

Appendix X

Light Assessment Documentation



Light Impact Assessment

Boat Harbour Remediation
Planning and Design
Pictou Landing, Nova Scotia

Nova Scotia Lands Inc.





Table of Contents

1.	Introduction.....	1
2.	Baseline Conditions.....	2
3.	Proposed Lighting	2
4.	Sensitive Receptors	3
5.	Method of Assessment.....	3
6.	Results and Discussion	5

Figure Index

Figure 1 Site and Point of Reception Location Plan

Table Index

Table 1	Light Source Summary Tables, Item No. 1 - Pipeline Decommissioning
Table 2	Light Source Summary Tables, Item No. 2 - Remediation Site Preparation
Table 3	Light Source Summary Tables, Item No. 3 - Remediation - Active
Table 4	Light Source Summary Tables, Item No. 4 - Building Decommissioning
Table 5	Light Source Summary Tables, Item No. 5 - Dam Decommissioning
Table 6	Light Source Summary Tables, Item No. 6 - Bridge
Table 7	Light Source Summary Tables, Item No. 7 - Disposal Cell Closure
Table 8	Comparison of Light Levels at Receptors - Pre-Curfew Operations
Table 9	Comparison of Light Levels at Receptors - Post-Curfew Operations



1. Introduction

GHD on behalf of Nova Scotia Lands Inc. (NS Lands) has undertaken an analysis of the proposed lighting installations for the Boat Harbour Remediation Project (BHRP) in Pictou Landing, Nova Scotia (Site). The Site is in a rural, mostly wooded area. The impacts of the proposed activities at the Site and along the roads within the study area on nearby sensitive receptors were quantified and compared with the guidelines published by The Institution of Lighting Engineers (ILE) in the document entitled "Guidance Notes for the Reduction of Obtrusive Light".

Definitions

Light trespass is defined as the spilling of light beyond the boundary of the property or area being lit, and is primarily a concern at night. Excess obtrusive light can be a nuisance to others, wastes electricity, and indirectly results in unnecessary emissions of greenhouse gases. Light trespass, or light pollution, can also negatively impact the surrounding ecosystem by disrupting the habits of native species. As such, it is important to understand the potential light impacts from this development, and to endeavor to minimize them.

Luminous flux is the quantity of the energy of the light emitted per second in all directions. The unit of luminous flux is lumen (lm).

Illuminance refers to the amount of light that covers a surface. If Φ is the luminous flux and S is the area of the given surface then the illuminance E is determined by $E = \Phi/S$. Illumination is quantified in terms of lux. One lux is the illuminance of a 1 square metre (m^2) surface uniformly lit by 1 lm of luminous flux.

A residence that may experience an objectionable encroachment of light over the property line is referred to as a residential receptor or sensitive receptor. This undesirable light spill may include the entry of unwanted light through windows, or direct line of sight to bright light sources.

Effects of light on fauna are not well understood and are generally described qualitatively. Some insects are attracted by nighttime lighting. Bats may follow these insects into human-occupied areas in order to hunt. Nighttime lights can adversely affect birds which fly at night, and can increase the incidence of bird impacts on buildings (especially highly reflective buildings or glass buildings where interior lighting may confuse birds).

Nocturnal animals may be adversely affected by excessive light in the nighttime hours. Nocturnal animals which may be affected by nighttime light, changing their movement patterns or activities, include owls, mink, badgers, bats, coyotes, wolves, mice, opossums, raccoons, foxes, skunks, and mountain lions (cougar). Deer and moose prefer dawn and dusk hours, both of which may be affected by project lighting, however the effects of project lighting are likely to be less significant to hunting practices than general human activity.

Deer and moose prefer to avoid people, if possible, and may modify their behavior/distribution due to the presence of the site activities, regardless of lighting.



2. Baseline Conditions

Boat Harbour, formerly known as A'se'k in Mi'kmaq, was originally a tidal estuary connected to the Northumberland Strait in Nova Scotia. The Province of Nova Scotia (the Province) constructed the Boat Harbour Effluent Treatment Facility (BHEFT) (Facility) in 1967 to treat effluent from industrial sources including a chlor alkali plant and a kraft bleached pulp mill, reconstructing the natural tidal estuary into a closed effluent stabilization lagoon. The kraft mill owner is currently responsible for operating the Facility under a lease agreement with the Province. The Province has committed to ceasing the reception and treatment of new effluent to the BHETF by January 31, 2020 in accordance with the Boat Harbour Act. Once operations have ceased, the Province will remediate Boat Harbour and lands associated with the BHETF and restore Boat Harbour to a tidal estuary (Project Area). As part of the restoration work, the existing causeway along Highway 348 and the dam will be removed and replaced with a bridge that will permit boat access to Boat Harbour.

The ILE has developed an Environmental Zone classification system whereby the existing ambient light levels at a site are used to determine the recommended maximum amount of light trespass to nearby receptors. The classification for rural areas, small villages, or relatively dark urban locations is "E2 Low district brightness areas". Based upon this classification, the light trespass limit at an off-site receptor after curfew (typically considered to be 11:00 p.m.) is 1 lux, which is the accepted equivalent to moonlight. The after curfew (post-curfew) limit was used to assess the impact of lighting from the remediation activities from the Project Area as under full-scale operation they are scheduled to be 24 hours per day.

Furthermore, the ILE trespass limit at an offsite receptors before curfew is 5 lux. The current schedule allows for transport trucks entering and leaving the site occurring between 12-16 hours a day, and not during post-curfew hours (after 11:00 p.m.). No other proposed lighting will exist along the haul route. As such, the light trespass at receptors along the haul route was evaluated against the before curfew (pre-curfew) limit of 5 lux.

The use of lights will be limited to the amount necessary to ensure safe operation, with the recognition that excessive lighting can be disruptive to wild species. Light pollution will be reduced by installing downward-facing lights on site infrastructure and site roads. Wherever possible, motion-sensing lights will be installed where practical to ensure lights are not turned on when they are not necessary. Only direct and focused light will be used for worker safety. Bird collisions with Project lighting and subsequent mortality are expected to be rare but if it occurs, it would not likely have significant effects on migrating bird populations. Efforts will be made to reduce the effect of lighting on migrating birds. No monitoring is being proposed for the Project Area.

3. Proposed Lighting

The remediation project is expected to occur over seven separate stages. Tables 1 to 7 summarize the complete list of the proposed light sources to be used during each of the stages. The tasks are summarized as follows:

- Table 1 – Task #1 – Pipeline Decommissioning
- Table 2 – Task #2 – Remediation Site Preparation



- Table 3 – Task #3 – Remediation Active (24 hour per day activities)
- Table 4 – Task #4 – Building Decommissioning
- Table 5 – Task #5 – Dam Decommissioning
- Table 6 – Task #6 – Bridge Demolish and Replace
- Table 7 – Task #7 – Disposal Cell Closure

Since the exact locations of the equipment/lights at each stage are unknown the closest location compared to the receptor was used for the purposes of the calculations. As it is unknown the specific equipment type that is going to be used throughout the program it was estimated that standard equipment would be used. It was assumed that the trucks lights would be the only source of light along the haul road and that lighting would not be installed for the project.

4. Sensitive Receptors

The nearest residential receptors were identified in each direction around the property and work areas. Nine receptors were identified from a review of aerial imagery. These nine receptors were used in the analysis of the impacts of light trespass from the remediation activities. The remediation activities for six of the seven tasks will only occur during pre-curfew hours. The active remediation (Task # 3) is expected to occur for 24 hours per day.

Figure 1 provides the locations of all these receptors and the locations of the proposed site activities.

5. Method of Assessment

GHD completed the assessment based on the equipment list that was generated as part of the greenhouse gas assessment. From known information about the power output of the installations and typical efficiencies, the luminous flux of each light source was calculated:

$$\text{Luminous Flux (lm)} = \text{Power Output (watts)} \times \text{Efficiency} \left(\frac{\text{lumens}}{\text{watt}} \right)$$

The power output of the proposed lighting was known from manufacturer information, and the efficiency was based on typical industry published values, as presented in the following table.

Type of Light	Typical Efficiency (lumens/watt)
LED	58 – 113
Compact Fluorescent	70
Linear Fluorescent	108
Incandescent	15
Halogen	20
High Pressure Sodium	100



Sample Calculation:

For Task #1 (Table 1) there is expected to be a single truck and excavator. It is expected that each piece of equipment will have six mounted halogen lights having a power output of 65 watts each and with average efficiencies of 20 lumens/watt. The luminous flux of the trucks can be calculated as follows:

$$\text{Power Output} = 1 \text{ excavator} \times 6 \frac{\text{Lights}}{\text{excavator}} \times 65 \frac{\text{W}}{\text{Light}} = 390 \text{ W}$$

$$\text{Luminous Flux} = 390 \text{ W} \times 20 \frac{\text{lumens}}{\text{W}} = 7,800 \text{ lumens}$$

After determining luminous flux estimates for each light source, the impacts of the incident light at the identified sensitive receptors can be determined.

Table 1 indicates the estimated distance to the sensitive receptors from these sources. The illuminance level at a receptor is equal to the combined total from each light source. It has been conservatively assumed that 50 percent of the incident light will not reach the receptor due to the thick tree cover at the Site and surrounding area. The following equation was used to estimate the illuminance contribution from each light source:

$$E = \frac{\phi}{d^2} \times 50\%$$

Where:

E = illuminance (lux).

ϕ = luminous flux (lm).

d = distance to the receptor (m).

Sample Calculation:

The luminous flux from the equipment that will be used for Task #1 is an estimated 7,800 lm. The distance to the closest receptor (Receptor #1) from the pipeline decommissioning operations is approximately 106 m. The illuminance contribution from the excavator to Receptor #1 can be estimated as follows:

$$\text{Illuminance} = \frac{7,800 \text{ lumens}}{(106 \text{ m})^2} \times 50\% = 3.47 \times 10^{-1} \text{ lux}$$

This method was used to determine the estimated illuminance at each receptor from each of the light sources. The sum of all contributions for each receptor represents the total estimated level of light that will be present at the receptor.

The table summarizing each task (Table 1 to Table 7) provides the individual contributions as well as the summation of all light sources being used during that task. Table 8 provides a summary of all the different tasks and compares the task with the highest potential impact versus the pre-curfew limit of 5 lux. Table 9 provides the comparison of the post-curfew activities (active remediation) to the post-curfew criteria of 1 lux.



For the purposes of this assessment, pre-curfew was assumed to be before 11:00 p.m. and post-curfew was between 11:00 p.m. and 7:00 a.m.

6. Results and Discussion

The calculated light levels at the identified sensitive receptors are below the limits recommended by the ILE guidelines during both post- and pre-curfew conditions, as shown in Tables 8 and 9, respectively.

The predicted illuminance levels represent the worst-case operating conditions of the remediation project. The assessment considers when all of the equipment is operating at the same time and at the closest location to the receptor. The areas surrounding the Site are wooded with varying topography and inhibit the spread of light. It was conservatively assumed for screening purposes that 50 percent of the light will not reach the receptors due to directionality and line of sight obstructions. In reality the amount of light blocked by the surrounding woodland and topographic changes will likely be much greater than this (>90 percent), especially during the seasons when trees are in full bloom.

All of Which is Respectfully Submitted,

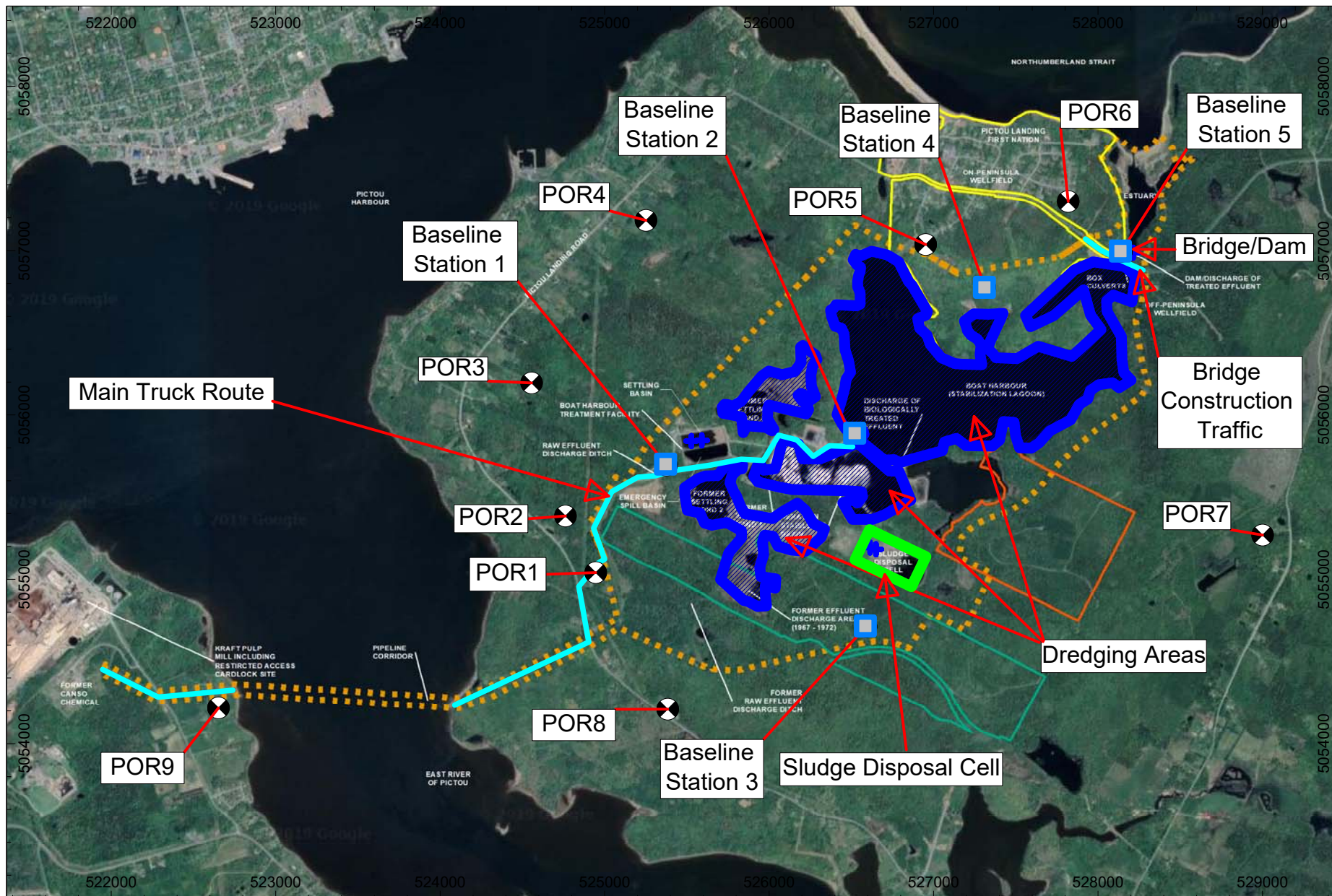
GHD

A handwritten signature in blue ink, appearing to read "Matthew Griffin".

Matthew Griffin, P. Eng.

A handwritten signature in blue ink, appearing to read "Christine Skirth".

Christine Skirth, C.E.T., PMP



- + Point Source
- Line Source
- Area Source
- Sensitive Receptor
- Baseline Station

ENVIRONMENTAL IMPACT STATEMENT - LIGHT ASSESSMENT
 BHRP - PICTOU LANDING, NOVA SCOTIA

FIGURE 1
 POINT-OF-RECEPTION & OPERATION LOCATION PLAN

Table 1

Light Source Summary Tables
Item No. 1 - Pipeline Decommissioning
Boat Harbour Remediation
Pictou Landing, Nova Scotia

Percentage of incident lumens assumed to reach the receptor considering directionality and line of site obstructions: **50%**

Area	Source (3)	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #1		Receptor #2		Receptor #3		Receptor #4		Receptor #5	
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)
Cleaning, Inspecting, and Surface Infrastructure	Truck (4) 6 mounted halogen lights	390	1	390	7800	106	3.47E-01	195	1.03E-01	915	4.66E-03	1157	2.91E-03	1955	1.02E-03
	30 Ton Excavator 6 mounted halogen lights	390	1	390	7800	106	3.47E-01	195	1.03E-01	915	4.66E-03	1157	2.91E-03	1955	1.02E-03

POST-CURFEW	Total, R1:	6.94E-01	Total, R2:	2.05E-01	Total, R3:	9.32E-03	Total, R4:	5.83E-03	Total, R5:	2.04E-03
PRE-CURFEW	Total, R1:	6.94E-01	Total, R2:	2.05E-01	Total, R3:	9.32E-03	Total, R4:	5.83E-03	Total, R5:	2.04E-03

Area	Source (3)	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #6		Receptor #7		Receptor #8		Receptor #9	
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)
Cleaning, Inspecting, and Surface Infrastructure	Truck (4) 6 mounted halogen lights	390	1	390	7800	2708	5.32E-04	3470	3.24E-04	551	1.28E-02	80	6.09E-01
	30 Ton Excavator 6 mounted halogen lights	390	1	390	7800	2708	5.32E-04	3470	3.24E-04	551	1.28E-02	80	6.09E-01

Total, R6:	1.06E-03	Total, R7:	6.48E-04	Total, R8:	2.57E-02	Total, R9:	1.22E+00
Total, R6:	1.06E-03	Total, R7:	6.48E-04	Total, R8:	2.57E-02	Total, R9:	1.22E+00

Notes:

⁽¹⁾ Unless specified, the average Lumens /Watt used were as follows (United States Department of Energy, Solid-State Lighting LED Basics <https://energy.gov/eere/ssl/led-basics>):

- LED lights typically are 58-113 lumens/ per watt.
- Compact Fluorescent lights are typically 70 lumens/watt.
- Linear Fluorescent lights are typically 108 lumens/watt.
- Incandescent lights are typically 15 lumens/watt.
- Halogen lights are typically 20 lumens/watt.
- High Pressure Sodium lights are typically 108 lumens/watt.

⁽²⁾ Illuminance = Luminous Flux/square of distance United States Department of Energy, Solid-State Lighting LED Basics <https://energy.gov/eere/ssl/led-basics>

⁽³⁾ Mobile equipment with headlights was assumed to be stationary for simplicity. It was assumed that each piece of equipment has 6 mounted halogen lamp lights, 65 watts each.

⁽⁴⁾ As a worst-case scenario, the light impacts from the truck was assessed at each receptor along the Haul Route. The truck was assumed to be at the closest location to each receptor along the Haul Route.

Table 2
Light Source Summary Tables
Item No. 2 - Remediation Site Preparation
Boat Harbour Remediation
Pictou Landing, Nova Scotia

Percentage of incident lumens assumed to reach the receptor considering directionality and line of site obstructions: **50%**

Area	Source (3)	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #1		Receptor #2		Receptor #3		Receptor #4		Receptor #5	
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)
Site Preparation	Truck (4) 6 mounted halogen lights	390	1	390	7800	1110	3.17E-03	1115	3.14E-03	1275	2.40E-03	1308	2.28E-03	1615	1.50E-03
	30 Ton Excavator 6 mounted halogen lights	390	1	390	7800	1110	3.17E-03	1115	3.14E-03	1275	2.40E-03	1308	2.28E-03	1615	1.50E-03
	Loaders 6 mounted halogen lights	390	1	390	7800	1110	3.17E-03	1115	3.14E-03	1275	2.40E-03	1308	2.28E-03	1615	1.50E-03
	Dozers 6 mounted halogen lights	390	1	390	7800	1110	3.17E-03	1115	3.14E-03	1275	2.40E-03	1308	2.28E-03	1615	1.50E-03
	Compactor 6 mounted halogen lights	390	1	390	7800	1110	3.17E-03	1115	3.14E-03	1275	2.40E-03	1308	2.28E-03	1615	1.50E-03

POST-CURFEW	Total, R1:	1.58E-02	Total, R2:	1.57E-02	Total, R3:	1.20E-02	Total, R4:	1.14E-02	Total, R5:	7.48E-03
PRE-CURFEW	Total, R1:	1.58E-02	Total, R2:	1.57E-02	Total, R3:	1.20E-02	Total, R4:	1.14E-02	Total, R5:	7.48E-03

Area	Source (3)	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #6		Receptor #7		Receptor #8		Receptor #9	
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)
Site Preparation	Truck (4) 6 mounted halogen lights	390	1	390	7800	2325	7.21E-04	3045	4.21E-04	1497	1.74E-03	3286	3.61E-04
	30 Ton Excavator 6 mounted halogen lights	390	1	390	7800	2325	7.21E-04	3045	4.21E-04	1497	1.74E-03	3286	3.61E-04
	Loaders 6 mounted halogen lights	390	1	390	7800	2325	7.21E-04	3045	4.21E-04	1497	1.74E-03	3286	3.61E-04
	Dozers 6 mounted halogen lights	390	1	390	7800	2325	7.21E-04	3045	4.21E-04	1497	1.74E-03	3286	3.61E-04
	Compactor 6 mounted halogen lights	390	1	390	7800	2325	7.21E-04	3045	4.21E-04	1497	1.74E-03	3286	3.61E-04

POST-CURFEW	Total, R6:	3.61E-03	Total, R7:	2.10E-03	Total, R8:	8.70E-03	Total, R9:	1.81E-03
PRE-CURFEW	Total, R6:	3.61E-03	Total, R7:	2.10E-03	Total, R8:	8.70E-03	Total, R9:	1.81E-03

Notes:

⁽¹⁾ Unless specified, the average Lumens /Watt used were as follows (United States Department of Energy, Solid-State Lighting LED Basics <https://energy.gov/eere/ssl/led-basics>):

- LED lights typically are 58-113 lumens/ per watt.
- Compact Fluorescent lights are typically 70 lumens/watt.
- Linear Fluorescent lights are typically 108 lumens/watt.
- Incandescent lights are typically 15 lumens/watt.
- Halogen lights are typically 20 lumens/watt.
- High Pressure Sodium lights are typically 108 lumens/watt.

⁽²⁾ Illuminance = Luminous Flux/square of distance travelled; therefore 1 Lux = 1 lumen/m2.

⁽³⁾ Mobile equipment with headlights was assumed to be stationary for simplicity. It was assumed that each piece of equipment has 6 mounted halogen lamp lights, 65 watts each.

⁽⁴⁾ As a worst-case scenario, the light impacts from the truck was assessed at each receptor along the Haul Route. The truck was assumed to be at the closest location to each receptor along the Haul Route.

Table 3

Light Source Summary Tables
Item No. 3 - Remediation - Active
Boat Harbour Remediation
Pictou Landing, Nova Scotia

Percentage of incident lumens assumed to reach the receptor considering directionality and line of site obstructions: **50%**

Area	Source	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #1		Receptor #2		Receptor #3		Receptor #4		Receptor #5	
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)
Boat Harbour	Trucks (4) 6 mounted halogen lights	390	4	1560	31200	1660	5.66E-03	1690	5.46E-03	1720	5.27E-03	1250	9.98E-03	250	2.50E-01
	30 Ton Excavator 6 mounted halogen lights	390	1	390	7800	1660	1.42E-03	1690	1.37E-03	1720	1.32E-03	1250	2.50E-03	250	6.24E-02
	MC 225 Dredge 6 mounted halogen lights	390	2	780	15600	1660	2.83E-03	1690	2.73E-03	1720	2.64E-03	1250	4.99E-03	250	1.25E-01
ASB & Settling Basins	Trucks (4) 6 mounted halogen lights	390	4	1560	31200	1215	1.06E-02	1300	9.23E-03	1530	6.66E-03	1580	6.25E-03	1623	5.92E-03
	30 Ton Excavator 6 mounted halogen lights	390	1	390	7800	1215	2.64E-03	1300	2.31E-03	1530	1.67E-03	1580	1.56E-03	1623	1.48E-03
	MC 225 Dredge 6 mounted halogen lights	390	2	780	15600	1215	5.28E-03	1300	4.62E-03	1530	3.33E-03	1580	3.12E-03	1623	2.96E-03
Estuary	Truck (4) 6 mounted halogen lights	390	1	390	7800	3920	2.54E-04	3853	2.63E-04	3650	2.93E-04	3060	4.17E-04	1250	2.50E-03
	30 Ton Excavator 6 mounted halogen lights	390	1	390	7800	3920	2.54E-04	3853	2.63E-04	3650	2.93E-04	3060	4.17E-04	1250	2.50E-03
	MC 225 Dredge 6 mounted halogen lights	390	2	780	15600	3920	5.08E-04	3853	5.25E-04	3650	5.85E-04	3060	8.33E-04	1250	4.99E-03
Wetlands	30 Ton Excavator 6 mounted halogen lights	390	1	390	7800	630	9.83E-03	750	6.93E-03	1050	3.54E-03	1050	3.54E-03	880	5.04E-03
	Dozers 6 mounted halogen lights	390	1	390	7800	630	9.83E-03	750	6.93E-03	1050	3.54E-03	1050	3.54E-03	880	5.04E-03
	Truck (4) 6 mounted halogen lights	390	1	390	7800	630	9.83E-03	750	6.93E-03	1050	3.54E-03	1050	3.54E-03	880	5.04E-03

POST-CURFEW	Total, R1:	5.89E-02	Total, R2:	4.76E-02	Total, R3:	3.27E-02	Total, R4:	4.07E-02	Total, R5:	4.72E-01
PRE-CURFEW	Total, R1:	5.89E-02	Total, R2:	4.76E-02	Total, R3:	3.27E-02	Total, R4:	4.07E-02	Total, R5:	4.72E-01

Area	Source	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #6		Receptor #7		Receptor #8		Receptor #9	
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)
Boat Harbour	Trucks (4) 6 mounted halogen lights	390	4	1560	31200	453	7.60E-02	1290	9.37E-03	1925	4.21E-03	4085	9.35E-04
	30 Ton Excavator 6 mounted halogen lights	390	1	390	7800	453	1.90E-02	1290	2.34E-03	1925	1.05E-03	4085	2.34E-04
	MC 225 Dredge 6 mounted halogen lights	390	2	780	924000	453	3.80E-02	1290	4.69E-03	1925	2.10E-03	4085	4.67E-04
ASB & Settling Basins	Trucks (4) 6 mounted halogen lights	390	4	1560	31200	2300	2.95E-03	15280	6.68E-05	2815	1.97E-03	3400	1.35E-03
	30 Ton Excavator 6 mounted halogen lights	390	1	390	7800	2300	7.37E-04	15280	1.67E-05	2815	4.92E-04	3400	3.37E-04
	MC 225 Dredge 6 mounted halogen lights	390	2	780	924000	2300	1.47E-03	15280	3.34E-05	2815	9.84E-04	3400	6.75E-04
Estuary	Truck (4) 6 mounted halogen lights	390	1	390	7800	445	1.97E-02	2253	7.68E-04	4150	2.26E-04	6075	1.06E-04
	30 Ton Excavator 6 mounted halogen lights	390	1	390	7800	445	1.97E-02	2253	7.68E-04	4150	2.26E-04	6075	1.06E-04
	MC 225 Dredge 6 mounted halogen lights	390	2	780	924000	445	3.94E-02	2253	1.54E-03	4150	4.53E-04	6075	2.11E-04
Wetlands	30 Ton Excavator 6 mounted halogen lights	390	1	390	7800	470	1.77E-02	1730	1.30E-03	620	1.01E-02	2840	4.84E-04
	Dozers 6 mounted halogen lights	390	1	390	7800	470	1.77E-02	1730	1.30E-03	620	1.01E-02	2840	4.84E-04
	Truck (4) 6 mounted halogen lights	390	1	390	7800	470	1.77E-02	1730	1.30E-03	620	1.01E-02	2840	4.84E-04

POST-CURFEW	Total, R6:	2.70E-01	Total, R7:	2.35E-02	Total, R8:	4.22E-02	Total, R9:	5.87E-03
PRE-CURFEW	Total, R6:	2.70E-01	Total, R7:	2.35E-02	Total, R8:	4.22E-02	Total, R9:	5.87E-03

Notes:

⁽¹⁾ Unless specified, the average Lumens /Watt used were as follows (United States Department of Energy, Solid-State Lighting LED Basics <https://energy.gov/eere/ssl/led-basics>):

- LED lights typically are 58-113 lumens/ per watt.
- Compact Fluorescent lights are typically 70 lumens/watt.
- Linear Fluorescent lights are typically 108 lumens/watt.
- Incandescent lights are typically 15 lumens/watt.
- Halogen lights are typically 20 lumens/watt.
- High Pressure Sodium lights are typically 108 lumens/watt.

⁽²⁾ Illuminance = Luminous Flux/square of distance travelled; therefore 1 Lux = 1 lumen/m².

⁽³⁾ Mobile equipment with headlights was assumed to be stationary for simplicity. It was assumed that each piece of equipment has 6 mounted halogen lamp lights, 65 watts each.

⁽⁴⁾ As a worst-case scenario, the light impacts from the truck(2) was assessed at each receptor along the Haul Route. The truck was assumed to be at the closest location to each receptor along the Haul Route. When multiple trucks are a potential scenario it is assumed all trucks

Table 4

Light Source Summary Tables
Item No. 4 - Building Decommissioning
Boat Harbour Remediation
Pictou Landing, Nova Scotia

Percentage of incident lumens assumed to reach the receptor considering directionality and line of site obstructions: **50%**

Area	Source	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #1		Receptor #2		Receptor #3		Receptor #4		Receptor #5	
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)
Demolish	Truck (4)	390	1	390	7800	1500	1.73E-03	1510	1.71E-03	1620	1.49E-03	1510	1.71E-03	1295	2.33E-03
	30 Ton Excavator	390	1	390	7800	1500	1.73E-03	1510	1.71E-03	1620	1.49E-03	1510	1.71E-03	1295	2.33E-03
POST-CURFEW						Total, R1:	3.47E-03	Total, R2:	3.42E-03	Total, R3:	2.97E-03	Total, R4:	3.42E-03	Total, R5:	4.65E-03
PRE-CURFEW						Total, R1:	3.47E-03	Total, R2:	3.42E-03	Total, R3:	2.97E-03	Total, R4:	3.42E-03	Total, R5:	4.65E-03

Area	Source	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #6		Receptor #7		Receptor #8		Receptor #9	
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)
Demolish	Truck (4)	390	1	390	7800	2010	9.65E-04	2640	5.60E-04	1775	1.24E-03	3670	2.90E-04
	30 Ton Excavator	390	1	390	7800	2010	9.65E-04	2640	5.60E-04	1775	1.24E-03	3670	2.90E-04
POST-CURFEW						Total, R6:	1.93E-03	Total, R7:	1.12E-03	Total, R8:	2.48E-03	Total, R9:	5.79E-04
PRE-CURFEW						Total, R6:	1.93E-03	Total, R7:	1.12E-03	Total, R8:	2.48E-03	Total, R9:	5.79E-04

Notes:

⁽¹⁾ Unless specified, the average Lumens /Watt used were as follows (United States Department of Energy, Solid-State Lighting LED Basics <https://energy.gov/eere/ssl/led-basics>):

- LED lights typically are 58-113 lumens/ per watt.
- Compact Fluorescent lights are typically 70 lumens/watt.
- Linear Fluorescent lights are typically 108 lumens/watt.
- Incandescent lights are typically 15 lumens/watt.
- Halogen lights are typically 20 lumens/watt.
- High Pressure Sodium lights are typically 108 lumens/watt.

⁽²⁾ Illuminance = Luminous Flux/square of distance travelled; therefore 1 Lux = 1 lumen/m².

⁽³⁾ Mobile equipment with headlights was assumed to be stationary for simplicity. It was assumed that each piece of equipment has 6 mounted halogen lamp lights, 65 watts each.

⁽⁴⁾ As a worst-case scenario, the light impacts from the truck(2) was assessed at each receptor along the Haul Route. The truck was assumed to be at the closest location to each receptor along the Haul Route.

Table 5
Light Source Summary Tables
Item No. 5 - Dam Decommissioning
Boat Harbour Remediation
Pictou Landing, Nova Scotia

Percentage of incident lumens assumed to reach the receptor considering directionality and line of site obstructions: **50%**

Area	Source	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #1		Receptor #2		Receptor #3		Receptor #4		Receptor #5		
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	
Demolish	Truck	6 mounted halogen lights	390	1	390	7800	3500	3.18E-04	3516	3.15E-04	3400	3.37E-04	2900	4.64E-04	1055	3.50E-03
	45 Ton Excavator	6 mounted halogen lights	390	1	390	7800	3500	3.18E-04	3516	3.15E-04	3400	3.37E-04	2900	4.64E-04	1055	3.50E-03

POST-CURFEW	Total, R1:	6.37E-04	Total, R2:	6.31E-04	Total, R3:	6.75E-04	Total, R4:	9.27E-04	Total, R5:	7.01E-03
PRE-CURFEW	Total, R1:	6.37E-04	Total, R2:	6.31E-04	Total, R3:	6.75E-04	Total, R4:	9.27E-04	Total, R5:	7.01E-03

Area	Source	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #6		Receptor #7		Receptor #8		Receptor #9		
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	
Demolish	Truck	6 mounted halogen lights	390	1	390	7800	450	1.93E-02	1780	1.23E-03	3656	2.92E-04	5700	1.20E-04
	45 Ton Excavator	6 mounted halogen lights	390	1	390	7800	450	1.93E-02	1780	1.23E-03	3656	2.92E-04	5700	1.20E-04

POST-CURFEW	Total, R6:	3.85E-02	Total, R7:	2.46E-03	Total, R8:	5.84E-04	Total, R9:	2.40E-04
PRE-CURFEW	Total, R6:	3.85E-02	Total, R7:	2.46E-03	Total, R8:	5.84E-04	Total, R9:	2.40E-04

Notes:

⁽¹⁾ Unless specified, the average Lumens /Watt used were as follows (United States Department of Energy, Solid-State Lighting LED Basics <https://energy.gov/eere/ssl/led-basics>):

- LED lights typically are 58-113 lumens/ per watt.
- Compact Fluorescent lights are typically 70 lumens/watt.
- Linear Fluorescent lights are typically 108 lumens/watt.
- Incandescent lights are typically 15 lumens/watt.
- Halogen lights are typically 20 lumens/watt.
- High Pressure Sodium lights are typically 108 lumens/watt.

⁽²⁾ Illuminance = Luminous Flux/square of distance travelled; therefore 1 Lux = 1 lumen/m².

⁽³⁾ Mobile equipment with headlights was assumed to be stationary for simplicity. It was assumed that each piece of equipment has 6 mounted halogen lamp lights, 65 watts each.

⁽⁴⁾ As a worst-case scenario, the light impacts from the truck(2) was assessed at each receptor along the Haul Route. The truck was assumed to be at the closest location to each receptor along the Haul Route.

Table 6

**Light Source Summary Tables
Item No. 6 - Bridge
Boat Harbour Remediation
Pictou Landing, Nova Scotia**

Percentage of incident lumens assumed to reach the receptor considering directionality and line of site obstructions: **50%**

Area	Source	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #1		Receptor #2		Receptor #3		Receptor #4		Receptor #5		
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	
Demolish and Replace	Truck (4)	6 mounted halogen lights	390	1	390	7800	3500	3.18E-04	3516	3.15E-04	3400	3.37E-04	2900	4.64E-04	1055	3.50E-03
	30 Ton Excavator	6 mounted halogen lights	390	1	390	7800	3500	3.18E-04	3516	3.15E-04	3400	3.37E-04	2900	4.64E-04	1055	3.50E-03
	Dozer	6 mounted halogen lights	390	1	390	7800	3500	3.18E-04	3516	3.15E-04	3400	3.37E-04	2900	4.64E-04	1055	3.50E-03
	Compactor	6 mounted halogen lights	390	1	390	7800	3500	3.18E-04	3516	3.15E-04	3400	3.37E-04	2900	4.64E-04	1055	3.50E-03

POST-CURFEW	Total, R1:	1.27E-03	Total, R2:	1.26E-03	Total, R3:	1.35E-03	Total, R4:	1.85E-03	Total, R5:	1.40E-02
PRE-CURFEW	Total, R1:	1.27E-03	Total, R2:	1.26E-03	Total, R3:	1.35E-03	Total, R4:	1.85E-03	Total, R5:	1.40E-02

Area	Source	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #6		Receptor #7		Receptor #8		Receptor #9		
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	
Demolish and Replace	Truck (4)	6 mounted halogen lights	390	1	390	7800	450	1.93E-02	1780	1.23E-03	3656	2.92E-04	5700	1.20E-04
	30 Ton Excavator	6 mounted halogen lights	390	1	390	7800	450	1.93E-02	1780	1.23E-03	3656	2.92E-04	5700	1.20E-04
	Dozer	6 mounted halogen lights	390	1	390	7800	450	1.93E-02	1780	1.23E-03	3656	2.92E-04	5700	1.20E-04
	Compactor	6 mounted halogen lights	390	1	390	7800	450	1.93E-02	1780	1.23E-03	3656	2.92E-04	5700	1.20E-04

Total, R6:	7.70E-02	Total, R7:	4.92E-03	Total, R8:	1.17E-03	Total, R9:	4.80E-04
Total, R6:	7.70E-02	Total, R7:	4.92E-03	Total, R8:	1.17E-03	Total, R9:	4.80E-04

Notes:

⁽¹⁾ Unless specified, the average Lumens /Watt used were as follows (United States Department of Energy, Solid-State Lighting LED Basics <https://energy.gov/eere/ssl/led-basics>):

- LED lights typically are 58-113 lumens/ per watt.
- Compact Fluorescent lights are typically 70 lumens/watt.
- Linear Fluorescent lights are typically 108 lumens/watt.
- Incandescent lights are typically 15 lumens/watt.
- Halogen lights are typically 20 lumens/watt.
- High Pressure Sodium lights are typically 108 lumens/watt.

⁽²⁾ Illuminance = Luminous Flux/square of distance travelled; therefore 1 Lux = 1 lumen/m².

⁽³⁾ Mobile equipment with headlights was assumed to be stationary for simplicity. It was assumed that each piece of equipment has 6 mounted halogen lamp lights, 65 watts each.

⁽⁴⁾ As a worst-case scenario, the light impacts from the truck(2) was assessed at each receptor along the Haul Route. The truck was assumed to be at the closest location to each receptor along the Haul Route.

Table 7

**Light Source Summary Tables
Item No. 7 - Disposal Cell Closure
Boat Harbour Remediation
Pictou Landing, Nova Scotia**

Percentage of incident lumens assumed to reach the receptor considering directionality and line of site obstructions: **50%**

Area	Source	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #1		Receptor #2		Receptor #3		Receptor #4		Receptor #5		
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	
Waste Management & Capping	Truck (4)	6 mounted halogen lights	390	1	390	7800	1770	1.24E-03	20110	9.64E-06	2400	6.77E-04	2415	6.69E-04	1885	1.10E-03
	30 Ton Excavator	6 mounted halogen lights	390	1	390	7800	1770	1.24E-03	20110	9.64E-06	2400	6.77E-04	2415	6.69E-04	1885	1.10E-03
	Loader	6 mounted halogen lights	390	1	390	7800	1770	1.24E-03	20110	9.64E-06	2400	6.77E-04	2415	6.69E-04	1885	1.10E-03
	Dozer	6 mounted halogen lights	390	1	390	7800	1770	1.24E-03	20110	9.64E-06	2400	6.77E-04	2415	6.69E-04	1885	1.10E-03

POST-CURFEW	Total, R1:	4.98E-03	Total, R2:	3.86E-05	Total, R3:	2.71E-03	Total, R4:	2.67E-03	Total, R5:	4.39E-03
PRE-CURFEW	Total, R1:	4.98E-03	Total, R2:	3.86E-05	Total, R3:	2.71E-03	Total, R4:	2.67E-03	Total, R5:	4.39E-03

Area	Source	Power (watts)	Qty	Total Power (watts)	Luminous Flux ⁽¹⁾ (lumens)	Receptor #6		Receptor #7		Receptor #8		Receptor #9		
						Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	Approximate Distance (m)	Illuminance ⁽²⁾ (lux)	
Waste Management & Capping	Truck (4)	6 mounted halogen lights	390	1	390	7800	2355	7.03E-04	2100	8.84E-04	1595	1.53E-03	3945	2.51E-04
	30 Ton Excavator	6 mounted halogen lights	390	1	390	7800	2355	7.03E-04	2100	8.84E-04	1595	1.53E-03	3945	2.51E-04
	Loader	6 mounted halogen lights	390	1	390	7800	2355	7.03E-04	2100	8.84E-04	1595	1.53E-03	3945	2.51E-04
	Dozer	6 mounted halogen lights	390	1	390	7800	2355	7.03E-04	2100	8.84E-04	1595	1.53E-03	3945	2.51E-04

POST-CURFEW	Total, R6:	2.81E-03	Total, R7:	3.54E-03	Total, R8:	6.13E-03	Total, R9:	1.00E-03
PRE-CURFEW	Total, R6:	2.81E-03	Total, R7:	3.54E-03	Total, R8:	6.13E-03	Total, R9:	1.00E-03

Notes:

⁽¹⁾ Unless specified, the average Lumens /Watt used were as follows (United States Department of Energy, Solid-State Lighting LED Basics <https://energy.gov/eere/ssl/led-basics>):

- LED lights typically are 58-113 lumens/ per watt.
- Compact Fluorescent lights are typically 70 lumens/watt.
- Linear Fluorescent lights are typically 108 lumens/watt.
- Incandescent lights are typically 15 lumens/watt.
- Halogen lights are typically 20 lumens/watt.
- High Pressure Sodium lights are typically 108 lumens/watt.

⁽²⁾ Illuminance = Luminous Flux/square of distance travelled; therefore 1 Lux = 1 lumen/m².

⁽³⁾ Mobile equipment with headlights was assumed to be stationary for simplicity. It was assumed that each piece of equipment has 6 mounted halogen lamp lights, 65 watts each.

⁽⁴⁾ As a worst-case scenario, the light impacts from the truck(2) was assessed at each receptor along the Haul Route. The truck was assumed to be at the closest location to each receptor along the Haul Route.

Comparison of Light Levels at Receptors - Pre-Curfew Operations
 Boat Harbour Remediation
 Pictou Landing, Nova Scotia

	Item #1	Item #2	Item #3	Item #4	Item #5	Item #6	Item #7	ILE Guidance Limit ⁽¹⁾	Percentage of Criteria ⁽³⁾
Receptor	Illuminance (lux) Pre-Curfew ⁽²⁾	Illuminance (lux) Pre-Curfew ⁽²⁾	Illuminance (lux) Pre-Curfew ⁽²⁾	Illuminance (lux) Pre-Curfew ⁽²⁾	Illuminance (lux) Pre-Curfew ⁽²⁾	Illuminance (lux) Pre-Curfew ⁽²⁾	Illuminance (lux) Pre-Curfew ⁽²⁾	Pre-Curfew ⁽²⁾ (lux)	Pre-Curfew ⁽²⁾ (%)
Receptor #1	6.94E-01	1.58E-02	5.89E-02	3.47E-03	6.37E-04	1.27E-03	4.98E-03	5	13.88%
Receptor #2	2.05E-01	1.57E-02	4.76E-02	3.42E-03	6.31E-04	1.26E-03	3.86E-05	5	4.10%
Receptor #3	9.32E-03	1.20E-02	3.27E-02	2.97E-03	6.75E-04	1.35E-03	2.71E-03	5	0.65%
Receptor #4	5.83E-03	1.14E-02	4.07E-02	3.42E-03	9.27E-04	1.85E-03	2.67E-03	5	0.81%
Receptor #5	2.04E-03	7.48E-03	4.72E-01	4.65E-03	7.01E-03	1.40E-02	4.39E-03	5	9.45%
Receptor #6	1.06E-03	3.61E-03	2.70E-01	1.93E-03	3.85E-02	7.70E-02	2.81E-03	5	5.40%
Receptor #7	6.48E-04	2.10E-03	2.35E-02	1.12E-03	2.46E-03	4.92E-03	3.54E-03	5	0.47%
Receptor #8	2.57E-02	8.70E-03	4.22E-02	2.48E-03	5.84E-04	1.17E-03	6.13E-03	5	0.84%
Receptor #9	1.22E+00	1.81E-03	5.87E-03	5.79E-04	2.40E-04	4.80E-04	1.00E-03	5	24.38%

Notes:

All operations, with the exception of Item 3, only occur during Pre-Curfew hours.

⁽¹⁾ Based on a classification of the area as Environmental Zone E2- Low district brightness areas (Guidance Notes for the Reduction of Obtrusive Light, The Institute of Lighting Engineers (2011)).

⁽²⁾ Curfew = the time after which stricter requirements for the control of obtrusive light will apply. If not defined by the local planning authority, the ILE suggests 11:00 p.m. The Institute of Lighting Engineers (2011).Obstrusive Light, "Table 1-Obtrusive Light Limitations for Exterior Lighting Installations",)

⁽³⁾ Based on conservative assumption of 50% reduced light due to directionality and line of site obstructions.

**Comparison of Light Levels at Receptors - Post-Curfew Operations
Boat Harbour Remediation
Pictou Landing, Nova Scotia**

	Item #3	ILE Guidance Limit ⁽¹⁾	Percentage of Criteria ⁽³⁾
Receptor	Illuminance (lux)	Pre-Curfew ⁽²⁾	Pre-Curfew ⁽²⁾
	Pre-Curfew ⁽²⁾	(lux)	(%)
Receptor #1	5.89E-02	1	5.89%
Receptor #2	4.76E-02	1	4.76%
Receptor #3	3.27E-02	1	3.27%
Receptor #4	4.07E-02	1	4.07%
Receptor #5	4.72E-01	1	47.23%
Receptor #6	2.70E-01	1	26.99%
Receptor #7	2.35E-02	1	2.35%
Receptor #8	4.22E-02	1	4.22%
Receptor #9	5.87E-03	1	0.59%

Notes:

Only item 3 occurs post-curfew, all other operations are limited to pre-curfew

⁽¹⁾ Based on a classification of the area as Environmental Zone E2- Low district brightness areas (Guidance Notes for the Reduction of Obstrusive Light, The Institute of Lighting Engineers (2011)).

⁽²⁾ Curfew = the time after which stricter requirements for the control of obtrusive light will apply. If not defined by the local planning authority, the ILE suggests 11:00 p.m.
The Institute of Lighting Engineers (2011).Obstrusive Light, "Table 1-Obtrusive Light Limitations for Exterior Lighting Installations",)

⁽³⁾ Based on conservative assumption of 50% reduced light due to directionality and line of site obstructions.



about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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