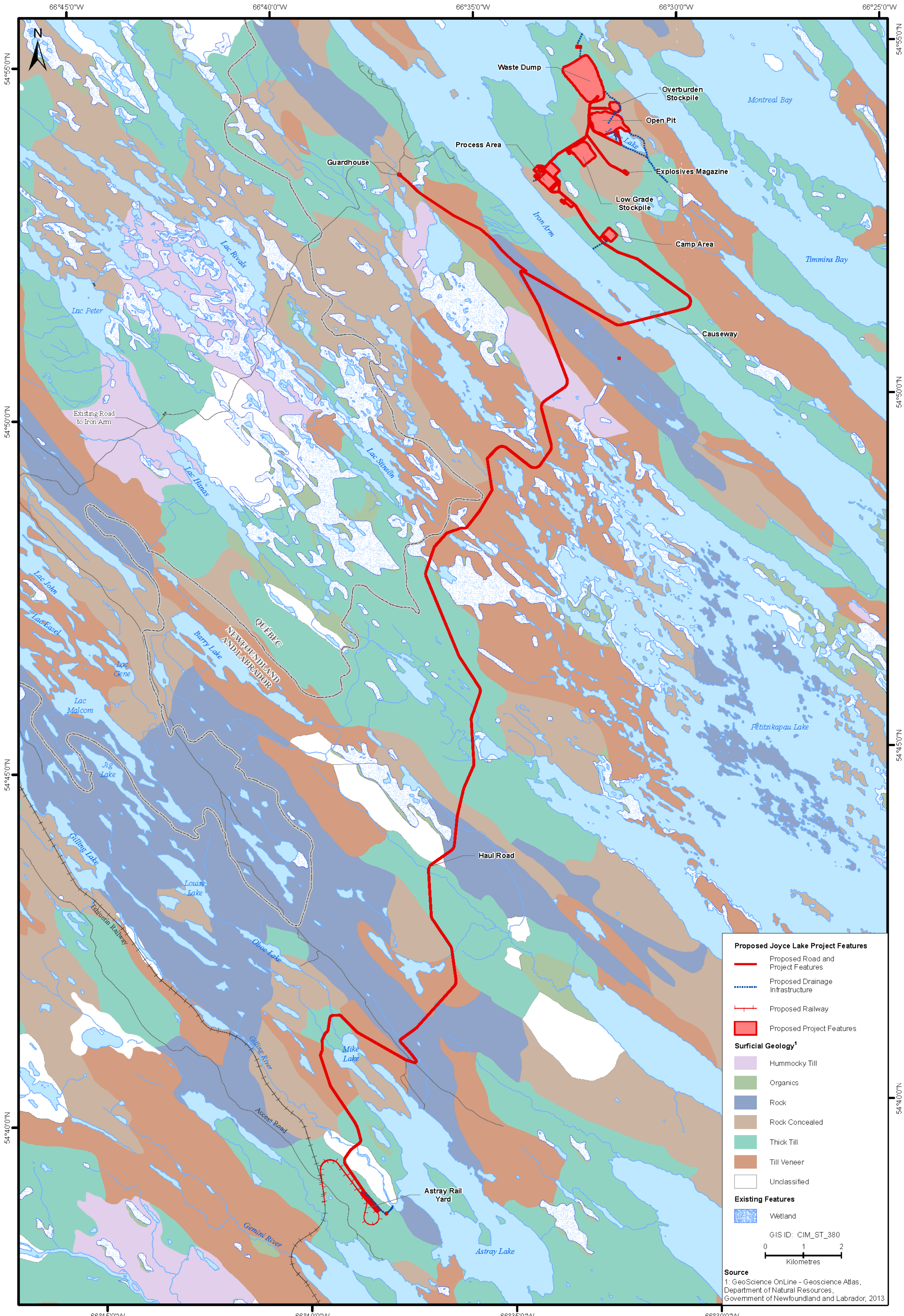

FIGURE TITLE: Surficial Geology in the Terrain and Acid Rock Drainage/Metal Leaching Local Study Area			
CLIENT: LABEC CENTURY IRON ORE INC.			
CHECKED BY: DF/CS	FIGURE ID: FIGURE 13.6	PROJECT NUMBER: 121511139	FIGURE SOURCES: Project features provided by BBA version 2v3 received 2015/07/20. Basemap information from NRCan CanVec database and Newfoundland and Labrador Department of Natural Resources.

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Figure 13.6 Surficial Geology in the Terrain and Acid Rock Drainage/Metal Leaching Local Study Area

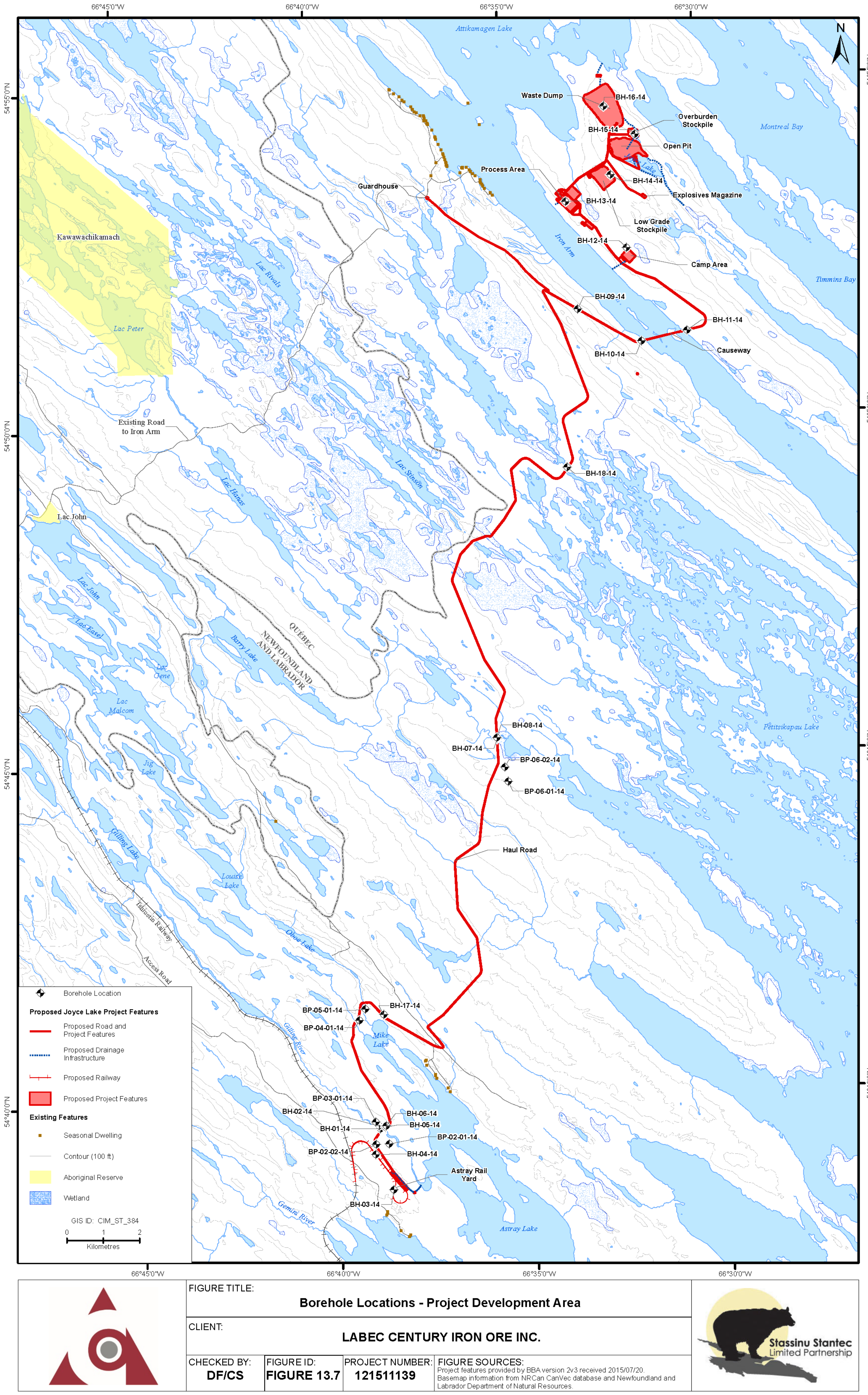

Figure 13.7 Borehole Locations - Project Development Area

At the site level, based on the Geotechnical Feasibility Study, it appears that the thickest layers of overburden (8 to 20 m thick) are located along the road near the approach to the Gilling River (original alignment) and near the approach to the lake at kilometre 17. The remainder of the roadway and the general site areas (processing plant, stockpile areas, rail loop, camp, etc.) were found to have thinner layers of overburden, ranging from 0.15 m to 4.6 m.

On a broad scale, based on the field visit conducted by Stassinu Stantec hydrogeologists and based on the range of overburden thicknesses reported in the exploration borehole logs, it is likely that the till overburden is thinnest (e.g., a thin veneer to exposed rock) along the bedrock ridges, and thicker in intervening valleys. The thickest overburden (6 to 16 m) is noted both northwest and southeast of Joyce Lake. It is suspected that this may be related to a northwest trending bedrock depression beneath Joyce Lake.

For further detail on geological stratigraphic frameworks for the surficial sediments and bedrock including physical and visual descriptions, permeability, strength, weathering, etc., refer to the Geotechnical Feasibility Study (Appendix D), and the Baseline Hydrogeology Scoping Study (Appendix S), and other exploration data and assessments.

13.5.3.3 Physiography and Landforms

The RSA is situated within the Attikamagen lake system, a series of lakes and fjord-like waterways that cover an estimated 1,000 km^2 in northwestern Labrador. The Project is located within relatively rugged terrain with rolling hills and valleys reflecting the northwest trending structure of the underlying bedrock. Elevation in the area varies from 472 m on the shores of Iron Arm up to 564 m at the high point about 350 m north of Joyce Lake.

Based on available aerial imagery (Stassinu Stantec 2012), the area has numerous areas of apparent exposed bedrock or wetlands. The topography of the RSA is predominantly bedrock-controlled having been reshaped by glacial and fluvio-glacial events.

Glacial melting, river flow, moraines and glacial damming has resulted in a broad range of surficial deposits (eskers and moraines) that provide a potential source for sands and gravels. Eskers are typically developed sub-glacially, and can include relatively thick deposits of sand and gravel. These glacial features are not considered unique to the RSA because they are a characteristic terrain feature of the Michikamau Ecoregion of central and western Labrador (Bolduc 1992; NLDOECC 2007). Bolduc (1992) indicates that eskers are abundant on plateau areas of central and western Labrador and also suggests that the lithologies of esker ridges found in western and central Labrador are derived from up-esker till (in a corridor up to 3.5 km on either side of the ridge), which is itself derived from bedrock. This would suggest that the esker is likely composed of mainly sand, with a secondary component of gravels, cobbles and boulders. Previously identified glacial features and deposits within the RSA are indicated in Figure 13.8. While none of the esker features identified on this Figure overlap with any planned Project infrastructure, field studies conducted in the LSA for this Project have identified several other possible esker features.

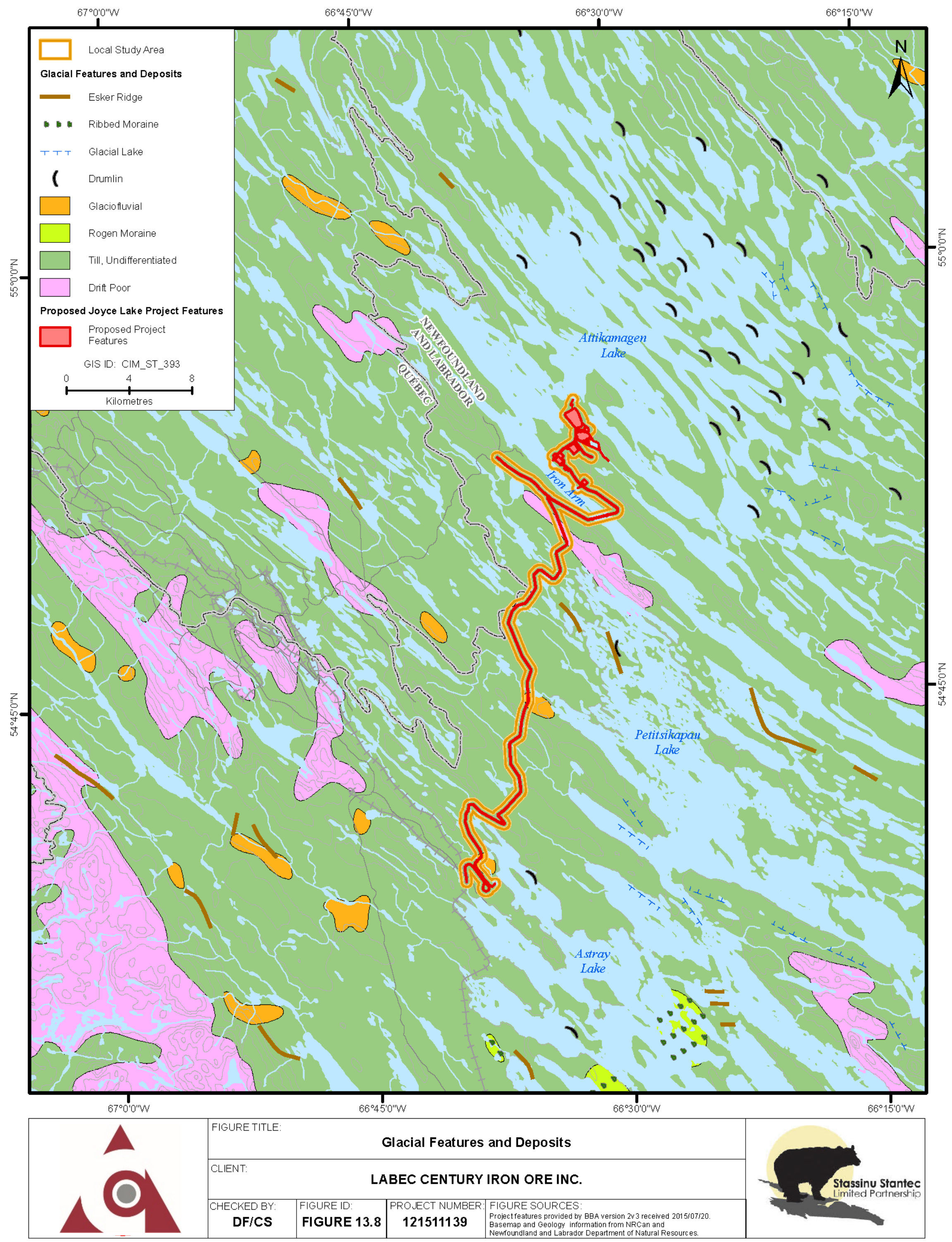

Figure 13.8 Glacial Features and Deposits

Stassinu Stantec (2012) identified a total of six elevated landforms exhibiting sinuous esker (four sites) or drumlin features (two sites) and four bedrock exposures were identified as potential aggregate sources during a study described in Section 13.5.2. Two of the four sites identified in this report as esker features are located within the PDA. Based on sampling at three of the identified glacial features (including the two sites located within the PDA), the material has been classified as silty sand with gravel (SM) to sandy silt (ML). These materials are not considered the best option or type of materials to use for earthworks construction due to high fines contents ranging from 33.2% to 50.1%. Typically, where the fines content of a soil is high, the soil will tend to soften, become unsuitable, and difficult to work when it becomes wetter than its optimum moisture content and is disturbed. In addition, silty type soils that have been successfully compacted and approved, may require removal if they become wet and softened from groundwater seepage or precipitation. Silty soils are also frost susceptible. The Project will be obtaining any required borrow material from an existing borrow pit location.

The RSA is generally comprised of forested and shrubland upland terrains, wetlands, post-fire regeneration and rock barrens. The forested areas are found on moderately to well-drained glacial terrain and are generally situated on gentle slopes ranging from 4% to 15% at sampling stations. Shrublands are generally located on slopes ranging from gentle to moderate (4% to 30%) and are transitional between forested areas and more exposed summits. Slightly weathered rock barrens occupy large flatlands, with slopes of 0% to 3%, and consist of large-sized fractured rock. Moderately and highly-weathered rock barrens are found at the highest elevations in the LSA and reflect alpine tundra environments. Slopes observed at sampling stations in these barrens ranged from no slope (0% to 3%) to strong slopes (31% to 40%) (Genivar 2013). Wetlands in the LSA are situated in flat, poorly-drained depressions on impermeable substrates and are closely associated with watercourses (Genivar 2013). Wetlands and their ecological function are further discussed in Chapter 14: Wetlands.

13.5.3.4 Permafrost

The Project is located within the discontinuous, sporadic or isolated permafrost zone (Brown and Pewe 1973; Brown 1979; Smith 2011). Permafrost is a thermal state of the subsurface defined as ground that remains at or below 0°C for at least two years (National Research Council Canada 1988). In order for permafrost to occur at a specific site, this site has to be exposed to an extended period of subzero mean annual air temperatures. As a result of such a “boundary condition”, heat is extracted/transferred to the atmosphere from the subsurface, which may cool to subzero temperatures, hence creating permafrost conditions. The rate of heat transport in subsurface materials depends on thermal properties of the subsurface materials. The difference between air temperature and ground surface temperature at any specific location is determined by slope/aspect, vegetation, snow thickness and other microclimatic factors (Williams and Smith 1989), which are typically summarized in an “N”-factor, which is often used to transform air temperature into ground temperature. Since this thermal state is based on the thermal history of the location, and subjected to a constantly changing air temperature and microclimate (Williams and Smith 1989), permafrost is a dynamic or transient subsurface material condition.

Air temperature has been measured in the Schefferville region since mining activity commenced in the 1950s. Unfortunately temperature recording at Schefferville ceased in 1992 and only recommenced in 2009. The temperature trend during the time temperature was not recorded at Schefferville can be estimated comparing the Schefferville air temperature record to the Labrador City/Wabush air temperature record.

Researchers from the McGill University Subarctic Research Station at Schefferville with funding from IOC have recorded ground temperatures at a variety of depths between the ground surface and 100 m below the ground surface at 192 locations from mines in the Schefferville area from the late 1950s to the early 1980s (see Figure 13.9). The database is stored at and available from the National Snow and Ice Data Center, University of Colorado, Boulder (http://nsidc.org/). These data show variable trends and support the classification of the LSA as discontinuous and sporadic.

Landforms associated with permafrost such as pingos, palsas and stone nets are found in the physiographic region, but have not been identified within the Joyce Lake PDA, LSA or RSA. The presence of permafrost was assessed as part of the Geotechnical Feasibility Study (Appendix D). According to the geotechnical details obtained in boreholes BH-01-14 through BH-18-14 (Figure 13.7), no evidence of permafrost was observed.

13.5.3.5 Soils

Based on a review of the Soils of Canada map (www.soilsofcanada.ca), prepared by the University of Saskatchewan, on a regional scale, soils from the Podzolic and Organic soil orders are anticipated in the Project LSA and RSA. Soils of the Podzolic order have B horizons in which the dominant accumulation product is amorphous material composed mainly of humified organic matter combined in varying degrees with Al and Fe. Typically Podzolic soils occur in coarse- to medium-textured, acid parent materials, under forest or heath vegetation in cool to very cold humid to perhumid climates. Soils of the Organic order are composed largely of organic materials. They include most of the soils commonly known as peat, muck, or bog and fen soils. Most Organic soils are saturated with water for prolonged periods. These soils occur widely in poorly to very poorly drained depressions and level areas in regions of subhumid to perhumid climate and are derived from vegetation that grows in such sites. Organic soils contain more than 17% organic C (30% or more organic matter) by weight.

In the mapped forested and shrubland areas of the LSA (Genivar 2013), Podzolic soils are anticipated to consist of moderately coarse sandy loam with moderate to good drainage. Soils observed at the sampling plots of the Vegetation Baseline Study (Genivar 2013) consisted predominantly of Humo-Ferric Podzols to Ferro-Humic Podzols. These are considered the most common soil type in the LSA at approximately 60% of the area, and are distributed throughout. The main Project infrastructure (plant site and open pit area) are primarily situated in these upland areas.

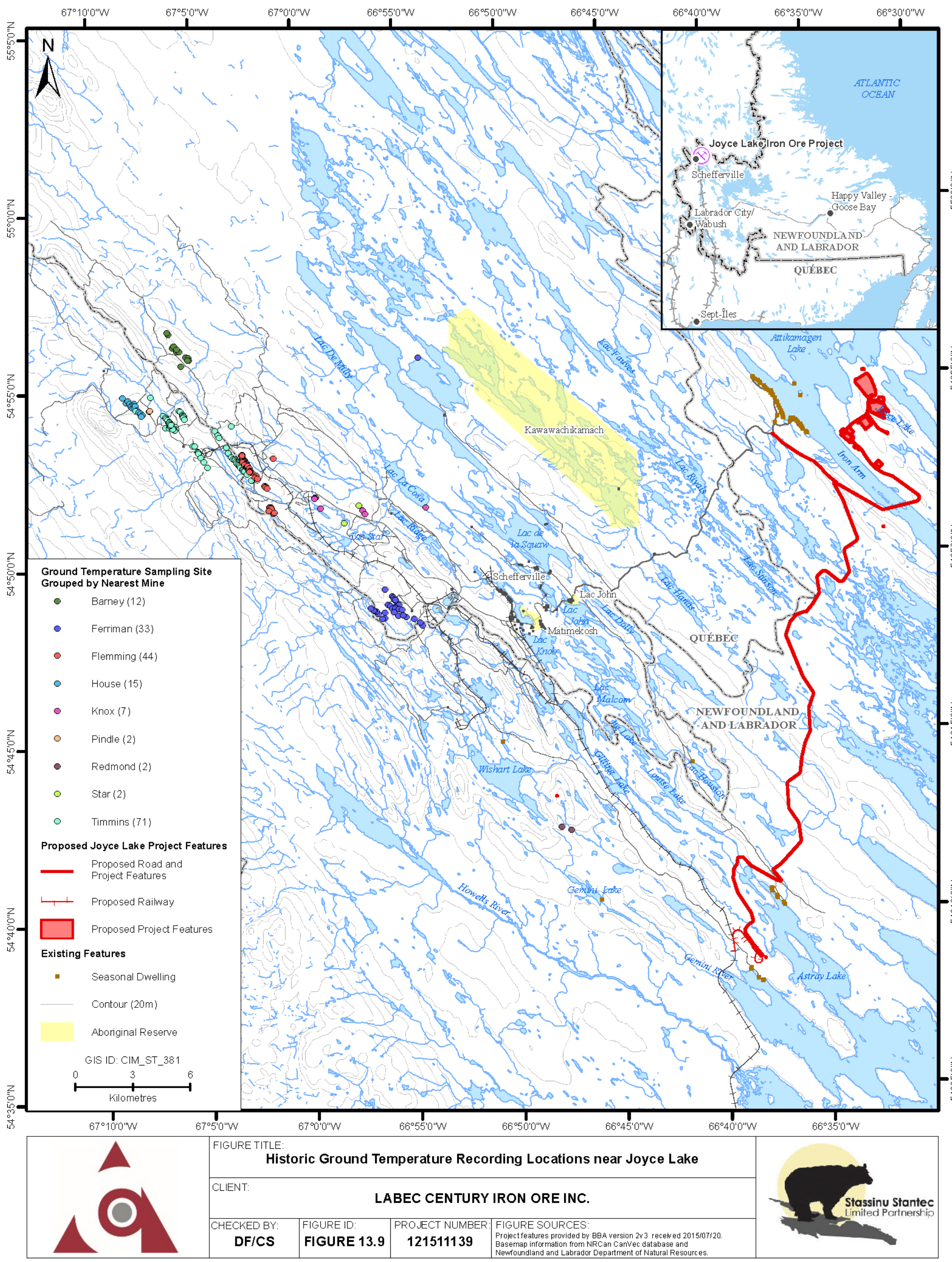

Figure 13.9 Historic Ground Temperature Recording Locations near Joyce Lake

Organic soils, common to wetland classified ecological areas, are the next most common soil type anticipated in the LSA at approximately 20% of the area. Soils observed at sampling plots of the Vegetation Baseline Study (Genivar 2013) consisted predominantly of Mesisols and Fibrisols. Drainage was noted as very poor to poor. The most extensive occurrences of anticipated Organic soils are located along a stream approximately 800 m west of the proposed open pit on the Joyce Lake Peninsula near the proposed processing plant location. Dispersed local deposits of Organic soils are observed along the proposed haul road and in the southern portion of the LSA. Thicknesses of organic soils are estimated to range from 60 to 130 cm (Genivar 2013).

Table 6 of Appendix D provides further details of soil conditions in the PDA, describing stratigraphic units encountered in the boreholes.

Re-vegetation trials will be conducted prior to Construction to determine suitability of soils and vegetation for reclamation. There are limited organic materials and overburden on site and the reclamation plan will include measures to optimize soil use.

13.5.3.6 Geological Hazards

A full description of geological hazards and the potential effects of terrain hazards on the Project is provided in Section 6: Effects of the Environment on the Project.

Events resulting from geological hazards, recorded in Newfoundland and Labrador, have predominantly occurred in coastal or offshore (e.g., Grand Banks) locations of the province. The events recorded include landslides, avalanches, rockfalls and coastal flooding as a result of seismic activity (Liverman et al. 2001, 2003). Of the events recorded and published, none were observed in the western Labrador region of the Joyce Lake area.

Due to the gentle undulating landscape, bedrock control of topography and lack of historic precedence for landslides in the region, landslide-generated tsunamis are not considered a hazard in the LSA and RSA.

The Project is located within a relatively low seismic hazard area, referred to as the "stable central region" (see Figure 13.10, NRCan 2019). A "stable central region" means that there has been no record of relatively large earthquakes, and there are relatively low predicted ground accelerations. The recorded earthquakes in the region are not larger in size than 4.5 on the Richter scale. A 4.4 magnitude earthquake hit central Labrador, about 150 km south, southwest of Happy Valley-Goose Bay on Sunday, July 8, 2012. The last earthquake of that size in the region happened approximately 50 years earlier. According to a seismologist of the Geological Survey of Canada, earthquakes of this size are not large enough to cause any damage; however, significant shaking would be felt (http://www.cbc.ca/news/canada/newfoundland-labrador/story/2012/07/08/nl-labrador-earthquake-0708.html). The Project infrastructure and features will be designed, sited, and constructed using the latest version of the National Building Code of Canada (2015) design guidelines for seismic events.

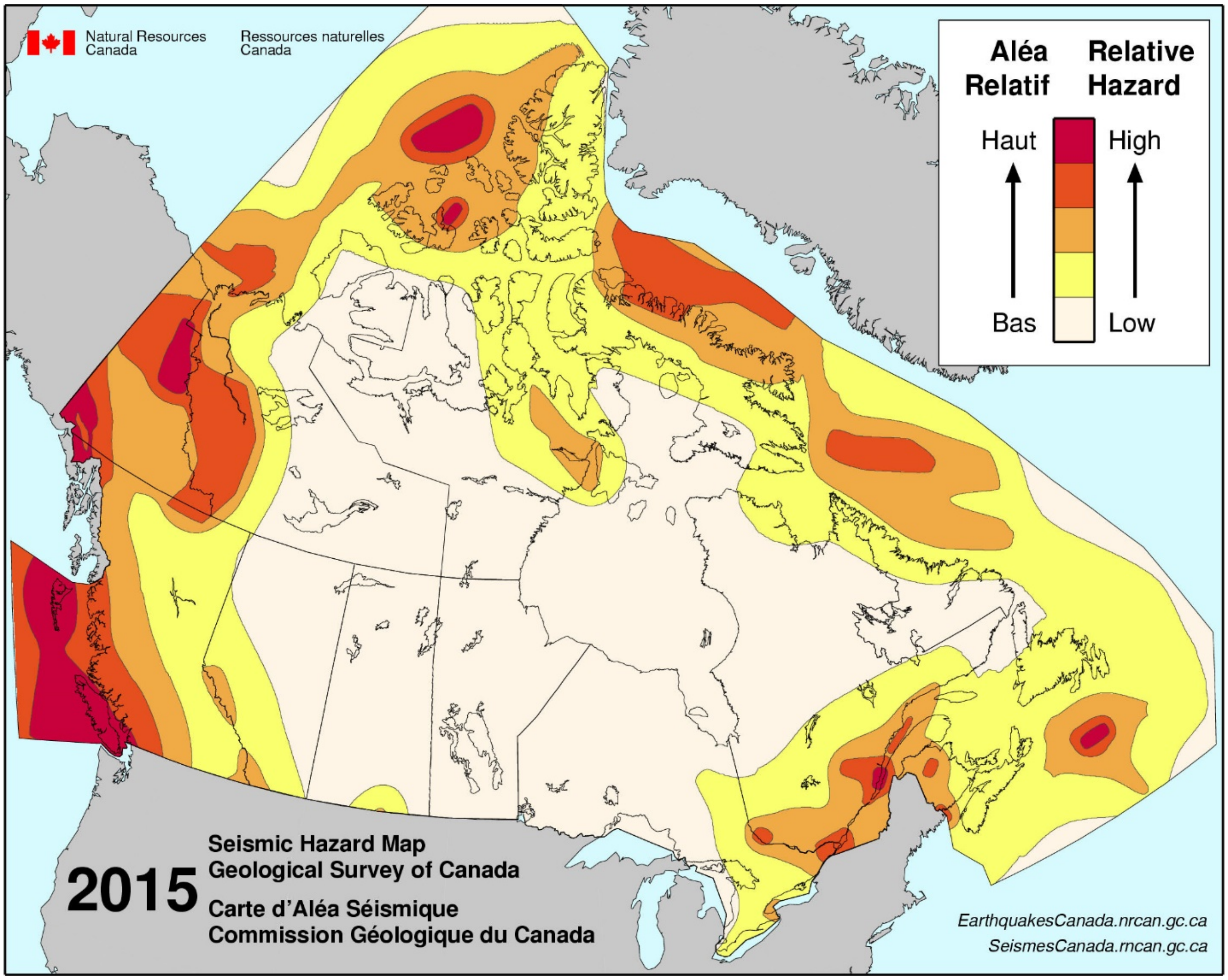

Figure 13.10 Seismic Hazard in Canada

13.5.3.7 Snow Conditions

The Project site is located within the Interior Labrador climate zone. The climate is typified by lengthy, very cold winters with deep snow cover. The continental climate has significant seasonal variations in temperature. The average daily temperatures typically drop below freezing by the end of October and remain below zero until April. Monthly mean temperature extremes in the area can range from -29°C in the winter to 17°C in the summer, with a mean annual temperature of -5.3°C.

Average annual precipitation is approximately 780 mm based on period of record 1948-2010 and 823 mm based on period of record 1971-2000 (climate normal). These annual precipitations are typical of western Labrador. Based on climate normal data, annual precipitation occurs approximately 49.5% (408 mm) as rainfall and 50.5% (415 mm) as snow. The annual snowfall is estimated to be 440 cm/year occurring mainly between October and May.

The 10-Year and 100-Year wet annual precipitation amounts are estimated to be 948 mm and 1,074 mm, respectively. The 10-Year and 100-Year dry annual precipitation amounts are estimated to be 564 mm and 448 mm, respectively. The climate normal precipitation is approximately 823 mm/year. The annual snowfall is estimated to be 441 cm/year occurring mainly between October and May. The mean monthly snow cover peaks in February, March and April. The snow cover is usually melted by the end of May and returns with a mean monthly value of 7 cm in October. A more detailed description of climate conditions is found in Chapter 10: Atmospheric Environment and Climate.

13.5.3.8 Ice Conditions

The lacustrine ice environment within the LSA varies with respect to waterbody size and relative climatic conditions. In general, freeze-over occurs around November 1, resulting in a mean maximum ice thickness ranging from 125 cm to 150 cm, with ice-free conditions expected for area lakes around June 1. A more detailed discussion of the lacustrine ice environment is provided in Chapter 11: Water Resources.

13.5.3.9 ARD/ML

Stantec previously assessed two mine sites in the Schefferville area, where mining activities have occurred since the 1950s (LIM 2009). Acid-Base Accounting indicated that the waste rock could be classified as non-acid generating based on NPR criteria. No ARD has been associated with these mines.

In general, the waterbodies in the LSA and RSA present good-quality water and results are typical of low-productivity waters. In Joyce Lake and Attikamagen Lake, water is sensitive to acidification due to low pH and low alkalinity. The 75th percentile CWQG for the Protection of Freshwater Aquatic Life was exceeded for total iron and copper in Attikamagen Lake. The exceedances might be related to high concentration of these elements in suspended particles or to the natural metal leaching from the sulfide bearing Ruth shale and the Menihek formation naturally exposed in the LSA.

13.6 Assessment of Project-Related Environmental Effects

This Section describes and assesses the potential effects of Project activities on the following Terrain and ARD/ML VC elements: landforms and terrain stability, soil quality and quantity, snow and ice, and ARD/ML. The Project activities and interactions assessed in the following sections are those rated as 2 in Table 13.3.

13.6.1 Assessment of Effects on Landforms and Terrain Stability

With respect to landforms, the main concern is effects on sensitive, valuable or fragile landforms and eskers in particular. As described in Section 13.5.3.3, while there are eskers in the RSA and eskers are common in general in this area of Labrador, mapping and geology information from available from NRCan and NLDIET did not identify any eskers in the LSA. However, site specific studies did identify the potential presence of two esker features intersecting the PDA.

Construction

Site preparation, construction of roads, the causeway and stream crossings are rated 2 in Table 13.3, for interactions with landforms and terrain stability. Removal of vegetation and earth material during clearing, grubbing, excavation/slope cuts and ditching may affect spatial distribution of surficial materials (e.g., till, glaciofluvial, organic), as well as thermal regime and drainage. Construction of mine roads, access roads, embankments, and other Project components may require cutting and filling of naturally occurring soils and imported fills that will require proper engineering strategies to ensure stability of slopes and adequate bearing capacity of placements to reduce settlement effects. Borrow material required for the Project will be obtained from an existing borrow source.

Operation and Maintenance

Open pit mining activities, such as drilling and blasting, excavation, waste and ore haulage and stockpiling affect the stability of pit walls, benches and the waste and ore piles and are therefore rated as 2 in Table 13.3. Dewatering of Joyce Lake and waste rock disposal on surface have also been rated as 2 in Table 13.3. Dewatering of Joyce Lake may have some effects on landforms immediately bordering the lake and present a change in the stability of the lake shores. Slope stability of the waste rock stockpile will also be a long term concern.

The effects of terrain hazards on the Project are further assessed in Chapter 6: Effects of the Environment on the Project.

13.6.1.1 Mitigation of Project Environmental Effects on Landforms and Terrain Stability

The following measures will be implemented to mitigate potential effects on landforms and terrain stability:

- Development on steep slopes will be avoided where possible. Areas of sensitive terrain will be avoided where practicable.
- Where steep slopes and sensitive terrain cannot be avoided, further detailed investigations may be required by qualified geoscientists and/or geotechnical engineers and additional mitigation measures may be implemented.
- In areas where excavation is required, surface protection will be installed upon the till surface to protect the slopes against surface erosion, gully formation and local instabilities.
- Where possible, till material removed from cuts will be used for embankments or as an engineering fill.
- Compacted snow pads will be used for winter Project activities.
- Potentially unstable slopes and/or areas sensitive to thaw may require monitoring and additional mitigation.
- Banks of streams crossings will be stabilized, where required.

- Terrain, soil and vegetation disturbances will be limited to that which is necessary to complete the work within the defined Project boundaries.
- Wherever possible, organic soils, mineral soils, glacial till, and excavated rock will be stockpiled separately for later rehabilitation work.
- Surface disturbances will be stabilized to limit erosion and promote natural re-vegetation.

Pit walls, roads, ore stockpile and waste rock piles will be engineered for slope stability and managed to acceptable engineering risk factors. Pit wall slope stability is further discussed in Chapter 6: Effects of the Environment on the Project.

Esker features can be of value from a historic resources perspective. Field work and mapping of relative archaeological potential in the LSA has not identified any historic features in association with the two eskers intersecting the PDA. A Project-specific EPP will detail the procedures to follow in the event of an accidental/inadvertent discovery of Archaeological and Cultural Resources; further detail on these procedures can be found in Section 18.7.

A Rehabilitation and Closure Plan will be prepared and submitted, as required under the Newfoundland and Labrador *Mining Act*, Chapter M-15.1, Sections (8), (9) and (10). This plan will be based on the existing baseline conditions and will provide prescriptive methods for reclamation of areas disturbed by Project activities (i.e., open pit, waste rock disposal areas, mine site infrastructure and potential borrow areas), including progressive rehabilitation. This will include measures to:

- Re-establish site drainage patterns, as near as practical, to natural, pre-development conditions or otherwise to meet land use objectives; and
- Grade disturbed areas and/or otherwise scarify or landscape to control erosion and sedimentation.

In particular, the waste rock stockpile will be re-vegetated throughout the mine operations. The overburden and ore stockpiles footprint will be scarified, graded and re-vegetated at the end of mining. The open pit will be flooded.

13.6.1.2 Characterization of Residual Project Environmental Effects on Landforms and Terrain Stability

Construction

As stated in Section 13.5.3, the landforms (e.g., eskers, wetlands, undulating bedrock with discontinuous glacial drift) are not considered unique to the RSA. The materials that make up the eskers in the area, which were tested during the preliminary borrow search, are not considered the best option or type of materials to be used for earthworks construction due to high fines contents ranging from 33.2% to 50.1%; therefore it is unlikely that these eskers will be used for aggregate materials at any future point and existing borrow sources will be used. Field work and mapping of relative archaeological potential in the LSA has not identified any historic features in association with the two eskers intersecting the PDA and mitigation will be in place for any accidental discovery of archaeological resources as further described in Section 18.7. The effects of the Project on wildlife habitat (potentially associated with landforms in the LSA) are fully assessed in Chapter 16: Birds, Wildlife and their Habitats.

The residual effects of the Project on landforms will be low in magnitude, local in geographic extent, medium-term, and reversible upon site reclamation. The residual effect is considered not significant, as the limited loss of potential esker features identified within the PDA will be assessed and mitigated for any potential interactions with cultural/historic features. This limited loss or change in eskers would not be to the degree where sustainable wildlife populations cannot be maintained within the RSA. The confidence level associated with these predictions is high.

Construction also has the potential to affect terrain stability by altering the spatial distribution of surficial materials during earthworks and altering natural drainage patterns. Mitigation measures for potential Project effects on terrain include best practices in engineering design of infrastructure, and active stabilization where required during construction. The haul road and rail loop will mostly be built over till deposits or rock outcrops where no noticeable settlement is expected (Appendix D). Where the alignments cross wetlands or organic peat units, additional mitigation measure will be taken. In areas where cuts are required, surface protection will be used to protect slopes against surface erosion, gullies formation and local instabilities. These mitigations will limit the Project's effects on terrain stability to levels acceptable for engineering design standards.

Through the application of these mitigation measures, the residual effects to terrain stability in the Construction phase are predicted to be adverse, but low in magnitude as measures will be put in place as needed to stabilize areas of terrain instability as part of standards construction practices or as part of progressive rehabilitation. The geographic extent of these effects will be local, confined to the area of active surface disturbance in the PDA. It is anticipated that the duration of these effects will be medium to long term and reversible, occurring as early as the Construction phase, but not extending beyond Closure and Decommissioning of the Project when reclamation activities of Project infrastructure included within this phase will be complete. The residual effect of the Project on terrain stability is predicted to be not significant with a high degree of confidence.

Operation and Maintenance

During Operation and Maintenance, no further effects on eskers in the LSA are predicted, as there will be no requirement for further surficial disturbance in these areas.

Activities such as drilling and blasting, excavation, waste and ore haulage and stockpiling will have an effect on terrain stability within the PDA. The stability of the open pit walls and the engineered benches of the waste and ore stockpiles will be mitigated through engineering design and implementation of progressive rehabilitation and final reclamation in accordance with a Rehabilitation and Closure Plan. Further details on pit stability can be found in Section 6: Effects of the Environment on the Project.

Through the application of these mitigation measures, the residual effects to terrain stability in the Operation and Maintenance phase are predicted to be adverse, local in geographic extent and low in magnitude. The duration of most of these effects will be medium term, not extending beyond Closure and Decommissioning of the Project, but permanent for certain features not reclaimed to original conditions (e.g., open pit and the waste rock stockpile). These features will be stabilized and monitored, thereby limiting any long-term effects on terrain stability. The residual effect of the Project on terrain stability is predicted to be not significant, with a high level of confidence.

13.6.2 Assessment of Change in Soil Quality and Quantity

Construction

Site preparation (e.g., clearing, grubbing, excavation, grading, and removal of overburden) and construction of roads are rated 2 in Table 13.3 due to potential for change in soil quality and quantity. Peat and topsoil will be salvaged during these activities and stored on site for use during progressive rehabilitation and site reclamation. Changes to surface and groundwater flow patterns associated with the Project may result from these activities and have potential to affect soil moisture conditions and alter soil quality.

Disturbances to native soils during site preparation and road construction have potential to contribute to erosion, including streambank and wind erosion, and deposition of airborne sediment and dust. Site preparation and road construction activities that disturb the surface organic horizon will increase the risk of sediment transport via wind or water. The risk of wind erosion depends on soil texture and climatic factors; risk of water erosion depends on soil texture, slope, steepness and length and climatic factors. Based on the generally gentle to moderate slopes observed in the LSA (see Section 13.5.3.3, Physiography and Landforms), and limited thickness of surficial sediments, natural gullying and erosion are not anticipated to be significant.

Organic soils will be stripped and stored during Construction and Operation and Maintenance for the purpose of re-vegetation during Closure and Decommissioning. Peat and topsoil storage and replacement have the potential to alter soil quality through admixing, wind and water erosion, biogeochemical alterations during storage, and changes to soil moisture status. Admixing and compaction can degrade soil quality by changing both the physical (e.g., pore space) and chemical properties (e.g., pH) of the soil material. Excavated soils will be stored so that they retain volume and quality required for reclamation activities.

Airborne deposition of dust particles associated with site preparation and road construction can change soil quality. However, the parent geological material contains substantial amounts of iron; therefore, deposition of dust composed of iron particulates should not adversely affect the quality of upland soils. Podzols are characterized by amorphous material composed mainly of humified organic matter combined in varying degrees with aluminum and iron. Project environmental effects on air quality (e.g., dust) are further addressed in Chapter 10: Atmospheric Environment and Climate.

Operation and Maintenance

Waste rock disposal on ground surface is rated as 2 in Table 13.3 as there is ongoing potential for change in soil quality and quantity during the Operation and Maintenance phase.

Waste rock disposal on the surface has potential to alter soil moisture and affect soil chemistry. Natural drainage patterns will be maintained through the proper placement of waste rock and the use of appropriately sized culverts and trenching. Project environmental effects on surface water are addressed in Chapter 11: Water Resources. Effects for groundwater are addressed in Chapter 12: Groundwater Resources.

Closure and Decommissioning

Closure and Decommissioning activities will be carried out in accordance with a Rehabilitation and Closure Plan and will include the replacement and redistribution of stored overburden and topsoil. While the long term result of these Project activities will be a positive change in soil quality and quantity, the physical activities associated with Closure and Decommissioning will include equipment and vehicle operation and manipulation of soil stockpiles, such that some adverse effects could result.

13.6.2.1 Mitigation of Project Environmental Effects on Soil Quality and Quantity

A Rehabilitation and Closure Plan will be prepared and implemented. This plan will provide procedures for stripping, handling, storage and replacement of soils to manage soil quality and quantity in the LSA.

The collection and storage of soil stockpiles will be managed to reduce erosion and mixing of soil horizons. In particular, stripping activities and erosion protocols documented in the Rehabilitation and Closure Plan will be implemented. Soil stockpiles will be revegetated to prevent erosion during storage, and the volumes of soils in each stockpile will be estimated for future tracking.

To mitigate the effect of the Project on soil quality and quantity, the following erosion and sediment control measures will be implemented, if required, to the extent feasible:

- Progressive revegetation and direct placement of topsoil and peat will be implemented so that the seedbanks and propagules present in recently stripped topsoil can be used;
- Soil and overburden will be stored to preserve it for site rehabilitation;
- Soil handling will be suspended during and after heavy rainfall events to avoid erosion and loss of valuable organic soils;
- Surface runoff will be contained and/or directed in appropriately sized ditches; and
- Terracing, mulch or coarse woody debris, or matting will be used on newly-constructed stockpiles or recently replaced soils.

In addition to the erosion and sediment control measures, other applicable mitigation will include:

- Wherever possible, organic soils, mineral soils, glacial till, and excavated rock will be stockpiled separately for later rehabilitation work. Soil stockpiles will be maintained at lower heights to prevent decomposition of the organics and will be hydro-seeded where possible to prevent erosion and washout of material.
- Signs will be installed to clearly identify soils located in each stockpile;
- Spill prevention and clean up protocols will be followed; and
- Traffic plans will be followed to reduce soil pulverization and compaction.

Project activities will be carried out in consideration of surface water management (refer to Chapter 11: Water Resources), which will in turn reduce effects on soil. Rehabilitation activities will be planned, designed and implemented to reduce environmental effects resulting from compaction and erosion. Given the relatively low quantity of organics on site, revegetation activities will be designed to optimize soil use. For example, it is assumed that concentrated re-vegetation “islands” or areas, located in relatively protected areas, will be the most effective re-vegetation strategy. This method would concentrate the limited organic materials and overburden in areas relatively protected from wind and water scour (e.g., near the toe of the waste rock stockpile where the underlying soils (rock) would not drain moisture away). These vegetation islands would then shed organic materials, primarily in the prevailing wind direction, which will accumulate and provide sufficient base for the same vegetation to spread and cover additional areas naturally.

13.6.2.2 Characterization of Residual Project Environmental Effects on Soil Quality and Quantity

Construction

Changes in soil quality resulting from deposition of dust particulates during Construction are not likely as deposited dust will likely be composed of iron particulates, similar to the parent geologic material. The upland soils as Podzols, which are so common throughout the PDA and LSA, are characterized by amorphous material composed mainly of humified organic matter combined in varying degrees with Al and Fe and therefore will not be significantly affected by dust from Project activities.

Changes in soil quantity during this phase will be reduced through the stockpiling of peat and topsoil as activities disturb the ground surface. These stockpiled soils will be managed throughout the Construction phase to be used to rehabilitate the site progressively and at decommissioning. Surface water management measures will be implemented throughout the site to limit the effects of drainage and erosion on native soils.

Changes in soil quality and quantity during Construction will be adverse in direction and low in magnitude. Much of the disturbed soil will be reclaimed, but some loss through transport and storage is anticipated. The geographic extent of these effects will be local, confined to the areas of active ground disturbance in the PDA. The frequency of occurrence will be rare, as these effects will occur only when earthworks are active, and will be reversible due to the ability to redistribute soils during progressive rehabilitation. The residual adverse effects are predicted to be not significant with a high confidence level.

Operation and Maintenance

During Operation and Maintenance, waste rock disposal on the surface has potential to alter soil moisture and affect soil chemistry. Peat and topsoil will be salvaged and stored for the progressive rehabilitation of waste rock stockpiles. Surface water will be managed through designed drainage systems (refer to Chapter 11: Water Resources for additional details).

During Operation and Maintenance, changes in soil quality and quantity will be adverse in direction. The geographic extent of these effects will be local and confined to the areas of disturbance within the PDA, more specifically the immediate vicinity of the waste rock stockpiles on Joyce Lake peninsula. The magnitude of these effects is low and the duration moderate to long term. The frequency of occurrence will be rare, occurring only as active earthworks take place and will be reversible. The residual adverse effects are predicted to be not significant with a high confidence level.

Closure and Decommissioning

Closure and Decommissioning will include the replacement and relocation of stored overburden and topsoil in accordance with a Rehabilitation and Closure Plan. Therefore, the long-term result of this phase will be positive with respect to soil quality and quantity as site features are regraded and stockpiled organic material is redistributed to near natural conditions. However, the physical activities associated with Closure and Decommissioning will include equipment and vehicle operation and manipulation of soil stockpiles, and some adverse effects (e.g., soil loss from erosion, compaction, admixing) could result. Given the limited organics on site, mitigation measures will be in place to reduce any soil loss during this phase and any effects will be low in magnitude, and local in geographic extent (i.e., confined to the areas of disturbance within the PDA). The duration will be permanent; the frequency of occurrence will be once and will be irreversible. The residual adverse effects are predicted to be not significant with a high confidence level.

13.6.3 Assessment of Change in Snow and Ice

Potential environmental effects on snow and ice may occur from interactions with Project activities and could include: changes in timing of snowmelt as a result of fugitive dust accumulation from construction and operations activities, changes in snow distribution and drifting as a result of site preparation and project infrastructure, and changes in winter ice conditions on nearby lakes resulting from blasting activities, dewatering processes, and from the construction and presence of the causeway.

Construction

Site preparation activities and any associated earthworks were rated as 2 in the effects assessment, as they may result in dust emissions that could reduce snow albedo and affect the timing of snowmelt during winter conditions (typically October through May). These activities include clearing, grubbing, excavation, material haulage, grading, removal of overburden, ditching, and stockpiling. It is anticipated that fugitive dust will be deposited to the southeast of the Project site, as the annual prevailing wind direction is from the northwest. Dust emissions during winter construction activities would be less than those generated during non-winter months, as the ground would be wet and/or frozen.

During this Project phase, construction of the mine site infrastructure, including site preparation, construction of roads, causeway, rail loop and associated infrastructure and stream crossings will also have potential to affect the physical distribution and drifting of snow in the PDA and were therefore rated as 2. Changes in the microtopography may influence wind direction and speed, which in turn will alter the distribution of snow relative to pristine conditions. These changes would be of most concern to land and resources users (e.g., snowmobilers, ice fishers); however, as these changes would likely be limited to the LSA, potential for interaction with land and resource users would be limited. These changes would not affect land and resource users within the broader RSA.

Operation and Maintenance

Those operational activities that may adversely affect snow and ice in the winter months (typically October to May) and were rated as 2 in the effects assessment include: presence and maintenance of the causeway, open pit mining, dewatering of Joyce Lake, ore processing, waste rock disposal and rail load out and transport.

Dewatering of Joyce Lake, groundwater dewatering, and water withdrawal for mine operations will result in lower water levels in Ponds B, C and D and Lake E, resulting in potential for changes to ice. However, water levels will remain within normal variability of baseline conditions, and therefore effects on ice formation are predicted to be low. Pond A will be completely dewatered and therefore effects on ice formation will be high. Water level changes in the Attikamagen Lake system, including Iron Arm, will be negligible and therefore effects on ice formation are expected to be negligible. This is further discussed Chapter 11: Water Resources.

Open pit mining, ore processing, and rail load out and transport may result in increased dust emissions that could reduce snow albedo and affect the timing of snowmelt. In a study of snow melt at Schefferville, Quebec (Nicholson 1975), it was found that dust-covered snow near active mine sites melted approximately four days prior to melting of the general snowpack in the area. The ability of dust to accelerate snowmelt depends on the rate of deposition, the absorptivity of the material and other factors; therefore, direct comparison with other mines is not possible. Air quality modelling conducted by WSP Global (Genivar 2013) indicates that detectable dust deposition in the LSA will likely be confined to a distance of 200 to 300 m from Project transportation infrastructure; however, complete cover by dust is likely to be restricted to a few metres from the roadways, and within the working mine area. Typically, airborne particulate will deposit within 100 m from the source. Prevailing northwest wind directions indicate that dust will deposited to the southeast of the project. Extent and distribution of dust emissions is further characterized in Chapter 10: Atmospheric Environment and Climate.

Waste rock disposal will result in continually changing microtopography in the Project area and may affect snow deposition and drifting in the disposal area, particularly downwind in the southeast direction.

Presence and maintenance of the causeway, open pit mining and dewatering of Joyce Lake also have the potential to affect ice conditions of nearby lakes in the LSA. Operation and maintenance of the causeway has potential to affect flow rates, water levels, and water circulation patterns in Iron Arm. As a result, ice flow patterns during breakup may change. Lakes in the region are considered to be snow-covered with a coefficient of ice growth of 19.5. Freeze-over occurs around November 1 in region and the mean maximum ice thickness is expected to range from 125 to 150 cm. To allow for ice coverage, clearance of 1.5 m above the normal water level is required. The ice-free condition occurs in the region around June 1. In addition, near shore ice is often under the greatest mechanical stress (Stassinu Stantec 2013). Presence of the causeway will result in additional shoreline and has the potential to alter ice breakup and formation dates in the vicinity of the causeway. Details on ice jamming considerations can be found in Chapter 11: Water Resources. Details on ice formation in the RSA can be found in the Lacustrine Ice Environment in the Regional Study Area Memo (Stassinu Stantec 2013).

Dewatering of Joyce Lake will result in a change from baseline conditions as this lake is currently ice-covered in winter. However, open pit mining will restrict any existing land and resource use of the immediate area, which will reduce these interactions.

The open pit will be mined primarily with drilling and blasting. Blasting will be used only as required, which may result in some ground vibrations. Ground vibration caused by any source rapidly decreases as the distance from the source increases (Missouri Limestone Producers 2012). In a study of maximum allowable charge size at a given location based on the distance to the nearest sensitive receptor location (commercial or residential) for the Hollinger Project open pit mine adjacent to Timmins, Ontario (Harding 2010), it was found that a 1,000 kg charge had a vibration radius of approximately 500 m; a 200 kg charge had a vibration radius of approximately 200 m. Blasting will be managed by the mining engineer so that the resulting ground vibrations will not adversely affect ice cover of nearby lakes.

Closure and Decommissioning

Site decommissioning and site reclamation activities that involve earthworks and disturbance to the mineral surface during winter conditions (October to May) may result in increased dust emissions that could affect snow cover by reducing albedo levels, although activities that could occur in winter months and potential for dust generation would be limited and are therefore rated as 1 in the effects assessment. Following removal of site infrastructure and reclamation, snow drifting patterns in the area would be expected to alter and potentially shift back to pre-Project conditions.

13.6.3.1 Mitigation of Project Environmental Effects

To mitigate the effects of the Project on snow, measures will be implemented such as: use of snow fences, progressive rehabilitation (e.g., revegetation) to restore natural windbreaks, and management of activities to reduce dust emissions and spreading (e.g., implementation of speed limits, use of water trucks). Other measures for dust control are provided in Chapter 10: Atmospheric Environment and Climate.

To reduce the potential effects of the Project on ice cover on lakes, blasting will be managed so that vibrations will not affect ice cover of nearby lakes. The causeway will be designed in accordance with best engineering practices to maintain the integrity and stability of ice in Iron Arm, to the extent feasible. Current design clearance for the causeway is 1.5 m above high water, which will accommodate formation of ice.

13.6.3.2 Characterization of Residual Project Environmental Effects

Construction

The construction of the Project will affect the snow and ice conditions within the PDA, but at a low magnitude. Dust emissions created during construction will be short-term, reversible and limited to the PDA or LSA in extent. Changes in drifting patterns will be medium-term as they will continue for as long as Project infrastructure is in place, but will also be localized in extent. The area immediately surrounding the mine site is most likely to be affected by these changing drift patterns, but due to safety restrictions, areas adjacent to site infrastructure are unlikely to be used by land and resource users. Land and resource use could occur adjacent to the haul road, but changes in drift patterns associated with the road are not likely to negatively affect these users. The cleared haul road could represent improved access for snowmobiles. Effects are not expected to extend beyond the LSA and the residual environmental effects are predicted to be not significant with a high level of confidence.

Operation and Maintenance

The effects of dust on snow are considered adverse, though likely low as studies (Nicholson 1975) have shown dust may promote advance snow-melt only four days sooner than baseline. The geographic distribution of this effect is local and likely distributed southeast of the emission source due to the dominant northwest wind direction during winter periods. While these effects will occur for the life of the Project, they will not continue beyond Project decommissioning and therefore these effects are considered reversible.

The potential effects of the Project on ice are considered adverse, though also likely low as studies indicate that best practices in blasting can mitigate the impact of ground vibrations on nearby structures such as ice and design of the causeway will allow for normal levels of ice formation. This effect will be local in geographic extent, confined primarily to the area of the PDA around the open pit mine, and will occur primarily during the Operation and Maintenance phase of the Project. Due to the seasonality of ice cover, this effect is considered reversible as effects are not anticipated beyond the life of the Project and natural ice formation will continue after decommissioning.

Based on the above, the residual adverse effects are predicted to be not significant with a high level of confidence.

13.6.4 Assessment of Acid Rock Drainage/Metal Leaching

Construction and Operation and Maintenance

Site-preparation and construction will result in the exposure of substantial quantities of bedrock and overburden. The potential for ARD/ML will extend into the Operation and Maintenance phase, and therefore both phases are addressed together for ease of discussion.

Overburden

Approximately 2.3 M tonnes of overburden will be removed during the Project. Of a total of 42 overburden samples, five exhibit Carbonate NPR values less than 2, accounting for 12% of the material tested; but only one of these samples (or 2%) have Carbonate NPR values less than 1, which can be classified as PAG. Based on a median Carbonate NPR value of 4.8, the overburden is classified as non-PAG material. The metal-leaching potential of the overburden is currently considered to be low, based on the compliance of concentrations from SFE and leachates from kinetic tests with the MDMER limits.

Waste Rock and Ore

The Open Pit will be developed within three upper lithological units of the meta-sedimentary Sokoman Formation: Lower Massive Hematite (LMH), Red Chert (RC), Upper Massive Hematite (UMH) (see Figures 13.3, 13.4 and 13.5). These units are composed of bands of magnetite and hematite within chert-rich rock with variable amounts of silicates, carbonates and sulfides. All units contain ore and waste rock, which will be separated based on the iron grade of the mining block.

The LMH unit contains 9% PAG and 19% uncertain samples based on Carbonate NPR (Table 13.5). A composite PAG sample of ore has generated acidity in humidity cells (Appendix Q2). Overall, the LMH unit is classified as non-PAG based on a median Carbonate NPR of 2.67. The potential for metal leaching is currently considered to be low based on the compliance of concentrations from SFE and leachates from kinetic tests with the MDMER limits.

Table 13.5 Percentages of Samples Non-compliant with Applicable ARD/ML Criteria for Bedrock Units and Other Materials Exposed During the Joyce Lake Direct Shipping Iron Ore Project

Parameter	Units	Criteria	LMH unit		RC unit		UMH unit		Overburden		Iron ore product	
			n	%	n	%	N	%	n	%	n	%
Acid-Base Accounting												
Samples analyzed for Acid-Base Accounting			32	100	46	100	8	100	42	100	15	100
Paste pH	pH Unit	<4.5	0	0	0	0	0	0	0	0	0	0
NPR sobek	ratio	<2	2	6	0	0	0	0	3	7	0	0
NPR sobek	ratio	<1	1	3	0	0	0	0	3	7	0	0
NPR carbonate	ratio	<2	9	28	5	11	1	13	5	12	15	100

Table 13.5 Percentages of Samples Non-compliant with Applicable ARD/ML Criteria for Bedrock Units and Other Materials Exposed During the Joyce Lake Direct Shipping Iron Ore Project

Parameter	Units	Criteria	LMH unit		RC unit		UMH unit		Overburden		Iron ore product	
			n	%	n	%	N	%	n	%	n	%
NPR carbonate	ratio	<1	3	9	0	0	0	0	1	2	8	53
Stot	wt%	>0.01	6	19	3	7	6	75	19	45	0	0
Samples analyzed for trace-metals			16	100	23	100	4	100	23	100	15	100
Shake Flask Extractions greater than the criteria – MDMER[1] Limits												
As	mg/L	>0.5	0	0	0	0	0	0	0	0	0	0
Cu	mg/L	>0.3	0	0	0	0	0	0	0	0	0	0
Ni	mg/L	>0.5	0	0	0	0	0	0	0	0	0	0
Pb	mg/L	>0.2	0	0	0	0	0	0	0	0	0	0
Zn	mg/L	>0.5	0	0	0	0	0	0	0	0	0	0

Note:
1 MDMER – Metal and Diamond Mining Effluent Regulations (2002)

Rec chert is represented by 89% non-PAG samples with a Carbonate NPR >2. The rest of the samples classify as uncertain with Carbonate NPR values between 1 and 2 and contain less than 0.02 wt percent sulfide sulfur. This unit has a low ARD potential based on a low percentage of PAG samples and median Carbonate NPR of 2.67. All SFE analyses and kinetic test leachates from the RC unit are compliant with the MDMER limits.

In UMH unit, the median Carbonate NPR is 2.13, indicating that this unit has a low ARD potential. Only one of eight samples (12.5%) has an uncertain Carbonate NPR value between two and one falling in the uncertain class. The rest of the samples are non-PAG and SFE leachates are compliant with the MDMER. Therefore, the UHM unit is classified as non-PAG material with low metal-leaching potential.

Figure 13.3 illustrates the boreholes within the open pit area that have been sampled for ARD/ML testing. Figures 13.4 and 13.5 show the spatial distribution of preliminary test results (NPR) along a representative longitudinal Section (2.0) and cross Section (3.0 N), respectively. Percentages of non-PAG rock were evaluated using Carbonate NPR values calculated from Labec Century's geochemical database containing over one thousand samples analyzed for total sulfur and total carbon (Appendix Q). The majority of AP and carbonate NP values were calculated using one half of the detection limit as the reported value, resulting in a relatively low percentage of samples with NPR values less than 2 in the LMH and RC units (Table 13.7). Almost half of these samples have concentrations of sulfur either at or below the detection limit (0.01 wt. percent, Appendix Q). Therefore, an alternative estimate was also considered, excluding samples with low sulfur content, wherein additional criterion for total sulfur was arbitrarily selected. Samples that are classified as uncertain or PAG materials have NPR values below 2 and total sulfur content above 0.01 wt percent. Based on the primary and alternative estimates, 94.5% and 99.1% of waste rock are classified as non-PAG, respectively. The remaining mass of uncertain and PAG waste rock ranges between 0.9% and 5.5% of total waste rock volume (Table 13.6). Due to low percentages, special handling and separate disposal of these PAG rock types is not warranted as mitigation for ARD.

Table 13.6 Percentages of PAG and Uncertain Waste Rock

Lithological Unit	LMH		RC		UMH	
Waste Rock (tonnes)	3,395,760		11,167,200		5,719,440	
Parameter	n	%	N	%	n	%
Samples analyzed for S and C	569	100	331	100	224	100
Samples NPR<2	28	5	26	7.9	3	1.3
Samples NPR<2 and S total >0.01%	16	3	14	4.2	3	1.3

Key:
n number of samples

Open Pit

The walls of the proposed open pit will be represented by the three lithological units described above. The rock from the three units all have low ARD/ML leaching potential based on static and kinetic tests (see Figures 13.3, 13.4 and 13.5) and historical data form other iron mines in the Schefferville area. Therefore, it is unlikely that the mine water will be acidic or contain trace elements in concentrations exceeding the MDMER limits. If further monitoring of the mine water from the pit indicates a potential for ARD/ML, predictive modelling of pit water quality will be conducted for all phases of the Project. If mine water effluent does not meet MDMER guidelines, the effluent will be treated.

Iron ore product and intermediate products, to be stored on the site during operations, are classified as non-PAGs, based on Sobek NPR values being above 2 (Appendix Q1). Carbonate NPR values cannot be used because they are impacted by a mathematical artifact resulting from use of one half the detection limit discussed above. Based on the compliance of concentrate metal concentrations from SFE and kinetic tests with the MDMER limits, the metal leaching potential of iron ore product is low.

No subaqueous disposal in artificial (e.g., open pit) or natural water bodies is currently proposed. Therefore, no impact to the water bodies in the area is anticipated.

Summary

Based on historical data and site-specific information presented above, the ARD/ML potential of overburden, waste rock, ore, and iron ore product is expected to be low. Therefore, no adverse environmental effects related to ARD/ML are expected from Construction and Operation and Maintenance activities, including removal of overburden, open pit mining, ore processing, and waste rock disposal, and rail load out and transportation.

Closure and Decommissioning

Based on the results presented above, ARD is not expected to occur in overburden, waste rock, ore and iron ore product and seepage from these materials is anticipated to meet MDMER criteria at closure; therefore, these components of the Project should not cause any adverse environmental effects during Closure and Decommissioning. A pit lake will be formed after mine closure by flooding of the mine. The discharge from the pit lake unlikely will be acidic and is expected to meet MDMER discharge criteria based on characteristics of units comprising pit walls. This expectation is also consistent with the water quality of existing pit lakes in closed iron mines in the Schefferville area, which do not show any evidence for ARD/ML (LIM 2009). Additional analysis, including modelling, will be undertaken in order to understand mine-water quality and the chemistry of the pit lake. If the modelling and monitoring of the water quality indicates the possibility of ARD/ML, mitigation measures (see Section 13.6.4.1) will be applied to limit adverse effects on environmental receptors during operation and after closure. These measures will be discussed in ARD/ML monitoring and management plan, which will be developed during permitting process.

13.6.4.1 Mitigation of Project Environmental Effects

Based on historical data and static tests of geological materials from the Project, ARD/ML is not likely to occur in the overburden, open pit, ore, iron ore product stockpiles and waste rock disposal areas. Discharge from runoff from the stockpiles and mine water will be monitored for pH and concentrations of metals, sulfate and TDS to verify predictions. If additional modelling, and monitoring water quality show potential effects from ARD/ML, the discharges will be treated to meet MDMER discharge criteria. In this case, the following approaches to potential ARD management may include:

- Isolation/encapsulation of ARD waste rock/overburden material in waste rock disposal areas; and
- Limiting of overland flow over exposed PAG surfaces;
- Reduction of waste rock and overburden in-pit exposure to groundwater seepage and runoff;
- If ARD occurs, treatment of acidic leachate and capping of the waste rock piles.

13.6.4.2 Characterization of Residual Project Environmental Effects

Construction and Operation and Maintenance

It is unlikely that ARD/ML producing material will be encountered during Construction and Operation and Maintenance. Therefore, there will be no residual adverse effects. As a precautionary measure, the water quality of discharges from sedimentation ponds will be monitored for pH, metals, and sulfates. Testing of waste rock for Acid-Base Accounting will be required if waste rock is segregated. If monitoring and modelling of discharge (e.g., pit water quality, waste rock runoff) shows potential effects from ARD/ML, the discharge will be treated to meet MDMER discharge criteria, again resulting in no residual adverse effects on the aquatic environment.

Closure and Decommissioning

Based on the information provided above, it is unlikely that ARD/ML producing material be an issue during Closure and Decommissioning. Therefore, there will be no residual adverse effects. As a precautionary measure, the water quality of discharges from sedimentation ponds will be monitored for pH, metals, and sulfate. Testing of waste rock for Acid-Base Accounting will be required if waste rock is segregated. If monitoring and modelling of discharge (e.g., pit water quality, waste rock runoff) shows potential effects from ARD/ML, this will be addressed in the Rehabilitation and Closure Plan.

13.6.5 Summary of Residual Effects

A summary of residual adverse environmental effects for the Terrain and ARD/ML VC is provided in Table 13.7.

13.7 Assessment of Cumulative Environmental Effects

In association with the Project environmental effects discussed above, an assessment of the potential cumulative environmental effects was conducted for other projects and activities that have potential to interact with the Project.

Other projects and activities considered in the cumulative effects scoping are presented in Table 13.8 along with ratings for potential cumulative environmental effects to Terrain and ARD/ML based on the nature and degree to which important Project-related environmental effects overlap with those of other projects and activities. Projects and activities which are considered to have no cumulative interactions (i.e., 0 rating) are not discussed.

Table 13.7 Summary of Residual Environmental Effects – Terrain and ARD/ML

Project Phase	Mitigation/Compensation Measures	Direction	Residual Environmental Characteristics						Significance	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental/Socio-economic Context			
Effects on Landform and Terrain Stability											
Construction	• Progressive rehabilitation • Avoidance of steep slopes and sensitive terrain where practicable • Where steep slopes and sensitive terrain cannot be avoided, use of further investigations and additional mitigation measures as needed • Use of compacted snow pads for winter Project activities • Stabilizing banks of stream crossings where required • Refer to Section 13.6.1 for additional measures	A	L	L	MT-LT	S	R	U	N	H	No additional follow-up and monitoring requirements have been identified.
Operation and Maintenance		A	L	L	MT-P	F	I	U	N	H	

Table 13.7 Summary of Residual Environmental Effects – Terrain and ARD/ML

Project Phase	Mitigation/Compensation Measures	Direction	Residual Environmental Characteristics						Significance	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental/Socio-economic Context			
Change in Soil Quality and Quantity											
Construction	• Manage the collection and storage of soil stockpiles. • Promote the vegetation of soil stockpiles to prevent erosion. • Design surface drainage to prevent flooding of stockpile areas. • Follow erosion control protocols. • Measure and track volumes of soil stored in stockpiles from salvage to replacement. • Undertake progressive rehabilitation. • Follow through with fugitive dust suppression programs. • Refer to Section 13.6.2 for additional measures	A	L	L	MT	R	R	U	N	H	No additional follow-up and monitoring requirements have been identified.
Operation and Maintenance		A	L	L	MT-LT	R	R	U	N	H	
Closure and Decommissioning		A/P	L	L	P	O	I	U	N	H	
Change in Snow and Ice											
Construction	• Design facilities and activities to reduce dust emissions. • Use of snow fences and snow removal. • Manage blasting so that the vibrations will not affect ice cover at nearby lakes. • Construct causeway over Iron Arm with sufficient clearance to allow ice formation.	A	L	L	ST-MT	R	R	U	N	M	No additional follow-up and monitoring requirements have been identified.
Operation and Maintenance		A	M	L	ST-MT	F	R	U	N	M	

Table 13.7 Summary of Residual Environmental Effects – Terrain and ARD/ML

Project Phase	Mitigation/Compensation Measures	Direction	Residual Environmental Characteristics: Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental/Socio-economic Context	Significance	Prediction Confidence	Recommended Follow-up and Monitoring
ARD/ML											
Construction	• Effluent discharge will be monitored and, if required, treated to meet MDMER discharge criteria.	No residual effect predicted									Effluent discharge will be monitored for MDMER discharge criteria
Operation and Maintenance											
Closure and Decommissioning											

Key:

Direction:
A Adverse
N Neutral - No measurable change; or
P Positive

Magnitude:
N Negligible – No measurable adverse effect anticipated;
L Low - For terrain and landforms, minor changes to shape and stability in the RSA. For soil quality or quantity, a change of 1% to 5% in areal extent or volumetric extent relative to baseline conditions in the RSA. For ARD/ML and for change in snow and ice, effect is detectable but within normal variability of current baseline conditions;
M Moderate – For terrain and landforms, moderate changes to shape and stability in RSA. For soil quality or quantity, a change of 6% to 10% in areal or volumetric extent relative to baseline conditions in the RSA. For ARD/ML, effect is measurable but does not exceed regulatory thresholds. For change in snow and ice, effect is measurable and beyond the normal variability of baseline conditions, but does not affect land and resource use.
H High – For terrain and landforms, major changes in shape and stability in the RSA. For soil quality or quantity, a change greater than 10% in areal or volumetric extent relative to baseline conditions in the RSA. For ARD/ML, effect would independently or cumulatively with other sources cause an exceedance of regulatory standards or guidelines. For change in snow and ice, effect is measurable and beyond the normal variability of baseline conditions and affects land and resource use.
R Regional

Geographic Extent:
S Site
L Local

Duration:
ST Short term
MT Medium term
LT Long term
P Permanent

Frequency:
O Once per month or less.
S Occurs sporadically at irregular intervals.
R Occurs on a regular basis and at regular intervals.
C Continuous.
U Unlikely to occur

Reversibility:
R Reversible
I Irreversible

Environmental or Socio-economic Context:
U Undisturbed
D Developed

Significance:
S Significant.
N Not Significant.

Prediction Confidence:
L Low level of confidence.
M Moderate level of confidence.
H High level of confidence.

Table 13.8 Potential Cumulative Environmental Effects

Other Projects and Activities with the Potential for Cumulative Environmental Effects	Potential Cumulative Environmental Effects			
	Effects on Landform and Terrain Stability	Change in Soil Quality and Quantity	Change in Snow and Ice	ARD/ML
Kami Iron Ore	0	0	0	0
Fire Lake North Iron Ore Project	0	0	0	0
IOC Carol Mining Project	0	0	0	0
Scully Mine	0	0	0	0
Mont Wright Mine	0	0	0	0
Bloom Lake Mine and Rail Spur	0	0	0	0
Houston 1&2	1	1	1	0
Tata DSO Iron Ore Project	1	1	1	0
Lower Churchill Hydroelectric Generation Project	0	0	0	0

Key:

0 Project environmental effects do not act cumulatively with those of other projects and activities.

1 Project environmental effects act cumulatively with those of other projects and activities, but the resulting cumulative effects are unlikely to exceed acceptable levels with the application of best management or codified practices.

2 Project environmental effects act cumulatively with those of other projects and activities and the resulting cumulative effects may exceed acceptable levels without implementation of project-specific or regional mitigation.

An assessment of the potential cumulative effects of the Project in combination with those of other projects and activities within the RSA was conducted. Two iron ore mining projects were considered within the RSA: DSO Iron Ore Project (Tata Steel Minerals Canada), and Houston 1 & 2 (Labrador Iron Mines) at approximate distances of 20 and 25 km, respectively, from the Project (see Figure 13.1). All potential effects assessed for the Project are local in geographic context and are not anticipated to act cumulatively with any projects outside the defined RSA. The potential effects of Project activities on the following Terrain and ARD/ML VC elements were assessed in Section 13.6: effects on landforms and terrain stability, changes in soil quality and quantity, change in snow and ice, and ARD/ML.

Project-related effects on landforms and terrain stability will be mitigated through the use of well-established and proven development practices, and are predicted to be not significant, as presented in Section 13.6.1. Potential adverse environmental effects of the Project on glaciofluvial landform types are low in magnitude due to the common nature of this topographical feature in the RSA, plus the fact that the materials have high silt content. They are also predicted to be local in geographic extent and not significant in nature. Because of the limited scope of residual effects resulting from the Project, there are no likely cumulative effects on landforms and terrain stability.

Changes in soil quality and quantity were assessed for the Project and as presented in Section 13.6.2, the potential residual effects were characterized as low and not significant with the implementation of proper mitigation measures and best-practices during mine development (e.g., soil handling procedures and rehabilitation plan). Other projects and activities in the RSA affecting soil quality and quantity that may act cumulatively with the Project will be required to implement similar mitigation regarding soil preservation and protection as those for the Project (e.g., control of runoff drainage, implementation of proper erosion and sediment control, stockpiling of soil by other mining operations), and are therefore not anticipated to act cumulatively with the Project.

The effects of dust emissions on snow and ice will only be within a few meters of the roads and Project features; therefore, the effects are localized and it is unlikely that there will be any cumulative effects from dust emissions. Blasting will be managed such that vibrations will not adversely affect ice cover of nearby lakes. Therefore, adverse environmental effects resulting from the Project will be limited in scale and extent and unlikely to result in cumulative effects in combination with other projects and activities on ice cover of nearby lakes.

Based on findings from other mines within the RSA (i.e., DSO Iron Ore Project and Houston 1 & 2), there will be no residual environmental effects arising from ARD/ML. Because there are no likely residual environmental effects resulting from the Project, there are no likely cumulative effects resulting from ARD/ML.

Future projects and activities will be required to comply with planning and regulatory processes, and therefore cumulative effects will be managed as necessary.

13.8 Accidents and Malfunctions

Reasonable worst-case scenarios for accidents and malfunctions that may result from the Project include:

- Hydrocarbon Spill
- Train Derailment
- Forest Fire
- Settling/Sedimentation Pond Overflow
- Premature or Permanent Shutdown

Table 13.3 rates the potential interactions of these events with each of the potential environmental effects for Terrain and ARD/ML. As the potential for interaction with effects on landforms and terrain stability and changes in snow and ice were all rated as 0 or 1, these effects are not further assessed in this section. In addition, premature or permanent shutdown was rated as 0 for all effects and is therefore not further assessed in this section.

13.8.1 Hydrocarbon Spill

Fuel storage on the site will include diesel and fuel oil tanks located at the rail unloading area, near the diesel generators at the mine site, and the process plant area. The maximum total storage capacity for diesel fuel will be 250,000 L. The fuel storage tanks will be located in secondary containment to control spills and will comply with requirements of the applicable provincial and federal acts and regulations, as well as the conditions of the permit and authorizations. The control measures will be able to contain the maximum capacity of all tanks in a storage area. Hydrocarbon spills have the potential to result in contamination of soils and subsequent loss of soils, where contaminated soils are removed from site as part of spill response and clean-up.

13.8.1.1 Emergency Response/Mitigation of Environmental Effects

Diesel and fuel storage tanks will be designed to mitigate and reduce the probability of accidents and malfunctions. The fuel storage tanks will be located in secondary containment to control spills and will comply with requirements of the applicable provincial and federal acts and regulations, and the conditions of the permit and authorizations.

As part of the Emergency Response and Spill Response Plan, spill prevention and response protocols will include the daily inspection of vehicles and hydraulics for leaks or damage that could cause minor spills and rapid spill response. Vehicles and equipment will be stored in controlled areas where containment of spills can be provided. Staff will be trained in the handling of emergency response and spill scenarios.

Spill response equipment stored on site will include containment and absorbent booms, pads, barriers, sand bags, and skimmers, as well as natural and synthetic sorbent materials. The Emergency Response and Spill Response Plan will include the identification of persons responsible for managing spill response efforts, including their authority, role, and contact details, and a description of steps to take to immediately contain and recover spills. In the event of a spill, hydrocarbon-saturated soil will be removed for temporary storage and eventual treatment / disposal.

13.8.1.2 Characterization of Residual Environmental Effects

In the event of a fuel spill, and with the implementation of spill measures as noted above to remediate soils, any effects will be adverse, but low in magnitude, site-specific, short-term and reversible. Therefore, residual environmental effects on soil quality and quantity are predicted to be not significant with a high degree of confidence.

13.8.2 Train Derailment

Iron ore product will be transported by truck from the Project site to the Astray rail loop which connects directly to the Tshiuetin/QNS&L railway for transport to Sept-Îles. Diesel fuel will be transported by rail to Schefferville and then by contracted trucker to site. On average, iron ore will be transported on approximately four trains each week during summer months between the Astray rail loop and the Sept-Îles port. Each train set will carry approximately 24,000 tonnes of ore in 240 gondola cars. Based on the speed the train will be travelling in the rail loop (5 miles per hour or 8 km/h), the reasonable worst case is the derailment of a maximum of four to five cars. This could result in the iron ore being spilled onto the ground or at stream crossings. Such an event is highly unlikely.

It is estimated that diesel fuel transport frequency will be a maximum of six 96,000 L tank cars per week for all site purposes.

Fuel tank car numbers are based on shipment in standard 96,000 L tank cars similar to those already in fuel haulage service between Sept-Îles and Labrador City. In a reasonable worst case scenario (i.e., where six tanks of diesel fuel are de-railed), approximately 576,000 L (127,000 Imperial gallons) of diesel fuel could be released.

13.8.2.1 Emergency Response/Mitigation of Environmental Effects

The trains will be operated under current QNS&L and TSH environmental and safety procedures. A detailed Emergency Response and Spill Response Plan will also be developed by Labec Century. This plan will include measures such as:

- Immediate response through the use of absorbent booms and pads;
- Liquid clean up using a vacuum truck (both fuel and groundwater);
- Reclamation of contaminated soils, removal of contaminated soils and replacement with clean soil.

Additional mitigation measures to be implemented to limit the potential for a train derailment include:

- Manual inspection of rolling stock to confirm there are no problems with the wheels, couplers, carbody or brakes;
- Track inspections in accordance with Transport Canada regulations;
- Properly maintained equipment; and
- Fuel transport amounts will be limited to the amounts required by the Project.

The Emergency Response and Spill Response Plan will also include measures for the removal and cleanup of spilled ore from the rail cars. Special consideration will be given if any spilled material is determined to be PAG. To reduce the likelihood of such an event, emphasis will be placed on safety and accident prevention.

13.8.2.2 Characterization of Residual Environmental Effect

A train derailment and subsequent fuel spill has the potential to contaminate the soil or spill iron ore product/ore or other materials on the ground. Based on historical data and site-specific information presented in Section 13.6.4, the ARD/ML potential of overburden, waste rock, ore, and iron ore product is expected to be low. Ongoing humidity testing will provide further insight into the metal leaching potential of different materials exposed during the Project. As part of the emergency response, spilled ore from the rail cars will be removed and cleaned up, further limiting any potential for longer-term effects. With the implementation of the emergency response measures described above, the effects will be adverse, but low in magnitude, localized, temporary and reversible. Therefore, residual environmental effects on soil quality and quantity and ARD/ML are predicted to be not significant with a high degree of confidence.

13.8.3 Forest Fire

Although unlikely, Project activities involving the use of heat or flame could result in a fire, which could spread to nearby vegetation. The occurrence of a forest fire has the potential to affect soil quality and quantity by increasing the risk of erosion and changing soil moisture storage levels through a reduction in plant consumption and increase in surface runoff.

13.8.3.1 Emergency Response/Mitigation of Environmental Effects

A plan for preventing and combating forest fires will be incorporated into the Emergency Response and Spill Response Plan.

13.8.3.2 Characterization of Residual Environmental Effects

The likelihood and effects of a forest fire are highly variable, depending on factors such as wind, forest structure and composition, precipitation, topography, and fine fuel moisture. Crown fires can spread through tree tops, leaving ground vegetation largely intact, while some severe fires can destroy all vegetation as well as the organic material in the soil. In such cases, there are often long delays before the vegetation community can regenerate, thereby reducing the potential for further soil erosion. However, the effects of fire are temporary and the ecosystem has evolved with fire as a major disturbance regime. The vegetation community has a natural resilience to forest fire. While it is acknowledged that a fire could have a medium to long-term effect on species composition within the affected area, it is expected that any fire would not affect a large area; given the resilience of vegetation to adapt and recover from fire, it is expected that the area would recover. If a fire were to burn on site and damage the soil stockpiles, only the upper layers would be affected and the remainder of the soil would still be appropriate for reclamation purposes The resulting potential effect would be adverse, potentially regional in geographic extent and long-term in duration; however the residual effect is anticipated to be not significant.

13.8.4 Settling/Sedimentation Pond Overflow

Settling/sedimentation ponds will be established at waste rock, overburden, run-of-mine stockpile areas, at the crushing and screening plant area, at the accommodation camp area, and at the rail loop. Run-off from the stockpiles and site run-off will be directed to the settling/sedimentation ponds prior to discharge to the receiving environment. The likelihood of an overflow is low because the ponds will be designed to contain run-off associated with a 1:100 year precipitation event and the entire project scheduled to occur over a period of <10 years. However, in such an event, settling / sedimentation ponds could overflow, releasing untreated water. Untreated water could have elevated levels of total suspended solids. No other contaminants are anticipated.

13.8.4.1 Emergency Response/Mitigation of Environmental Effects

In the unlikely event of an overflow event, contingency plans will be in place as part of the Emergency Response and Spill Response Plan (refer to Chapter 7: Environmental Management) to mitigate environmental effects to the receiving environment. Water sampling of TSS and pH levels will be conducted in downstream water bodies.

13.8.4.2 Characterization of Residual Environmental Effects

In the vicinity of an overflow, the water released to nearby soils may exceed MDMER guidelines for TSS and may therefore result in local effects of admixing and erosion. However, it is anticipated that this effect would be temporary and one from which the receiving soils would be expected to recover naturally. Following an overflow, efforts will be made to stabilize and repair erosion control measures as needed and to prevent future overflows. The adverse residual effects would be moderate, localized and short-term and are predicted to be not significant with a high degree of confidence.

13.8.5 Summary of Residual Effects Resulting from Accidents and Malfunctions

A summary of residual environmental effects resulting from accidents and malfunctions is summarized in Table 13.9.

13.9 Determination of Significance of Residual Adverse Environmental Effect

13.9.1 Project Residual Environmental Effects

The terrain within the LSA is relatively rugged terrain with rolling hills and valleys reflecting the northwest trending structure of the underlying bedrock. The natural overburden material is an undifferentiated till material at thicknesses ranging from 0 to 13.7 m. Two potential esker features have been identified within the PDA, but due to high silt content would not be suitable for construction. No historic resources or high potential for historic resources have been identified in the vicinity of the two eskers and, as they occur commonly in the RSA, they are not considered to be unique from the perspective of wildlife habitat. There is no evidence of any landslides in the PDA and, with the application of standard and prescribed mitigation such as maintaining existing drainage conditions, no low-angle landslides are likely. Therefore, the residual adverse effect on landforms and terrain stability is predicted to be not significant.

Project activities will require earthworks and ground disturbance, and will therefore affect soil quantity and quality within the PDA. These effects are likely to occur primarily during the Construction and Rehabilitation phases of the Project. As noted in Section 13.6.2, organic soils will be salvaged, using appropriate stripping methods, and stockpiled during construction for use during rehabilitation and closure. The stockpiled soil will be maintained throughout the Operation and Maintenance phase of the Project so that the soil is suitable for rehabilitation purposes. Therefore, the residual adverse environmental effect on soil quantity and quality is not likely to be significant.

The effect of accelerated snowmelt resulting from dust accumulation will likely be confined to a distance of 200 to 300 m from Project transportation infrastructure; however, complete cover by dust is likely to be restricted to a few metres from the roadways, and within the working mine area. Based on available studies, the temporal extent of the acceleration of snowmelt is estimated to be four days. Effects of the Project on the integrity of nearby lake ice will be managed by best practices during drilling and blasting operations at the open pit and through sound engineering of the causeway. Therefore, the residual adverse environmental effects on snow and ice are not likely to be significant.

Table 13.9 Summary of Residual Environmental Effects – Accidents and Malfunctions

Project Phase	Emergency Response/Contingency Measures	Direction	Residual Environmental Characteristics						Significance	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental/ Socio-economic Context			
Train Derailment	• Emergency Response and Spill Response Plan (refer to Chapter 7)	A	L	L	ST	O	R	U	N	H	Monitoring program for successful remediation.
Forest Fire		A	M	L-R	LT	O-S	R	U	N	H	Not applicable.
Hydrocarbon Spill		A	L	S-L	ST	O-S	R	U	N	H	Monitoring program for successful remediation.
Settling/Sedimentation Pond Overflow		A	L	S-L	ST	O	R	U	N	H	Monitoring program for successful remediation.

Key:

Direction:
A Adverse
N Neutral - No measurable change; or
P Positive

Magnitude:
N Negligible – No measurable adverse effect anticipated;
L Low - For terrain and landforms, minor changes to shape and stability in the RSA. For soil quality or quantity, a change of 1% to 5% in areal extent or volumetric extent relative to baseline conditions in the RSA. For ARD/ML and for change in snow and ice, effect is detectable but within normal variability of current baseline conditions;
M Moderate – For terrain and landforms, moderate changes to shape and stability in RSA. For soil quality or quantity, a change of 6% to 10% in areal or volumetric extent relative to baseline conditions in the RSA. For ARD/ML, effect is measurable but does not exceed regulatory thresholds. For change in snow and ice, effect is measurable and beyond the normal variability of baseline conditions, but does not affect land and resource use.
H High – For terrain and landforms, major changes in shape and stability in the RSA. For soil quality or quantity, a change greater than 10% in areal or volumetric extent relative to baseline conditions in the RSA. For ARD/ML, effect would independently or cumulatively with other sources cause an exceedance of regulatory standards or guidelines. For change in snow and ice, effect is measurable and beyond the normal variability of baseline conditions and affects land and resource use.
R Regional

Geographic Extent:
S Site
L Local

Duration:
ST Short term
MT Medium term
LT Long term
P Permanent

Frequency:
O Once per month or less.
S Occurs sporadically at irregular intervals.
R Occurs on a regular basis and at regular intervals.
C Continuous.
U Unlikely to occur

Reversibility:
R Reversible
I Irreversible

Environmental or Socio-economic Context:
U Undisturbed
D Developed

Significance:
S Significant.
N Not Significant.

Prediction Confidence:
L Low level of confidence.
M Moderate level of confidence.
H High level of confidence.

Based on historic data and site-specific information presented above, the ARD/ML potential of overburden, waste rock, ore, and iron ore product is expected to be low. Therefore, no adverse residual environmental effects related to ARD/ML are predicted from Project activities. Ongoing humidity testing will provide further insight into the metal leaching potential of different materials exposed during the Project. The level of confidence in this prediction is moderate.

With the proposed mitigation and environmental protection measures, the environmental effects of the Project on the Terrain and ARD/ML VC are not likely to be significant. A summary of the residual adverse effects is presented in Tables 13.8 and 13.10.

13.9.2 Cumulative Environmental Effects

The landforms identified within the LSA are common throughout the RSA, and significant cumulative effects are not likely. Adverse cumulative effects on soil quantity and quality and snow and ice are not likely, as the extent of the effects from the Project is site specific. Implementation of mitigation measures will result in soils that will be suitable both in quantity and quality for use during site rehabilitation.

Based on findings from other mines within the RSA and with the implementation of mitigation, no residual environmental effects are expected to arise from ARD/ML. Because there are no likely residual environmental effects resulting from the Project, there are no likely cumulative environmental effects resulting from ARD/ML.

Therefore, the cumulative effects on the Terrain and ARD/ML VC due to the Project acting in combination with other past, present and planned projects and activities are not likely to be significant.

13.9.3 Accidents and Malfunctions

There are no significant residual environmental effects on landforms and terrain stability, soil quantity and quality, snow and ice, or ARD/ML as a result of accidents and malfunctions. With the implementation of preventative measures, emergency response and mitigation strategies outlined in Section 13.8, the effects on the Terrain and ARD/ML VC are not likely to be significant.

13.10 Follow-Up and Monitoring

Effects on Landforms and Terrain Stability

There are no additional requirements for this component of this VC other than those related monitoring commitments identified in Chapter 7: Environmental Management.

Change in Soil Quality and Quantity

There are no additional requirements for this component of this VC other than those related monitoring commitments identified in Chapter 7: Environmental Management.

Change in Snow and Ice

No follow-up or monitoring programs are proposed with respect to the effect of changes in snow and ice.

ARD/ML

Based on existing conditions on site and historical data from similar mines in the area, ARD/ML is not likely to have significant environmental effects. Prior to construction, an EPP will be developed and mitigation measures for ARD/ML will be incorporated based on on-going testing and subsequent analysis.

However, the water quality of discharges from sedimentation ponds will be monitored for pH, metals, and sulfates. Testing of waste rock for Acid-Base Accounting will be required if waste rock requires management. If monitoring and modelling of discharge (e.g., pit water quality, waste rock runoff) shows potential effects from ARD/ML, mitigation measures preventing these effect will be employed per the EPP.

13.11 Summary

Given the proposed development plan for the Project and proposed mitigation, there are likely no significant residual or cumulative environmental effects on Terrain and ARD/ML. Effects of ARD/ML are not likely based on testing to date of site materials and experience with other operations. Water quality predictions are required to confirm the assessment, as presented herein, and will be completed prior to final design. In the event that ARD/ML predicted to occur, proactive mitigation strategies may include management of problematic materials and treatment of effluents to meet regulatory requirements, if needed.

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Chapter 14:

Wetlands

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14.0 ENVIRONMENTAL ASSESSMENT - WETLANDS

As detailed in chapter 1, Joyce Direct Iron Inc. succeeded Labec Century Iron Ore Inc. ("Labec Century") as the Project Proponent on February 18, 2021 following an internal reorganization. All references to Labec Century as the Project proponent may be interpreted as now referring to Joyce Direct Iron Inc.

14.1 VC Definition and Rationale for Selection

This VC was selected for environmental assessment to satisfy requirements under Section 4.22 of the Newfoundland and Labrador Environmental Impact Statement Guidelines for the Joyce Lake Direct Shipping Iron Ore Project (the Project). The EIS Guidelines for the Project specified that Wetlands be considered in the EIS because of the potential for interactions between Project activities and wetlands, and relationship between wetlands and vegetation and wildlife, and other biological and physical environments. Wetlands are addressed in federal and provincial policies and/or legislation and are a requirement of the IAAC EIS Guidelines for the assessment of the Project, and are identified as a requirement for assessment under Water Resources in the NLDOECC EIS Guidelines.

For this environmental assessment, “wetland” is defined according to the Federal Policy on Wetland Conservation (FPWC) (Government of Canada 1991) as:

> *“…land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment. Wetlands include organic wetlands or "peatlands", and mineral wetlands or mineral soil areas which are influenced by excess water but produce little or no peat*.”

Wetlands are an important feature of the landscape, cover a sizable proportion of the natural landscape of Labrador and are a major constituent of the undisturbed boreal ecosystem, performing many biological, hydrological, social/cultural, and socio-economic functions considered of value to regulatory agencies, the public, and environment as a whole. These include (but are not limited to):

- Provision of habitat for many important plant and animal species;
- Groundwater recharge;
- Amelioration of flooding;
- Removal of some contaminants; and
- Regulation of various bio-geochemical processes.

Wetlands are also often linked to the traditional way of life for local Indigenous people, in part because of the cultural significance of the many wildlife species (e.g., muskrat, beaver) and wetland plants (e.g., bog cranberry, sphagnum moss) that inhabit them. Further benefits of wetlands include value for education, research, recreation and harvesting (e.g., berries, game, peat).

Aspects of this VC (wildlife habitat) are assessed in Chapter 16: Birds, Wildlife and their Habitat; and Chapter 17: Species at Risk and Species of Conservation Concern.

14.1.1 Approach to Assessment of Effects

The assessment considers the environmental effects of the Project on wetlands that cannot be reasonably avoided. Information on the presence of wetlands within or in proximity to the PDA was derived from a variety of data sources, including:

- Project field data collected (2011-2013) as a part of the environmental baseline program for the Project (GENIVAR 2013 (Appendix U); WSP 2014);
- Information concerning wetlands or any other botanical information (e.g., Regional floras - Gray's Manual of Botany (Fernald 1950), Flora of Canada (Scoggan 1978) and available volumes of the Flora of North America (FNA; 1993, 1997, 2002, 2006, 2007);
- Published and unpublished literature by the Study Team and others, including peer-reviewed academic journals, research project reports, government publications and available studies conducted in the Schefferville area; and
- Recent aerial photographs and topographical maps that could indicate the occurrence of wetlands or wetland habitats.

Prior to the field work, a work plan was prepared in collaboration with Stassinu Stantec team members including field methods. Due to limited information available on the wetland types found in the Study Area, sampling plots were selected during field work.

14.2 Scope of the Assessment

14.2.1 Regulatory Setting

Federal and provincial legislation, regulations, policies, and guidelines published by the governments of Canada and Newfoundland and Labrador address wetland management. An assessment of Project-related effects on wetlands and wetland habitats, and their significance, is required under CEAA 2012 and NLEPA, and appropriate mitigation measures must be identified.

Federal and provincial acts and associated regulations that apply to Wetlands, including wetland habitat, in the Project area include:

- CEAA 2012;
- Canada *Wildlife Act*;

- Canada *Fisheries Act*;
- Canada *Migratory Birds Convention Act* (MBCA).
- SARA;
- NLEPA and associated *Environmental Assessment Regulations*;
- NLESA; and
- Newfoundland and Labrador *Wild Life Act* (NLWLA).
- Newfoundland and Labrador *Water Resources Act*.

The Project will also be subject to the applicable federal, provincial and non-governmental policy and guidelines, including:

- Environmental Code of Practice for Metal Mines;
- FPWC, and
- Newfoundland and Labrador Policy for Development in Wetlands.

14.2.2 Federal and Provincial Legislation and Policy

Canada

As part of ECCC – Canadian Wildlife Service (CWS) commitments, wetland conservation is promoted federally by the FPWC (Government of Canada 1991). The FPWC focuses on wetland functions on federal lands as the target for conservation efforts (Environment Canada 1996). The FPWC sets a conservation goal of no net loss of wetland function. Wetland function is defined by the FPWC (Government of Canada 1991) as:

> *…the natural processes and derivation of benefits and values associated with wetland ecosystems, including economic production (e.g., peat, agricultural crops, wild rice, peatland forest production), fish and wildlife habitat, organic carbon storage, water supply and purification (groundwater recharge, flood control, maintenance of flow regimes, shoreline erosion buffering), and soil and water conservation, as well as tourism, heritage, recreational, educational, scientific, and aesthetic opportunities.*

Coordination of implementation of the FPWC is the responsibility of ECCC, specifically the CWS. Although there is no specific federal legislation regarding wetlands, they may be protected federally under SARA, if they contain critical habitat for species at risk, MBCA 1994, if they contain nests of migratory birds, and/or the *Fisheries Act*, if the wetland contributes to an existing or potential fish habitat. Details on the application of the MBCA and SARA for protection of wildlife and fish and fish habitat are provided in Sections 16.2.1 (Birds, Wildlife and their Habitat VC) and 15.2.1 (Freshwater Fish and Fish Habitat VC), respectively.

The principle of "no net loss" requires federal land managers to work through a sequence of mitigation alternatives of avoidance, minimization, and compensation, with clear criteria and defined outcomes. Mitigation alternatives and associated criteria should recognize the limitations in the understanding of wetland functions (and ways and means to assess such functions), as well as the capacity to rehabilitate or create new wetlands (Environment Canada 1996).

The Project and its associated components in western Labrador do not overlap with any federal lands, as defined by the IAAC.

Newfoundland and Labrador

Wetlands in Newfoundland and Labrador are protected by the Newfoundland and Labrador *Water Resources Act* (SNL 2002, c. W-4.01) where a "body of water" means:

> *"A surface or subterranean source of fresh or salt water within the jurisdiction of the province, whether that source usually contains liquid or frozen water or not, and includes water above the bed of the sea that is within the jurisdiction of the province, a river, stream, brook, creek, watercourse, lake, pond, spring, lagoon, ravine, gully, canal, wetland and other flowing or standing water and the land occupied by that body of water."*

and wetland is defined as:

> *"Land that has the water table at, near or above the land surface and includes bogs, fens, marshes, swamps and other shallow open water areas."*

The *Water Resources Act* addresses control and management of water resources in the province; it states:

> *"The minister may control and determine the use of, or modifications which shall apply to, wetlands, including the drainage, infilling and permanent flooding of wetlands and the addition of wastewater or stormwater discharges to, or the physical, chemical or biological modification of, wetlands where, in the minister's opinion, there may be an impact upon the hydrology of that wetland or its recreational, aesthetic or other natural functions and uses."*

Activities requiring Certificates of Approval under the Act include:

- Certificate of Approval for Any Alteration to a Body of Water - approval is required before undertaking any construction activities within 15 m of the high watermark of a surface water body or activities related to a water body that has the potential to affect the aquatic environment (i.e., flood plains, shorelines and wetlands) (Government of Newfoundland and Labrador 2002, Part II, c. W-4.01 s30). A separate permit is required for each alteration.

- Certificate of Approval for Any In-stream Activity (including culvert installation, bridges, and fording of a water course) – approval is required for any in-stream activity, including culvert installation and fording activities, before undertaking the work. This also includes any development within 15 m of the high watermark of a surface water body.

- Certificate of Approval for Development Activity in a Protected Public Water Supply Area or Wellhead Protected Public Water Supply Area – approval is required for any activity in a Protected Public Water Supply Area prior to commencement of any work.

- Certificate of Approval for Construction Site Drainage – approval is required for any run-off from the project site being discharged to receiving waters.

Under the Policy for Development in Wetlands (the Policy), development activities in and affecting wetlands require a permit under Section 48 of the *Water Resources Act* (Government of Newfoundland and Labrador 2002). The objective of the Policy is to permit developments in wetlands that do not adversely affect the water quantity, water quality, hydrologic characteristics or functions and terrestrial and aquatic habitats of the wetlands (Government of Newfoundland and Labrador 2011).

Under this Policy, all uses and developments of wetlands that result in potentially adverse changes to water quantity or water quality or hydrologic characteristics or functions of the wetlands require the implementation of mitigative measures to be specified in the terms and conditions for the environmental approval. A goal of “no net loss” is not identified; however, in Newfoundland and Labrador, as it is elsewhere, the mitigative sequence for decision-making is the foundation for achieving wetland conservation. The sequence – avoidance, minimization, compensation – assists proponents in planning and designing project proposals that will be acceptable to NLDOECC. Avoidance is the priority, and requires consideration of project alternatives that would have less adverse effects on the wetland. Minimization requires that the project be designed and implemented using techniques, materials and site locations that reduce or remediate the project effects on the wetland. Compensation requires that the residual effects on the wetland functions are compensated for by the enhancement, restoration or creation of wetland habitat at an area ratio commensurate with the loss. Although compensation for the loss of wetland habitat, either through direct or indirect Project effects, is not specified to replace wetland functions lost as a result of the wetland alterations, the terms and conditions of the environmental approval will specify the restoration measures to be implemented upon cessation of activities or abandonment of facilities on wetland areas, which may include compensation (Government of Newfoundland and Labrador 2011).

The *Water Resources Act* (Government of Newfoundland and Labrador, Part II, Section 30(2)) and Sections 5(1) and 5(2) of the associated *Environmental Control Water and Sewage Regulations, 2003* (O.C. 2003-231) also identifies controls to wastewater and stormwater discharges into a wetland, and chemical and biological alterations of a wetland.

14.2.3 Influence of Consultation and Engagement on the Assessment

Labec Century has conducted a stakeholder consultation program as part of the issues scoping exercise for the Project. The consultation program focused primarily on the area(s) most likely to be affected by the Project, including the Town of Schefferville in the province of Québec, and local Indigenous groups.

Few specific issues or concerns regarding wetlands were raised during consultation and engagement activities with regulatory agencies (i.e., ECCC, NLDOECC), Indigenous groups, stakeholder groups, and the general public. These issues and response/location in the EIS are summarized in Table 14.1.

Table 14.1 Issues Raised by Indigenous Groups and Stakeholders

Issue	Community/Organization	Summary of Comments Raised During Consultation and Engagement Activities	Response/Location in the EIS
No issues related to wetlands were raised during consultation. Issues related to wildlife are addressed in Chapter 16: Wildlife, Birds and their Habitats.			

14.2.4 Temporal and Spatial Boundaries

The temporal boundaries for the environmental assessment include the Project phases of Construction, Operations and Maintenance, and Closure and Decommissioning. The temporal boundary for Construction is one year (pre-operation), for Operations and Maintenance is approximately seven years, and for Closure and Decommissioning is approximately one year.

Most potential Project environmental effects on Wetlands will begin and peak during Construction, and diminish during Operation and Maintenance of the Project. The Closure and Decommissioning phase includes any monitoring or active site management. During Construction, and Operation and Maintenance, Project-related effects are considered to be temporary, while effects that persist after Closure and Decommissioning are considered to be permanent.

The spatial boundaries for the environmental effects assessment of the Wetlands VC are defined below, and take into account the appropriate scale and spatial extent of potential environmental affects, existing scientific and traditional knowledge, current land and resource use, and biological and ecological considerations.

Project Development Area (PDA): The PDA includes the area of physical disturbance (i.e., footprint for the Project), including the mine site and associated mine infrastructure, including a crushing and screening plant, settling and sedimentation ponds, waste rock and overburden disposal areas, stockpiles, rock causeway and roadways, rail track, yard, loop, and accommodations camp (Figures 14.1 and 14.2). The PDA covers an area of approximately 413 ha. Details on these components are provided in Chapter 2: Project Description.

Local Study Area (LSA): The LSA is the maximum area within which Project-related environmental effects can be predicted or measured with a reasonable degree of accuracy and confidence. The LSA includes the PDA plus a 500 m buffer where Project-related environmental effects may reasonably be expected to occur (Figures 14.1 and 14.2). Along the approximately 43 km haul road, the 1 km wide right-of-way corridor (buffered approximately 500 m on either side) allows for minor revisions to the right-of-way alignment, if needed, for environmental (e.g., for mitigation purposes) or technical reasons.

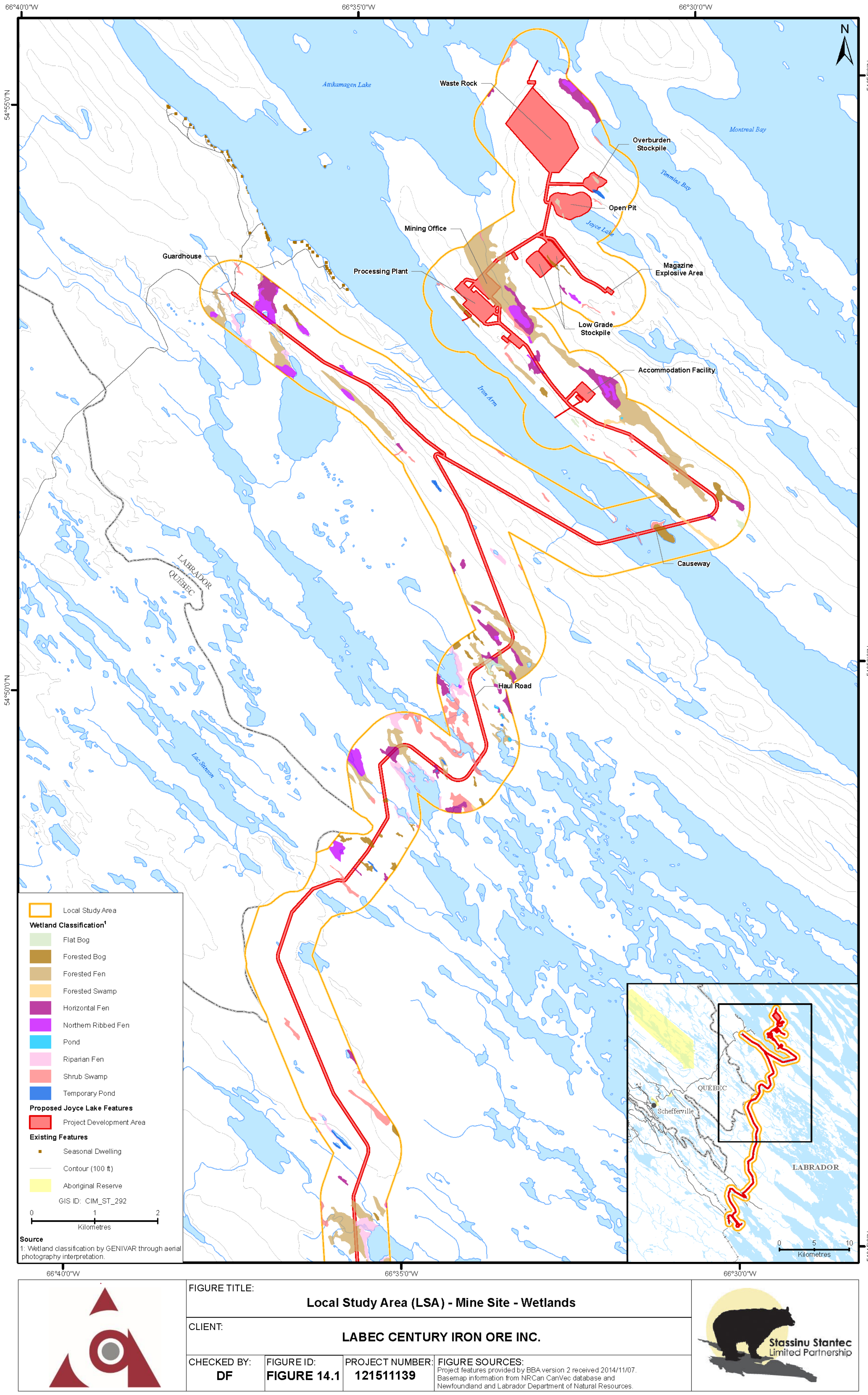

Figure 14.1 Wetlands within the Local Study Area; Mine Site Wetlands

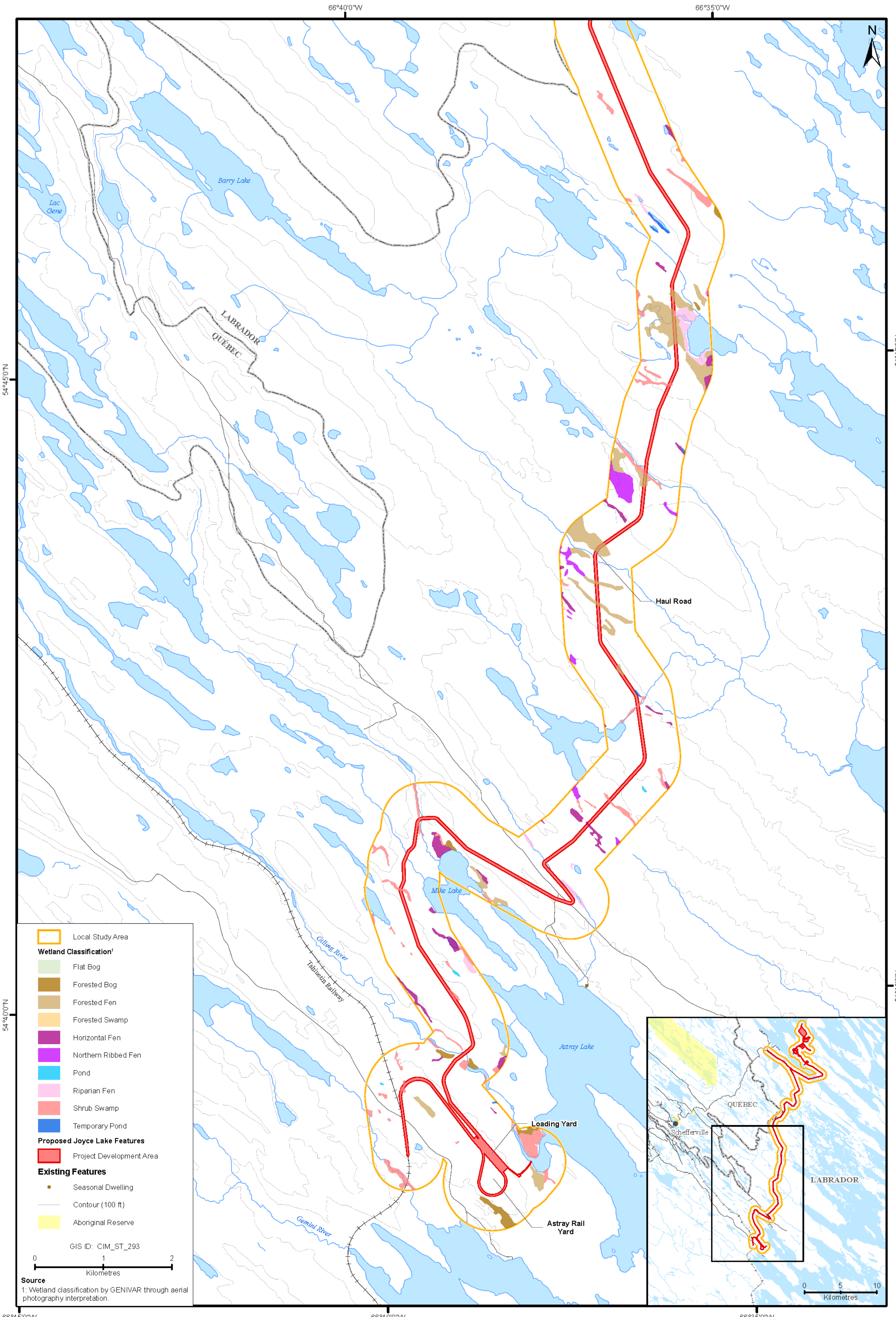

FIGURE TITLE:
Local Study Area (LSA) - Astray Rail Yard - Wetlands

CLIENT:
LABEC CENTURY IRON ORE INC.

CHECKED BY:	FIGURE ID:	PROJECT NUMBER:	FIGURE SOURCES:
DF	**FIGURE 14.2**	**121511139**	Project features provided by BBA version 2 received 2014/11/07. Basemap information from NRCan CanVec database and Newfoundland and Labrador Department of Natural Resources.

Stassinu Stantec Limited Partnership

Figure 14.2 Wetlands within the Local Study Area; Rail Loop Wetlands

Delineating the LSA based on a 500-m buffer of the Project footprint is a method that has been consistently used, and accepted, in previous EAs completed for similar projects in the region. The buffer also represents a zone in which most potential indirect effects of the Project will occur (e.g., air emissions on soils and vegetation, dust on vegetation, and sensory disturbance to wildlife).

The spatial boundary of the LSA for the assessment of Wetlands is approximately 6,174 ha (Figure 14.1).

Regional Study Area (RSA): The RSA includes the LSA and surrounding area, and provides a regional context for understanding wetlands (Figure 14.3) and is representative of the area within which cumulative environmental effects on wetlands may occur. The RSA is based on the extent of existing watershed boundaries and stream layers from digital datasets in GIS format. Watershed boundaries are typically defined by topographic divides and delineate areas where surface water runoff drains into surface waterbodies, including lakes, ponds, rivers, streams, and wetlands.

The RSA is approximately 123,686 ha and is bounded to the north and west by the Québec-Labrador border, which follows existing watershed boundaries. In the south and east, the RSA is limited to and includes a portion of the primary watershed (Attikamagen Lake) encompassing the Joyce Lake peninsula along with several sub-watersheds, including Joyce Lake, Lake E and several unnamed brooks and lakes intersected by the rail line corridor (Figure 14.3).

For the purposes of the assessment, directly affected wetlands (or portions thereof) are those that are subject to a physical disturbance as a result of a Project activity (e.g., drainage, clearing, removal of overburden excavation, infilling, leveling, and grading) that results in a loss or severe alteration of wetland area (and therefore wetland function). These wetlands are likely to correlate with, or be in close proximity to, the area of physical ground disturbance (i.e., PDA).

Indirectly affected wetlands (or portions thereof) are those that are not directly affected by any Project activity and physical work (i.e., ground disturbance) but which could be at risk of functional degradation (e.g., alteration to hydrologic flow patterns, increased erosion and sedimentation, alteration of chemical composition, habitat fragmentation) as a result of their location and connectivity to Project activities. Such effects may extend beyond the PDA.

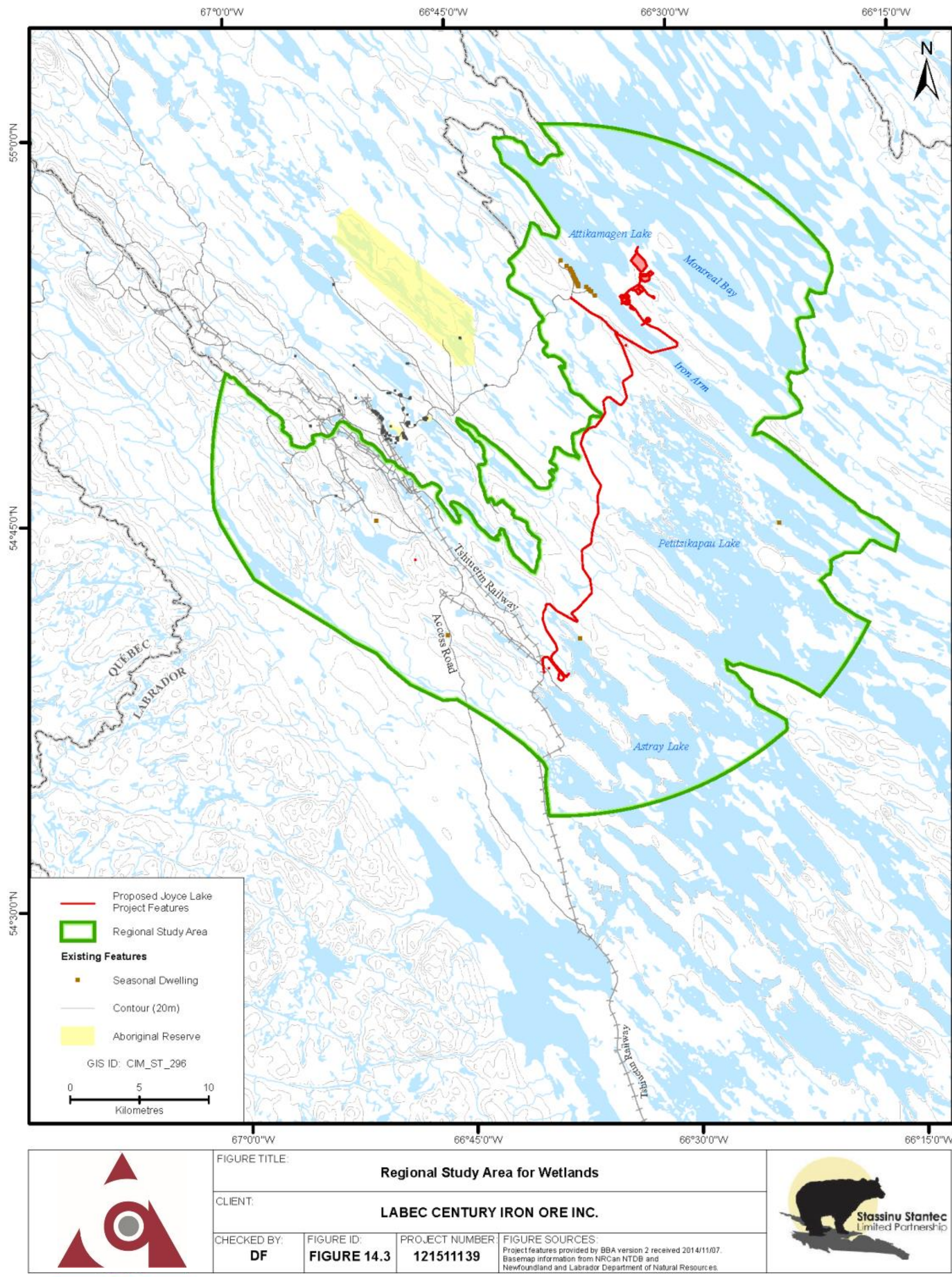

Figure 14.3 Regional Study Area for Wetlands

14.2.4.1 Selection of Environmental Effects and Measurable Parameters

The environmental assessment of wetlands is focused on the following environmental effect:

- Change in Wetland Area or Function.

This environmental effect captures the range of wetland effects that may occur, including direct and indirect effects. Wetland area is the most common and practical indicator of wetland function, because of accuracy for measurement and relationship to wetland function. By assessing the potential loss of wetland area, assumptions can be made regarding the loss or degradation of wetland function. The amount of wetland area is also a factor in determining mitigation for change in wetland function. Whereas change in wetland area is quantifiable using information on the location and extent of Project components, assessment of loss of wetland functions requires a more qualitative approach. Avoiding the loss of both wetland area and function aligns with regulatory objectives.

The environmental effects and associated measurable parameters, with rationale, are summarized in Table 14.2.

Table 14.2 Measurable Parameters for Wetlands

Environmental Effect	Measurable Parameter	Rationale for Selection of the Measurable Parameter
Change in Wetland Area or Function	Wetland area altered (ha)	• Provides an estimate of the maximum amount of wetland potentially affected and used to guide mitigation measures; • Alteration or loss of wetland area could affect vegetation species presence, ecosystem health, and biodiversity; and • Quantifiable based on results in the wetlands assessment and when conditions measured by comparison to the baseline.
	Altered area of wetland contributing a particular function	• Wetland function is an important indicator in accordance with FPWC; • Alteration or direct loss of potential habitat may lead to changes in plant species abundance, ecosystem health and/or biodiversity; • Spread of non-native species, including weeds and invasive agronomic species; and • Alteration or loss of wetland function due to altered hydrologic function.

14.3 Standards or Thresholds for Determining the Significance of Residual Environmental Effects

The following terms are used to characterize residual environmental effects (i.e., after application of proposed mitigation measures) for Wetlands:

- Direction
  - Adverse: a decrease in wetland area or function.
  - Positive: an increase in wetland area or function.
  - Neutral: no net change in wetland area or function.
- Magnitude
  - Negligible: measurable adverse effects to wetland area or function are not anticipated.
  - Low: no measurable change in the existing wetlands is expected; residual Project environmental effects to wetlands (alteration/loss) are not expected to exceed 5% of the total area of wetland in the RSA.
  - Moderate: measurable change occurs; residual Project environmental effects to wetlands (alteration/loss) are expected to be greater than 5% and not exceed 25% of the total area of wetland in the RSA.
  - High: residual Project environmental effects to wetlands (alteration/loss) are expected to exceed 25% of the total area of wetland in the RSA. Effect can be easily observed, measured and described, and may be widespread.
- Geographic Extent
  - Site-specific: residual environmental effect confined to the PDA (limited to directly affected wetlands).
  - Local: residual environmental effect extends into the LSA.
  - Regional: residual environmental effect extends into the RSA, where indirect or cumulative environmental effects may occur.
- Frequency:
  - Once: environmental effect occurs once per month or less (e.g., Site preparation/ clearing).
  - Sporadic: environmental effect occurs sporadically at irregular intervals (e.g., vegetation clearing, road maintenance).

- Regularly: environmental effect occurs on a regular basis and at regular intervals (e.g., fuel transport).
- Continuous: environmental effect occurs continuously.
- Unlikely: environmental effect is not likely to occur.

- Duration
  - Short Term: residual environmental effect occurs during the Construction phase of the Project (i.e., one year).
  - Medium Term: residual environmental effect extends throughout the Construction and Operation and Maintenance phases of the Project (i.e., up to seven years).
  - Long Term: residual environmental effect extends beyond Closure and Decommissioning (i.e., >10 years).
  - Permanent: measurable parameter unlikely to recover to baseline (i.e., residual environmental effect persists).
- Reversibility
  - Reversible: will recover after Project closure and reclamation.
  - Irreversible: environmental effect is permanent.
- Ecological/Socio-economic Context
  - Undisturbed: area relatively or not adversely affected by human activity.
  - Disturbed: area has been substantially previously disturbed by human development or human development is still present.
- Prediction Confidence
  - Low: there is low confidence in the prediction of effects.
  - Moderate: there is moderate confidence in the prediction of effects.
  - High: there is high confidence in the prediction of effects.

A significant adverse residual environmental effect on Wetlands is defined as:

- a Project-related environmental effect that results in a permanent loss of a type/class of wetland in the RSA.
- a Project-related environmental effect that results in a permanent loss of a wetland function in the RSA.

- a Project-related environmental effect that results in a permanent loss of wetland area (greater than 10% of wetland area and associated function within the RSA).

A 10% loss of wetlands within the RSA was identified as a threshold for a determination of a significant adverse environmental effect to wetlands in consideration of the relative size of the PDA in comparison to the RSA. Because the PDA (approximately 413 ha) is less than 1% of the size of the RSA (approximately 123,686 ha), an effect to 10% of the wetlands within the RSA would represent a relatively high, disproportionate amount of wetland affected in relation to the footprint of the Project. Although there is currently a lack of information on the regional role of wetlands and thresholds related to impacts, 10% is considered conservative. An environmental effect that does not meet the above criteria is rated as not significant.

14.4 Potential Project-VC Interactions

Each activity and physical work associated with the Project is listed in Table 14.3. Based on the level of interaction that is expected to occur between each activity or physical work and identified potential environmental effects, interactions were rated as 0 (no interaction occurs), 1 (interaction occurs but can be managed through proven mitigation and codified practice), or 2 (an interaction occurs and requires further assessment). The rating takes a precautionary approach, whereby interactions with a meaningful degree of uncertainty will be rated 2 and will be assessed in detail.

Those interactions rated 0 or 1 are further assessed within this section and those that are rated 2 are further assessed and described in Section 14.6; or in the case of Accidents and Malfunctions, in Section 14.9. The accompanying text will elaborate upon or describe the nature and/or extent of the interaction, or provide the rationale for activities that are determined to not result in an interaction with wetlands. The analysis provides a first order assessment of environmental effects of each phase or Project activity on Wetlands and will serve to focus the remainder of the environmental effects assessment on those issues that may result in substantive interactions or have potential for significant residual environmental effects. All potential residual environmental effects that are rated 0 or 1 are considered to be not significant.

Table 14.3 Potential Project Environmental Effects to Wetlands

Project Activities and Physical Works	Potential Environmental Effects
	Change in Wetland Area or Function
Construction	
Site Preparation (including clearing, grubbing, excavation, material haulage, grading, removal of overburden, ditching, and stockpiling)	2
Construction of Roads	2
Construction of Causeway	2
Construction of Site Buildings and Associated Infrastructure	2
Construction of Rail Loop and Associated Infrastructure	2
Construction of Stream Crossings	2
Installation of Water Supply Infrastructure (wells, pumps, pipes)	1

Table 14.3 Potential Project Environmental Effects to Wetlands

Project Activities and Physical Works	Potential Environmental Effects
	Change in Wetland Area or Function
On-site Vehicle/Equipment Operation	1
Waste Management	0
Transportation of Personnel and Goods to Site	1
Expenditures	0
Employment	0
Operation and Maintenance	
Maintenance of Causeway	1
Open Pit Mining (including drilling, blasting, ore and waste haulage, stockpiling, dewatering)	2
Dewatering (temporary) Joyce Lake	2
Ore Processing (including crushing, conveying, storage, grinding, screening)	0
Waste Rock Disposal on Surface	1
Water Treatment (including mine water and surface runoff) and Discharge	1
Rail Load-Out and Transport	0
On-site Vehicle/Equipment Operation and Maintenance	1
Waste Management	0
Transportation of Personnel and Goods to Site	1
Fuel Transport	1
Fuel Storage and Dispensing	1
Progressive Rehabilitation	1
Expenditures	0
Employment	0
Closure and Decommissioning	
Site Decommissioning	1
Site Reclamation (building demolition, grading, scarifying)	1
Accidents and Malfunctions	
Hydrocarbon Spill	2
Train Derailment	2
Forest Fire	2
Settling/Sedimentation Pond Overflow	2
Premature or Permanent Shutdown	2

Key:

0 No interaction.

1 Interaction occurs; however, based on past experience, the resulting environmental effect can be managed to acceptable levels through standard operating practices and/or through the application of best management or codified practices. No further assessment is warranted.

2 Interaction occurs, and resulting environmental effect may exceed acceptable levels without implementation of specific mitigation. Further assessment is warranted.

Interactions rated 0 or 1 are discussed in in the following sub-sections.

14.4.1 Interactions Rated 0

The following Project activities are not anticipated to interact adversely with Wetlands:

- Construction – Waste Management, Expenditures, and Employment;
- Operation and Maintenance – Ore Processing, Rail Load-out and Transport, Waste Management, Expenditures, and Employment.

These activities have limited potential to interact with wetlands as they are to be contained within areas or structures that are removed from the terrestrial habitats in the area. Waste management will follow applicable laws, regulations, and standards for safe use, handling, storage, and will use existing facilities as feasible. Expenditures and employment are not physical works or activities, and will therefore not interact with wetlands. The activities of ore processing and concentrating, and rail load out and transport, will not affect wetland area or function.

14.4.2 Interactions Rated 1

Project activities rated 1 may interact with Wetlands (e.g., introduction of dust or invasive species); however, standard environmental protection practices including adherence to regulations, standards, and policies and procedures will be implemented to effectively mitigate these interactions. Environmental protection measures designed to manage the effects associated with all Project phases will be detailed in a separate Project-specific Environmental Management Plan (EMP), prepared prior to construction in support of the EIS and subsequent permitting. The EMP will describe the specific environmental protection and mitigation measures that will be applied throughout the life of the Project to avoid or reduce potential Project-related effects.

The potential effects of the Project activities rated 1 are discussed below. All potential residual environmental effects that are rated 1 are not likely to be significant because applicable guidelines, documented standard mitigation approaches and codified practices are available to reduce these Project effects; further assessment is not required.

14.4.2.1 Construction

During Construction, standard mitigation measures, guidelines or codified practices are available and will be implemented for the following activities:

- Installation of water supply infrastructure (wells, pumps, pipes);
- On-site vehicle/equipment operation; and
- Transportation of personnel and goods to the site.

Installation of Water Supply Infrastructure (Wells, Pumps, and Pipes)

Water supply construction includes all infrastructure associated with water obtained from groundwater wells and Attikamagen Lake. Infrastructure associated with groundwater and surface water extraction is not anticipated to have a direct influence on wetlands or wetland habitat because disturbance will be temporary and will not affect drainage patterns. The infrastructure will be designed and installed using guidelines, practices and technology (including DFO and NLDOECC - Water Resources Division guidelines) to maintain the natural hydrology, and to prevent ponding or dewatering.

On-site Vehicle/Equipment Operation and Transportation of Personnel and Goods to Site

On-site vehicle and equipment operation has potential to increase generation of air or waterborne particulates and could facilitate the dispersal, propagation, and establishment of non-native and invasive species, resulting in changes to wetland area, and thus wetland function.

Dust is generated throughout the life of mine and can interact with rare plant species that may be associated with wetlands during onsite vehicle/equipment operation and the transportation of personnel and goods to site during the construction phase of the Project. Dust may be generated by vehicles travelling on unpaved roads, or can be the result of blasting, excavation of soil, overburden and bedrock, or the transportation of materials or processing of iron ore. Dust particles can affect the surrounding vegetation by physically damaging cells; blocking stomata thereby affecting plant respiration and transpiration; and reducing the amount of light reaching photosynthetic cells. The effects of dust have been found to occur up to 200 m from roads, but mostly within a 100 m distance (Forman and Alexander 1998; Santelmann and Gorham 1988). Indirectly, dust can result in increased susceptibility of plants to drought, insects, disease and pathogens, in addition to changes in soil biogeochemistry by affecting soil pH and physico-chemical dynamics (Farmer 1993; Forman and Alexander 1998; Santelmann and Gorham 1988). Peat-dominated communities and epiphytic lichens are particularly sensitive to road dust (Auerbach et al. 1997; Walker and Everett 1987). The effect of dust can however be managed to acceptable levels through standard operating practices and/or through the application of best management or codified practices including the use of dust suppressants. Although the *Environmental Protection Act* does not require permits for the application of dust suppressants in Newfoundland and Labrador, all suppressants (other than water) should be reviewed with the appropriate regulating agencies to identify any particular concerns. Dust generation will also be reduced through installation of erosion and sediment controls including development of vegetation cover.

On-site vehicle/equipment operation, transportation of personnel and goods to site, and unauthorized recreational access can spread non-native and invasive species through the transferred soil and propagules to and within the site. These activities can also cause direct mechanical damage to plants.

This interaction has been rated 1 indicating that adverse effects can be managed to acceptable levels through standard operating practices and/or through the application of best management or codified practices.

14.4.2.2 Operations and Maintenance

During the Operations and Maintenance phase, potential environmental effects associated with the following Project activities can be limited to acceptable levels through standard mitigation and/or through the application of best management or codified practices:

- Maintenance of Causeway;
- Waste Rock Disposal on Surface;
- Water Treatment and Discharge;
- On-site Vehicle/Equipment Operation and Maintenance;
- Transportation of Personnel and Goods to the Site;
- Fuel Transport;
- Fuel Storage and Dispensing; and
- Progressive Rehabilitation.

Maintenance of Causeway/Open Pit Mining/Waste Rock Disposal on Surface

The primary effects of the Project on Wetlands associated with the mining of ore and disposal/ management of waste rock are the direct loss of wetlands that occur during Construction and are considered further in Section 14.6. Maintenance of the causeway, mining and processing of ore, and waste rock disposal on surface are expected to be within the area already cleared during site preparation (assessed in Section 14.6), and thus not anticipated to result in further ground disturbance activities in previously undisturbed areas. Maintenance will also not include the addition of Project-related infrastructure in areas within or directly adjacent to wetlands and wetland habitats. Thus, these operation phase activities have very limited potential to cause direct adverse environmental effects to these resources.

Open pit development is expected to generate approximately 72.42 million tonnes of overburden and waste rock during operation of the mine. This material will be stored in a designated overburden and waste rock stockpile areas located north of the open pit. The direct effect of the generation and stockpiling of waste rock (e.g., infilling of wetlands if avoidance is not possible) is assessed as an effect of site preparation during Construction (Section 14.6).

Dewatering for open pit mining is discussed further in Section 14.6.

Mitigation measures will be implemented for all Project phases including management of non-native and invasive plants.

Vegetation management will be periodically required adjacent to the mine site, mine infrastructure and within the ROW for the proposed 43 km long (184 ha) haul road. Vegetation management will consist primarily of mechanical control of vegetation, although the use of herbicides may be considered where undesirable species persist. Vegetation control during Operation and Maintenance could pose a hazard to wetlands, either through direct disturbance or indirectly by modifying wetland habitats through introduction of non-native or invasive species. Potential interactions between vegetation management activities within the road ROW corridor and wetland habitats will be reduced through avoidance, where possible. Maintenance employees or contractors will be informed of the occurrence of wetlands along the route, and equipment will adhere to exclusion zones, where possible.

Blasting near wetlands has the potential to open fractures that may result in wetland draining, and a subsequent change in wetland function. The wetlands most susceptible to this effect are those that have permeable substrate such as sand. Wetlands that are underlain by clay or have peat substrate are unlikely to be affected because of the low permeability of these soils. The wetlands in close proximity to the blasting in the open pit area potentially affected by groundwater drawdown or directly affected by Project components are assessed in Section 14.6.

Water Treatment and Discharge

Wetland chemistry is affected greatly by the chemistry of source waters. Nutrients, pH, and deleterious substances in wastewater can disrupt wetland functioning and health. Effluent from mine operation and stormwater runoff will be treated and managed; therefore, deleterious effects of untreated wastewater or effluent release are not expected during normal operation. Wastewater or effluent discharge to the environment will comply with regulatory requirements and will not be directly discharged to wetlands; discharge will occur up-gradient and at a distance that will not affect wetland hydrology.

On-site Vehicle/Equipment Operation and Maintenance/Transportation of Personnel and Goods to the Site/Fuel Transport, Storage and Dispensing

The potential effects of, and mitigation for vehicle and fuel movement, storage and dispensing or equipment operation during the Operation and Maintenance phase are the same as those described for the Construction phase above.

Progressive Reclamation

The site will be progressively rehabilitated. Progressive reclamation is considered a mitigation strategy that reduces the extent of disturbance at the site at any one time and reclaims disturbances to a predetermined land use or naturalized condition as soon as possible after these areas are no longer needed. To make progressive reclamation possible, wetland soil that is disturbed in the mining and construction process is removed, segregated and stockpiled. The salvage and reuse of wetland soil provides appropriate substrate and can contain seeds and root material that can speed recovery of the botanical community. This also provides opportunities for restoration of wetland function.

The potential effects of, and mitigation for progressive reclamation during the operation and maintenance phase will occur primarily in areas of existing mine disturbance. Reclamation initiatives will be conducted in accordance with applicable laws and regulations and are anticipated to achieve a net positive effect on biodiversity by maintaining, enhancing, or preserving an area of equal or greater habitat value.

14.4.2.3 Closure and Decommissioning

During Closure and Decommissioning, the following activities may result in effects requiring standard mitigation practices:

- Site Decommissioning; and
- Site Reclamation.

Site Decommissioning and Site Reclamation

In accordance with requirements under the *Mining Act*, Chapter M-15.1, Section (9), a Closure and Reclamation Plan will be prepared. The Closure and Reclamation Plan will specify procedures for decommissioning, removal, and disposal of site equipment and structures, and for site remediation, where required. It will contain measures to achieve targeted environmental goals and will also have a contingency to allow for shutdown at any time during the anticipated Project life, if required. The Closure and Reclamation Plan will reflect the environmental requirements in place at the time of decommissioning, including consideration of the waste disposal, diversion, or recycling requirements.

At Closure and Decommissioning, the landscape will remain dominated by wetlands, and all wetland classes currently present will continue to be represented. Reclamation techniques will be used to promote the natural regeneration of wetlands when Project components are removed, the details of which will be documented in the Closure and Reclamation Plan. Reclamation methods may include site grading and drainage, reestablishing salvaged wetland soils from overburden stockpiles, and promoting the regeneration of wetland plants either naturally (by allowing plants to establish in salvaged substrate) or artificially (i.e., direct seeding or planting).

14.4.3 Interactions Rated 2

Potential Project interactions on Wetlands rated 2 are associated with all site preparation activities (including clearing, excavation, filling, material haulage, grading, removal of overburden, and stockpiling) during Project Construction. During the Operation phase, open pit mining and waste rock and overburden disposal will not generally include ground disturbance in previously undisturbed areas, or the addition of Project-related infrastructure within or directly adjacent to wetlands and have been rated 1 as noted above.

A detailed environmental effects analysis (Section 14.6) was completed for the following interactions that have the potential to result in significant adverse environment effects (i.e., rated 2 in Table 14.3).

Construction

- Site Preparation (including clearing, excavation, material haulage, grading, removal of overburden, and stockpiling);
- Construction of Roads;

- Construction of Causeway;
- Construction of Site Buildings and Associated Infrastructure;
- Construction of Rail Loop and Associated Infrastructure; and
- Construction of Stream Crossings.

Operation and Maintenance

- Open Pit Mining/Temporary Dewatering;

Accidents and Malfunctions

- Hydrocarbon Spill;
- Train Derailment;
- Forest Fire;
- Settling/Sedimentation Pond Overflow; and
- Premature or Permanent Shutdown.

14.5 Existing Environment

14.5.1 Information Sources

Information used in support of the assessment of wetlands was derived from reviews of both historical and baseline data sources, including:

- A review of existing literature information on distribution and character of wetlands within the region as well as functional assessment methodologies;
- Published and unpublished literature, including peer-reviewed academic journals, research project reports, and government publications;
- Recent aerial photographs (2012) and topographical maps that could indicate the occurrence of wetlands or wetland habitats; and
- Project field data collected (2011-2013) as a part of the environmental baseline program for the Project (GENIVAR 2013; WSP 2014).

The majority of data were collected through on-site surveys of the RSA, LSA and PDA, as completed during the 2011-2013 field seasons (GENIVAR 2013, WSP 2014). The field surveys included detailed vegetation surveys, wetland inventories, and rare plant surveys. Relevant data from AC CDC, CDPNQ, and other non-governmental and provincial conservation programs, were also used to describe the existing environment.

While traditional knowledge pertaining specifically to Wetlands was not identified, the traditional knowledge results identified in Chapter 3: Engagement and Traditional Knowledge have been considered and integrated throughout the assessment.

14.5.2 Method for Characterization of Baseline Conditions

14.5.2.1 Desktop Work and Photo-Interpretation

Desktop and field analyses were used to classify vegetation units and delineate wetlands within the LSA. The standard terrestrial ecosystem mapping approach used in Labrador is the Ecological Land Classification (ELC), developed by the federal government (Lopoukhine et al. 1978; Wilken 1986). However, the Labrador territory is only mapped at the regional scale (ecoregion). To provide finer scale wetland mapping, aerial-photo interpretation was used. High resolution images (10cm/pixel) taken in 2012 were used to identify and map vegetation type and delineate wetlands.

14.5.2.2 Field Surveys

Vegetation field surveys were conducted by WSP Global during the periods of August 4, August 14 to August 24, 2012, and from August 5 to August 12, 2013, during which wetland characterization took place. During the survey, emphasis was put on wetland characterization and identification of rare or potentially uncommon plant species. The vegetation communities and plant diversity description were conducted using sampling plots combined with random survey transects. Low-altitude helicopter flights were also used to aid identification of vegetation units.

14.5.2.3 Wetland Classification

Wetlands were generally classified using the Canadian Wetland Classification System (National Wetlands Working Group 1997). In some cases, the classification methods proposed by the MDDEPQ (2006), Ménard et al. (2006) and Payette and Rochefort (2001) were used as guidelines for characterization in the field.

Four primary wetland classes were used: fens, bogs, swamps and shallow water. These classes were further subdivided into the forms described by the Canadian Wetland Classification System. Forested fens and bogs were classified using vegetation physiognomy. Because of very similar vegetation associations, swamp forms were grouped together and were divided into two different types (shrub and forested). The shallow water class was divided into temporary ponds and ponds.

Peatlands (fens and bogs) were classified based on the trophic status based on the character of their vegetation (Garneau 2001) and on structural properties. Peatlands represent a mosaic of different nutrient, drainage and physical properties which influence local plant associations. For this reason, some of the survey plots represent only the local conditions and were part of larger assemblages that were described by photo-interpretation.

14.5.2.4 Wetland Ecological Function

Classifications were used to assign ecological function to each wetland. Hanson et al. (2008) reported that many different methods have been developed to assess wetland functions, and that no single method is best for all regions and situations in Canada. However, most researchers and authors generally agree on the major categories of wetland functions, and the validity of the general method for assessing potential environmental effects. Overall, hydrology, habitat, biochemical cycling and climate are considered highly relevant. Depending on the wetland ecosystem, other wetland functions can also be assessed including: flood control; groundwater recharge; shoreline and erosion protection; water quality; biological productivity; habitat and nursery; recreational hunting; recreational fishing and biodiversity (Hanson et al. 2008).

The determination of ecological function for the assessment of Project-related effects on Wetlands was based primarily on the guidelines outlined in Correlating Enhanced National Wetlands Inventory Data with Wetland Functions or Watershed Assessments: A Rationale for Northeastern U.S. (Tiner 2003), as summarized in NovaWET (NSE 2011). These guidance documents provide a method for predicting a number of key wetland functions based primarily on wetland classification, landscape position, landform, and water flow path. Correlations between wetland characteristics and potential wetland functions are based on expert opinion and supported by the published literature and have been developed and used by the US Fish and Wildlife Service for conducting landscape level assessments in the northeast United States. Although the correlations have been developed for wetlands in more southern regions, they are generally considered to be relevant for a wide geographic area (Tiner 2003). Additional information obtained during both field surveys and desktop assessments were used to modify interpretation, where applicable, and to provide specific context for the functional assessment.

The wetland ecological functions were determined to include only the wetlands found within the LSA. For each of the wetland functions examined, an estimate of the contributing area within the wetland ecological function assessment zone was calculated by summing the wetland polygon area that was considered to significantly contribute to that function. These summations are based on polygons that are often composed of wetlands with multiple forms and types; wetland classes were typically delineated separately, however, and do not necessarily account for variation within a wetland.

Wetlands were divided into nine wetland function categories for the Project assessment; including:

- surface water detention;
- sediment and other particulate retention;
- streamflow maintenance;
- carbon sequestration;
- shoreline stabilization;

- fish habitat/stream shading;
- waterfowl and waterbird habitat; and
- species of conservation concern habitat.

The determination of wetland function was primarily based on wetland classification, landscape position, landform, and water flow path. Groundwater recharge was not considered in the assessment due to the lack of relevant information to determine specific wetland contribution to recharge or the discharge.

Wetland-related economic benefits, recreation, education and research were also not assessed due to the lack of wetland-specific information on land use, and the general remoteness and limited accessibility of the wetlands within the LSA. In the RSA, areas most frequented by the local population for activities such as birdwatching, wildlife photography, fishing, furbearer harvest and berry gathering would likely be Attikamagen Lake, Mike Lake and Astray Lake due to road accessibility.

14.5.2.5 Technical Considerations

Technical boundaries for the Wetlands include: spatial limitations in existing data sources used to characterize vegetation communities in the LSA and RSA. Spatial limitations in the detailed analysis of historical air photo coverage, and field surveys conducted in the PDA (i.e., vascular plants can only be identified where field surveys were conducted, but not beyond. Temporal variations associated with the presence of some vascular plants could occur from one growing season to another; for example plant communities could be present at one location during one year but not the next (e.g., Norwegian Arctic-cudweed). To characterize vegetation communities in the LSA and RSA, existing information used for the assessment includes aerial imagery (2012), LiDAR (Light Detection and Ranging) data (2010), remotely-sensed satellite imagery, AC CDC elemental occurrence and expert opinion range map data, and 2012 and 2013 field survey data. These data are sufficient to describe existing conditions and assess potential Project-related environmental effects.

14.5.3 Baseline Conditions

Ten wetland vegetation types were identified in the LSA; each is discussed in sub-section 14.5.3. Each wetland was assigned ecological function(s) based primarily on these classifications.

14.5.3.1 Ecological Context

The RSA covers an area of approximately 123,686 ha and lies within the Mid Subarctic Forest and the High Subarctic Tundra ecoregions. The Mid Subarctic Forest ecoregion is characterized by cold and snowy winters, cool summers with moderate rainfall and a 100-120-day growing season (NLDNR 2012). The harsh climate restricts closed-canopy forests to sites protected from the wind. Black spruce (*Picea mariana*), white spruce (*Picea glauca*) and tamarack (*Larix laricina*) are, in general, the only tree species that survive in the northern part of this ecoregion (Groupe Hémisphères 2009). Black spruce-moss stands are found on moderately drained sites, while stands of spruce and lichens are common on well-drained sites established on thin till deposits. Vast complexes of wetlands are common and peatlands are predominant.

The High Subarctic Tundra ecoregion is characterized by cold and windy winters, cool summers with moderate rainfall and an 80 to 100-day growing period (NLDNR 2012). Trees are generally absent from this ecoregion. The vegetation is mostly dominated by shrubs, low shrubs and grass (Meades 1990).

14.5.3.2 Wetland Types

Wetlands are relatively common throughout the RSA, LSA and PDA, accounting for approximately 13% (15,914 ha; Figure 14.3), 11% (687.5 ha; Figures 14.1 and 14.2), and 7% (32 ha; Figures 14.1 and 14.2), respectively. Ten wetland vegetation types were identified (Tables 14.4 to 14.6).

Table 14.4 Wetland types and relative abundance in the RSA

Wetland Class[1]	Wetland Form	# Wetlands[2]	Area (ha)	Relative % of wetlands in RSA
Fen	Horizontal Fen	-	4,492	28.2
	Northern Ribbed Fen			
	Riparian Fen			
Fen/Bog/Swamp	Forested Fen	-	11,422	71.8
	Forested Bog			
	Flat Bog			
	Shrub Swamp			
	Forested Swamp			
Shallow Water	Pond	-	-	-
	Temporary Pond			
Total		-	2,298	100

Notes:
1. Note: Mapping is provided on the basis of detailed aerial photography and satellite imagery used to define wetlands in the LSA and RSA, respectively. Data sources (i.e., satellite imagery) used to define habitat/wetland types in the RSA are at a higher scale (lower resolution) than those of the LSA. As such, wetland cover within the RSA is determined by combining all of the mature wetland community types from the ELC mapping. This means that Bogs, Swamps and some Fen (i.e., forested fen) dominant communities are considered part of the broader and more general concept of 'wetland cover' as it pertains to habitat. Similarly, Fens, including riparian fen, northern ribbed fen, and horizontal fen are also grouped. It should also be noted that there are many sub dominant wetland communities complexed into the ELC mapping units.

2 detailed wetland inventory data are not available throughout the extent of the RSA.

Table 14.5 Wetland types and relative abundance in the LSA

Wetland Class	Wetland Form	# Wetlands	Area (ha)	Relative % of wetlands in LSA
Fen	Forested Fen	52	266.6	38.8
	Horizontal Fen	52	102.4	14.9
	Northern Ribbed Fen	29	65.2	9.5
	Riparian Fen	27	46.0	6.7
Bog	Forested Bog	37	60.7	8.8
	Flat Bog	13	8.6	1.3
Swamp	Shrub Swamp	101	112.8	16.4
	Forested Swamp	9	16.8	2.4
Shallow Water	Pond	10	2.2	0.3
	Temporary Pond	15	6.0	0.9
Total		345	687.5	100

Table 14.6 Wetland types and relative abundance in the PDA

Wetland Class	Wetland Form	# Wetlands	Area (ha)	Relative % of wetlands in PDA
Fen	Forested Fen	21	20.0	62.7
	Horizontal Fen	8	2.3	7.1
	Northern Ribbed Fen	2	1.3	4.0
	Riparian Fen	1	0.1	0.3
Bog	Forested Bog	9	3.0	9.5
	Flat Bog	4	1.9	5.8
Swamp	Forested Swamp	3	0.7	2.1
	Shrub Swamp	15	2.5	7.8
Shallow Water	Pond	0	0.0	0.0
	Temporary Pond	2	0.2	0.7
Total		65	32.0	100

Wetlands in the LSA occupy flat, poorly-drained depressions on impermeable substrates and are closely associated with watercourses. Wetlands occur either in large assemblages or small and isolated areas. Peatlands are by far the most abundant wetland type, and account for 535 ha or 9% of the LSA. In the Québec-Labrador peninsula, this type of habitat represents 10% to 15% of the surface area (Allington 1961).

Fens (forested, horizontal, northern ribbed and riparian) are the most abundant peatlands found in the LSA (Figures 14.1 and 14.2). Unlike bogs, which receive water primarily from precipitation with relatively little water from surface flows and discharge only through groundwater, fens receive both surface and subsurface water and have both surface and subsurface outflows. As a result, fens tend to reflect the chemistry of the underlying bedrock and are mostly influenced by the leaching of dissolved minerals. These areas can be quite alkaline when fed from limestone sources similar to that which occur throughout portions of the LSA and which are reflected in the diversity of vegetation present (i.e., occurrence of calcicolous plants). Swamps are the second most abundant wetland type and are usually found at the edge of lakes and rivers. Bogs occupy a lesser portion of the LSA and are generally found in depressions fed by rainwater. Temporary ponds and ponds are small in size, isolated and scattered throughout the LSA.

Forested Fen

Forested fens are found on poorly-drained sites enriched by minerals seeping through the substrate, and are often associated with other types of wetlands. Soils in this wetland type are composed of well-decomposed organic material that overlays an impermeable layer of fine sand and silt. Black spruce (*Picea mariana*), tamarack (*Larix laricina*) and occasionally white spruce (*Picea glauca*) can be found in forested fens. They typically have well developed herbaceous and moss stratums. Forested fens are the most common type of wetland in the LSA, accounting for 266.6 ha, or 38.8% of wetlands.

Horizontal Fen

Horizontal fens are flat and uniform wetlands found on poorly-drained terrain enriched with minerals seeping through the substrate. Vegetation is typically dominated by sedges. Soils are made up of a thick layer of moderately decomposed organic material. Sedges dominate the vegetation cover, and may be comprised of water sedge (*Carex aquatilis* var. *aquatilis*), lesser panicled sedge (*C. diandra*), and northern bog sedge (*C. gynocrates*). The herbaceous layer is poorly developed and includes three-leaved false Solomon's seal (*Maianthemun trifolium*). Horizontal fens are common, accounting for 14.9% of wetlands in the LSA.

Northern Ribbed Fen

Northern ribbed fens are often found in association with other types of wetlands where they to form a complex mosaic of habitats. This type of wetland is characterized by the presence of dissolved minerals provided by groundwater or surface water runoff, low peat ridges running perpendicular to the direction of surface flow and elongated wet hollows or shallow ponds. Soil is generally composed of a very thick layer of moderately decomposed organic material. The herbaceous layer is well developed in this vegetation type, and includes meagre sedge (*C. exilis*), mud sedge (*C. limosa*) and alpine clubrush (*Trichophorum alpinum*) on the ridges, and livid sedge (*C. livida*), bog buckbean (*Menyanthes trifoliata*) and swollen beaked sedge (*C. rostrata*) in the depressions. Northern ribbed fens account for 9.5% of wetlands in the LSA. They are more abundant in the RSA, where they account for 17% of wetlands.

Shrub Swamp

Shrub swamps occupy the edges of streams and lakes, and as such are subject to seasonal flooding. These wetlands are characterized by dissolved mineral-enriched water and vegetation dominated by shrubs. The shrub layer is dominant and comprised of American green alder (*Alnus viridis* subsp. *crispa*), tea-leaved willow (*Salix planifolia*) and Labrador willow (*S. argyrocarpa*).

Shrub swamps are the second most abundant type of wetland in the LSA; they account for 112.8 ha, or 16.4% of wetlands in the LSA.

Forested Bog

Forested bogs are often located in poorly-drained areas. Soils are made up of poorly-decomposed organic material overlying an impermeable layer of fine sand and silt. Black spruce and tamarack are common. Forested bogs account for 60.7 ha, or 8.8% of wetlands in the LSA.

Riparian Fen

Riparian fens are found on poorly-drained stations enriched with minerals provided by bordering watercourses. Soils are generally composed of well-decomposed organic material that lies on an impermeable layer of fine sand and silt. This wetland type is a transition zone between aquatic and upland ecosystems. Tree and shrub layers are generally sparse, and the moss layer is well developed. The herbaceous layer contains numerous species, including sheathed sedge (*C. vaginata*), water sedge and marsh cinquefoil (*Comarum palustre*). Riparian fens account for 46 ha, or 6.7% of wetlands in the LSA.

Forested Swamp

The forested swamps in the LSA generally occupy the edges of streams, lakes and other waterbodies. They experience seasonal flooding and are characterized by water enriched with dissolved minerals. This wetland type is dominated by trees and shrubs, including white spruce, tamarack, American green alder and tea-leaved willow. Nine forested swamps were identified in the LSA. Forested swamps account for a relatively small portion of wetlands in the LSA, at 2.4%, or 16.8 ha.

Flat Bog

Flat bogs receive water exclusively from precipitation and are very acidic. As such, they support vegetation dominated by ericaceous shrubs, including leatherleaf (*Chamaedaphne calyculata*), bog laurel (*Kalmia polifolia*), glaucous-leaved bog rosemary (*Andromeda polifolia* var. *latifolia*), common Labrador tea (*Rhododendron groenlandicum*), small cranberry (*V. oxycoccos*) and *Pleurozium sp.* and *Sphagnum* sp. moss carpets typical of boreal peatlands. Organic matter is more than 1m thick. Flat bogs are fairly uncommon in the LSA and account for 1.3% of wetlands or 8.6 ha.

Temporary Pond

Temporary ponds occupy depressions in the landscape and are subject to drought and flooding. Soils are composed of compacted coarse to fine sand. Common vegetation species include tea-leaved willow, common Labrador tea and alpine bilberry (*Vaccinium uliginosum*). Common haircap moss (*Polytrichum commune*) is abundant. Temporary ponds are an uncommon wetland type in the LSA, accounting for less than 1% of all wetlands and only 6 ha of land.

Pond

Ponds have permanent standing water with depths of less than 2 m in mid-summer. Ponds are uncommon in the LSA. Ten ponds were identified in the LSA, which account for 2.2 ha, or less than 1% of the total wetlands area.

14.5.3.3 Wetland Ecological Function

Wetland functions are the natural processes (physical, chemical, biological) that occur in wetlands. While most wetland functions are generally present in all wetlands, the scale and importance of each function is highly variable. The value of the functions provided by a wetland is determined by the importance of the service and the need for the service. For this analysis, functions that are directly linked to services of likely value in the watershed area considered.

Key information used to identify and assign wetland functions and values are provided in Table 14.7. Because functions were assigned at a generalized level for wetlands or wetland complexes consistent with available data, they do not necessarily reflect the range of site-specific conditions and functional characteristics). A complete presentation of the functions for individual wetlands in the LSA is provided in the Vegetation Baseline Study (Genivar 2013; WSP 2014).

Table 14.7 Estimated Number of Contributing Wetlands within the LSA and Key Functions

Function	Key Criteria used for the Identification of Wetland Functions and Values within the LSA	Number of Contributing Wetlands	Contributing Wetland Area (ha)
Surface Water Detention	• fens with ribbed forms; • swamps, fens and bogs associated with a terrene pond landscape position; and • other wetlands with surface water features.	249	225.1
Sediment and Other Particulate Retention	• all lentic and lotic wetlands with riparian vegetation (most shrub swamps and riparian fens).	78	175.9
Streamflow Maintenance	• all lentic landscape position; • headwater wetlands; • position outflow and throughflow; and • all wetlands with the capacity to store and release water over a long period surface water detention.	161	314.0
Carbon Sequestration	• all fens and bogs; and • most swamps, except those with a high carbon release (with a lentic landscape position).	276	592.4
Shoreline Stabilization	• wetlands with lentic or lotic landscape position, excluding those with an island landform; and • wetlands bordering the bank of a waterbody or a watercourse.	113	294.4
Provision of Fish Habitat	• wetlands contiguous with a permanent waterbody or watercourse lentic and lotic	112	245.9
Fish Habitat (Stream Shading)	• wetlands containing trees and shrubs adjacent to a waterbody or a watercourse or located upstream from a fish habitat.	113	243.9

Table 14.7 Estimated Number of Contributing Wetlands within the LSA and Key Functions

Function	Key Criteria used for the Identification of Wetland Functions and Values within the LSA	Number of Contributing Wetlands	Contributing Wetland Area (ha)
Provision of Waterfowl and Waterbird Habitat	• all wetlands with a lentic and lotic landscape position; • all wetlands with a surface water feature; and • ponds, temporary ponds.	206	362.7
Species of Conservation Concern Habitat	• all wetland habitats.	345	687.5

Some wetland functions are likely to be overrepresented where functions have been assigned based on the presence of select wetland forms or other features. For example, entire wetlands identified in the database were identified as contributing to the function of shoreline stabilization when they bordered waterbodies, although only a small proportion of their area would have comprised the shoreline itself.

All nine wetland functions were performed in varying degrees by wetlands in the LSA (Figures 14.1 and 14.2). Although all wetland habitats have the potential to provide habitat for species of conservation concern, no mammal, herpetile, or fish species deemed to be "at risk" or "of conservation concern" are likely to depend solely on those wetland habitats occurring within the LSA. A single federally and provincially protected bird, the rusty blackbird, was identified to have wetland associations (GENIVAR 2013). Although no federally or provincially designated plant species at risk were identified in the LSA, a total of 35 other rare vascular plant species were found to be associated with wetland habitats.

After species of conservation concern habitat, the ecological service provided by the largest area of wetlands in the LSA is carbon sequestration (592.4 ha). Carbon sequestration is directly related to the rate of peat production within wetlands. Bogs and fens can be important carbon sinks by storing large volumes of organic matter. Swamps may also be important for sequestering carbon, although their ability to do so depends on the hydrological regime (Tiner 2003; NSE 2011).

Provision of waterfowl and waterbird habitat is another wetland function performed by a relatively large portion of wetlands (362.7 ha) in the LSA. Wetlands can provide important habitat for many species of birds, which may use these areas for nesting, staging, feeding, breeding and/or brood rearing. The ability of wetlands to provide habitat for waterfowl and other waterbirds varies according to their position relative to waterbodies and watercourses, the presence and character of open water, and the availability of appropriate vegetation for foraging and nesting opportunities.

14.6 Assessment of Project-Related Environmental Effects

In this section, the changes to wetlands in the immediate vicinity of the LSA and PDA are assessed. Only the interactions rated 2 in Section 14.4 are addressed in this section; all other interactions previously rated 0 or 1 were rated as not significant and are not discussed further. The environmental effect of Change in Wetland Area or Function is assessed below for each

Project phase. Accidents and malfunctions with respect to wetlands are discussed in Section 14.8.

There are uncertainties associated with the effects assessment of wetlands. For example, the performance of key services by individual wetlands, such as carbon sequestration, has not been quantified. To accommodate this, conservative assumptions (i.e., assumptions that err on the side of over-stating an effect) were used in the assessment.

Some of the assumptions made in this effects assessment are:

- In this assessment, it is assumed that wetland function is directly related to wetland area; functions assigned to an individual wetland are performed equally throughout the wetland; and a reduction in wetland area results in a proportional reduction in its assigned function. Relating wetland function to wetland area is a common and practical way to quantify wetland function, primarily because of its accuracy of measure. The amount of wetland area is also a factor in determining mitigation in conjunction with change in wetland function.

- Aerial photography is available for a majority of the LSA, however, re-routing of the proposed haul route has resulted in data gaps with respect to the vegetation classification and vegetation communities within a few small segments of the LSA. These small gaps are not expected to reduce the overall confidence in the effects assessment.

- Habitats in the RSA were classified using a supervised satellite classification for key/ representative land cover, vegetation, or other discrete class types. In supervised classification, the image processing software is guided by the user to specify the land cover classes of interest. Supervised classification can be very effective and accurate in classifying satellite images, though it relies on the distinctness of the classes. If two or more classes are very similar to each other in terms of their spectral reflectance (e.g., Forested Bog vs. Forested Fen), misclassifications may result. Transitional vegetation types (e.g., Closed Spruce Moss Forest) can also result in an overestimation of some closely linked classes. Reference to and comparisons between the area of each class lost and/or altered are used to predict environmental effects on vegetation types, and were deemed a conservative measure of the environmental effect of the Project on Wetlands.

14.6.1 Assessment of Change in Wetland Area or Function

Project activities that may have an environmental effect on wetland area or function are assessed in this section based on the areal extent of wetlands lost or altered as a result of these activities.

14.6.1.1 Construction

There are several construction activities related to the Project that have the potential to affect wetlands. Construction-related interactions with wetlands with an associated rating of 2 (Table 14.3) include:

- Site Preparation (including clearing, excavation, material haulage, grading, removal of overburden, and stockpiling);
- Construction of Access Roads (from haulage road to the existing road; and between the crushing and screening plant, waste and overburden stockpiles, and the explosives storage);
- Construction of Haul Roads;
- Construction of Causeway;
- Construction of Portable Crushing and Screening Plant and Associated Stockpiles;
- Construction of Site Buildings and Associated Infrastructure;
- Construction of Rail Loop and Associated Infrastructure; and
- Construction of Stream Crossings.

These activities will result in a disturbance or loss of wetland area in the PDA and a change in the function associated with disturbed or lost wetland area. A direct, permanent loss of wetland area and associated function is anticipated where vegetation clearing and grubbing, excavation, and grading during site preparation is required in areas identified as wetland.

There is potential for indirect changes in wetland area and associated function during Project construction as a result of erosion and sedimentation, introduction of non-native and invasive plant species, and through changes in local hydrology.

Erosion and sedimentation during construction can result in a disturbance (temporary loss of area and associated function) beyond the area of direct disturbance. Erosion in areas draining to wetlands may result in the deposition (i.e., sedimentation) of non-wetland soils into wetland areas. This can result in vegetation mortality and local changes in nutrient availability which can cause changes in the vegetation community. Erosion in wetland areas can result in the loss of soil substrate for vegetation.

Construction activities can facilitate opportunities for colonization by non-native and invasive plant species. Vegetation communities differ in their susceptibility to invasion by non-native and invasive species. Non-native and invasive plants could affect wetland function, as non-native and invasive plants often have higher rates of reproduction when compared to native plant species and can out-compete these species for resources (e.g., available nutrients). Activities that result in soil disturbances, such as the construction of linear corridors (e.g., roads, conveyors) further favour the establishment of non-native and invasive plants by facilitating the dispersal, propagation, and establishment of these species into and across the region.

Construction of the drainage management may result in changes in surface water flows to adjacent water bodies, wetlands and watercourses. Minor disruptions in wetland hydrology can alter species composition and various wetland processes, and thus wetland function and critical habitats for a variety of hydrophytic plant species.

In addition to the direct physical disturbance of the construction of watercourse crossings, they also have potential to result in flow restrictions if not designed appropriately (e.g., undersized culverts or improperly placed culverts or flow passages). If impoundment of flows occurs in a wetland area, a change in species composition and function may occur as the vegetation community composition adapts to the new hydrologic conditions.

14.6.1.2 Operation and Maintenance

Open pit mining, particularly dewatering, has the potential to interact with wetlands during the Operation and Maintenance phase of the Project.

Dewatering for the open pit mine may alter components of the water balance sustaining wetlands and their functions. Dewatering activities will include partial or complete dewatering of Joyce Lake. Dewatering of Joyce Lake will lower water levels in the lake. Wetlands that are present on the lake shoreline (riparian or fringe wetlands) have formed as a result of favorable topographic conditions and direct influences of lake hydrology. This dewatering will result in a direct loss of this wetland area and associated function.

Dewatering of Joyce will take place during Operations and Maintenance and groundwater levels surrounding the former lake shore will begin to decline to the new base level (i.e., the lake bottom) once the water is removed (See Chapter 12: Groundwater Resources). It is likely that the water table (surface of the saturated zone) in overburden and bedrock will be lowered substantively in the immediate vicinity of the open pit mine and Joyce Lake, declining with distance from these features. Drawdown effects are not expected to extend beyond Iron Arm or Attikamagen Lake. It is expected that the large lakes surrounding the Project will act as hydraulic boundaries for dewatering effects (Chapter 12). Wetlands within the area of groundwater drawdown related to dewatering for open pit mining may be affected by the resulting change in water availability for sustaining wetland conditions and functions depending on their baseline hydrology. Wetlands receiving groundwater (e.g., fens and some swamps) will be most vulnerable to dewatering effects. Wetlands that are primarily rain fed (e.g., bogs) will likely be unaffected.

Although not within the LSA of the Project, there is potential for effects to wetland habitat along watercourses discharging from Joyce Lake as a result of increased flows to this area during dewatering activities. Discharge from the dewatering system at the open pit mine will be pumped to perimeter ditches where it will drain by gravity to the Joyce Lake outlet. Average monthly flows to this area are anticipated to increase by approximately 250% in the first year of dewatering, and anywhere from 6% to 51% in subsequent years (Chapter 11: Water Resources). While predicted monthly average flows during dewatering are less than the peak flows that occur naturally in this drainage area, the baseflows will be higher than natural conditions later into the growing season.

This is likely to result in increases in inundation depth in wetlands associated with drainage courses from Joyce Lake and subsequently, wetland vegetation mortality.

Progressive rehabilitation will be implemented during Operation and Maintenance phase of the Project, and may include: rehabilitation of construction-related buildings; stabilization and re-vegetation of waste rock disposal areas, and repair of wetland areas affected negatively by hydrology changes at the outlet of Joyce Lake. These activities may result in a net increase in wetland area, when compared to the Construction phase. An environmental monitoring program will be conducted as part of the mine development, and the resulting information will be used to evaluate the progressive rehabilitation program on an ongoing basis.

14.6.1.3 Closure and Decommissioning

There are no potential interactions with Wetlands during the Closure and Decommissioning phase of the Project with an associated rating of 2 (Table 14.3).

14.6.2 Mitigation of Project Environmental Effects

Project planning, design, and the application of known and proven mitigation measures will be implemented as part of the Project to avoid or reduce environmental effects on Wetlands. This includes the use of appropriate, accepted best practices to limit activities resulting in disturbance to habitat, to the extent practical, and compliance with the requirements of applicable permits (e.g., buffer widths and permitted activities at these locations).

Consistent with the goals of the FPWC and the provincial Policy for Development in Wetlands, a Wetland Mitigation and Monitoring Plan will be developed as part of the EMP, incorporating a hierarchical progression of mitigation alternatives, where feasible.

14.6.2.1 Avoidance

The location of wetlands will be considered in Project planning and avoided in the placement of facilities and infrastructure, where feasible. To achieve this, baseline surveys have been undertaken to evaluate habitat conditions at the mine site and associated infrastructure locations and to identify opportunities to reduce effects through final siting of these facilities during detailed design. Linear facilities (i.e., roads, rail lines) will also be located during detailed routing to avoid wetlands, where feasible.

14.6.2.2 Minimization

The abundance of wetlands on the Joyce Lake peninsula constrains the ability to completely avoid alteration of wetland habitat during site development. In locations where wetlands cannot reasonably be avoided, standard mitigation will be employed to reduce the effects. The Wetland Mitigation and Monitoring Plan will be developed for the Project prior to start of the construction phase and will outline a number of mitigative measures to reduce effects to wetlands. The Plan will be developed in consultation with regulatory agencies, participating municipalities, and other stakeholders and in accordance with Newfoundland and Labrador regulations related to wetlands and all conditions of approval for the Project.

The following general mitigation is proposed to reduce direct and indirect effects on wetlands:

- Comply with provincial and federal legislation, permits, approvals and guidelines;
- Reduce construction footprint (i.e., the PDA) to the extent feasible and restrict construction activities to the PDA;
- Select the final locations of Project facilities and infrastructure, including overburden and low grade and waste rock disposal areas, haul roads and rail corridors, to avoid wetlands to extent feasible;
- Implement a pre-construction communication plan for communicating with the construction crew on the environmental sensitivities of wetlands, wetland flagging, keeping machinery and vehicles out of wetlands, and maintaining sediment and erosion control around wetlands;
- Maintain natural buffers around wetlands and riparian zones;
- Flag the boundaries of wetlands clearly in the field before commencing construction, and avoid locations of avoidable wetland boundaries, to the extent feasible;
- Avoid siting of temporary work areas (for example, lay-down areas for equipment and materials storage) in wetlands;
- On-site environmental monitors will be assigned to confirm that construction practices are consistent with the goals and plans of the Wetland Mitigation and Monitoring Plan in the Project-specific EMP;
- Avoid known areas of sensitive species and their habitats associated with wetlands, where feasible;
- Maintain natural wetland hydrology, where possible, through assessment of pre-construction hydrology and use of appropriately sized and placed culverts, infiltration galleries, berms, vegetated channels;
- Reduce disturbance and infilling within adjacent wetlands and maintain hydrological conditions to the extent feasible;
- Protect remnant wetlands that have not been affected by mine activities and maintain natural buffers around wetlands and riparian zones;
- Where practical, limit construction in wetlands during winter months when soil and water are more likely to be frozen and vegetation is dormant, to the extent feasible;
- Use mats (e.g., rig mats) and wide-track vehicles to spread the distribution of equipment weight when crossing wetlands (if crossing is unavoidable) during the growing season or when wetlands are not frozen;

- Salvage and stockpile wetland soils (peat) separately from upland soils for use in site reclamation;

- Implement erosion prevention and sediment control measures, with an emphasis on reducing the area of exposed soils at any one time; and

- Conduct progressive rehabilitation and/or wetland restoration.

14.6.2.3 Restoration or Compensation

Wetland restoration or compensation will be undertaken to offset the loss of wetland area and associated function resulting from the Project where losses are considered significant (greater than 10% of wetland area in the RSA).

14.6.3 Characterization of Residual Project Environmental Effects

14.6.3.1 Construction

After the application of mitigation, the potential residual effects associated with the Project on wetland area and its associated function, are predicted to be adverse, because there will be a permanent alteration and/or reduction in the amount of available wetland area.

Following effective implementation of general and site specific mitigation plans, adverse residual environmental effects to wetlands as a result of Project construction are expected to be limited to the LSA, and primarily within the PDA. These disturbances will be a result of site preparation and construction of Project components and facilities that intersect wetlands, where avoidance of wetland areas was not feasible. Because of the conservative approach taken in this analysis, it is possible that disturbance to wetlands and a decline in their associated function may be further reduced from current estimates.

Project construction is expected to result in the direct disturbance of 65 wetlands, accounting for approximately 32 ha, or 4.7% of the wetland area available in the LSA (Table 14.8). Direct effects of the Project on wetlands have been estimated to vary from approximately less than 1% (riparian fen, shrub swamp and pond) to 22% (flat bog) of the contributing area within the LSA. The large majority of the wetland area within the PDA is associated with the construction of roads (i.e., haulage road, mine site access road and Schefferville Service Road), which are approximately 22 ha (5% of PDA) in size. Wetland habitats with the PDA of the mine and its associated infrastructure are primarily forested fen (20 ha), with lesser amounts of forested bog (3 ha), forested swamp (2.5 ha) and horizontal fen (2.3 ha). Flat bogs are the wetland type with the largest portion affected at 22%, followed by forested swamps at 14.9%. Disturbances to shallow water wetland types (i.e., temporary ponds, ponds) are expected to be minor, primarily restricted to wetlands located in the southern portion of the PDA in association with the haulage road.

Table 14.8 Wetland Number and Area within the LSA and PDA by Class

Wetland Class	Wetlands within LSA		Wetlands within PDA		Proportion of Area Affected in the LSA (%)
	#	Area (ha)	#	Area (ha)	
Forested Fen	52	266.6	21	20.0	7.5
Horizontal Fen	52	102.4	8	2.3	2.2
Northern Ribbed Fen	29	65.2	2	1.3	2.0
Riparian Fen	27	46.0	1	0.1	0.2
Forested Bog	37	60.7	9	3.0	4.9
Flat Bog	13	8.6	4	1.9	22.1
Shrub Swamp	101	112.8	3	0.7	0.6
Forested Swamp	9	16.8	15	2.5	14.9
Pond	10	2.2	0	0.0	0.0
Temporary Pond	15	6.0	2	0.2	3.3
Total (Rounded)	345	687.5	65	32.0	4.7

Disturbance to wetlands in the PDA will be accompanied by a corresponding loss to wetland functions. The area estimated to contribute to each of the assessed functions and potential direct effects is provided in Table 14.9.

Project features are estimated to affect between approximately 5.6 and 32 ha of wetland area contributing to evaluated wetland functions, with effects to carbon sequestration and habitat for species of conservation concern being the greatest (Table 14.9). The dominance of wetlands providing these functions in the PDA is attributed to the fact that all wetlands evaluated were assigned as providing potential habitat for species of conservation concern, and the dominant peatlands were assigned the function of carbon sequestration. The functions that wetlands in the PDA support are well represented throughout the LSA. The proportions of wetland area that are contributing functions within the LSA that are estimated to be affected by the Project range from approximately 2.5% to 5.2%, with shoreline stabilization being highest.

The Project construction is expected to result in a permanent loss of 32 ha of wetland area and associated functions in the LSA. This represents effects to 65 wetlands, most of which are forested fen (21) and shrub swamp (15).

Although detailed wetland inventory data are not available throughout the extent of the RSA, ELC data suggest that the Project will affect less than 1% of wetlands within the RSA. Wetlands and wetland habitats, particularly peatlands are regionally abundant in the RSA and substantial alteration or loss of wetlands from within the RSA is not likely.

Table 14.9 Estimated Contributing Wetland Area (ha) for each of the Assessed Wetland Functions by Project Component

Project Component	Surface Water Detention	Sediment and Other Particulate Retention	Streamflow Maintenance	Carbon Sequestration	Shoreline Stabilization	Fish Habitat	Stream Shading	Waterfowl and Waterbird Habitat	Habitat for Species of Conservation Concern
Haul Road	4.2	5.6	7.7	15.3	6.5	6.5	6.5	8.0	18.1
Low Grade Stockpile	-	-	-	0.7	-	-	-	-	0.7
Mine Site Access Roads	-	-	-	2.0	2.0	-	-	-	2.0
Open Pit Mine	0.8	-	-	0.8	-	-	-	0.8	0.8
Overburden Stockpile	0.7	-	-	0.5	-	-	-	0.7	0.7
Railway	-	-	-	0.4	-	-	-	-	0.4
Schefferville Service Road	1.3	-	-	1.9	-	-	-	1.3	1.9
Sedimentation Pond	-	-	-	0.4	-	-	-	-	0.4
Warehouse Area	-	-	-	6.9	6.9	-	-	-	6.9
Total in PDA	**7.0**	**5.6**	**7.7**	**29.0**	**15.4**	**6.5**	**6.5**	**10.8**	**32.0**
Total in LSA	**225.1**	**175.9**	**314.0**	**592.4**	**294.4**	**245.9**	**243.9**	**362.7**	**687.5**
Proportion of LSA Affected (%)	**3.1**	**3.2**	**2.5**	**4.9**	**5.2**	**2.6**	**2.7**	**3.0**	**4.7**

Note:
‘-‘ indicates that wetland area was identified as not contributing this function

Adverse residual environmental effects on wetland area and associated wetland function are anticipated to be singular (occurring once) in frequency during the Construction phase and long-term (e.g., access roads) to permanent (i.e., waste rock pile) in duration. In some cases, this has the potential to be reversed if wetland restoration is undertaken at the conclusion of the Project. The effect on wetland functions are likely reversible over the long-term once hydrologic regimes are re-established and water quality effects have ceased after Closure and Decommissioning. However, there is uncertainty associated with this, as wetlands have low resilience due to their susceptibility to disturbance; physical, chemical, and biotic changes can have long-lasting effects on wetland function. Not all rehabilitated areas within the Project footprint will return to pre-construction conditions, and the alteration of those wetlands would be permanent (i.e., irreversible).

14.6.3.2 Operation and Maintenance

Operation of the open pit mine is expected to affect wetlands and their associated functions directly and indirectly. Direct effects to wetlands and their associated functions are expected to occur where the locations selected for the stockpile areas intersect wetlands (Figure 14.1). However, wetlands in these areas would have been previously affected as a result of site preparation during Construction; these effects are discussed above.

During open pit mining, dewatering will be required, which will result in a decline in water levels in Joyce Lake and wetlands along the shoreline of this lake. This is expected to result in a temporary disturbance of wetland area and associated functions. A single wetland is identified on the shore of the lake, a shrub swamp that is 0.8 ha in area. This wetland contributes to shoreline protection, sediment retention, and potentially habitat for species of conservation concern. This wetland is outside of the LSA, and no direct physical disturbance is expected. The effect of dewatering the wetland is expected to be a temporary shift in species composition as the plant community adapts to the drained conditions. It is expected that this effect would reverse when water levels return after the completion of the Project.

Wetlands associated with drainage courses at the downgradient end of Joyce Lake may be affected by increased average flows as a result of the open pit mine dewatering. Average monthly flows during Year 1 are expected to increase by 250% as excess water is directed here during dewatering. Baseflow in subsequent years is expected increase between 6% and 51% over natural conditions. Increased flows at this location may result in deeper inundation of wetlands in this area, later in the growing season. Wetlands with stable water levels are particularly vulnerable to changes in seasonal water levels because the plants have a narrow range of inundation tolerance. Vegetation mortality as a result of a change in the depth and timing of inundation is expected to be temporary in nature and the herbaceous plant community is expected to recover in one to two years, whereas populations of trees may take five to ten years to recover.

Wetlands in the landscape surrounding Joyce Lake may also be affected by the dewatering depending on their water source (groundwater, precipitation, runoff or channel flow) and proximity to the open pit mine and Joyce Lake. Wetlands that are primarily groundwater fed (e.g., wetlands classified as fen) have the greatest potential to be affected as their water supply is reduced or eliminated. These effects could result in temporary changes in species composition, wetland function and a possible loss of wetland area. Wetlands that are primarily maintained through precipitation or local runoff (e.g., bog or pond) to a confined basin are the least likely to be affected. However, as vertical hydraulic gradients increase in areas affected by groundwater drawdown, there may be an increase in discharge of wetland water to groundwater in any wetland resulting in drier conditions and changes in wetland function.

The distance from Joyce Lake up to which wetlands would be affected by the dewatering for open pit mining will depend on hydraulic conductivity of the underlying till, the local topography and location of the wetland in the local and regional groundwater flow systems. The results of groundwater modelling to predict the zone of influence are not yet available. Seven wetlands are present in the LSA within 500 m of dewatering in the open pit mine and Joyce Lake and have the greatest potential to be affected (Figure 14.1). Of these, three are completely within the PDA and are expected to be completely altered as a result of site preparation during Construction. The remaining four wetlands comprise 1.8 ha in total area and include flat bog, temporary pond, and shrub swamp. These wetlands are identified as providing surface water detention, carbon sequestration, waterfowl habitat and potentially habitat for species of conservation concern (although no instances have been documented). Bogs receive the majority of their sustaining water levels from rain. Temporary ponds and shrub swamp may or may not have groundwater inputs. The effect of a decline in groundwater contribution to these wetlands may include a change in species composition as the vegetation community adapts to dry conditions. This effect is likely to be temporary and reversible when groundwater levels return to pre-existing conditions at the conclusion of the open pit mining.

In summary, Operation and Maintenance of the Project is expected to result in direct and indirect effects to wetlands and their associated functions in the LSA. A loss of one 0.8 ha shrub swamp will likely result from the Joyce Lake dewatering for open pit mining. The loss of this wetland and its associated functions is expected to be temporary and reversible when water levels in the lake return to natural conditions at the conclusion of open pit mining and dewatering. This dewatering during open pit mining may also indirectly affect four wetlands in the landscape adjacent to the open pit mine and Joyce Lake. These wetlands comprise 1.8 ha in total area, and effects are expected to be temporary and will naturally reverse when groundwater levels return to baseline conditions following completion of open pit mining. Vegetation mortality in wetlands associated with the drainage from Joyce Lake is expected as a result of changes in the timing and volume of flows to this area during open pit mine dewatering. These areas have not been previously characterized in order to predict the resulting loss of area and function, but will be assessed, mitigated and monitored as part of the Wetland Mitigation and Monitoring Plan. In total, Project Operation and Maintenance may affect 2.6 ha of wetland area and its associated functions (less than 1% of wetland area in the LSA), in addition to effects to wetlands associated with drainage from Joyce Lake. This does not include the permanent loss of 32 ha of wetland area and associated functions within the LSA noted above resulting from the direct effects of Construction.

Project activities associated with the Operation and Maintenance phase will therefore result in adverse environmental effects on wetland area and function within the PDA, primarily through the temporary dewatering of the open pit mine and Joyce Lake. The magnitude of adverse effects will be low, as less than 5% of the wetland area available in the LSA (and less than 1% of the available RSA) will be lost or altered as result of Project activities. The environmental effects will be singular, and are anticipated to be medium-term (i.e., lasting throughout operations) and reversible.

Prediction confidence for analyses of wetland area and function is moderate to high as they were both qualitative and quantitative in nature and given the conservative nature of the analysis and mitigation measures proposed.

14.6.3.3 Closure and Decommissioning

There are no expected residual effects of project Closure and Decommissioning on change in wetland area and associated function.

A Closure and Reclamation Plan will be prepared in accordance with the Newfoundland and Labrador *Mining Act*. The Closure and Reclamation Plan will describe the process of rehabilitation of the Project up to and including closure, and will define the actions necessary to achieve plan objectives and requirements.

Closure and Decommissioning is expected to reverse some of the effects of the Project on wetland area and function in the RSA through reinstatement. Full restoration of wetlands in the mine footprint upon decommissioning is unlikely; however, removal of the rail line, roads and facilities can include wetland reinstatement. Quantification of Project effects on wetland area and function do not take into account the opportunity for reinstatement during Project Closure and Decommissioning.

14.6.4 Summary of Project Residual Effects

A summary of residual adverse environmental effects is provided in Table 14.10.

Table 14.10 Summary of Residual Environmental Effects – Wetlands

Project Phase	Mitigation/Compensation Measures	Residual Environmental Effects Characteristics									Recommended Follow-up and Monitoring
		Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental or Socio-Economic Context	Significance	Prediction Confidence	
Change in Wetland Area and Function											
Construction	• Adherence to Wetland Mitigation and Monitoring Plan. • Comply with provincial and federal legislation, permits, approvals and guidelines. • Reduce construction footprint (i.e., PDA) to the extent feasible. • Flagging the avoidable wetland boundaries clearly in the field. • Implement a pre-construction communication plan, communicating with the construction crew on the environmental sensitivities of wetlands and wetland mitigation. • Maintain natural buffers around wetlands and riparian zones. • Maintain natural wetland hydrology, where possible. • Where practical, limit construction in wetlands to winter months, to the extent feasible. • Use mats (e.g., rig mats) and wide-track vehicles to spread the distribution of equipment weight when crossing wetlands during the growing season or when wetlands are not frozen; • Salvage and stockpile wetland soils (peat) separately from upland soils for possible use in reclamation;	A	M	S	LT/ P	O	I	U/D	N	H	Monitor for compliance with mitigation measures. Implementation of and adherence to Wetland Monitoring Plan.

Table 14.10 Summary of Residual Environmental Effects – Wetlands

Project Phase	Mitigation/Compensation Measures	Residual Environmental Effects Characteristics									Recommended Follow-up and Monitoring
		Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental or Socio-Economic Context	Significance	Prediction Confidence	
	• Implement erosion prevention and sediment control measures. • Conduct invasive species management. • Conduct progressive rehabilitation and wetland restoration where possible.										
Operation and Maintenance	• Adherence to Wetland Mitigation and Monitoring Plan. • Comply with provincial and federal legislation, permits, approvals and guidelines. • Implement erosion prevention and sediment control measures. • Conduct progressive rehabilitation and/or wetland restoration.	A	L	S	LT	O	R	D	N	M/H	Monitor for compliance with mitigation measures. Characterization of wetlands associated with drainage courses from Joyce Lake Adherence to Wetland Monitoring Plan.
Closure and Decommissioning	• Comply with provincial and federal legislation, permits, approvals and guidelines. • Include wetland reinstatement as a part of revegetation following the removal of facilities and infrastructure, to the extent practical. • Implement erosion prevention and sediment control measures. • Conduct invasive species management.	P	N	S	LT	O	R	D	N	M	Monitor for compliance with mitigation measures. Adherence to Wetland Monitoring Plan.

Table 14.10 Summary of Residual Environmental Effects – Wetlands

Project Phase	Mitigation/Compensation Measures	Residual Environmental Effects Characteristics									Recommended Follow-up and Monitoring
		Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental or Socio-Economic Context	Significance	Prediction Confidence	

KEY

Direction:
P Positive
A Adverse
N Neutral

Magnitude:
L Low
M Moderate
H High

Geographic Extent:
S Site-specific: environmental effect confined to the PDA.
L Local: environmental effect extends into the LSA.
R Regional: environmental effect extends into the RSA, where indirect or cumulative environmental effects may occur.

Duration:
ST Short-term: residual environmental effect occurs during the Construction phase (i.e., one year)
MT Medium-term: residual environmental effect extends through the Operations and Maintenance phase (i.e., up to seven years)
LT Long-term: residual environmental effect is greater than seven years
P Permanent: measurable parameter unlikely to recover to baseline

Frequency:
O Once: Once per month or less.
S Sporadically: Occurs sporadically at irregular intervals.
R Regularly: Occurs on a regular basis and at regular intervals.
C Continuous.
U Unlikely.

Reversibility:
R Reversible: effect is reversible following closure and reclamation
I Irreversible: residual environmental effect is permanent (i.e., remains indefinitely as a residual effect).

Environmental or Socio-economic Context:
U Undisturbed: Area relatively or not adversely affected by human activity.
D Disturbed: Area has been substantially previously disturbed by human development or human development is still present.

Significance:
S Significant.
N Not Significant.

Prediction Confidence:
Based on scientific information and statistical analysis, and effectiveness of mitigation or effects management measure
L Low level of confidence.
M Moderate level of confidence.
H High level of confidence.

14.7 Assessment of Cumulative Environmental Effects

In association with the Project environmental effects discussed above, an assessment of the potential cumulative environmental effects was conducted for other projects and activities that have potential to interact with the Project. Potential cumulative effects on Wetlands are primarily related to wetland alteration or loss as a result of Project activities in combination with those of other developments or activities within the RSA, including past, current, and future mining initiatives.

Other projects and activities considered in the cumulative effects analysis are presented in Table 14.11, including a rating of interactions with other projects as 0, 1, or 2 with respect to the nature and degree to which important Project-related environmental effects overlap with those of other projects and activities.

Table 14.11 Potential Cumulative Environmental Effects

Other Projects and Activities with the Potential for Cumulative Environmental Effects	Potential Cumulative Environmental Effects
	Change in Wetland Area or Function
Champion Iron Ltd. Kami Iron Ore	0
Arcelor-Mittal Mont Wright Mine	0
Champion Iron Ltd. Fire Lake North Iron Ore Project	0
Tacora Resources Inc. Scully Mine	0
Champion Iron Ltd. Bloom Lake Mine and Rail Spur	0
IOC Labrador Operation (Carol Lake)	0
Labrador Iron Mines Houston 1&2	1
Lower Churchill Hydroelectric Generation Project	0
Maritime Transmission Link Project	0
Tata Steel Minerals Canada - DSO Iron Ore Project	1

Key:
0 Project environmental effects do not act cumulatively with those of other projects and activities.
1 Project environmental effects act cumulatively with those of other projects and activities, but the resulting cumulative effects are unlikely to exceed acceptable levels with the application of best management or codified practices.
2 Project environmental effects act cumulatively with those of other projects and activities and the resulting cumulative effects may exceed acceptable levels without implementation of project-specific or regional mitigation.

The environmental effects of past and present projects and activities on Wetlands in the RSA are reflected in the baseline conditions (Section 14.5.3). Several mining developments and railway infrastructure, as well as associated transmission line infrastructure, contribute to the existing conditions for the Project. Environmental effects identified in Table 14.11 and their potential to interact cumulatively with residual effects of other projects and activities are discussed below by rating. Cumulative environmental effects that are likely to result from the Project in combination with other projects and activities are discussed in greater detail. Projects and activities which are considered to have no cumulative interactions (i.e., rated 0) are not discussed.

14.7.1 Interactions Rated 0

A number of potential interactions noted in Table 14.11 are not expected to occur (rated 0) or might occur, but do not warrant further assessment because Project environmental effects do not act cumulatively with those of other projects and activities.

14.7.2 Interactions Rated 1

Other projects and activities rated 1 in Table 14.11 may have cumulative environmental effects on Wetlands; however, standard environmental protection practices and mitigation measures such as those described in Section 14.6.2 are available and will be implemented to reduce these effects.

The Project will interact with some historic and existing projects, including those of Houston 1 & 2 (Labrador Iron Mines) and DSO Iron Ore Project (Tata Steel Minerals Canada), with the potential to affect wetlands within the RSA.

The Schefferville Iron Ore Mine (now closed) involved two deposits located in southern Labrador – the James deposit and the Redmond deposit. The James property (64.5 ha) contains nine wetlands that total 6.9 ha, of which only approximately 0.5 ha are within the actual proposed mining footprint (Labrador Iron Mines Limited 2009). Wetland communities observed within the James property include:

- Basin Fen: low, closed herb graminoid stand dominated by sedge species;
- Stream Fen: low, closed herb graminoid stand dominated by sedge species;
- Riparian Swamp: intermediate, sparse tamarack evergreen stand with willows; and
- Riparian Swamp: tall, closed evergreen tree stand dominated by black spruce with mosses.

All wetlands within the footprint are basin fen type wetlands.

Within the Redmond property, there are 14 wetlands comprising 38.5 ha, with no wetlands within the proposed mining footprint. Wetlands communities observed within the Redmond property include:

- Basin Fen: low, closed herb graminoid stand dominated by sedge species;
- Floating Fen: low, closed herb graminoid stand dominated by sedge species;
- Stream Fen: low, closed herb graminoid stand dominated by sedge species;
- Northern Ribbed Fen: low, closed herb graminoid stand dominated by sedge species;
- Riparian Swamp: intermediate, sparse tamarack evergreen stand with willows;

- Riparian Swamp: tall, open tamarack black spruce, evergreen stand with sphagnum moss; and
- Riparian Swamp: tall, closed black spruce evergreen stand with sphagnum moss.

Tata Steel Minerals Canada - DSO Iron Ore Project (currently pre-operations) has a study area that includes 15 wetland environments occupying approximately 100 ha, or 5% of the project study area. Fen is the most common type of wetland, with four types of fens found. A single depression bog was also observed. Wetlands in the Tata Steel Minerals Canada - DSO Iron Ore Project study area generally cover a limited area and only four have an area greater than 10 ha.

The Project and its interaction with other local project will result in a cumulative loss of wetland. However, the area of wetlands with the potential to be affected by Project interactions is low. With application of codified environmental protection practices, adherence to regulations and the commitments of their environmental approvals, wetland effects as a result of these projects will be reduced. Additional environmental protection measures designed to manage effects associated with the Project will be detailed in a separate EMP and Wetland Mitigation and Monitoring Plan. No other projects and activities that were rated 1 which would result in effects deemed not to be acceptable and which would warrant further assessment.

14.7.3 Interactions Rated 2

As identified in Table 14.12, no potentially significant cumulative environmental effects of the Project in combination with other projects and activities that have been or will be carried out are considered likely. With respect to the activities of other future projects with potential for cumulative environmental effects, there were no other projects and activities that were rated 2 which would result in effects deemed not to be acceptable and which would warrant further assessment.

14.7.4 Summary of Cumulative Environmental Effects

Other future projects in the RSA have potential for cumulative environmental effects with the Project, as shown in Table 14.11. These projects are expected to result in a cumulative loss or disturbance of wetland area and associated function in the RSA. Mitigation and adherence to regulations and commitments will reduce these effects to less than 10% of wetland within RSA, and it is expected that all wetland classes and associated functions will continue to be represented in the RSA. The cumulative environmental effects on Wetlands will therefore not be significant.

14.8 Accidents and Malfunctions

Design features and procedures will be incorporated to reduce to likelihood of Project-related accidents and malfunctions resulting in adverse environmental effects. Proven engineering design techniques and codes of practice are available to prevent these accidents and will be employed for the Project. Safety, spill response, and contingency plans will be developed and implemented to reduce any adverse environmental effects resulting from such incidents. All safety procedures will be documented and in place prior to the commencement of the Project.

An Emergency Response and Spill Response Plan will be developed to further reduce the magnitude of effects resulting from forest fire or train derailments. Design features and safety precautions at the Project will also reduce the likelihood of significant effects due to accidents and malfunctions.

Reasonable worst-case scenarios for accidents and malfunctions that may result from the Project and may have an environmental effect on Wetlands include:

- Hydrocarbon Spill;
- Train Derailment;
- Forest Fire;
- Settling/Sedimentation Pond Overflow; and
- Premature or Permanent Shutdown.

14.8.1 Hydrocarbon Spill

Fuel storage on the site will include diesel and fuel oil tanks located at the rail unloading area, near the diesel generators at the mine site, and the process plant area. The maximum total storage capacity for diesel fuel will be 250,000 L. The fuel storage tanks will be located in secondary containment to control spills and will comply with requirements of the applicable provincial and federal acts and regulations, as well as the conditions of the permit and authorizations. The control measures will be able to contain the maximum capacity of all tanks in a storage area.

14.8.1.1 Emergency Response/Mitigation of Environmental Effects

The main mitigation measures for a hydrocarbon spill relate to prevention and rapid and effective cleanup. As part of the Emergency Response and Spill Response Plan, spill prevention and response protocols will include the inspection of vehicles and hydraulics on a daily basis for leaks or damage that could cause minor spills and rapid spill response. Vehicles and equipment will be stored in controlled areas where secondary containment of spills can be provided. Staff will be trained in the handling of emergency response and spill scenarios. Response equipment stored on site will include containment and absorbent booms, pads, barriers, sand bags, and skimmers, as well as natural and synthetic sorbent materials.

14.8.1.2 Characterization of Residual Environmental Effects

The environmental effects of a fuel spill on Wetlands are predicted to be adverse, but localized and reversible through remediation and restoration. The magnitude and duration of any environmental effect depends on a number of factors including the nature of material spilled, the quantity spilled, the location of the spill, and the time of year in which the incident occurs. Substantial fuel spills are unlikely to occur, and with appropriate mitigation, the magnitude of the environmental effects is likely to be low, or under potentially worst case scenarios, moderate. Spill prevention and response protocols included in the Emergency Response and Spill Response

Plan will further reduce the likelihood of a fuel spill. Reversibility of the environmental effects will depend on the specific habitat involved, the proportion of habitat affected, and the potential for those habitats to be used by species, but would be anticipated to occur naturally over a number of years. Remediation and restoration can be undertaken to restore wetland area and function in consultation with applicable regulatory authorities.

14.8.2 Train Derailment

Iron ore product will be transported by truck from the Project site to the Astray rail loop which connects directly to the Tshiuetin/QNS&L railway for transport to Sept-Îles. Diesel fuel will be transported by rail to Schefferville and then by contracted trucker to site. On average, iron ore will be transported on approximately four trains each week during summer months between the Astray rail loop and the Sept-Îles port. Each train set will carry approximately 24,000 tonnes of ore in 240 gondola cars. Based on the speed the train will be travelling in the rail loop (5 miles per hour or 8 km/h), the reasonable worst case is the derailment of a maximum of four to five cars. This could result in the iron ore being spilled onto the ground or at stream crossings. Such an event is highly unlikely.

It is estimated that diesel fuel transport frequency will be a maximum of six 96,000 L tank cars per week for all site purposes.

Fuel tank car numbers are based on shipment in standard 96,000 L tank cars similar to those already in fuel haulage service between Sept-Îles and Labrador City. In a reasonable worst case scenario (i.e., where six tanks of diesel fuel are de-railed), approximately 576,000 L (127,000 Imperial gallons) of diesel fuel could be released.

14.8.2.1 Emergency Response/Mitigation of Environmental Effects

The trains will be operated under current Tshiuetin/QNS&L environmental and safety procedures. A detailed Emergency Response and Spill Response Plan will also be developed by Labec Century. This plan will include measures such as:

- Immediate response through the use of absorbent booms and pads;
- Liquid clean up using a vacuum truck (both fuel and groundwater);
- Reclamation of contaminated soils, removal of contaminated soils and replacement with clean soil.

Additional mitigation measures to be implemented to limit the potential for a train derailment include:

- Manual inspection of rolling stock to confirm there are no problems with the wheels, couplers, carbody or brakes;
- Track inspections in accordance with Transport Canada regulations;

- Properly maintained equipment; and
- Fuel transport amounts will be limited to the amounts required by the Project.

14.8.2.2 Characterization of Residual Environmental Effects

A train derailment may occur during any phase of the Project resulting in the deposition of hazardous materials and/or iron ore product into surrounding lands. Iron ore spills are usually highly localized and can be effectively cleaned up by on-site crews using standard equipment and spill response materials. The release of hazardous materials or contaminants into surrounding lands could result in a degradation of terrestrial, wetland, and/or aquatic habitats, with potential effects on populations that use these habitats. The magnitude and duration of any environmental effect depends on a number of factors including the nature of material spilled, the quantity spilled, the location of the spill, and the time of year in which the incident occurs. With mitigation, the magnitude of the environmental effects attributable to these infrequent and unlikely accidents and malfunctions is likely to be low. In the unlikely event of a train derailment and deposition of hazardous materials and/or iron ore product into surrounding wetlands, emergency containment and recovery procedures developed in the Emergency Response and Spill Response Plan will include:

- Containment measures will immediately be initiated to limit the spread of the spill;
- Any nearby drainage (non-watercourse) culverts will be blocked to limit spill migration if required;
- Physical excavation and removal of contaminated soils for temporary storage, and eventual permanent treatment/disposal removal of contaminated soil and replacement with clean soil;
- Conduct post-spill response investigation to evaluate the performance of spill prevention measures; and
- Collection of post-response samples of soil and water for testing.

In a worst case scenario, defined as large fuel spill into a wetland complex, the magnitude may be moderate. Reversibility of the environmental effects may be achievable through remediation and wetland restoration measures identified above. The success of restoration in returning affected wetland classes and functions will depend on the specific habitat involved, and the proportion of habitat affected, and the potential for those habitats to be used by species. Restoration will be undertaken with regulatory consultation.

Based on spill response actions that will be implemented if a derailment occurs, the low potential for a large spill to occur, the limited geographic extent of the potential interactions following remediation and restoration, and in consideration of the planned and effective mitigation to reduce environmental effects (e.g., Emergency Response and Spill Response Plan measures and provincial/federal regulatory spill response system), the potential environmental effects of a

Project-related train derailment on Wetlands are rated as not significant. This prediction is made with a high degree of confidence.

14.8.3 Forest Fire

Although unlikely, Project activities involving the use of heat or flame could result in a fire. Fires can alter habitat, consume riparian vegetation, destabilize shore area soils, and lead to erosion and sedimentation events. The extent and duration of a fire would be dependent on response efforts and meteorological conditions.

14.8.3.1 Mitigation of Environmental Effects

Fire suppression water systems will be maintained on site. The fire suppression water supply at the Project site will be extracted from wells and stored in a 200,000 L fire water tank prior to use. The fire suppression water at the rail loop will be extracted from Astray Lake. Staff will be trained to prevent and control fires. A plan for preventing and combating forest fires will be incorporated into the Emergency Response and Spill Response Plan.

The nearest district forest management unit office in Labrador is in Wabush, which has staff and equipment to provide initial suppression activities. The Town of Schefferville also provides fire control services. Labec Century is discussing a reciprocal response arrangement with the Town of Schefferville, approximately 20 km away from the site. In the event of a fire, the on-site response and proximity of fire suppression services in Schefferville will limit the size of any burn.

14.8.3.2 Characterization of Residual Environmental Effects

The effects of a forest fire on important habitat are predicted to be adverse, because it would reduce availability of habitat for most birds and wildlife. The magnitude and geographic extent of the environmental effect is largely dependent on the scale and intensity of the forest fire; extensive fires may result in significant adverse residual environmental effects if uncontrolled. Reversibility of the physical effects of a fire is high, but would be anticipated to occur over a number of years. The restoration of important habitats would rely upon the re-establishment of vegetation communities through succession and the maintenance of those ecological conditions that existed prior to disturbance, and thus environmental effects on habitat may be of short to long duration. The likelihood of a forest fire occurring naturally is low; fire cycles in Labrador can exceed 400 to 500 years (Elson 2009). A worst case (i.e., extensive) Project-caused fire could have significant effects on Wetlands; this prediction is made with a high degree of confidence.

14.8.4 Settling/Sedimentation Pond Overflow

Settling/sedimentation ponds will be established at waste rock, overburden, ROM stockpile areas, at the crushing and screening plant area, at the accommodation camp area, and at the rail loop. Run-off from the stockpiles and site run-off will be directed to the settling/sedimentation ponds prior to discharge to the receiving environment. The likelihood of an overflow is low because the ponds will be designed to contain run-off associated with a 1:100 year precipitation event. In such an event, settling/sedimentation ponds could overflow, releasing untreated water. Untreated water could have elevated levels of total suspended solids. No other contaminants are anticipated.

14.8.4.1 Emergency Response/Mitigation of Environmental Effects

In the unlikely event of an overflow, contingency plans will be in place as part of the Emergency Response and Spill Response Plan to mitigate environmental effects to the receiving environment. Water sampling of TSS and other MDMER parameters will be conducted in downstream water bodies. Applicable stakeholders, including regulatory agencies, First Nations and communities, will be consulted to discuss such events and mitigation measures to be implemented.

14.8.4.2 Characterization of Residual Environmental Effects

The magnitude of adverse residual environmental effects of a settling/sedimentation pond overflow largely depends on the volume released, but would likely be low to moderate, following implementation of mitigation and emergency response measures. The occurrence of an overflow is unlikely, given the design standards for the ponds. In the unlikely event of an overflow, environmental effects are anticipated to be short to long term duration as wetland plants are stressed or killed by the influx of mineral sediment and potentially differing pH of released water. Following the release, the wetland community is expected to recover naturally over a number of years. No significant effects on Wetlands are predicted; this prediction is made with a high degree of confidence.

14.8.5 Premature or Permanent Shutdown

As currently planned, the mine will have an operational production period of seven years, (following one year of construction) at which time decommissioning and rehabilitation will commence. However, should factors arise that result in the premature shutdown of the mine, regulatory requirements include provision for financial assurance from Labec Century.

14.8.5.1 Emergency Response/Mitigation of Environmental Effects

Rehabilitative measures may be implemented by the NL Minister of Industry, Energy and Technology. In this case, costs incurred by the Crown in implementing these measures may be recovered through the financial assurance provided by the proponent. Any required cost expenditures over and above the financial assurance provided would be considered debt by Labec Century to the Crown.

14.8.5.2 Characterization of Residual Environmental Effects

In the event of a premature or permanent shutdown, it is anticipated that adverse environmental effects would be low, assuming that rehabilitative measures would be realized following implementation by the Crown. Residual environmental effects would be site specific, and short to long term duration for some habitats following site rehabilitation, or permanent for other habitats that may not return to pre-Project conditions (e.g., open pit). No significant effects on Wetlands are predicted; this prediction is made with a high degree of confidence.

14.8.6 Summary of Residual Effects Resulting from Accidents and Malfunctions

A summary of residual environmental effects resulting from accidents and malfunctions is summarized in Table 14.12.

14.9 Determination of Significance of Residual Adverse Environmental Effects

14.9.1 Significance Determination for Project-related Environmental Effects

The Project is likely to result in a change in the baseline condition of Wetlands. The effects of the Project on Wetlands will occur primarily during the Construction phase. The effects will be site-specific and long-term/permanent. No wetland types or wetland functions will be lost completely in the LSA/RSA as a result of Project activities, although the areal extent of number of individual wetlands will be altered. All wetland types occurring within and/or adjacent to the Project at baseline are anticipated to remain upon Closure and Decommissioning.

As stated in Section 14.4, a significant effect to wetland area and function would be one that results in effects to more than 10% of wetland area and associated function present in the RSA.

Specific mitigation measures, best management and codified practices that will be implemented to reduce potential environmental effects associated with the Project are summarized in Section 14.6.2. Details related to these measures will be provided in the EMP, Wetland Mitigation and Monitoring Plan, and the Emergency Response and Spill Response Plan for the Project.

Although detailed wetland inventory data are not available throughout the entire extent of the RSA, the ELC data indicate the residual loss or disturbance of wetlands due to the Project will affect less than 1% of wetlands within the RSA. The Project will also not result in a change or decline in the wetland area or function, such that the likelihood of its long-term viability within the LSA/RSA is substantially reduced. The wetland area and associated functions to be affected by the Project Construction (32 ha) and Operation and Maintenance (2.6 ha) is predicted to be approximately 5% of the wetland area present in the LSA (687.5 ha). There is potential to reverse some of the effects of loss or disturbance of wetland area during Closure and Decommissioning where wetland reinstatement is included in site revegetation plans.

In summary, the wetland area and associated functions to be affected by the Project Construction, Operation and Maintenance, and Closure and Decommissioning represents <10% of the wetland area present in the RSA and therefore potential residual effects of the Project on wetlands are not significant.

There is a moderate to high degree of confidence in the effects assessment based on use of conservative assumptions and analytic methods, knowledge of environmental interactions and use of proven mitigation measures.

Table 14.12 Summary of Residual Environmental Effects – Accidents and Malfunctions

Project Phase	Emergency Response/Contingency Measures	Direction	Residual Environmental Characteristics						Significance	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental/Socio-economic Context			
Operation and Maintenance											
Fuel Spill	• Emergency Response and Spill Response	A	L/M	S	ST/MT	S/R	R	U/D	N	H	Monitor success of response and mitigation measures.
Train Derailment	• Emergency Response and Spill Response Plan	A	L/M	S	ST/MT	S/R	R	U/D	N	H	Monitor success of response and mitigation measures.
Forest Fire	• Emergency Response and Spill Response Plan	A	L/H	S/R	ST	R	R	U/D	S	H	Monitor success of response and mitigation measures.
Settling/ Sedimentation Pond Overflow	• Emergency Response and Spill Response Plan	A	L/M	S	ST/LT	R	R	U	N	H	Monitor success of response and mitigation measures.
Premature or Permanent Shutdown	• Work with NLDIET to implement rehabilitative measures.	A	L	S	ST/P	R	R/I	U	N	H	Monitor success of response and mitigation measures.

Table 14.12 Summary of Residual Environmental Effects – Accidents and Malfunctions

Project Phase	Emergency Response/Contingency Measures	Direction	Residual Environmental Characteristics						Significance	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Environmental/Socio-economic Context			

Key:

Direction:
P Positive
A Adverse
N Neutral

Magnitude:
L Low
M Moderate
H High

Geographic Extent:
S Site-specific: environmental effect confined to the PDA.
L Local: environmental effect extends into the LSA.
R Regional: environmental effect extends into the RSA, where indirect or cumulative environmental effects may occur.

Duration:
ST Short-term: residual environmental effect occurs during the Construction phase (i.e., one year)
MT Medium-term: residual environmental effect extends through the Operations and Maintenance phase (i.e., up to seven years)
LT Long-term: residual environmental effect is greater than seven years
P Permanent: measurable parameter unlikely to recover to baseline

Frequency:
O Once: Once per month or less.
S Sporadically: Occurs sporadically at irregular intervals.
R Regularly: Occurs on a regular basis and at regular intervals.
C Continuous.
U Unlikely.

Reversibility:
R Reversible: effect is reversible following closure and reclamation
I Irreversible: residual environmental effect is permanent (i.e., remains indefinitely as a residual effect).

Environmental or Socio-economic Context:
U Undisturbed: Area relatively or not adversely affected by human activity.
D Disturbed: Area has been substantially previously disturbed by human development or human development is still present.

Significance:
S Significant.
N Not Significant.

Prediction Confidence:
Based on scientific information and statistical analysis, and effectiveness of mitigation or effects management measure
L Low level of confidence.
M Moderate level of confidence.
H High level of confidence.

14.9.2 Significance Determination for Cumulative Environmental Effects

This Project-specific cumulative environmental effects assessment considered the identified potential environmental residual effects of the Project and the past, present and future effects of existing and reasonably foreseeable projects and activities. The contribution of the Project to potential cumulative effects was negligible to low when considered in the context of the RSA; 34.6 ha of a possible 15,914 ha or <1% of the wetlands in the RSA. The effects to wetlands from other projects in the RSA was considered in the characterization of baseline conditions. The Project will not result in a change or decline in the distribution or abundance of wetlands and/or associated wetland functions dependent upon that habitat (e.g., species at risk and/or species of conservation concern), such that the likelihood of its long-term viability within the RSA is substantially reduced as a result.

Two future projects were identified with predicted effects to small proportions of RSA wetlands. The combined effects to wetlands is not expected to be significant (affecting >10% of wetland area in the RSA). These future projects and activities will be subject to provincial and federal regulatory requirements for wetlands and are not expected to have significant residual environmental effects that will act in combination with those of the Project. Therefore, the residual adverse cumulative environmental effects of the Project acting in combination with past, present, and future projects and activities on Wetlands are not likely to be significant.

14.9.3 Significance Determination for Accidents and Malfunctions

Residual adverse environmental effects on Wetlands resulting from Accidents and Malfunctions are anticipated to be not significant, as design features and engineering techniques will be incorporated to reduce potential effects (e.g., techniques to prevent or reduce risk of fires). In the unlikely event of an accident or malfunction, an Emergency Response and Spill Response Plan will be implemented to further reduce adverse environmental effects.

14.10 Follow-up and Monitoring

Compliance monitoring will be conducted to confirm that mitigation measures are implemented. Follow-up monitoring programs to assess the effectiveness of mitigation measures, if required, will be developed in consultation with the appropriate regulatory authorities.

Wetlands associated with the drainage from Joyce Lake require characterization. A site specific mitigation plan including confirmatory monitoring is required to determine the resulting effects from changes to the volume and timing of flow to these areas during dewatering.

Environmental protection measures for Wetlands will be incorporated into the EMP prior to construction, including development and implementation of a Wetland Monitoring Plan Monitoring will be carried out following completion of the Construction phase, to determine the extent of “as built” direct effects on wetlands and to monitor the function of potentially indirectly affected wetlands upstream and downstream, particularly those on the Joyce Lake peninsula with potential to experience a loss of hydrological function and drainage area. Long-term wetland monitoring is expected to detect potential changes in wetland quality and quantity (e.g., changes in drainage patterns, presence of invasive species).

Monitoring will also be necessary following the unlikely event of contamination from an accidental spill or malfunction. Required monitoring will be detailed in the Emergency Response and Spill Response Plan.

14.11 Summary

The Project is located in variable terrain that contains many wetlands, including several large peatlands *(*i.e.*,* bogs and fens). Through desktop information gathering, field data collection and analyses, wetlands have been identified and their functions evaluated across the LSA. Interaction between the Project and Wetlands will occur within the LSA, specifically within the PDA, primarily during the construction phase resulting from ground disturbance activities.

At the completion of Construction, wetlands are anticipated to decrease in the LSA by approximately 32 ha or <5% which represents effects to a total of 65 wetlands, a majority of which are forested fen (21) and shrub swamp (15) wetland types. Following Operation and Maintenance, an additional 2.6 ha of wetland have the potential to be affected. Within the RSA, the Project will however have a limited effect on wetlands, with a net loss of <1% (34.6 ha of 15,914 ha available in the RSA).

Wetlands are expected to remain abundant and widely distributed throughout the RSA. Because the long-term viability of wetland types is not expected to be significantly affected, the adverse cumulative effect on Wetlands of all past, present and reasonably foreseeable projects and activities, in combination with the environmental effects of the Project, is considered not significant.

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