9 AMBIENT LIGHT

9.1 Introduction

Ambient light assessment is primarily an assessment of the effects of project lighting on sensitive receptors within a zone of influence. Light pollution is an issue that has gained prominence within the context of environmental assessment because of the following considerations:

- It is recognized that the aesthetic components of the environment have value; in particular, daytime vistas (viewsheds) and nighttime skies are valued social components.
- Light pollution is associated with nuisance-related effects of stray light, physiological changes in humans (similar to those experienced by shift workers), and disorientation of migrating wildlife (see Section 11).

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

The Ambient Light valued component (VC) is also related to the Visual Quality VC (Section 17) with respect to the overall visual effects from the Project on sensitive receptors within the respective viewsheds. Potential effects on Ambient Light arising from accidents and malfunctions are addressed separately in Accidents and Malfunctions (see Section 22).

9.2 Scope of Assessment

9.2.1 Regulatory and Policy Setting

There are no legal requirements (e.g., regulations, guidelines, or policies) in place in British Columbia that regulate the amount of obtrusive light being emitted from facilities. However, the Commission Internationale de L'Éclairage (CIE), also known as the International Commission on Illumination, has developed sets of maximum values for light spill and glare that should not be exceeded. These guidelines have been adopted in Great Britain and form the basis of a number of recommendations in the LEED Green Building Council Certification Program of Canada (LEED 2004). Such guidelines have also been adopted for other industrial projects in Canada.

9.2.1.1 Guidelines Adopted for this Assessment

The values represented in the guidelines are based on environmental zones and time of day. The CIE has established four environmental zones as a basis for outdoor lighting regulations (CIE 2003). These four zones are summarized in Table 9-1.

Table 9-1: Environmental Zones

Zone	Surrounding	Lighting Environment
E1	Natural	Intrinsically dark
E2	Rural	Low district brightness
E3	Suburban	Medium district brightness
E4	Urban	High district brightness

Source: CIE (2003)

9.2.1.2 Definitions of Types of Lighting Effects

Light Spill – refers to the spilling of light from fixtures within a facility to the environment and receptors outside the facility. The unit of measure for light spill is a lux. A lux is equal to 1 lumen per square metre (lumen/m^2). For example, problematic light spill would occur when lights located on the outside of an industrial facility shine in through the windows of nearby residential homes. In the middle of the night, light spill at residential properties should not exceed 1 lux (CIE 2003). An example of this effect is the excess light that may shine into a sleeping space and disrupt the ability of the residents to achieve a good night's sleep.

Glare – refers to intense, harsh, or contrasting lighting conditions that reduce humans, birds, and other organisms' ability to see. The most common example is oncoming high-beam headlights that provide lots of light but paradoxically make it difficult to see. The unit of measure for glare, sometimes referred to as luminance, is lumens per steradian which equals a candela (cd).

Sky Glow – refers to the illumination of the clouds by light sources on the surface of the earth, such as street lighting, and haze in the atmosphere that replaces the natural night time sky with a translucent to opaque lighted dome. The sky appears washed out or brownish-purple and may be devoid of visible stars in the extreme. Sky glow is the cumulative effect of all of the lights at the surface either emitting upward or being reflected upward by the surface. The unit of measure for sky glow is in magnitudes per square arcsecond (mag/arcsec^2). Values for sky glow range from approximately 22 mag/arcsec^2 in a rural environment where stars are abundant to approximately 18 mag/arcsec^2 in an urban environment where stars are barely visible.

9.2.1.3 Recommended Maximum Values

The maximum values recommended by CIE for light spill (illuminance) on properties by environmental zone and time of day are listed in Table 9-2.

Table 9-2: Recommended Maximum Values of Light Spill (Illumination) on Properties

Time of Day	Environmental Zones			
	E1	E2	E3	E4
19:00–23:00	2 lux	5 lux	10 lux	25 lux
23:00–6:00	0 lux	1 lux	2 lux	5 lux

Source: CIE (2003)

The maximum values recommended by CIE for glare (intensity of luminaires) in designated directions by environmental zone and time of day are listed in Table 9-3.

Table 9-3: Recommended Maximum Values for Glare (Intensity of Luminaires) in Designated Directions

Time of Day	Environmental Zones			
	E1	E2	E3	E4
19:00–23:00	2,500 cd	7,500 cd	10,000 cd	25,000 cd
23:00–6:00	0* cd	500 cd	1,000 cd	2,500 cd

NOTES:
* If for public lighting, value may be up to 500 cd
Source: CIE (2003)

The location of the Project and areas surrounding Port Edward would be considered to fall in an E1/E2 (natural/rural) category, while port Edward could be characterized as E2/E3 (rural/suburban)

Reference levels of sky glow are listed in Table 9-4. The higher the number, the more the sky is dominated by the natural background; the lower the number, the greater the degree of sky glow that is caused by reflection of lighting from the atmosphere.

Table 9-4: Reference Levels of Sky Glow

Sky Glow (mag/arcsec^2)	Corresponding Appearance of the Sky
21.7 (Rural)	The sky is crowded with stars that appear large and close. In the absence of haze the Milky Way can be seen to the horizon. The clouds appear as black silhouettes against the sky.
21.6	The above with a glow in the direction of one or more cities is seen on the horizon. Clouds are bright near the city glow.
21.1	The Milky Way is brilliant overhead but cannot be seen near the horizon. Clouds have a greyish glow at the zenith and appear bright in the direction of one or more prominent city glows.
20.4	The contrast of the Milky Way is reduced and the detail is lost. Clouds are bright against the zenith sky. Stars no longer appear large and near.
19.5	Milky Way is marginally visible, only near the zenith. Sky is bright and discoloured near the horizon in the direction of cities. The sky looks dull grey.
18.5 (Urban)	Stars are weak and washed out and reduced to a few hundred. The sky is bright and discoloured everywhere.

Source: Berry (1976)

9.2.2 Influence of Consultation on the Assessment

Through consultation, concerns were raised about visual effects of the proposed Project, as viewed from Kitson Island. Kitson Island is located approximately 2 km southwest of the proposed LNG facility. Light emission from the proposed Project, and from navigational lights of vessels during docking and departure, would form a part of any potential visual effects, particularly during night-time. These concerns reinforced the considerations previously noted (see Section 9.1).

9.2.3 Selection of Potential Effects

The environmental effect selected for the assessment of project-related ambient light is the change in ambient light compared with pre-project conditions.

9.2.4 Selection of Measurable Parameters

The measureable parameters that are used to facilitate qualitative measurement of potential effects on ambient light are listed in Table 9-5.

Table 9-5: Measurable Parameters for Change in Ambient Light

Effect	Measurable Parameter(s)and Units of Measurement	Notes or Rationale for Selection of the Measureable Parameter
Change in ambient light	**Light Spill** – light output from the project perimeter on vertical surface of receptors **Glare** –contrast between project lighting and background lighting **Sky Glow** – ratio of upward directed lighting to total lighting	Light received beyond the project perimeter is spill or spill lighting. Increased glare is a safety issue and an aesthetic issue. Sky glow is a result of wasted light shining upwards and from excessive lighting reflected upwards. All forms of light pollution are of concern because of the potential effects it could have on migrating wildlife and sensitive human receptors.

9.2.5 Boundaries

9.2.5.1 Temporal Boundaries

Based on the project schedule, the temporal boundaries for each project phase are:

- **Construction:** Q1 2015 – Q4 2018
- **Operations:** Q1 2019 – 2048+
- Decommissioning: 2048+

9.2.5.2 Spatial Boundaries

The spatial boundaries for the effects assessment of Ambient Light are defined below.

Project development area (PDA): Lelu Island to within 30 m of the average high water mark, the bridge abutments and access road corridor, and areas covered by the bridge, pioneer dock, materials off-loading facility, marine terminal, and associated dredging.

Local assessment area (LAA): The LAA is the area within 8 km of the Project.

Regional assessment area (RAA): The RAA includes the LAA plus those areas beyond 8 km, from which project lighting is visible at night.

Figure 9-1 illustrates the spatial boundaries for this VC.

9.2.5.3 Administrative and Technical Boundaries

Administrative boundaries for this assessment are established based on whether light is navigational or considered to be distracting from navigational light.

Technical boundaries for the assessment are established based on the light's line of sight.

9.2.6 Residual Effects Description Criteria

Residual effects are those that remain after mitigation measures have been applied; they are defined for the assessment of Ambient Light in Table 9-6.

Table 9-6: Characterization of Residual Effects for Ambient Light

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Characterization of Residual Effects		
Context	The current and future sensitivity and resilience of the VC to change caused by the Project.	**Low resilience**—sensitive human receptors and wildlife accustomed to existing low levels of ambient lighting (e.g., rural development). **Moderate resilience**—sensitive human receptors and wildlife accustomed to moderate levels of existing lighting (e.g., street lights and occasional commercial development). **High resilience**—sensitive human receptors and wildlife accustomed to high levels of industrial and large-scale commercial development.
Magnitude	Expected size or severity of the residual effect. When evaluating magnitude of residual effects, consider the proportion of the VC affected within the spatial boundaries and the relative effect.	**Negligible**—no measurable change from baseline conditions. **Low**—effect is detectable but is reduced through design mitigation. **Moderate**—plant lighting is effectively controlled, but navigation, security and other required lighting have a measurable effect. **High**—the design is without regard to lighting design criteria.
Extent	The spatial scale over which the residual effect is expected to occur.	**PDA**—effects are restricted to the PDA. **LAA**—effects prevalent in the LAA. **RAA**—effects prevalent in the RAA.
Duration	The length of time the residual effect persists.	**Short-term**—measurable for less than one month. **Medium-term**—measurable for more than one month but less than two years. **Long-term**—measurable for the life of the Project**.** **Permanent**—measurable parameter unlikely to recover to baseline.
Reversibility	Whether or not the residual effect on the VC can be reversed once the physical work or activity causing the disturbance ceases.	**Reversible**—will recover after project closure and reclamation. **Irreversible**—permanent.
Frequency	How often the residual effect occurs and is usually closely related to the frequency of the physical work or activity causing the residual effect.	**Single event**—effect occurs once over the life of the Project. **Multiple irregular event (no set schedule)**—effect occurs at sporadic intervals. **Multiple regular event**—effect occurs on a regular basis and at regular intervals. **Continuous**—effect occurs continuously through life of the Project.

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Likelihood of Residual Effects		
Likelihood	Whether or not a residual effect is likely to occur	**L** = low probability of occurrence **M** = medium probability of occurrence **H** = high probability of occurrence

9.2.7 Significance Thresholds for Residual Effects

For the purposes of this assessment, a significant adverse effect on ambient light is defined as an increase in project-related light emissions such that the guidelines (Section 9.2.1) for light spill and glare in a suburban environment are exceeded and the resulting conditions related to sky glow would be typical of an urban environment.

9.3 Baseline Conditions

This section presents information about the existing conditions in the assessment areas for Ambient Light.

9.3.1 Baseline Methods and Data Sources

Three methods were used in this study to document ambient light in the night sky, including the following:

- Photographs were taken at a number of designated viewpoint areas using a high-quality (Canon 60D DSLR) digital camera. Panoramic and individual exposures were made that can be compared with future cases to assess changes.
- A Unihedron Sky Quality Meter was used to measure sky brightness. This meter was developed for astronomical applications to document the level of sky brightness, with the measurement consisting of light within an approximate 60 degree solid angle of sky. This meter offers the distinct advantage for this purpose that it is designed for the resolution of the very low levels that are expected in the remote project areas, although the units of measurement are not standard.
- A conventional, integrating hemispherical light meter (Extech EA33) with a resolution of 0.01 lux was used to provide measurements of incident light levels primarily within the town of Port Edward.

9.3.2 Overview of Baseline Conditions

C-style lighting is used in Port Edward and Prince Rupert. Dockside facilities in both communities have luminaires that cast excessive glare and light spill on adjacent properties. However, neither community is very large and both are close to large areas where ambient light levels are extremely low. Port Edward does not have a sufficient number of facilities that use highly intense lighting to cause problems to residents in the viewshed. Some facilities, such as the grain elevator, are of an older design style with limited regard for lighting design. Newer facilities, such as the proposed Canpotex facilities, have incorporated lighting assessment into their environmental assessment process. The baseline conditions reflect past designs where this was likely not the case.

Light readings were obtained at 17 locations (Table 9-7). These locations are also represented in Figure 9-2. The on-site findings of April 2, 2013, are as follows in Table 9-7.

Table 9-7: Ambient Light Measurements, Night of April 2, 2013

Time	ID	Site (Brightest to darkest by SQM Reading)	SQM (mag/arcsec^2)	Light (lux)
21:45	14	Shopping mall parking lot, Prince Rupert	9.19	88.8
21:53	16	Corner of 2nd Avenue, 3rd Street, Prince Rupert	14.2	11.7
21:42	13	Central business district, Prince Rupert	15.98	4.2
21:51	9	North Pacific	17.5	0.5
21:50	15	Prince Rupert waterfront	17.6	3.2
22:30	2	Wildwood and Skeena	19.1	0.27
22:04	7	Lelu South	19.3	1.1
22:35	1	Port Edward School	19.4	0.41
21:38	10	South End	19.5	0.09
22:11	4	Port Edward South	20.48	0.37
22:58	12	Background (Ridley Island Road)	20.85	0.03
21:56	17	Background (Between 9, 10)	20.94	0.01
22:56	11	Background (Ridley Island Road)	21.15	0.04
22:00	8	South Channel	21.15	0.03
22:08	6	Lelu Centre	21.26	0

These readings show large variation between the levels in the town (urban to suburban) and outside (rural to natural). Within the urban areas, glare is the most prevalent issue, followed by light spill. The sky itself is not evident, and the use of horizontal cutoff street lighting, as many municipalities are incorporating for economic and energy reasons, would improve the ambient light environment. Industrial lighting on Ridley Island is an aesthetic factor; that is, it can be seen in one sector of the horizon, but it is far enough away that it does not add substantially to the nighttime lighting levels in Port Edward.

9.4 Project Interactions with Ambient Light

The potential interactions between the project activities and ambient light have been summarized and rated in Table 9-8.

Table 9-8: Potential Effects on Ambient Light

Project Activities and Physical Works	Potential Effects
	Change in Ambient Light
Construction	
Site preparation (land-based)	2
Onshore construction	1

Project Activities and Physical Works	Potential Effects
	Change in Ambient Light
Vehicle traffic	2
Dredging	1
Marine construction	2
Waste management and disposal	0
Disposal at sea	0
Operational testing and commissioning	2
Site clean up and reclamation	1
Operations	
LNG facility and supporting infrastructure on Lelu Island	2
Marine terminal use	2
Shipping	1
Waste management and disposal	0
Fish habitat offsetting	0
Wetland habitat compensation	0
Decommissioning	
Dismantling facility and supporting infrastructure	1
Dismantling of marine terminal	1
Waste disposal	0
Site clean up and reclamation	1

KEY:

0 = No interaction.

1 = Potential adverse effect requiring mitigation, but further consideration determines that any residual adverse effects will be eliminated or reduced to negligible levels by existing codified practices, proven effective mitigation measures, or best management practices.

2 = Interaction may occur and the resulting effect may exceed acceptable levels without implementation of project-specific mitigation. Further assessment is warranted.

9.4.1 Justification of Interaction Rankings

During construction and operations, activities ranked as 0, either do not involve the use of artificial lighting, the activity is limited to daytime hours, or the activity occurs indoors with no source of outdoor lighting. Activities ranked as 1, have the potential to interact with the environment, and result in an environmental effect on ambient light, yet can be managed to acceptable levels through standard operating practices.

Interactions between on-shore construction and vehicle traffic, and ambient light, with potential adverse effects have been ranked as 1, therefore requiring some mitigation. These interactions are considered here. The use of nighttime lighting on the bridge could result in light spill and sky glow, and the travel of workers along this route during the night could result in glare because of vehicle headlights. However, the construction traffic on the bridge will be a temporary activity, and the design

and continuing operation of the bridge will incorporate codified practices, and standard operating procedures. Because these interactions can be mitigated though design and operating standards, no additional analysis is warranted.

Interactions between dredging, site clean-up and reclamation (both during construction and decommissioning), dismantling of the facility, supporting infrastructure and the marine terminal, and ambient light with potential adverse effects have been ranked as 1, therefore requiring some mitigation. These interactions are considered here. The use of outdoor lighting during these activities has the potential to result in an effect on ambient light. Such activities will be temporary in nature, localized and will be mitigated through standard construction management procedures. Because these interactions can be mitigated though standard procedures, no additional analysis is warranted.

Those activities ranked as 2s are assessed within Section 9.5

9.5 Effects Assessment

9.5.1 Analytical Methods

9.5.1.1 Analytical Assessment Techniques

The analysis of change in ambient light focuses on the potential effects of project infrastructure and activities on light spill, glare, and sky glow. The method is qualitative as the design of the Project was not at a stage to quantify project light levels at the time of this assessment. The qualitative predictions are, however, based on the professional judgment of the study team and incorporate design mitigation to manage potential light effects to acceptable levels, as published in a number of national and international guidelines. The baseline measurements provide an index to determine if the completed Project exceeds objectives.

Sources of light emissions during the construction and operation of the Project are described in the following subsections and only the interactions ranked as a 2 in Table 9-8 are assessed. All other interactions are rated as not significant.

9.5.1.2 Assumptions and the Conservative Approach

The final design of the Project will incorporate the lighting design standards presented in the following sections pertaining to the types of lighting and mitigation proposed. These standards represent a conservative approach to the reduction of project-related light pollution.

9.5.2 Change of Ambient Light

9.5.2.1 Potential Effects

Construction

Because the majority of project construction will occur during daytime hours, project-related lighting during nighttime hours will be limited. The use of portable artificial lighting may occur during site preparation, construction of the LNG facility and support infrastructure, construction of the marine terminal and offloading facility, installation of bridge and roads, and through the operation of construction equipment during times of the year when the days are short and the working day

extends into the dark or during times when nighttime construction is required. During these times, the use of lighting will be required to provide a secure and safe work environment for construction workers. However, directed light (when and where required) will be used to avoid excessive sky glow and light spill beyond the PDA. Project staff and construction works will adhere to lighting practices that avoid adverse effects during construction.

As construction continues and facilities are constructed, permanent lighting fixtures will provide outdoor lighting required to complete project construction and conduct operational testing and commissioning.

Therefore, during project construction, lighting be limited to that which is required for safe, secure, and efficient work at night, directed to work areas where it is intended (that is, avoiding off-site directions) and that it is of shielded, cut off design.

Operations

During project operations, the following activities have the potential to interact with the environment to result in a change in ambient light:

- The operation of the LNG facility and supporting infrastructure on Lelu Island
- Marine terminal use
- Shipping.

To safely and successfully carry out these project activities, permanent building lighting, both exterior and interior, will be required, as well as streetlights along access roads, bridges and surrounding the marine terminal. The area located directly across from Lelu Island (to the northeast and east of Lelu Island) is largely uninhabited and can be considered a natural/rural environment. Located further to the north is the town of Port Edward, a rural/suburban environment, and to the southwest is Kitson Island. There is potential that the exterior lighting associated with some project components (e.g., storage tanks, flare) will be visible to receptors located directly across from and to the north and south of Lelu Island, because of the physical height of these components and the surrounding topography.

Because of the positioning of the marine terminal component of the Project, for the most part, the exterior lighting associated with the terminal itself and the ships will likely not be as visible to the residents living in Port Edward and to the east of Lelu Island. The onshore portion of the Project will be visible at Kitson Island, from the north shore of the island only. During the visits by the carriers (ships), vessel lighting will be visible from the western side of Kitson Island. Navigational lighting is distinctly different from the lighting used for onshore installations. Vessels use lights to indicate their orientation and their motive power so that other vessels can determine how to pass safely according to navigational rules. The navigational lights on a vessel are only those that are necessary and sufficient for these purposes; extraneous lighting can be confusing and contrary to these purposes and thus is generally avoided, although some additional lighting on a vessel is essential to permit safe movement of crew and passengers on the deck. Whereas vessels such as cruise ships, which do frequent this area, are extensively illuminated, LNG carriers are not. Of primary concern with regards to the marine terminal component of the Project is the potential effect of lighting on safety (other than those working on site). Because of the proximity of navigation routes for ships and

aircraft, it is essential and a given that lighting will be planned in conformance with the restrictions and standards applied by Transport Canada. Other aspects of visual quality related to the Project are discussed in Section 17.

As the conceptual lighting design for the Project has yet to be developed, quantitative predictions regarding the potential for light spill, glare, and sky glow on nearby receptors resulting from the operation of the Project have not been conducted. Pacific NorthWest LNG Limited Partnership (PNW LNG) has committed to the use of luminaires that will reduce wasted light (i.e., light that is directed upwards, above the horizontal, or directly into the eyes of the observers, as glare). These design goals are contained within the Canada Green Building Council LEED guidelines, where applicable (LEED 2004), and the International Commission on Illumination (CIE 2003). The use of such guidelines and recommended techniques therein can markedly reduce stray light that directly or indirectly contributes to the increase of sky glow and the adverse effect on the night sky.

Therefore, even though some of this lighting may be visible to the town of Port Edward and those receptors located directly across from Lelu Island, the amount of light spill, glare, and sky glow will be limited because of the use of the dark sky fixtures, cut-off design, and in some instances, the topography of the Island and surrounding lands.

9.5.2.2 Mitigation

Construction

Although construction is generally a temporary activity, the potential effects will be reduced with the following mitigations:

- Retain a 30 m mature vegetation buffer around Lelu Island to reduce effects of increased light
- Construction lighting to be selected to reduce spill-over light and will include shielded fixtures, where appropriate.

Permanent light fixtures, which will be in use during project commissioning, should be equipped with “dark sky” shielded fixtures, and light should be directed where it is needed. Streetlights that will likely be installed along the roadways and bridge should be of the shielded and cut-off design.

Vehicle lighting is more difficult to control, but some mitigation may be applied without affecting safety, security, or operating efficiency. In laydown areas and parking areas, vehicle lighting should be directed so that effects are avoided. This means, at least, avoiding pointing headlights toward Port Edward or other visible receptors, but ideally shutting off engines and headlights to reduce fuel consumption and reduce on-site glare that can compromise safety.

Some stationary facilities, such as batch-plants and mobile offices, may be located onsite for most or all of the construction period. Lighting in these areas should adhere as closely as is feasible to the CIE guidelines to be adopted for the permanent operating facility. CIE 150:2003 provides detailed discussion on the design of floodlit facilities, and these guidelines are suitable for incorporation into the lighting plan for the construction phase of this Project. Provided that these guidelines are followed, and the constraints resulting from proximity to navigation routes are followed, the effect of construction lighting should be limited.

Operations

Facility luminaires will be selected to reduce the wasted light (i.e., light that is directed upwards, above the horizontal, or directly into the eyes of observers as glare). These design goals are contained within the Canada Green Building Council LEED guidelines, where applicable (see LEED 2004 for examples), and the International Commission on Illumination (CIE 2003), *Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations*. The use of such guidelines and recommended techniques therein can markedly reduce stray light that directly or indirectly contributes to the increase of sky glow and the adverse effect on the night sky.

In addition to the above, the following mitigation measures during project operation will be implemented:

- Operational lighting to be selected to reduce spill-over light and will include shielded fixtures, where appropriate.
- Design principles (such as those within the Canada Green Building Council LEED guidelines (LEED 2004) and the International Commission on Illumination (CIE 2003)) will be used where applicable and consistent with overarching requirements of safety and security
- A centralized lighting control system will be used to selectively turn off lights when not required.

9.5.2.3 Characterization of Residual Effects

Proper lighting during all phases of the Project is necessary for a safe, secure, and productive LNG facility and marine terminal. It is expected that there could be some light from the Project observed in the town of Port Edward and along Skeena Drive (east of Lelu Island), although the local topography, vegetation, and design specifications will help to reduce this amount so that Port Edward and the surrounding areas remain characteristic of a rural/suburban environment and natural/rural environment, respectively. The residual effect is predicted to occur in a moderately resilient context, to be low in magnitude, restricted to the LAA, long term in duration, continuous in terms of frequency, and reversible. The existing lighting of Port Edward will be the greatest contributor to light in the nighttime sky, but it is anticipated that the current trend of municipal utilities to convert to the use of light-emitting diode (LED) street lighting, with their full horizontal cutoff luminaires and energy efficiency, will improve the nighttime aesthetics if used in the Port Edward area.

9.5.2.4 Likelihood

The change in ambient light is extremely likely if the Project proceeds. The use of navigational lighting on shore facilities and on the LNG carriers is required because of the applicable navigational standards. Current lighting practices are evolving with the advent of LED luminaires in a broader range of configurations and applications, and these typically reflect a greater concern for a limit to the light spill and glare that accompanied older designs. This evolutionary change is considered to be of medium likelihood, and will result in a reduction of project effects.

9.5.2.5 Determination of Significance of Residual Effects

With the proposed mitigation and PNW LNG's commitment to adhere to the design goals contained within the Canada Green Building Council LEED guidelines, where applicable (LEED 2004), and the

International Commission on Illumination (CIE 2003) *Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations*, an increase in project-related light emissions such that the guidelines in Section 9.2.1 are exceeded and where the project-related sky glow would be typical of an urban environment, are not likely. Therefore, no significant adverse effects are predicted.

9.5.2.6 Confidence and Risk

Confidence in the prediction of project effects on ambient light is high considering PNW LNG's commitment to standard mitigation as well as progressive lighting design guidelines such as International Commission on Illumination (CIE 2003) or LEED. There is little risk of contrary results because of the failure of the Project to adopt mitigation options that reduce obstructive lighting as the use of such lighting is beneficial to the Project in terms of long-term reductions in lighting costs. Since the confidence in this prediction is not low, no additional risk analysis has been conducted.

9.5.3 Summary of Residual Effects

The residual effects on a change in ambient light are summarized in Table 9-9.

Table 9-9: Summary of Residual Effects on Ambient Light

Project Phase	Proposed Mitigation Measures	Residual Effects Characteristics						Likelihood	Significance	Confidence	Follow-up and Monitoring
		Context	Magnitude	Extent	Duration	Reversibility	Frequency				
Change in Ambient Light											
Construction	▪ Fixtures selected to reduce wasted or stray light. ▪ Adherence to design specifications. ▪ Use of a centralized lighting control system. ▪ Maintain a 30 m vegetation buffer.	M	L	LAA	MT	R	C	L	N	H	None
Operation		M	L	LAA	LT	R	C				
Decommissioning		No effects anticipated									
Residual effects for all phases		M	L	LAA	LT	R	C				

Project Phase	Proposed Mitigation Measures	Residual Effects Characteristics						Likelihood	Significance	Confidence	Follow-up and Monitoring
		Context	Magnitude	Extent	Duration	Reversibility	Frequency				

KEY:
CONTEXT:
L = low resilience, sensitive to disturbance
M = moderate resilience
H = high resilience, not sensitive to disturbance

MAGNITUDE:
N = negligible: no measurable change from baseline conditions
L = low: effect is detectable but is minimized through design mitigation
M = moderate: plant lighting is effectively controlled, but navigation, security, and other required lighting have a measurable effect.
H) = high: the design is without regard to lighting design criteria

EXTENT:
PDA = effects are restricted to the PDA
LAA = effects are restricted to the LAA
RAA = effects are restricted to the RAA

DURATION:
ST = short-term: measurable for less than one month
M = medium-term: measurable for more than on month but less than two years
LT = long-term: measurable for the life of the Project
P = permanent: measurable parameter unlikely to recover to baseline

REVERSIBILITY:
R = reversible
I = irreversible

FREQUENCY:
SE = single event: effect occurs once over the life of the Project.
IE = multiple irregular event: effect occurs at sporadic intervals
RE = multiple regular event: effect occurs on a regular basis and at regular intervals
C = continuous: effect occurs continuous through the life of the Project

LIKELIHOOD:
L = low probability of occurrence
M = medium probability of occurrence
H = high probability of occurrence

SIGNIFICANCE:
S = significant
N = not significant

CONFIDENCE:
Based on professional judgment.
L = low level of confidence
M = moderate level of confidence
H = high level of confidence

9.6 Cumulative Effects

9.6.1 Context for Cumulative Effects

The RAA is defined as an area that incorporates those other existing, approved, or proposed projects and the residents whose viewshed and nighttime sky is affected directly or indirectly by the cumulative interaction of these projects. The existing, approved, and proposed projects that would fall within the RAA for the Project are listed in Table 9-10.

The locations of the above projects are displayed on Figure 9-3. Currently there are no existing developments located on Lelu Island. To the north west of Lelu Island is Ridley Island where Ridley Island Terminals Inc., Prince Rupert Grain Ltd and Ridley Island Log Sort are currently operating. Due to the locations and proposed locations of the above noted projects in relation to the proposed Project there is potential for them to be within the viewshed of those residents located in Port Edward and along Skeena Drive. The other projects, as shown in Figure 9-3, are located too far away from Port Edward and the proposed project site and at least partially shielded by topographic features, to be within the viewshed (for light spill and glare) of the RAA and too dispersed to contribute cumulatively to sky glow. In the past, light pollution has not been a strong design concern for project development; if progressive guidelines such as IEC or LEED are incorporated into future industrial developments the potential for cumulative effects will be reduced.

9.6.2 Cumulative Effects Assessment

The cumulative effects assessment is a two-step process to determine the potential for cumulative effects on Ambient Light. In conducting the cumulative effects assessment, the residual effects arising from interactions that are ranked as 1 or 2 in Table 9-8 are considered. The first step consists of a two questions:

- Is there a project residual effect?
- Does the project residual effect overlap spatially and temporally with those of other past, present or reasonably foreseeable future projects?

Where the answers to both of these two questions are affirmative, a check in Table 9-10 indicates that there is potential for the Project to contribute to cumulative effects on Ambient Light. Potential contribution of these project effects to cumulative effects is assessed below. The second step consists of one question:

- Is there a reasonable expectation that the contribution (i.e., addition) of the Project's residual effects would cause a change in cumulative effects that could affect the viability or sustainability of the VC?

Where the answer to this question is affirmative, additional assessment of the potential cumulative effects is described below.

Table 9-10: Potential Cumulative Effects on Ambient Light

Other Projects and Activities with Potential for Cumulative Environmental Effects	Potential Cumulative Effects
	Change in Ambient Light
Atlin Terminal	
Canpotex Potash Export Terminal	✓
CN Rail Line	✓
Douglas Channel LNG	
Enbridge Northern Gateway Project	
Fairview Container Terminal Phase I	
Fairview Container Terminal Phase II	
Kitimat LNG Terminal Project	
LNG Canada Project	
Mount McDonald Wind Power Project	
NaiKun Wind Energy Project	✓
Northland Cruise Terminal	
Odin Seafood	
Pinnacle Pellet Inc.	
Prince Rupert LNG Facility	✓
Prince Rupert Gas Transmission Project	
Prince Rupert Ferry Terminal	
Prince Rupert Industrial Park	
Prince Rupert Grain Limited	✓
Ridley Island Log Sort	
Ridley Terminals Inc.	✓
Rio Tinto Alcan Aluminium Smelter and Modernization Project	
WatCo Pulp Mill	
Westcoast Connector Gas Transmission Project	

NOTES:
✓ = Those 'other projects and activities' whose effects are likely to interact cumulatively with the Project's residual effects.

With the proposed mitigation and adherence to specific design standards, the resulting residual environment effect on a change in ambient light is considered to be low in magnitude, moderate in context, limited to the LAA in extent, regular in terms of frequency, long term in duration and reversible following project decommissioning, but not significant. This residual environment effect, however, does overlap both spatially (as discussed above) and temporally with other existing,

approved, and proposed projects in the area. Therefore, there is potential for these other projects to cumulatively interact with the proposed Project to result in an effect on ambient light. In the past, light pollution has not been a strong design concern for project development; if progressive guidelines such as CIE or LEED are incorporated into future industrial developments the potential for cumulative effects will be reduced. PNW LNG has expressed the intention to use these guidelines, and any local industry association and the Prince Rupert Port Authority (PRPA) should encourage adoption of lighting principles that protect aesthetics by using well designed site lighting.

9.6.2.1 Summary of Cumulative Effects

Provided that other industries subscribe to the energy efficient and reduced lighting design guidelines, the effect of growing industrialization of Lelu and Ridley islands are anticipated to produce effects on ambient light that are not significant on a cumulative basis. Confidence in this conclusion is medium with respect to acceptance of lighting guidelines by other future industry.

9.7 Follow-up and Monitoring

No follow-up and monitoring is required.

PNW LNG will provide an environmental monitor to oversee general construction and any other activities that could be disruptive concerning light. The environmental monitor will monitor the implementation of mitigation measures outlined in the environmental management plan (including light mitigation). Compliance monitoring during all phases the Project will be on a complaint-driven basis so specific light spill issues can be addressed.

PNW LNG will support and encourage any local industrial association or initiative by the PRPA to introduce lighting guidelines into the development agreements of future industry.

9.8 Conclusion

The proposed Project is located in an area with very little industrial activity currently; therefore, the existing ambient light environment on and surrounding the project site can be characterized as a natural/rural area. It is expected that there could be some light from the Project observed in the town of Port Edward and along Skeena Drive (east of Lelu Island), although the local topography, vegetation, and design specifications will help to reduce this amount so that the surrounding areas remain characteristic of a rural/suburban and natural/rural environment, respectively. With the proposed mitigation and PNW LNG's commitment to adhere to the design goals contained within the Canada Green Building Council LEED guidelines, where applicable (LEED 2004), and the International Commission on Illumination (CIE 2003) *Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations*, a significant adverse effect from project lighting is not anticipated. There is potential for cumulative effects in the future, however, as there are a number of approved and planned projects proposed for Kaien and Ridley islands. The added contribution of project lighting from these operations and existing ones could cumulatively interact to result in a significant effect on ambient light. Provided, however, that other industries subscribe to the energy efficient and reduced lighting design guidelines, the effect of growing industrialization of Kaien and Ridley islands will not significantly affect the ambient light environment.

Cumulative effects on Ambient Light are also expected to be not significant. Confidence in this conclusion is medium with respect to acceptance of lighting guidelines by other future industry.

9.9 References

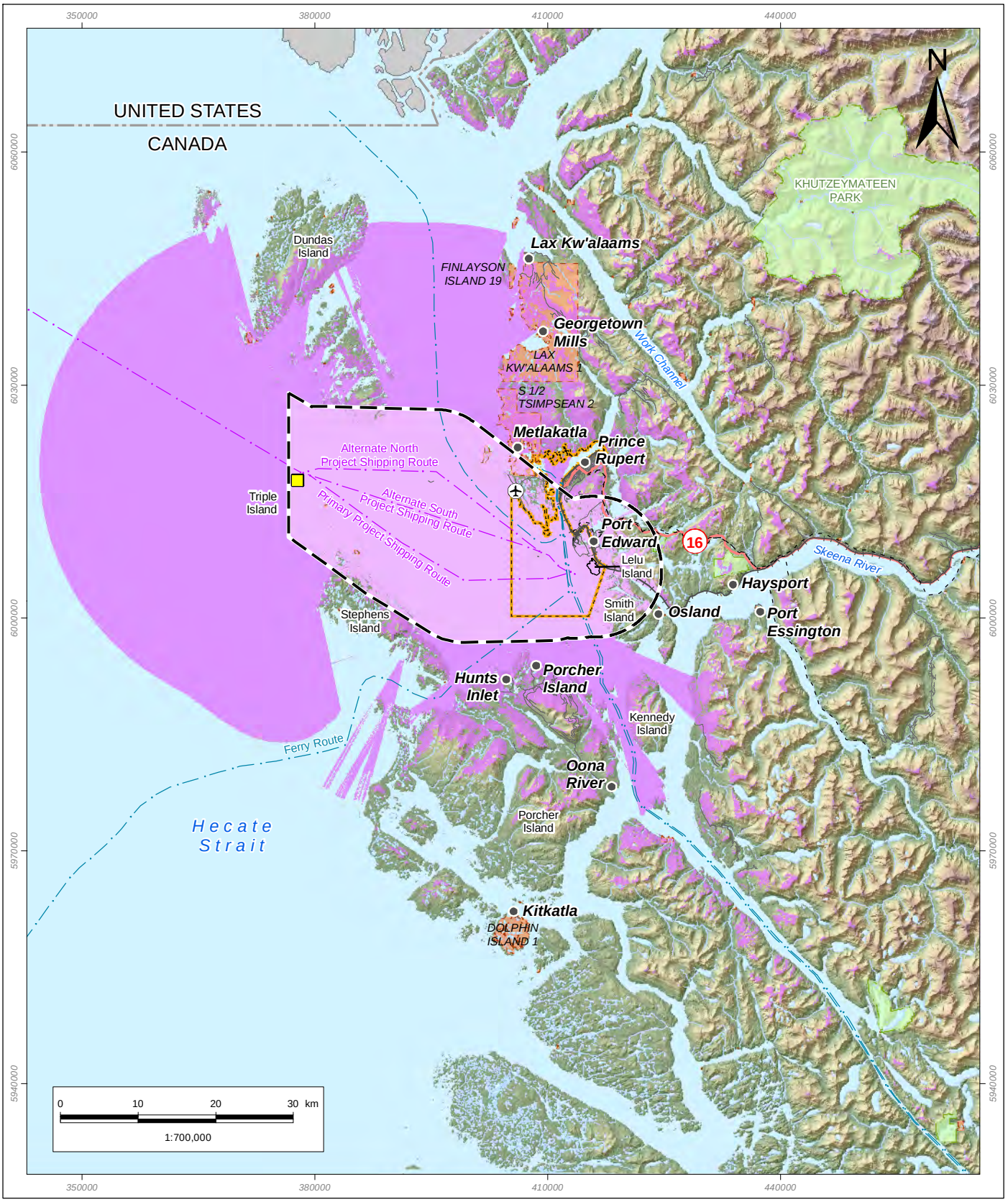
Berry, R. 1976. Light pollution in southern Ontario. *The Journal of the Royal Astronomical Society of Canada*, Vol.70, No.3.

Commission Internationale de l'Éclairage (CIE). 2003. *Guide on the Limitation of the Effects of Obtrusive Light from Outdoor Lighting Installations*.

LEED. 2004. *Green Building Rating System for New Construction and Major Renovations LEED Canada-NC* Version 1.0.

9.10 Figures

Please see the following pages.



Project Visibility in Local Assessment Area
Project Visibility in Regional Assessment Area*
Local Assessment Area
Project Shipping Route
Airport
City or Town
Pilotage Station

Electrical Power Transmission Line
Ferry Route
Highway
International Boundary
Railway
Secondary Road
Watercourse

Indian Reserve
Prince Rupert Port Authority Boundary
Protected Area
Waterbody

* The Regional Assessment Area is defined as the area beyond the Local Assessment Area from which the Project is visible.

Pacific NorthWest LNG

Ambient Light Local Assessment Area and Regional Assessment Area

Sources: Government of British Columbia; Government of Canada, Natural Resources Canada, Centre for Topographic Information.

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

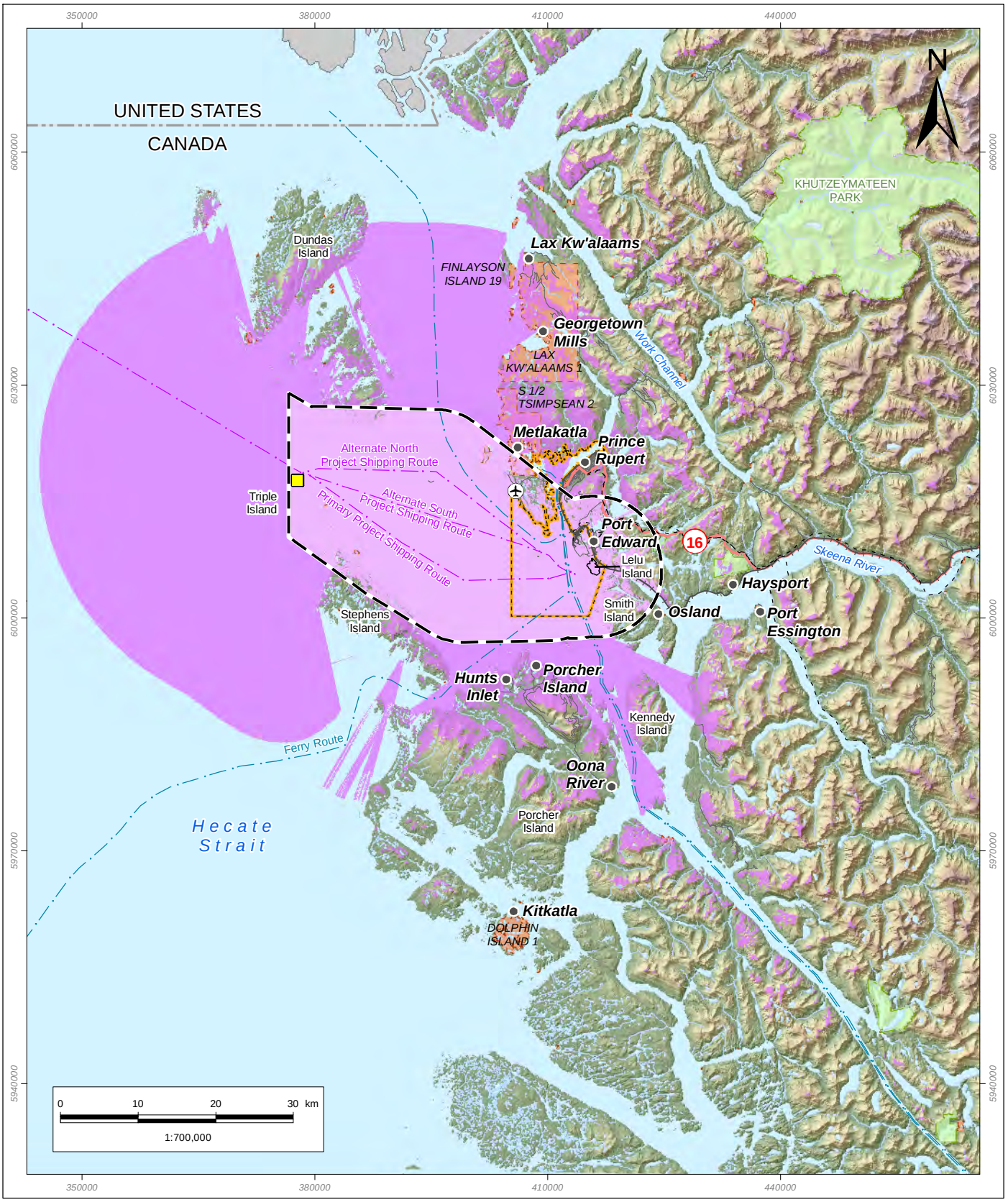
DATE: 03-FEB-14	PROJECTION: UTM - ZONE 9
FIGURE ID: 123110537-419	DATUM: NAD 83
DRAWN BY: K. POLL	CHECKED BY: G. HATCHER

PREPARED BY: Stantec

PREPARED FOR: Pacific NorthWest LNG

FIGURE NO: **9-1**

2/3/2014 - 3:02:53 PM V:\active\123110537\gis\figures\general\mxds\english\fig_123110537-419_ambient_light_study_areas.mxd



Project Visibility in Local Assessment Area
Project Visibility in Regional Assessment Area*
Local Assessment Area
Project Shipping Route
Airport
City or Town
Pilotage Station

Electrical Power Transmission Line
Ferry Route
Highway
International Boundary
Railway
Secondary Road
Watercourse

Indian Reserve
Prince Rupert Port Authority Boundary
Protected Area
Waterbody

* The Regional Assessment Area is defined as the area beyond the Local Assessment Area from which the Project is visible.

Pacific NorthWest LNG

Ambient Light Local Assessment Area and Regional Assessment Area

Sources: Government of British Columbia; Government of Canada, Natural Resources Canada, Centre for Topographic Information.

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

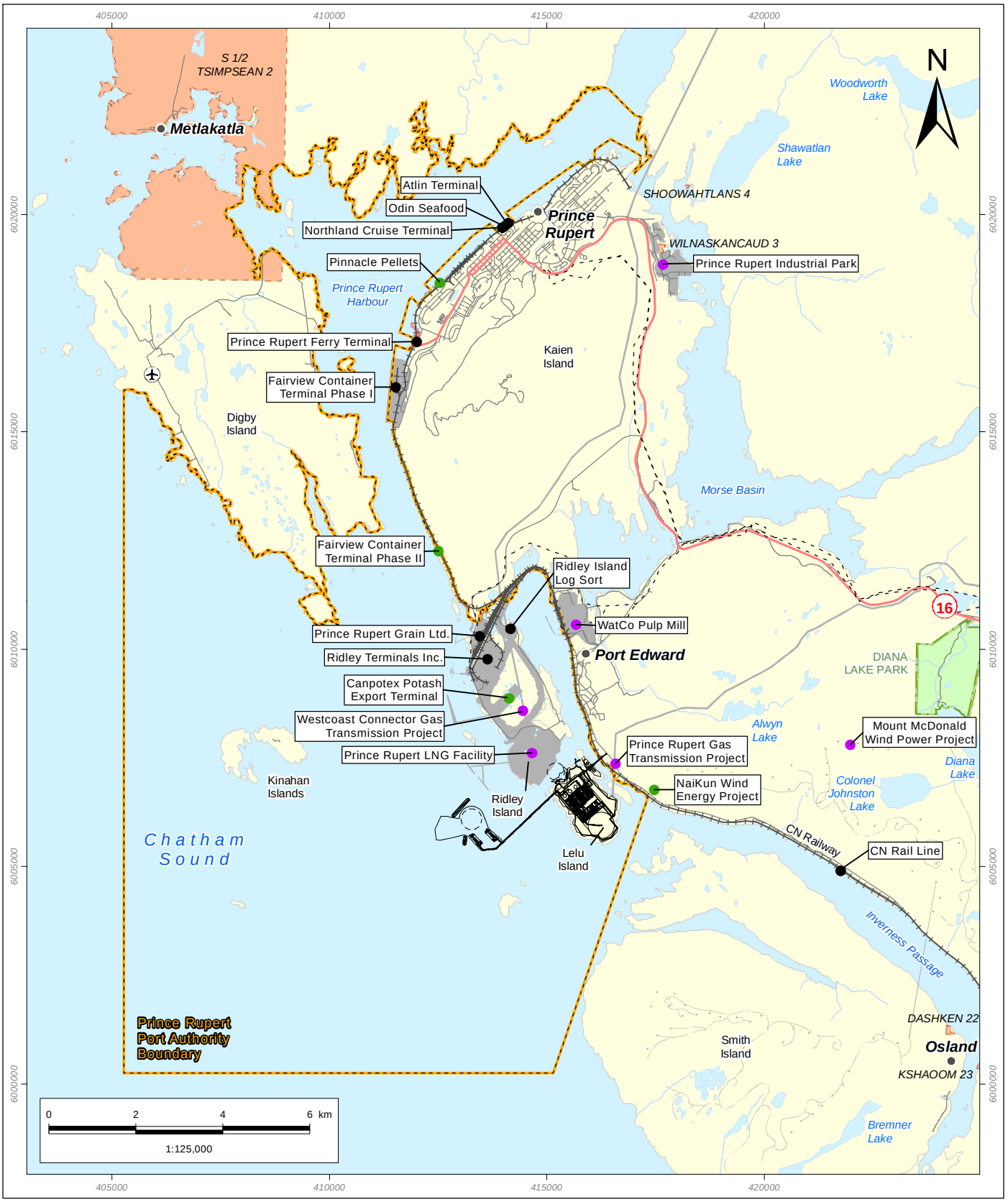
DATE: 03-FEB-14	PROJECTION: UTM - ZONE 9
FIGURE ID: 123110537-419	DATUM: NAD 83
DRAWN BY: K. POLL	CHECKED BY: G. HATCHER

PREPARED BY: Stantec

PREPARED FOR: Pacific NorthWest LNG

FIGURE NO: **9-1**

2/3/2014 - 3:02:53 PM V:\active\123110537\gis\figures\general\mxds\english\fig_123110537-419_ambient_light_study_areas.mxd



Project Locations

Status

- Approved
- Operational
- Proposed
- Project Component
- Turning Basin
- Proposed or Existing Industrial Development Footprint

- Airport
- City or Town
- Electrical Power Transmission Line
- Highway
- Railway
- Secondary Road
- Watercourse

- Indian Reserve
- Prince Rupert Port Authority Boundary
- Protected Area
- Waterbody

Pacific NorthWest LNG

Past, Present, and Reasonably Foreseeable Projects near the PNW LNG Project

Sources: Government of British Columbia; Government of Canada, Natural Resources Canada, Centre for Topographic Information; Progress Energy Canada Ltd.

Although there is no reason to believe that there are any errors associated with the data used to generate this product or in the product itself, users of these data are advised that errors in the data may be present.

DATE: 29-JAN-14	PROJECTION: UTM - ZONE 9
FIGURE ID: 123110537-476	DATUM: NAD 83
DRAWN BY: K. POLL	CHECKED BY: J. WALKER

PREPARED BY: Stantec

PREPARED FOR: Pacific NorthWest LNG

FIGURE NO: **9-3**

1/29/2014 - 3:32:40 PM V:\active\123110537\gis\figures\general\mxds\english\fig_123110537-476_approved_proposed_projects.mxd