

## 1 **7 VALUED COMPONENTS EFFECTS ASSESSMENT**

### 2 **7.5 Groundwater**

3 As specified in Section 5.0 of the Application Information Requirements (**AIR**), groundwater has been  
4 identified as a valued component (**VC**) to be assessed for the Project. This section describes and assesses  
5 the potential effects on groundwater from the Project (during all Project phases).

6 This assessment is linked to other VC assessments, either through integration (information from other  
7 VCs is incorporated into this assessment) or support (information from this assessment is incorporated  
8 into the assessment of other VCs). This assessment integrated and supported information from:

- 9 • Surface Water – for potential groundwater interactions
- 10 • Vegetation and Wetlands – for potential groundwater interactions
- 11 • Freshwater Fish and Fish Habitat – for changes in groundwater quantity and quality.

12 In addition, this assessment integrates information from and/or into the Summary of Biophysical Factors  
13 that Support Ecosystem Function section and information from Indigenous groups, as applicable.

#### 14 **7.5.1 Overview**

15 This section provides a brief summary of the Groundwater VC assessment.

16 During all Project phases the Project is expected to interact with Site preparation and clearing, and the  
17 construction of temporary and permanent land-based infrastructure. The Project has the potential to  
18 result in the following effects on groundwater:

- 19 • Change in groundwater levels or surface water-groundwater recharge/discharge characteristics

20 In assessing the potential effects of the Project on groundwater, existing conditions within the Project  
21 local and regional assessment area were considered. Primary and secondary data indicates that:

- 22 • Groundwater in the local assessment area (**LAA**) and regional assessment area (**RAA**) has not been  
23 affected by anthropogenic activities
- 24 • The Project footprint geology primarily consists of unconsolidated deposits and bedrock
- 25 • There is limited potential for groundwater flow and storage within the overburden unit and the  
26 bedrock
- 27 • The regional groundwater flow paths are towards the lowest elevations at Pearse Island and  
28 Portland Canal with a small vertical gradient

1 To reduce or avoid adverse residual effects, measures for water and stormwater management will be  
2 developed and implemented. With the implementation of key mitigation measures, adverse residual  
3 effects include a change in groundwater quantity due to changes in groundwater surface material,  
4 permeability, and decreased infiltration (recharge) rates. Adverse residual effects on groundwater  
5 quantity will be low in magnitude and reversible. The uncertainty of this assessment is low.

6 Because there are no past, present, or reasonably foreseeable future projects or activities that may  
7 interact temporally or spatially with potential residual effects of the Project on groundwater there is no  
8 potential for cumulative effects. The construction environmental management plan (**CEMP**) will  
9 recommend guidelines to reduce the change in surface recharge and increase the probability of the  
10 Project Site returning to pre-construction conditions.

### 11 **7.5.2 Relevant Statutes, Policies and Frameworks**

12 The management of groundwater is subject to several statutes, policies, and frameworks. These are  
13 identified in the AIR, and Table 7.5–1 provides a list of the key legislation, policy, and regulatory guidance  
14 documents applicable to the assessment of groundwater.

**Table 7.5–1 – Summary of Key Legislation, Policy, and Regulatory Guidance Documents for Groundwater**

<b>Regulation or Policy</b>	<b>Description</b>
<b>Federal</b>	
Canadian Drinking Water Quality Guidelines	Health Canada sets the Drinking Water Guidelines for permissible concentration limits of contaminants in drinking water. These limits are based on consultation with the Federal-Provincial-Territorial Committee on Drinking Water and the public.
<b>Provincial</b>	
BC <i>Water Sustainability Act</i>	Groundwater withdrawal for water supply purposes is regulated under the British Columbia <i>Water Sustainability Act (WSA)</i> , administered by the Ministry of Forests or the Oil and Gas Commission (BC OGC). Any groundwater used for a non-domestic water supply must receive a groundwater use authorization before withdrawal may commence. To obtain a groundwater use authorization, a permit application must be submitted via FrontCounter BC. Groundwater use authorization applications under the WSA must include a technical hydrogeological report that follows the guidance outlined in <i>Guidance for Technical Assessments in Support of an Application for Groundwater Use in British Columbia, Version 2</i> (Todd et al. 2020). Todd et al. (2020) outlines the typical technical assessment requirements based on proposed withdrawal.
BC Groundwater Protection Regulation	Sections 18, 29 and 63 of the Ground Water Protection Regulation (WSA) establish standards for the siting, drilling, construction, maintenance, alteration, and closure of wells in BC.

**Table 7.5–1 – Summary of Key Legislation, Policy, and Regulatory Guidance Documents for Groundwater**

Regulation or Policy	Description
BC <i>Drinking Water Protection Act</i>	The <i>Drinking Water Protection Act</i> , administered by the BC Ministry of Health, regulates all water sources other than supply systems for single-family dwellings. Under Section 6.0, the Act requires that the supplier provides safe potable water and meets additional permit requirement/regulations.
BC Drinking Water Protection Regulation	Under Section 5.2 of the Drinking Water Protection Regulation, and as administered by the BC Ministry of Health, drinking water from a water supply system must be disinfected if the water originates from surface water, or ground water that, in the opinion of a drinking water officer, is at risk of containing pathogens.
BC <i>Environmental Management Act</i>	The Environmental Management Act, administered by the BC Ministry of Environment and Climate Change Strategy, regulates industrial and municipal waste discharge, pollution, hazardous waste, and contaminated site remediation.

## NOTE:

There are no specific Nisga'a Lisims Government regulations or policies related to groundwater.

### 1 7.5.3 The Influence of Consultation and Engagement

2 The development of the AIR and this assessment were influenced by the Project's consultation with the  
3 technical advisory committee, Indigenous nations, and the public. This section describes information and  
4 concerns related to the Groundwater VC shared through consultation with government agencies,  
5 stakeholders, Indigenous nations, and community members.

#### 6 7.5.3.1 Indigenous Knowledge

7 Where made available by Indigenous nations through consultation, information gathering, and voluntary  
8 information sharing, information on Indigenous knowledge (IK) and land use has been included.

9 Sections 11.0 to 19.0 provide information regarding the alignment of the use of knowledge shared by  
10 Indigenous nations, with each nation's respective policies and protocols, consent for its use and public  
11 disclosure, and views regarding the characterization of IK within the Application. Sections 11.0 to 19.0 also  
12 advise, as applicable, if no feedback regarding the use, public disclosure, or characterization of IK was  
13 provided by an Indigenous nation. In this case and as applicable, the Application has considered publicly  
14 available information and non-confidential outcomes of Project consultation activities to date.

15 Refer to Section 6.0 for detailed methods regarding the incorporation of IK into the Application.

16 Nisga'a Nation were consulted regarding their knowledge of groundwater usage at Wil Milit; no on-going  
17 use was identified. Kitsumkalum First Nation identified concerns related to water quality. The potential  
18 for interaction between surface water and groundwater is considered within this VC section.

**Table 7.5–2 – Summary of Key Information, Indigenous Knowledge and Concerns for the Project Related to Groundwater**

Topic	Key Information and Concerns	Influence on the Assessment
Ground Water Quality	<ul style="list-style-type: none"> <li>▪ Kitsumkalum First Nation expressed concerns for groundwater quality.</li> </ul>	<ul style="list-style-type: none"> <li>▪ An assessment of changes in groundwater quality is considered in Section 9.0 (Malfunctions and Accidents) as the only anticipated effect of the Project on groundwater quality is through unintended spills.</li> <li>▪ No land-based or freshwater effluent discharge is planned as part of the Project; therefore, change to groundwater quality is not carried forward for this assessment.</li> </ul>
Ground Water Quantity	<ul style="list-style-type: none"> <li>▪ Gitxaala Nation expressed concerns for changes in local groundwater levels.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Project effects on groundwater quantity are assessed in Section 7.5.8.1.</li> </ul>

#### 1 7.5.4 Assessment Boundaries

2 The spatial, temporal, administrative, and technical boundaries for the assessment of effects on  
3 Groundwater are described below.

##### 4 7.5.4.1 Spatial Boundaries

- 5 • The **Project footprint** will encompass the land-based components of the Project infrastructure as  
6 well as the marine-based components of the Project infrastructure located in the intertidal area.  
7 This includes the Project fence line plus a 10 metre (**m**) buffer, the two overburden storage areas,  
8 and the intertidal portion of the defined Water Lot (see Figure 1.4 in Section 1.0). The Project  
9 footprint is located on two fee simple Category A district lots owned by Nisga'a Nation. The Project  
10 terrestrial footprint is estimated to be 43.6 hectares (**ha**)
- 11 • Spatial boundaries for the Groundwater LAA are the same as for the Surface Water LAA and  
12 Freshwater Fish and Fish Habitat LAA. The Groundwater LAA includes the Project footprint; the  
13 streams, lakes, and ponds at least 100 m upstream from the Project footprint; and the stream,  
14 lakes, and ponds between the Project footprint and the high tide mark at the ocean  
15 (Figure 7.5–3). Effects to groundwater from infrastructure construction and potential surface  
16 water withdrawal are expected to be limited to this area
- 17 • Groundwater is not being considered as a water supply source for the Project; therefore, the  
18 assessment areas for the potential effects to groundwater considered the geographic extent from  
19 infrastructure construction and potential surface water withdrawal over which Project activities  
20 may affect groundwater quantity. The groundwater RAA ( Figure 7.5–3) is a 1-kilometre (**km**)  
21 radius buffer from the LAA or the high tide mark, whichever is closer, around the Project Site  
22 (the **Site**). This is the area in which potential interactions with other past, present, or future  
23 activities or projects that may affect groundwater are expected to occur

1 As per Table 3 (Section 6.4) of the AIR, the Open Water Assessment Area and Transmission Line  
2 Assessment Area are not applicable for this VC.

### 3 **7.5.4.2 Temporal Boundaries**

4 Temporal boundaries identify when an environmental effect is evaluated in relation to specific Project  
5 phases and activities. Temporal boundaries are based on the timing and duration of Project activities and  
6 the nature of the interactions with groundwater.

7 Based on the current Project schedule, the temporal boundaries for the assessment are:

- 8 • **Construction:** three to four years commencing following receipt of necessary regulatory approvals  
9 and a final investment decision by the Project
- 10 • **Operation:** a minimum of 30 years following completion of construction
- 11 • **Decommissioning:** approximately 12 months following the end of operation

12 No IK was available for the Site that would influence the Project temporal boundaries.

### 13 **7.5.4.3 Administrative Boundaries**

14 The Project is located on Category A Treaty Land, as defined in the Nisga'a Treaty. The terrestrial  
15 components will be located within District Lots 5431 and 7235. There are no administrative boundaries  
16 imposed by political, economic, or social constraints related to Groundwater.

### 17 **7.5.4.4 Technical Boundaries**

18 The following technical boundaries were defined for the Groundwater assessment:

- 19 • Groundwater desktop assessment study for the LAA
- 20 • Project construction and design parameters – The Groundwater assessment has been prepared  
21 based on the understanding of the preferred construction methods and Project design at the time  
22 of filing. However, detailed engineering studies are ongoing. Results of these studies may change  
23 or refine the construction methods and/or Project design during permitting, prior to construction

### 24 **7.5.5 Existing Conditions**

25 This section summarizes the existing conditions as they relate to the Groundwater assessment and focuses  
26 on the assessment areas described in Section 7.5.4.

#### 27 **7.5.5.1 Methods**

28 Data and information sources used to characterize existing conditions were gathered through a review of  
29 relevant literature, publicly available provincial data, reported use information, and the Site data for the  
30 Project. No field studies were conducted in support of the Groundwater assessment.

1 Table 7.5–3 summarizes the data reviewed to characterize the existing groundwater conditions in the  
2 RAA.

3 **Table 7.5–3 – Data Sources Reviewed to Characterize the Existing Conditions for Groundwater**

Report or Dataset	Author/Source <sup>2</sup>
<b>Provincial Datasets</b>	
<a href="#">Ground Water Aquifers - Datasets - Data Catalogue (gov.bc.ca)</a>	BC ENV
<a href="#">Groundwater Wells - Datasets - Data Catalogue (gov.bc.ca)</a>	BC ENV
<a href="#">Water Rights Licences - Public - Datasets - Data Catalogue (gov.bc.ca)</a>	BC FOR
<a href="#">Bedrock Geology - Datasets - Data Catalogue (gov.bc.ca)</a>	BC EMLI
<a href="#">Geology Quaternary Alluvium and Cover - Datasets - Data Catalogue (gov.bc.ca)</a>	BC EMLI

NOTES:

BC ENV Ministry of Environment and Climate Change Strategy  
BC EMLI Ministry of Energy, Mines, and Low Carbon Innovation  
BC FOR Ministry of Forests

4 **7.5.5.2 Overview**

5 The following sections provide an overview of the existing conditions for Groundwater, based on the  
6 review of available existing data.

7 **7.5.5.2.1 Conceptual Model**

8 Groundwater flow regimes are conceptualized as nested regional, intermediate, and local scale systems  
9 (Toth 1963). Regional groundwater flow reflects the variation of large-scale topographic, physiographic,  
10 and geologic features. Local groundwater flow systems reflect smaller-scale variations in topography and  
11 geologic features (i.e., the variation of these features in the vicinity of the Project). Local areas are often  
12 dominated by one aspect of the larger-scale regional flow system (Freeze and Cherry 1979). On a regional  
13 scale, groundwater will generally recharge at higher elevations and discharge at lower elevations  
14 (Freeze and Cherry 1979).

15 The following summary of the existing hydrogeological regime provides the conceptual framework  
16 through which potential effects of the Project were evaluated. Based on available information,  
17 groundwater in the LAA and RAA have not been affected by any anthropogenic activities. Climate change  
18 and its potential effect on Groundwater in the LAA and RAA is discussed in Section 7.5.8.1.2.

19 **7.5.5.2.2 Site Setting**

20 The Site is located on District Lots 7235 and 5431 at the northern end of Pearse Island. Pearse Island is  
21 about 29 km long and 8 km wide at its widest point (iMAP BC 2022). Surface topography on both lots  
22 generally increases to the south, with maximum elevation at the southern edge of DL 7235 at  
23 approximately 60 metres above sea level (**masl**) and maximum elevation at the southern edge of DL 5431  
24 at approximately 120 masl (iMAP BC 2022). Elevations are greater along the eastern side of Pearse Island  
25 than along the western side.

### 1 **7.5.5.2.3 Surficial Geology**

2 Unconsolidated deposits mapped across the District Lots include glaciomarine sediments, colluvium, till,  
3 and organics (McCuaig 2003). Deposit landforms are generally veneers; thin (one to two metres thick),  
4 discontinuous horizons of material with numerous areas of exposed bedrock. Thicker glaciomarine  
5 sediments have been mapped about 400 m south of the parcel boundary (McCuaig 2003).  
6 The unconsolidated deposits with inferred descriptions and respective thicknesses are summarized in  
7 Table 7.5–4.

### 8 **7.5.5.2.4 Bedrock Geology**

9 Bedrock underlying the north half of Pearse Island has been mapped as early Tertiary granodiorite  
10 (MacIntyre et al. 1994). Fresh, competent granodiorite is typically characterized with low primary porosity  
11 (Freeze and Cherry 1979). Based on available literature, the only potential for any groundwater  
12 accumulation will depend on the characteristics of secondary fracturing joining to store and transmit  
13 water. The bedrock characteristics, along with thicknesses, are summarized in Table 7.5–4.

### 14 **7.5.5.2.5 Hydraulic Conductivity, Aquifers and Groundwater Elevations**

15 There is limited hydrogeological data for the RAA or Pearse Island. From the provincial database  
16 (iMAP 2022), there is no borehole data to confirm geology and estimate hydraulic conductivity and  
17 no reported monitoring wells or aquifer mapping on the Island. The hydraulic conductivity, aquifer  
18 (potential water storage), and groundwater elevations are inferred from the limited geological data  
19 and literature.

20 The reported surficial glaciomarine sediments (i.e., till and diamicton, both similar in grain size distribution)  
21 have high fractions of clay and silt particles. In general, deposits containing higher fractions of clay and silt  
22 have a high porosity (up to 50%) but have low permeability as the void space is not well connected  
23 (Freeze and Cherry 1979). Typically, hydraulic conductivity in till units ranges between  $1.0 \times 10^{-4}$  m/s and  
24  $1.0 \times 10^{-10}$  metres per second (**m/s**) (Freeze and Cherry 1979). The combination of typically low  
25 permeability sediment present in thin layers suggests that there is limited potential for groundwater flow  
26 and the unit would be considered as an aquitard.

27 Granodioritic bedrock typically has a low primary porosity ranging from 0.2-0.3 percent (Möri et al. 2021)  
28 and a low hydraulic conductivity ranging from  $1 \times 10^{-7}$  to  $1 \times 10^{-10}$  (Freeze and Cherry 1979) due to its  
29 crystalline structure. Any potential for hydraulic connectivity, and therefore groundwater flow, will  
30 depend on the presence and characteristics of secondary fracturing. There is considerable uncertainty  
31 associated with the presence of secondary fracturing; in general, however, likelihood of groundwater  
32 storage in the bedrock is low.

33 Where present, the groundwater table in the surficial deposits likely mimics the topography and any  
34 groundwater movement would be from topographically higher regions to topographically lower regions  
35 and water bodies. Groundwater is not expected to be present in the granodioritic bedrock, therefore  
36 groundwater flow in this unit would be negligible. Qualitative hydraulic conductivities and aquifer  
37 potential based on sediment descriptions from the literature are summarized in Table 7.5–4.

1 **Table 7.5–4 – Hydrogeological Characteristics of Surficial Sediments and Bedrock**

<b>Geologic Material and Landform<sup>a</sup> (Symbol)</b>	<b>Description</b>	<b>Thickness (m)</b>	<b>Permeability</b>	<b>Groundwater Storage (Aquifer) Potential</b>
Colluvium Veneer (Cv)	Diamicton; discontinuous cover with numerous areas of exposed bedrock; takes the form of underlying surface.	1 to 2	Low	Poor; based on thickness and permeability
Glaciomarine Veneer (Mv)	Massive silty clay with minor sand, silt, and granule gravel; discontinuous cover with numerous areas of exposed bedrock; takes form of underlying surface.	1 to 2	Very low	Poor; based on thickness and permeability
Till Veneer (Tv)	Till; discontinuous cover with numerous areas of exposed bedrock and locally, colluvial veneer; takes form of underlying surface.	1 to 2	Low	Poor; based on thickness and permeability
Tertiary Granodiorite (ETgd)	Granodiorite	100s	Primary: very low Secondary: low to Moderate	Poor to moderate, heavily dependent on presence of an interconnected network of water-bearing fractures or fracture systems.

NOTES:

<sup>a</sup> Landform descriptor applies to sediments.

Sediment Type, Landform, Description, and Thickness from McCuaig (2003). Permeability, and groundwater resource potential inferred by Stantec Consulting Ltd. (Stantec).

Bedrock type, symbol, and description from MacIntyre et al. (1994). Thickness, permeability, and groundwater resource potential inferred by Stantec.

Permeability assessment based on accepted permeability ranges for each sediment type in Freeze and Cherry (1979).

2

3 **7.5.5.2.6 Flow Paths and Groundwater Surface Water Interactions**

4 Based on available information for the Site, the regional groundwater flow-paths are interpreted to be  
5 towards the lowest elevations at the Pearse and the Portland Canals. Locally, the presence of clay and silt  
6 lenses makes the surficial sediments likely to act as confining or partially confining layers, depending on  
7 their lateral extent, and potentially as barriers to any groundwater flow. The bedrock is characterized as  
8 a distinct, lower permeability hydrostratigraphic unit, which likely restricts the existence of any  
9 groundwater flow system (i.e., no recharge with the precipitation water likely moving as the surface runoff  
10 or surface water body). Due to presence of these clay and silt lenses, vertical groundwater flow within the  
11 Project footprint is likely limited (i.e., low downward flow into the overburden and the bedrock).

12 Figure 7.5–3 presents an inferred groundwater flow direction for a general cross-section in the region.  
13 Figure 7.5–2 presents a general inferred flow direction for the RAA, with the green arrow representing a  
14 regional potential flow and the red arrows representing the shallow potential flow.

1 Flow between the groundwater system and surface water environment (groundwater - surface water  
2 interactions) occurs due to differences in groundwater and surface water elevations. Where the elevation  
3 of groundwater is higher than that of the overlying surface water environment, groundwater will flow  
4 towards and eventually discharge at the surface water environment (groundwater discharge conditions).  
5 Where the elevation of the surface water environment is higher than adjacent groundwater elevations,  
6 surface water will infiltrate to ground. In general, topography indicates where discharge or recharge  
7 conditions occur and, in the absence of Site-specific information, groundwater can be expected to  
8 discharge to streams in valley bottoms (Freeze and Cherry 1979) and areas adjacent to the marine  
9 environment. Since the LAA and RAA occupy the lowest elevations on the north end of Pearse Island,  
10 groundwater discharge conditions are expected within these areas.

11 Although differences between groundwater and surface water elevations (the hydraulic gradient) drive  
12 the direction of groundwater-surface water flow (groundwater discharge or recharge), the rate of flow  
13 depends on the permeability of the surficial and bedrock geology underlying the surface water  
14 environment. Since surficial and bedrock geology underlying the LAA and RAA are generally expected to  
15 be low-permeability (Table 7.5-3), the rate of groundwater discharge to the surface water environment is  
16 also expected to be low.

17 **7.5.6 Selection of Potential Effects and Indicators/Measurable Parameters**

18 The potential effects of the Project on Groundwater, identified in Table 7.5–5, was established in the AIR.  
19 The effect pathway and indicators/measurable parameters were identified to facilitate the quantitative  
20 or qualitative measurement of change caused by the Project. The assessment of potential effects on  
21 Groundwater considers change in groundwater quantity caused by direct and indirect effects resulting  
22 from Project activities.

23 Due to the lack of hydrogeological information available for the RAA and Pearse Island, the effects on  
24 Groundwater are predicted qualitatively through use of scientific literature, professional judgment, and  
25 relevant project experience.

**Table 7.5–5 – Potential Effects, Effects Pathways and Indicators/Measurable Parameters for Groundwater**

Potential Effect	Effect Pathway	Indicator and/or Measurable Parameter(s) and Units of Measurement
Change in local groundwater levels	Change in infiltration rate caused by Project construction and operation of land-based facilities.	<ul style="list-style-type: none"> <li>▪ Change in groundwater levels or surface water-groundwater recharge/discharge characteristics (e.g., artesian conditions in subsurface generating seeps/springs at surface or near surface).</li> </ul>

## 1 7.5.7 Project Groundwater Interactions

2 Table 7.5–6 identifies the potential interactions between the Project’s components and physical activities  
3 and groundwater. The table also lists the potential effects on Groundwater. Interactions that have been  
4 identified (ranked as 1 or 2) are carried forward and assessed. Each of the effects identified are discussed  
5 in detail, in the context of effects pathways, mitigation/enhancement, and residual effects. Rationale for  
6 interactions ranked as 0 is provided following Table 7.5–6.

**Table 7.5–6 – Potential Project Interactions and Effects on Groundwater**

Project Activities and Physical Works	Potential Project Effects
	Change in Local Groundwater levels
<b>Construction</b>	
Procurement of labour, goods, and services	0
Site preparation and clearing	1
Construction of temporary and permanent land-based infrastructure (includes transmission line within the TLAA*)	1
Construction of temporary and permanent marine-based infrastructure (includes transmission line within the TLAA*)	0
Marine transport of workforce and construction materials to the Site	0
Land transportation of workforce and construction materials from Terrace to Gingolx or Prince Rupert (for marine transport to Site)	0
Waste management	0
<b>Operation</b>	
Procurement of labour, goods, and services	0
Natural gas pre-treatment, liquefaction, storage and offloading of LNG and NGL products (condensate) at the FLNG barges (includes storage of NGLs)	0
LNG carrier and NGL product vessel loading	0
Marine shipping and transportation (include tugs) from Prince Rupert and/or Gingolx to Site	0
Land transportation of workforce to Gingolx (for marine transport to Site)	0
Facility and infrastructure maintenance (includes transmission line within the TLAA*)	0
Waste management	0
Temporary on-Site power generation on barges	0

**Table 7.5–6 – Potential Project Interactions and Effects on Groundwater**

Project Activities and Physical Works	Potential Project Effects
	Change in Local Groundwater levels
<b>Decommissioning</b>	
Procurement of labour, goods, and services	0
Decommissioning or re-purposing of land-based infrastructure (includes transmission line within the TLAA*)	1
Decommissioning of marine-based infrastructure (includes transmission line within the TLAA*)	0
Land transportation of workforce to Gingolx (for marine transport to Site)	0
Marine transport of decommissioned infrastructure	0
Waste management	0

**Key:**

0 = Negligible or no effect expected; no further consideration warranted.

1 = Potential adverse effect that warrants consideration, and requires mitigation through current legal or policy management, best management practice(s) and/or Project-specific mitigation.

2 = Potential adverse effect of particular importance or concern that warrants further detailed assessment

+ = Potential positive effect that can be enhanced; warrants further consideration

\* = As per Table 3 (Section 6.4) of the AIR, the Transmission Line Assessment Area is not applicable for this VC

- 1
- 2 Rationale for ‘negligible or no effect’ (ranked as 0) identified in Table 7.5–6 generally conform to one of
- 3 the following categories:
- 4 • Activities for which no apparent pathway to a potential effect exists (i.e., procurement of labour,
  - 5 goods, and services; marine-based infrastructure construction and re-purposing; land
  - 6 transportation of workforce; marine transport).
  - 7 • Localized or more passive activities within the Site boundaries (i.e., waste management, natural
  - 8 gas pre-treatment, liquefaction, storage, and offloading), which are conducted in isolation,
  - 9 resulting in no interaction with groundwater.
  - 10 • Localized activities within the Site boundaries (i.e., operation activities, facility and infrastructure
  - 11 maintenance) for which the effects on groundwater are predicted to be comparable to existing
  - 12 conditions.

## 1 **7.5.8 Assessment Methods**

2 This section describes the residual effects characterization terms, the key residual effect threshold, and  
3 the likelihood of residual effects categories. It is the framework for the assessment of the potential effects  
4 on Groundwater.

### 5 **7.5.8.1 Analytical Assessment Techniques**

6 As outlined in Table 7.5–5, a change in local groundwater levels may occur through the pathway of change  
7 in groundwater recharge caused by construction works activities that alter precipitation infiltration into  
8 the ground surface. The analysis of a change in groundwater recharge was completed by considering the  
9 areal extent where infiltration rate may change relative to current conditions and, using professional  
10 judgment, qualitatively assessing the resulting effect on groundwater levels near the Project footprint.

11 Project activities that may change the rate of groundwater recharge include the activities (Table 7.5–7)  
12 that change the evapotranspiration and runoff coefficients and include:

- 13 • Site preparation and clearing
- 14 • Construction of temporary and permanent land-based infrastructure

15 These changes may affect the fraction of precipitation that infiltrates as groundwater recharge and affect  
16 groundwater levels as a result. The two activities will increase the runoff coefficient, thereby decreasing  
17 the infiltration and the evapotranspiration. After the decommissioning phase the recharge and the  
18 associated evapotranspiration will revert to pre-construction values, assuming there has been no change  
19 in the presence/thickness of surficial sediments, thereby resulting in positive effects as compared to  
20 construction and operation phase.

### 21 **7.5.8.2 Residual Effects Characterization**

22 The groundwater LAA and RAA are in a relatively undisturbed area with little to no anthropogenic  
23 development and little disturbance except for some historical logging activities. The assessment of  
24 potential effects on groundwater with lack of available data are undertaken with an understanding of  
25 context, which establishes the circumstances and setting within which potential effects are expected to  
26 occur. The context for groundwater quantity is built into the assessment of residual effects and the  
27 assessment of cumulative effects and includes relevant regulatory framework, existing conditions, climate  
28 change projections, and Indigenous values.

29 Table 7.5–7 presents definitions and criteria that are used to characterize the adverse residual effects on  
30 groundwater.

**Table 7.5–7 – Characterization of Residual Effects**

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Magnitude	The amount of change in measurable parameters or the VC relative to existing conditions.	<p><b>No Measurable Change</b> – no measurable change in the groundwater levels.</p> <p><b>Low</b> – a change in groundwater level due to the Project that is predicted to be less than 1 m.</p> <p><b>Moderate</b> – a change in groundwater level due to the Project that is predicted to be between 1 m and 3 m.</p> <p><b>High</b> – a change in groundwater level due to the Project that is predicted to be greater than 3 m.</p>
Geographic Extent	The geographic area in which a residual effect occurs.	<p><b>Project footprint</b> – residual effects are restricted to the Project footprint</p> <p><b>LAA</b> – residual effects extend into the LAA</p> <p><b>RAA</b> – residual effects extend into the RAA</p>
Timing	Considers when the residual environmental effect is expected to occur. Timing considerations are noted in the evaluation of the residual environmental effect, where applicable or relevant.	<p><b>Not Applicable</b> – seasonal aspects are unlikely to affect residual effects on Groundwater Quantity</p> <p><b>Applicable</b> – seasonal aspects may affect residual effect on Groundwater Quantity</p>
Duration	The time required until the measurable parameter or the VC returns to its existing condition, or the residual effect can no longer be measured or otherwise perceived.	<p><b>Short-term</b> – residual effect restricted to no more than the duration of the construction phase (3-4 years)</p> <p><b>Medium-term</b> – residual effect extends through the operation phase (30 years)</p> <p><b>Long-term</b> – residual effect extends beyond the operation phase (&gt;30 years)</p>
Reversibility	Pertains to whether a measurable parameter or the VC can return to its existing condition after the Project activity ceases.	<p><b>Reversible</b> – the residual effect is likely to be reversed after activity completion and reclamation</p> <p><b>Partially reversible</b> – the residual effect can be partially reversed</p> <p><b>Irreversible</b> – the residual effect is unlikely to be reversed</p>
Frequency	How often the residual effect occurs and how often during the Project or in a specific phase.	<p><b>Single event</b> – effect occurs once</p> <p><b>Multiple irregular event</b> – occurs at no set schedule</p> <p><b>Multiple regular event</b> – occurs at regular intervals</p> <p><b>Continuous</b> – occurs continuously</p>

**Table 7.5–7 – Characterization of Residual Effects**

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories																																											
Risk (Likelihood and Consequences)	<p>Assesses the likelihood and consequences of the potential residual effect. Likelihood is the probability of the residual effect occurring and should consider many factors. Consequence is the potential outcome of the residual effect. Risk is the interaction between likelihood and consequence (see risk rating table).</p>	<p><b>Consequences:</b> defined as minor, moderate or major based primarily on a combination of Magnitude and Geographic Extent as:</p> <table border="1" data-bbox="768 443 1416 905"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="2">Geographic Extent</th> </tr> <tr> <th>Project Footprint or LAA</th> <th>RAA</th> </tr> </thead> <tbody> <tr> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">Magnitude</td> <td>No Measurable Change</td> <td>Minor</td> <td>Minor</td> </tr> <tr> <td>Low</td> <td>Minor</td> <td>Minor or Moderate</td> </tr> <tr> <td>Moderate</td> <td>Minor or Moderate</td> <td>Moderate</td> </tr> <tr> <td>High</td> <td>Moderate or Major</td> <td>Major</td> </tr> </tbody> </table> <p>*Where relevant, Duration is also taken into consideration (e.g., a high Magnitude event within the LAA may be Moderate or Major in Consequence and Duration could be considered)</p> <p><b>Likelihood:</b> defined as low (i.e., &lt;40% chance of occurring); medium (i.e., between 40% and 80% chance of occurring; and high (i.e., &gt;80% chance of occurring).</p> <p><b>Risk:</b> defined as low, moderate, and high risk of effect prediction as delineated by the various consequence and likelihood scenarios shown in the table below.</p> <table border="1" data-bbox="768 1318 1409 1669"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="3">Consequence</th> </tr> <tr> <th>Major</th> <th>Moderate</th> <th>Minor</th> </tr> </thead> <tbody> <tr> <td rowspan="3" style="writing-mode: vertical-rl; transform: rotate(180deg);">Likelihood</td> <td>High (&gt;80% chance)</td> <td>High</td> <td>Moderate</td> <td>Low</td> </tr> <tr> <td>Medium (40-80% chance)</td> <td>High</td> <td>Moderate</td> <td>Low</td> </tr> <tr> <td>Low (&lt;40% chance)</td> <td>Moderate</td> <td>Low</td> <td>Low</td> </tr> </tbody> </table>						Geographic Extent		Project Footprint or LAA	RAA	Magnitude	No Measurable Change	Minor	Minor	Low	Minor	Minor or Moderate	Moderate	Minor or Moderate	Moderate	High	Moderate or Major	Major			Consequence			Major	Moderate	Minor	Likelihood	High (>80% chance)	High	Moderate	Low	Medium (40-80% chance)	High	Moderate	Low	Low (<40% chance)	Moderate	Low	Low
		Geographic Extent																																											
		Project Footprint or LAA	RAA																																										
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	Medium (40-80% chance)	High	Moderate	Low																																									
	Low (<40% chance)	Moderate	Low	Low																																									

**Table 7.5–7 – Characterization of Residual Effects**

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Uncertainty	The degree of uncertainty as assessed for the data and methods including potential effectiveness of mitigation that have been used in the assessment of effects.	<p><b>Low</b> – good understanding of the pathway to effect(s) on the VC due to the Project activities and/or physical works and sufficient data is available to support the assessment. Uncertainty associated with data and/or modelling is low. The effectiveness of the selected mitigation is expected to be moderate to high. Overall, uncertainty in the predicted residual effect is low.</p> <p><b>Moderate</b> – potential uncertainty associated with the pathway to effect(s) on the VC due to the Project activities and/or physical works, e.g., due to unknown external variables or incomplete data. Potential for uncertainty associated with data and/or modelling. The effectiveness of mitigation is expected to be moderate to low. Uncertainty in the predicted residual effect is considered moderate.</p> <p><b>High</b> – poor understanding of the pathway to effect(s) on the VC due to the Project activities and/or physical works. May be unknown external variables and/or data for the Project is incomplete. Modelling results may vary considerably with inputs. The effectiveness of the mitigation may be expected to be low or is unproven. Overall, there is a high degree of uncertainty associated with the predicted residual effect.</p>

1

2 **7.5.9 Assessment of Residual Effects**

3 **7.5.9.1 Assessment of Change in Local Groundwater Levels**

4 This section describes the analytical pathways, mitigation measures, predicted residual effects, and

5 likelihood of predicted residual effects as they pertain to change in groundwater quantity.

6 **7.5.9.1.1 Project Pathways**

7 Project activities during construction, operation, and decommissioning are expected to result in changes

8 to groundwater quantity. Site preparation and clearing, construction of temporary and permanent land-

9 based infrastructure, and facility and infrastructure maintenance will result in a decrease in the

10 groundwater quantity. These changes will affect the top surface, which affects the fraction of precipitation

11 that infiltrates as groundwater recharge, contributing to groundwater quantity or levels. For example,

12 changing the ground surface from natural surface to a paved surface results in a decrease in recharge,

13 thereby resulting in increased runoff and a decrease in groundwater levels or quantity. A decrease in

14 groundwater levels could potentially reduce the assumed groundwater discharge to nearby surface water

15 environments by reducing the difference (the hydraulic gradient) between groundwater and surface

16 water elevations. Further, change in groundwater levels or quantity has the potential to influence the

17 incidence of saltwater intrusion; however, since there is no planned groundwater extraction associated

18 with the Project, the potential for the Project to affect a saltwater intrusion pathway is low.

1 Groundwater quantity will revert to pre-construction values after the decommissioning or re-purposing  
2 of land-based infrastructure, subject to limited change in surficial sediments.

### 3 **7.5.9.1.2 Climate Change and its Effects on Groundwater in the LAA and RAA**

4 Climate change is defined as the long-term continuous increase or decrease of any statistical form of  
5 climatic variables such as temperature and precipitation. The statistical form can be mean, variability, or  
6 extreme (ECCC 2022a). Climate change projections of future climates are available from numerous global  
7 climate models and emission scenarios. Climate change scenarios and projections for the Project-affected  
8 area are described in Section 8.0. Generally, year-round air temperatures and precipitation are expected  
9 to increase over time. Despite this increased precipitation, over time the snowpack is expected to  
10 decrease due to increased air temperatures, except in January.

11 Jyrkama and Sykes (2016) analyse the affects of climate change on groundwater. As they describe, climate  
12 change affects surface water resources directly through changes in the major long-term climate variables  
13 such as air temperature, precipitation, and evapotranspiration. The relationship between the changing  
14 climate variables and groundwater is more complicated and poorly understood. Groundwater resources  
15 are related to climate change through the direct interaction with surface water resources, such as lakes  
16 and rivers, and indirectly through the recharge process. Therefore, quantifying the impact of climate  
17 change on groundwater resources requires not only reliable forecasting of changes in the major climatic  
18 variables, but also accurate estimation of groundwater recharge, which is challenging.

19 The effects of these changing processes on groundwater will be spatially variable and complex, even  
20 within the LAA and RAA. Groundwater processes affected by expected climate change that are pertinent  
21 to groundwater quantity in the LAA and RAA include increased evapotranspiration, decreased snow  
22 accumulation and accelerated melt, altered timing and magnitude of streamflows, altered recharge due  
23 to vegetation change, and changes in the frequency/magnitude of hillslope and geomorphic processes  
24 (Pike et al. 2010).

### 25 **7.5.9.1.3 Mitigation and Enhancement Measures**

26 Mitigation and enhancement measures were selected based on provincial and federal regulations and  
27 policies, management practices and guidelines, and relevant peer-reviewed literature. Mitigation was  
28 selected to address Project interactions that affect groundwater quantity during all Project phases.  
29 Table 7.5–8 provides a summary of the mitigation measures to avoid or reduce change in groundwater  
30 quantity. No enhancement measures were identified. In conjunction with these measures, the Proponents  
31 will develop and implement a Project-specific CEMP that collects the mitigation and enhancement  
32 measures tied to Project-related activities and physical works associated with construction. The CEMP will  
33 be incorporated into appropriate construction-related contracts.

- 1 While the mitigation measures are intended for the Proponent, Project contractors will be required to
- 2 implement these measures as applicable to their scope of work.

**Table 7.5–8 – Mitigation Measure Proposed to Avoid or Reduce Change in Local Groundwater Levels**

Mitigation/Mitigation Mechanism	Rationale for Selection	Expected Success/Risks and Uncertainty	Timing	Management and/or Compensation Plans
<p><b>Mitigation 7.04-2:</b> Develop and implement measures for water and stormwater management</p> <p><b>Mitigation Mechanism:</b> The implemented mitigation measures will result in efficient management of stormwater (e.g., runoff), reducing impact on ground water quantity by limiting the change in groundwater recharge. Limiting the change in surficial deposits will reduce long-term changes to groundwater quantity.</p>	<p>Stormwater management methods to maintain groundwater recharge are widely used and are effective.</p> <p>This mitigation measure is recommended to reduce the change in surface recharge and increase the probability of the Site returning to pre-construction conditions.</p>	<p><b>Expected Success:</b> There is a high likelihood of success associated with this mitigation measure as implementing this will result in Site conditions like those present pre-construction.</p> <p><b>Risk and Uncertainty:</b> There is little uncertainty about the effectiveness of this mitigation measure; efficient stormwater management will reduce changes in groundwater quantity.</p>	<p><b>Project Phase:</b> Construction, Operation</p> <p><b>Effectiveness:</b> This mitigation measure is expected to be effective in the short-term and medium-term.</p>	<p>CEMP</p>

3  
4 **7.5.9.1.4 Project Residual Effect**

5 For the construction and operation phase, changes in ground surface material, permeability, or slope  
6 within the Project footprint where impervious surfaces remain, or vegetation is removed will result in  
7 reduced evapotranspiration rates, increased runoff, and may result in decreased infiltration (recharge)  
8 rates. There is no planned groundwater extraction associated with the Project.

9 The mitigation measures that will be implemented to avoid or reduce potential effects to ground water  
10 quantity during construction, operation, and decommissioning of the Project are expected to be highly  
11 effective. During construction and operation, industry-standard measures will be implemented to  
12 efficiently manage stormwater. These potential residual effects related to groundwater recharge will be  
13 managed through implementation of the CEMP which will include guidelines, best management practices  
14 (**BMPs**), and measures related to stormwater management to limit Project-related effects on  
15 groundwater quantity. During decommissioning, the reclamation of surficial deposits, as will be described  
16 in the CEMP, will result in the recharge rate and the associated groundwater levels returning to near

1 pre-construction values. These measures are industry standard and used throughout BC, including in  
2 north coast locations with similar conditions to those present in the Groundwater LAA.

3 The magnitude of the change in groundwater recharge, and therefore groundwater levels, is low; although  
4 this change cannot be quantified, the affected area will be restricted to the Project footprint. With the  
5 expected low magnitude of groundwater level changes associated with the Project, the potential for  
6 Project-induced effects such as a reduction in groundwater discharge to surface water environments or  
7 saltwater intrusion is considered low. The Project is expected to have a low magnitude residual effect on  
8 groundwater quantity; this residual effect will be localized to the LAA, a short-term (construction and  
9 decommissioning) to medium-term (operation), continuous event during each Project phase. The residual  
10 adverse effect to groundwater quantity will be reversible. With the implementation of mitigation  
11 measures, the likelihood of a residual effect to groundwater levels (quantity) due to decreased  
12 groundwater recharge during construction and operation is predicted to be low.

### 13 **7.5.9.2 Summary of Project Residual Effects**

14 Table 7.5–9 summarizes the Project residual effects on groundwater. As groundwater is not being  
15 considered as a water source, and with the suggested mitigation measures, the uncertainty associated  
16 with the residual effects is considered to be low.

17

**Table 7.5–9 – Project Residual Effects on Groundwater**

Project Phase	Proposed Mitigation and Enhancement Measures	Residual Effects Characterization Criteria								
		Magnitude	Geographic Extent	Timing	Duration	Reversibility	Frequency	Affected Sub-Populations	Risk (Likelihood and Consequences)	Uncertainty
<b>Change in Local Groundwater Levels</b>										
Construction	A	L	LAA	N/A	ST	R	C	N/A	L	L
Operation	A	L	LAA	N/A	MT	R	C	N/A	L	L
Decommissioning	A	L	LAA	N/A	ST	R	S	N/A	L	L
Residual Project effect for all phases	A	L	LAA	N/A	ST-MT	R	S-C	N/A	L	L

**KEY**

See Table 7.5– for detailed definitions.

**Project Phase**

- C: Construction
- O: Operation
- D: Decommissioning

**Magnitude:**

- NMC: No Measurable Change
- L: Low
- M: Moderate
- H: High

**Geographic Extent:**

- PA: Project footprint
- LAA: Local Assessment Area
- RAA: Regional Assessment Area
- OWAA: Open Water Assessment Area

**Timing:**

N/A: Not Applicable

A: Applicable

**Duration:**

- ST: Short-term
- MT: Medium-term
- LT: Long-term

**Reversibility:**

- R: Reversible
- PR: Partially reversible
- I: Irreversible

**Frequency:**

- S: Single event
- MIR: Multiple irregular event
- MR: Multiple regular event
- C: Continuous

**Affected Sub-Populations:**

- ED: Evenly distributed
- DD: Disproportionately distributed

**Risk (Likelihood and Consequences)**

- L: Low
- M: Moderate
- H: High

**Uncertainty:**

- L: Low
- M: Moderate
- H: High

1 **7.5.9.2.1 Summary of Adverse Residual Effects**

2 Construction (i.e., clearing and grading), operation, and decommissioning of the land-based infrastructure  
3 are expected to have an adverse residual effect on groundwater quantity that is low in magnitude,  
4 localized to the LAA, short-term to medium-term, and continuous during each Project phase. Potential  
5 adverse effects to groundwater quantity will be reversible.

6 With the implementation of mitigation measures (Table 7.5–8), the potential adverse residual effects on  
7 groundwater quantity are nearly eliminated or reduced. After decommissioning, the groundwater  
8 quantity is anticipated to revert back to pre-construction values.

9 **7.5.9.2.2 Summary of Positive Residual Effects**

10 No positive residual effects to groundwater quantity have been predicted, compared to existing  
11 conditions.

12 **7.5.10 Assessment of Cumulative Effects**

13 The Project is predicted to have a low magnitude adverse residual effect on groundwater quantity, as  
14 described in Section 7.5.8.1. However, because there are no past, present or reasonably foreseeable  
15 future projects or activities (see Table 6.7-1 in Section 6.7.1 in the Project and Physical Activities Inclusion  
16 List) that may interact temporally or spatially with the Project’s residual effect on groundwater quantity  
17 within the RAA there is no potential for a cumulative effect. Therefore, no cumulative effects assessment  
18 is required for Groundwater.

19 **7.5.11 Prediction Confidence**

20 Groundwater has not been considered as a water supply source for the Project. Data and information  
21 sources used to characterize existing conditions for the effect analysis were gathered through a review of  
22 relevant literature, publicly available provincial data, reported use information, and the Site data for the  
23 Project. There is a marked lack of hydrogeological data in the RAA or Pearse Island in general. Regarding  
24 the objective of the evaluation, the prediction confidence for Project residual effects and residual  
25 cumulative effects for groundwater is medium.

1 **7.5.12 Follow-up Program**

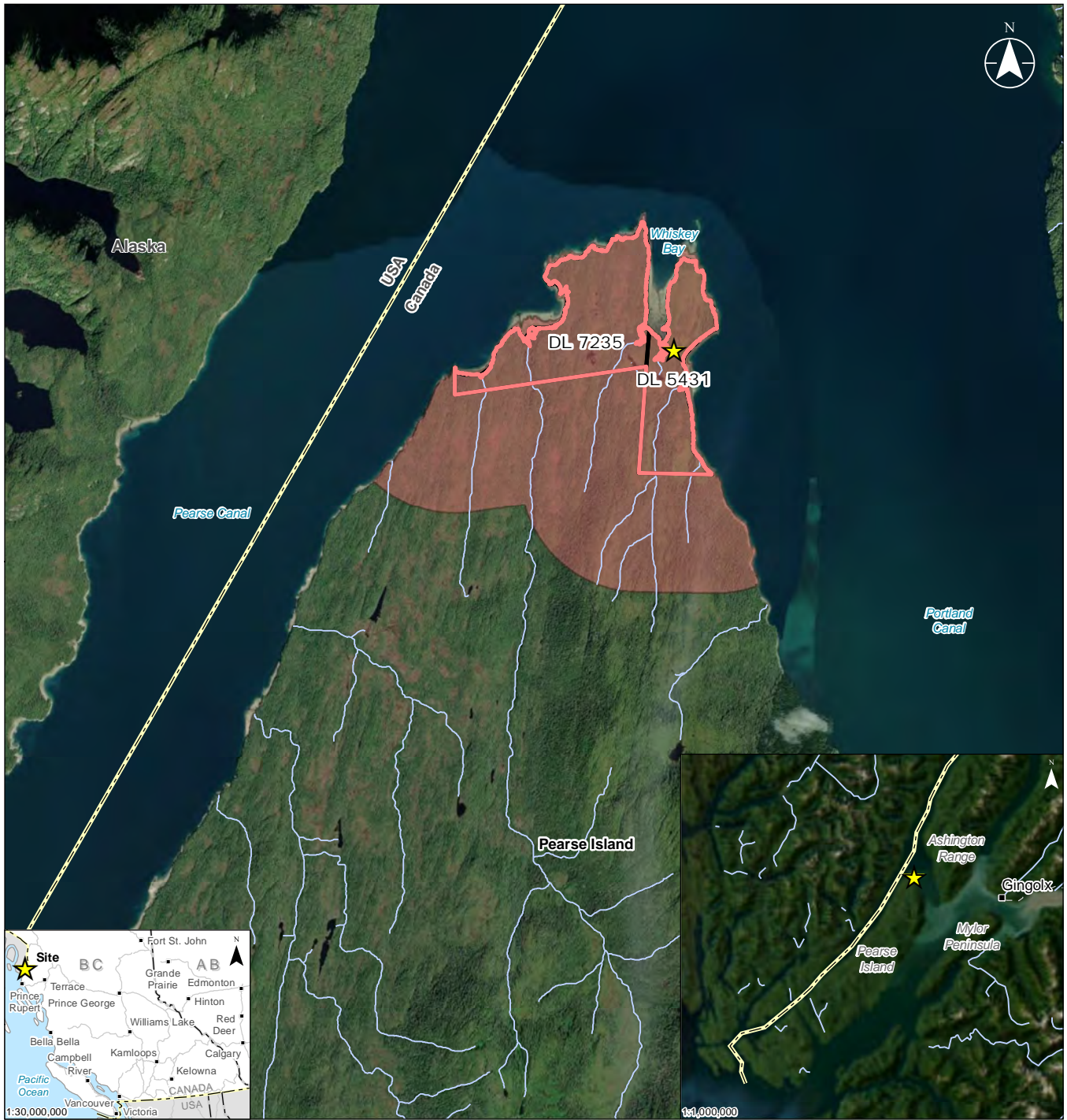
2 The assessment of potential effects on Groundwater did not result in the identification of material adverse  
3 effects. In addition, the proposed mitigation measure is a well established, standard industry practice.  
4 On this basis, the Proponents are not proposing a follow-up program for groundwater.







5 To verify compliance of the Project with commitments in this Application, and conditions of an  
6 environmental assessment certificate, the Proponents are committed to the development of a CEMP that  
7 contains the mitigation measures required as conditions of the environmental assessment certificate. The  
8 CEMP will describe mitigation measures that will be implemented during construction, operation and  
9 decommissioning phase of the Project to avoid or reduce potential adverse effects of Project activities on  
10 groundwater. These plans will be developed in consultation with Indigenous nations and will be provided  
11 to the BC OGC, BC EAO, and Impact Assessment Agency of Canada to document compliance with this  
12 commitment.

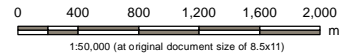
13

1 **7.5.13 Figures**

2



-  Site
-  Boundaries of District Lots 7235 and 5431
-  Groundwater Local Assessment Area
-  Groundwater Regional Assessment Area
-  International Boundary
-  Watercourse



Project Location: Pease Island, BC  
 Project Number: 123221820  
 Prepared by TQUILICHINI on 20220506  
 Requested by EWATERFIELD on 20220506  
 Checked by SMOSS on 20220506

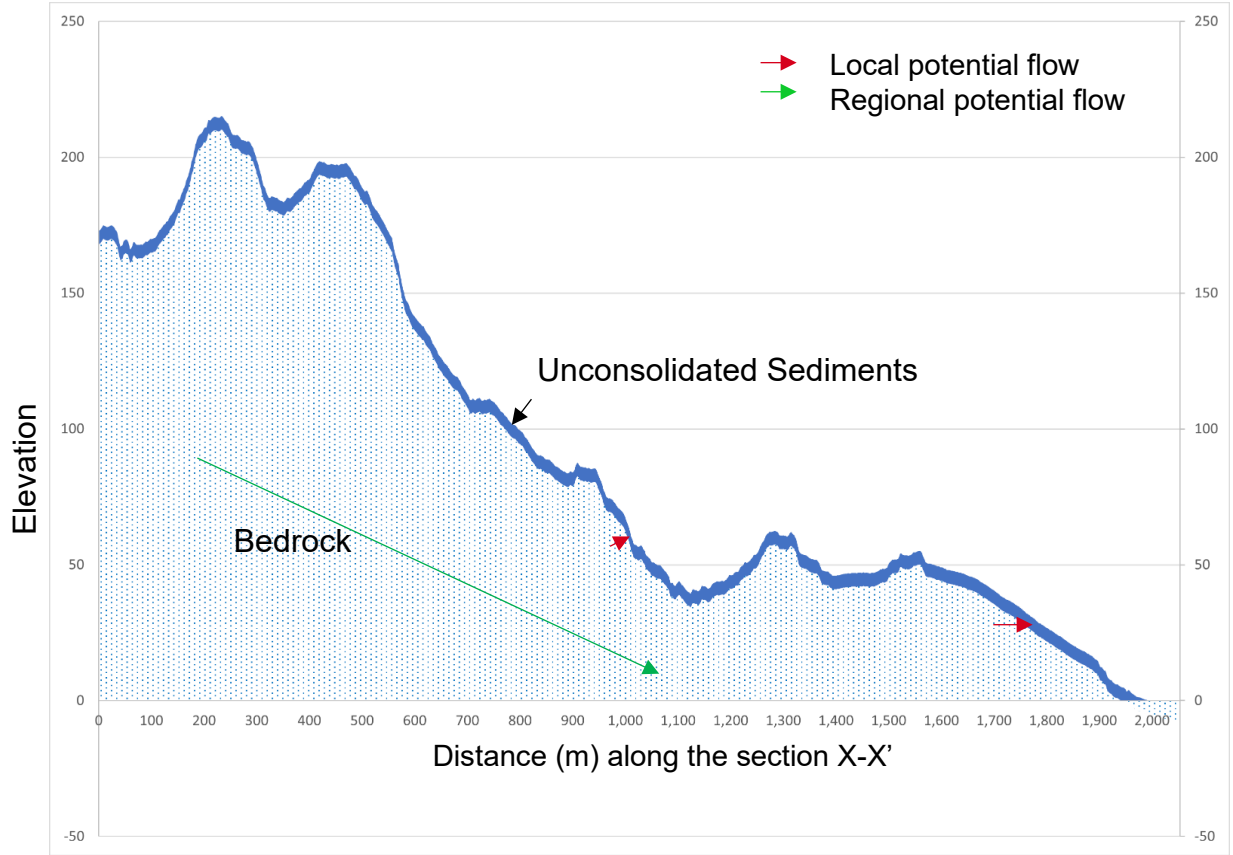
Client/Project/Report  
 Ksi Lisims LNG  
 Natural Gas Liquefaction and Marine Terminal  
 Effects Assessment - Groundwater

Figure No.  
**7.5-1**

Title  
**Groundwater Assessment Areas**

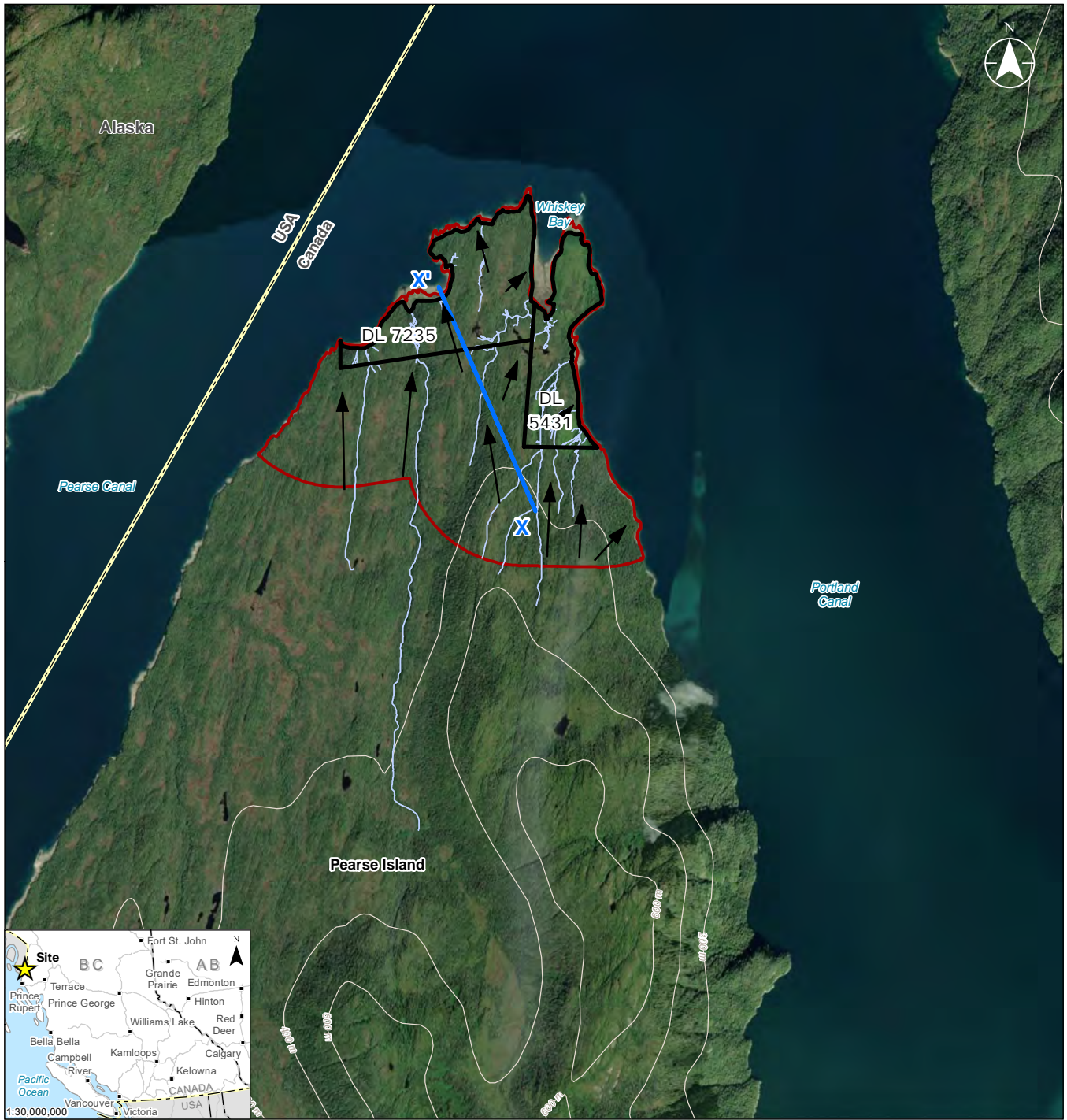
- Notes
1. Coordinate System: NAD 1983 UTM Zone 9N
  2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada
  3. Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

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1  
2  
3  
4

Figure 7.5-2 – Inferred Topographically-Controlled Groundwater Flow Directions along the Cross-Section X-X'

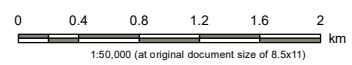


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**Notes**  
 1. Coordinate System: NAD 1983 UTM Zone 9N  
 2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada  
 3. Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

- Site
- Cross Section
- Inferred Groundwater Flow Direction
- Boundaries of District Lots 7235 and 5431
- Groundwater Regional Assessment Area
- International Boundary
- Topographic Contour
- Watercourse (Project-Mapped)



Project Location: Pearse Island, BC  
 Project Number: 123221820  
 Prepared by SLEMAY on 20221004  
 Requested by ASINGH on 20221003  
 Checked by TQULICHINI on 20221004

Client/Project/Report  
 Ksi Lisims LNG  
 Natural Gas Liquefaction and Marine Terminal  
 Effect Assessment – Groundwater

Figure No.  
**7.5-3**

Title  
**Inferred Groundwater Flow Directions for the RAA**

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