Parks Canada Parcs Canada

Guidelines and Specifications for Outdoor Lighting at Parks Canada

Dark skies, Ecosystem protection and energy savings

Canada

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REVIEW: These procedures will be updated as required.

Canada

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1.0 PURPOSE

This document presents best practices for outdoor lighting at Parks Canada facilities and specifies equipment to help achieve these best practices. The document outlines the rationale for the need to protect the night time environment from the excessive use of artificial lighting and specifies degrees of protection. There are three objectives for this Best Practices and Specifications for Outdoor Lighting document: darker skies, ecosystem protection and energy savings.

This document mainly serves as a reference tool for parks or sites that wish to become designated as Dark Sky Preserves. The initiative in establishing dark sky preserves in Canada came from the Muskoka Heritage Foundation working with the Ontario Ministry of Natural Resources, Parry Sound District. This cooperation led to the establishment of the Torrance Barrens Conservation Preserve as Canada's first dark sky preserve in 1999. This was followed in 2004 by the designation of the Cypress Hills Preserve, which includes Fort Walsh National Historic Site. PC now manages 10 of the 17 Dark Sky Preserves in Canada designated by the Royal Astronomical Society of Canada.

2.0 SCOPE

Categories of areas and facilities within Parks Canada are identified that may require artificial outdoor lighting. Lighting hardware is described and specified for each area category to assist in minimizing the impact of artificial lighting on the night time environment while maintaining safety.

3.0 GLOSSARY

CARS Canadian Aviation Regulations
CF Compact Florescent lamps

EI Ecological Integrity

FCO Full Cut-Off luminaires (0% up-light, Fully Shielded)

HID High Intensity Discharge lamps (LPS, HPS, MH lamps)
HPS High Pressure Sodium lamps (“yellow” coloured lamps)

IESNA Illumination Engineering Society of North America

LEDs Light Emitting Diodes
LPS Low Pressure Sodium lamps (monochromatic, single colour lamps)

MH Metal Halide lamps (“white” coloured lamps)

SCO Semi Cut-off luminaires (<2% up-light)
SAD Seasonal Affective Disorder

4.0 RATIONALE

The availability of electrical energy and efficient lighting fixtures has enabled the current urban lifestyle of non-stop "24-7" activity. Further, the advances in illumination technology have permitted illumination levels to increase over the last 50 years by a factor 10, with the use of the same amount of electrical power. The result is that most commercial luminaires are designed for high levels of illumination. Low intensity fixtures are primarily limited to decorative lighting such as Christmas lights.

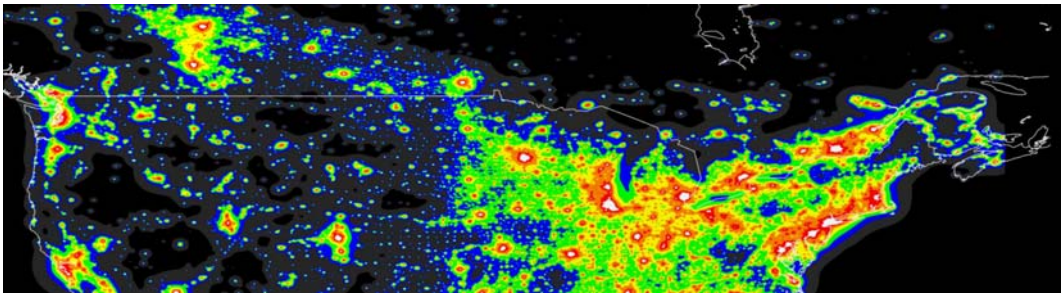

Figure 3.0.1 Mid Latitudes at Night1

It is now common in a city to be able to read a newspaper at night under the city's sky glow. In Figure 3.0.2, the light polluted skies of Toronto are compared to relatively good skies southwest of Ottawa on the Rideau Canal system to the dark skies of Algonquin Park. In Toronto only the brightest stars are visible. On the Rideau Lake, the Milky Way is easy to see but has the sky glow from Ottawa extending half way up in the northeast and from Kingston on the southwestern horizon. From Algonquin Park, there is virtually no visible sky glow and the Milky Way dominates the landscape after dark.

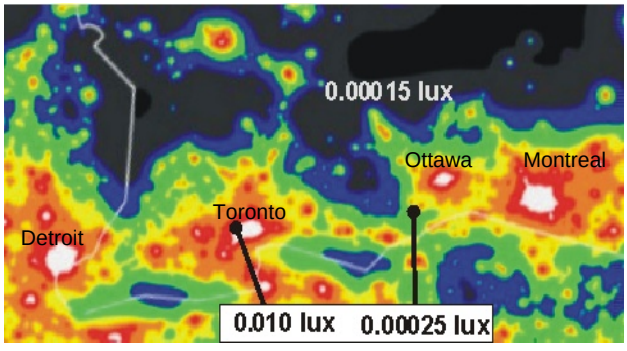

Figure 3.0.2 Light Pollution in Southern Ontario

(Readings under clear skies)

[1] P. Cinzano 2001

One of the most prevalent reasons given in cities for night time lighting is to reduce crime. This is generally based on the notion that more light improves visibility, and that this visibility discourages criminals. However, there is little evidence to indicate that more lighting reduces crime[2]. Most research literature about crime is based on studies of urban areas and more specifically the inner city neighbourhoods. A few researchers have looked at the impacts that more natural looking environments have on crime. They report that more natural environments lower the reports of crime and the fear of it[3]. This work is by no means conclusive, but it questions the appropriateness of extrapolating urban criminal studies into rural environments, and by extension into the extremely low population densities of a wilderness park or remote historic site.

Human Health

This proliferation of outdoor lighting can have an impact on the health and behaviour of humans[4]. "Biological clocks control our sleep patterns, alertness, mood, physical strength, blood pressure, and every other aspect of our physiology"[5]. The dominant mechanism for synchronizing this biological clock to our activity (the circadian rhythm) is the day-night contrast and the timely release of the hormone melatonin. This hormone regulates the ebb and flow of other hormones in our bodies. The timing of the circadian rhythm also affects our behaviour.

Ecological Health

Although many people are familiar with the activity of the natural world during the day (i.e., photobiology), few people are as familiar with similar activity at night. Humans are not the only species whose biological clock is controlled by day-night contrasts and the release of melatonin. It is found in animals wherein it plays a similar role[6]. Wildlife depends on the darkness of the night and the study of this dependence is called scotobiology. There is mounting scientific evidence documenting the profound impact of artificial light on the ecology of the night.

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[2] The Indiana Council on Outdoor Lighting Education (ICOLE), P.O. Box 17351, Indianapolis, IN 46217.

[3] Environment and Crime in the Inner City, Environment and Behavior, Vol. 33, No. 3, 343-367 (2001).

[4] Light Research Organization, Electric Power Research Institute.

[5] WebMD, March 06, 2007.

[6] "Lighting for the Human Circadian Clock", S. M. Pauley, Medical Hypotheses (2004) 63,588–596

Animal Behaviour

Artificial lighting changes the night time behaviour of species[7]. Over a month, the changing phases of the moon affect the ground illumination at night. Nocturnal mammals adapt their behaviour over the month in sympathy to moonlight to avoid predators. This behaviour includes, in part, limiting the foraging area and carrying food back to their shelters instead of eating it in the field. This latter adaptation limits how much they can eat[8].

Predator and prey behaviour depends on the darkness of the night[9]. Illumination levels that significantly affect wildlife are believed to be at the level of the full moon, although the effect begins to be evident at lower light levels[10]. To put this in context, an urban parking lot is often lit at more than 100 times this level (see Appendix A).

It is well documented that some insects are drawn towards light sources. This interrupts their normal mating and foraging activities and it concentrates them within a small area thus enhancing predation[11]. Animals separated from their normal foraging grounds by an illuminated road cannot see field beyond the lights. Their natural instinct is to wait until they can see where they are going. This can leave them in the open and vulnerable to predation. This may lead to them abandoning their established foraging patterns for new ones, which will impact other species as they compete for resources[12].

Aquatic Life and Navigation

Historically, waterways have been used for transportation and recreation. However, they are also important ecosystems that support wildlife. Shoreline property is valued by our society and this is causing human developments along rivers and around lakes. An increasing number of properties have shore lighting that illuminates the waterway. This impacts the river and lakes in two ways. From the human standpoint, bright lights along the shoreline make it very difficult to navigate the channel. Glare from unshielded shore lighting prevents our eyes from becoming adapted to the darkness. At night, a boater will only be able to see the points of light long the shore rendering the channel markers and out-of-channel hazards very difficult to see.

[7] The Urban Wildlands Group.
[8] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006, p. 28.
[9] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006.
[10] ibid., Chapter 11.
[11] ibid., Chapter 13.
[12] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006.

The second impact is on the fish and water plants[13]. The studies in Florida on the affect of artificial light on turtle hatchlings demonstrate how light can interfere with the normal behaviour of turtles[14]. When the hatchlings emerge from the sand they naturally head towards light. Usually this would be emitted by waves breaking on a beach. However, inland artificial lighting distracts the hatchlings and they travel inland instead of to the sea. They become vulnerable to predators and may try to cross roadways. These studies are not specific to Canadian waters, however they highlight the care that must be exercised in any alteration of the environment with something as apparently innocuous as light.

The effect of light on fish is not clear. Fish are attracted to the light from their natural feeding depths. The increase in the concentration of fish changes the hunting efficiency of predators. Although the behaviour of the nocturnal predator may not be compromised by artificial light, the ability of its prey to recognize the danger and to escape will affect their survival.

Cultural Impact

There is also a cultural imperative to protect the darkness of the night sky. Throughout recorded history (about 6,000 years) astronomy has been the focus of stories and mythologies. Those who have seen a dark sky are impressed by the serene majesty of the celestial sphere. It comes as no surprise that all civilizations have the constellations and asterisms woven into their culture.

After stepping outside from a lighted room and under a dark rural sky, our initial count of a few stars with photopic vision increases a hundred fold after only 10 minutes. This may increase by another order of magnitude after less than an hour as our eyes become fully dark-adapted. However, urban sky glow overwhelms the faint stars, and the glare from discrete light fixtures prevents our eyes from becoming dark-adapted. These limit the number of stars we can see from many thousands to only a few hundred. Our current generation is the first for whom much less than half the population has seen a star-filled night sky. Most children have never seen the Milky Way.

Energy Consumption

Light directed towards the sky represents inefficiency and waste. Focussing light to where it is needed as well as minimizing light output levels and duration will reduce electricity costs and greenhouse gas emissions.

[13] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006, Part V.

[14] B. E. Witherington, R. E. Martin, Florida Fish and Wildlife Conservation Commission, FMRI Technical Report TR-2, Second Edition 2000.

Summary

While it is recognized that lighting is important and necessary in certain situations, proper management and reduction of lighting will contribute to ecosystem protection, energy savings and darker skies.

5.0 GENERAL BEST PRACTICES

This section provides an overview of the general techniques that may be used to minimize light pollution with references to wildlife nocturnal behaviour. The equipment requirements and illumination levels are described more fully in Section 6.0.

Where necessary for basic safety:

- illumination should be to the minimum practical level;
- the affected area of illumination should be as small as practical;
- the duration of the illumination should be as short as practical; and
- illumination colour should be biased towards the red part of the visual spectrum.

What is “practical” depends upon the specific conditions of the area concerned and the technology available to illuminate the area.

5.1 Illumination Levels

Maximum illumination levels should be comparable to that of the full moon (1 lux max – 0.2 typical). The variation of illumination between new moon and full moon is up to 10,000:1. Where pedestrian traffic volume is known to be high after dark, illumination levels should be no more than 5 times that of the full moon. A lighting curfew should be imposed in all areas except where specifically identified. Where higher illumination levels are required for specific purposes, the area of illumination should be minimized.

5.2 Extent of Illumination

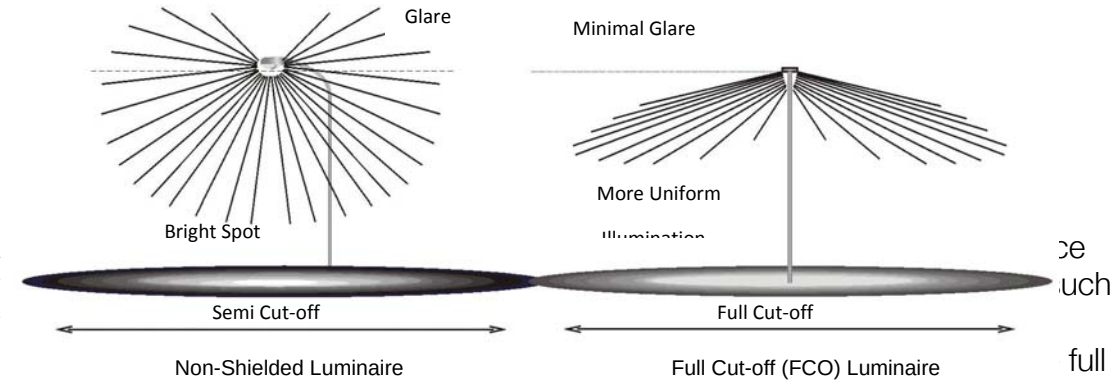
The light from non-shielded fixtures can be seen, literally, as far as the eye can see. Tall trees around a lighted area will significantly restrict the illumination to a small area, however it is more effective to use light fixtures that are engineered to limit the extent of the illumination.

Full cut-off fixtures (also called fully shielded fixtures) (see Figure 5.2) prevent light from shining beyond the immediate area and up into the sky. Since no light shines horizontally, the amount of glare at a distance from the fixture is significantly reduced from that of semi cut-off or unshielded luminaires. By reducing glare, eyes of both animals and humans can become more accustomed to the darkness allowing them to see into areas with lower illumination levels farther from the fixture.

The improvement in visibility at light levels that are lower with full cut-off fixtures permits lower wattage bulbs to be used that in turn reduce energy consumption. By

lowering the illumination levels, less light will reflect off the ground into the sky. This further reduces the extent, and impact, of the artificial light on the night environment.

To further limit the extent of the illuminated area, pole heights should be limited to below the surrounding trees so that the tree canopy will help to contain stray light from shining into the adjacent areas.



ce
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full

cut-off fixture in Figure 5.2)

Figure 5.2 Luminaires

5.3 Duration of the Illumination

Artificial illumination should be reduced or eliminated, where feasible, following a reasonable time after dark. Natural illumination levels are approximately 0.1% that of full sunlight just after sunset (100 lux) and 100X that of a full moon (see Appendix

A). At that time, indoor illumination (approximately 200 lux) is higher than the outdoor levels. After about 30 minutes, the natural illumination level due to dusk is about that of a full Moon (1 lux)[15].

If indoor lighting, especially for offices and stores, shines through windows it may have an impact on the areas outside. It may also produce glare that will prevent dark adaptation for people and animals. This has no effect until after sunset, at which time the sky illuminates the ground to a lower level. Window coverings should be used to prevent continued spillage of the indoor light through the windows.

A "dark time" may be defined, after which illuminated activity is discouraged. This recognizes that low-level activity may continue after sunset and dusk. Exterior lighting may remain on during this time, after which there should be a lighting curfew that would apply to Parks Canada lighting. The time of this curfew will depend on the nature of the facility and type of activity. A reasonable lighting curfew time (such as 2 hours after sunset) should be determined.

Timing circuits should turn off all exterior lighting fixtures at the beginning of the lighting curfew except where identified in this document. A light detector that is triggered by sunset should activate a timing circuit to turn light fixtures off within 30 minutes of sunset. Manually activated switches should also be available to turn off exterior lighting.

In areas with high volume of pedestrian traffic and where limited activity continues after dark that requires illumination, motion detectors should control light fixtures. Automatic timers should be used to turn them off after a reasonable period of time.

On a technical note, only Light Emitting Diodes (LEDs), compact fluorescent (CF) and incandescent lamps can be switched on for short periods of time. High Intensity Discharge (HID) lamps (Low Pressure Sodium and High Pressure Sodium) require several minutes to heat up before they will reach full brightness.

5.4 Colour of Illumination

Various light sources (lamps) have different colour content. These are discussed in Appendix B. Section 6.0 Specifications identifies where these lamps should be used.

Humans and animals are affected by the colour of light. Blue light (short wavelengths) affects their low level scotopic vision whereas red light (long wavelengths) is seen well by their photopic vision. The use of long wavelength light allows animals to see without degrading their sensitive scotopic vision.

[15] R. Dick, Carleton University, Ottawa, 2006.

Specifically, insects and birds[16] are affected more by white than red lights. The effect of lighting on birds has been documented in studies of bird mortality around communication towers that have navigation avoidance beacons[17].

The colour and type of light that is used may vary depending on the extent and use of the illuminated area. Colour content of light (spectral content) assists in identifying cars by colour or persons by the colour of their clothing. When artificial lighting is deemed necessary due to high pedestrian traffic, the colour content of the light source should provide sufficient colour content to allow fair colour recognition.

Where low illumination levels are necessary (pathways), lighting may only be possible with incandescent bulbs or Amber Light Emitting Diodes (LEDs). Where necessary, roadway marker lighting should use low pressure sodium (LPS) sources.

Where there is high volume pedestrian or vehicle traffic, light emitting diodes (LED), incandescent or high pressure sodium (HPS) lamps should be used. The level of required illumination should determine the specific type of lamp. Larger areas where high-level illumination is required may need high pressure sodium (HPS) sources (i.e. parking lots).

5.5 Light Pollution Abatement in Interpretive and Outreach Education Programs

In order for the public to understand and appreciate the efforts taken by Parks Canada to protect the nocturnal environment, an interpretation or an outreach program could be provided where human and financial resources for such programs exist. These initiatives present a very good opportunity for interpretation and outreach education personnel to take an active role in changing the public's perception of the nocturnal environment. By highlighting nature's vulnerabilities to human impacts as subtle as outdoor lighting, they will inform visitors of the benefits of more responsible lighting with the saving of energy and the reduction of power plant emissions.

6.0 SPECIFICATIONS

These specifications contain descriptive information to aid in the selection of the:

- type of lighting fixtures;
- wattage of luminaires;

[16] Ecological Consequences of Artificial Night Lighting, Rich, Longcore, Island Press, 2006, Part II, V
[17] Gehring, J. Aviation Collision Study for the Michigan Public Safety Communications System (MPSCS): Summary of Spring 2005 Field Season, Central Michigan University, August 12, 2005

- area of illumination;
- duration of the permitted illumination;
- colour of the illumination; and
- approximate illumination level.

The values for these parameters are summarized in tables for each area and application. Similar fixture hardware is specified to minimize the number of different spare parts required to be kept for repairs or replacement.

Illumination levels specified in this document are lower than urban areas for which most luminaires have been designed. This restricts the type of light sources that may be used. Although High Intensity Discharge (HID) lamps are very efficient, they may emit more light than is required to meet this specification. To address this, relatively inefficient, incandescent lights may be used for short periods of time or more advanced Light Emitting Diode (LED) luminaries may be installed.

Parks Canada is responsible for a variety of properties. In this section, specific areas are identified with a range of lighting conditions that reflect their varied use. Assessment of lighting levels that are most appropriate for their facility within the limits defined in General Best Practices is left to the discretion of Parks Canada staff.

These specifications address the use of the facility and expected pedestrian and vehicle traffic. Priority is given to respecting and protecting the natural environment. Lighting is limited to provide only what is required for navigation in built up areas. The artificial lighting is restricted to these areas and for the periods of human activity unless otherwise noted.

The following tenets have been used in developing these specifications.

1. Buildings require illumination only when open or available to humans. After people have left, all lighting visible from the outside should be turned off or covered.
2. To save energy and minimize the duration and extent of light pollution, lighted pathways should be illuminated only when pedestrians are in transit. All reasonable effort should be made to turn off lighting when pedestrian traffic is low or is no longer expected.
3. The areas covered by this specification should only provide a safe transition between lighted structures and the surrounding unlighted area and to assist in navigation.
4. The area of illumination should be limited.
5. Light activated timing circuits should turn off outdoor lighting. The time delay should begin at sunset and should extend to an appropriate time to permit the activity to end.

"Dark Time" is a term used to identify the end of significant activity within an area. This term is used herein to identify when light should be discouraged. In this document "Dark Time" is further assumed as being 2-hours after sunset. Appendix D contains a reference table with the approximate times of sunset for southern Canada.

6.1 Buildings

This section identifies six types of structures that may require illumination. In all cases, full cut-off luminaires should be used and illumination controlled to prevent light scattering beyond the immediate area. Further, the colour of this light should have minimal blue (short wavelength) content and lighting curfews should apply.

Interior and exterior lighting that remains on for extended periods after operating hours not only wastes energy but can also cause a nuisance. Insects are attracted to exterior building lights and interior lighting that shines through windows. In addition to the need for cleaning before the building opens for the public, the light distracts insects from their normal activity.

Illumination levels and luminaire types for various buildings are listed in Table 6.1.

This document uses five classifications for buildings:

- administrative and operational buildings;
- public buildings;
- stores;
- vending machine enclosures; and
- toilet and washroom facilities.

6.1.1 Administrative and Operational Buildings

Administrative and operational buildings are defined as those occupied by Parks Canada employees such as administration buildings, garages, workshops, warehouses, warden stations, etc. These buildings will generally be closed after dark. Illumination of the main doorway and especially any steps leading to the main door may be required after sunset or before the sunrise depending on the season.

After hours, either all interior lighting should be turned off, or window and door blinds should be used to prevent interior light from shining outside. Light activated timing circuits should turn off all outdoor lighting within 30 minutes of the office being closed. Manual reset switches may be used to extend this period.

6.1.2 Public Buildings

Public buildings are defined as those open to the public during business hours and may also contain private offices. Due to the public nature of these buildings with high pedestrian traffic, exterior illumination may be higher than for administration buildings.

After hours, either all interior lighting should be turned off, or window and door blinds should be used to prevent interior light from shining outside. All outdoor lighting should be turned off within 30 minutes of the office being closed. Exterior lighting should be limited to the main door area and steps (if any). Light activated timing circuits should turn the lighting on after dusk and off after a period of time specified. Manual reset switches may be used to extend this period.

6.1.3 Retail Stores

It is assumed retail stores will have higher pedestrian traffic than most other areas after dark while they remain open for business. Window coverings should be used so that interior lighting will not shine outside after sunset. Exterior light is permitted, and restricted to, the area around the door using full cut-off fixtures. All exterior lighting should be turned off within 30 minutes after business hours.

6.1.4 Vending Machines

There are several ways to reduce the extent of illumination coming from vending machines. These methods consist of eliminating display lighting, installing occupancy sensing devices or installing the vending machine in an enclosed space.

The first options are simple and inexpensive. They require that you talk to your vending machine supplier about disconnecting the lighting from the machines completely or retrofitting the machine with a simple timing mechanism to turn the lights off in unoccupied hours or retrofitting the machine with a passive infrared technology to cut power to vending machines while an area is unoccupied. In the latter option, the device is designed so that a machine will be shut down for up to two hours if no one walks by. At that point, the machine is turned back on to run a compressor cycle, after which it turns back off if the occupancy sensor indicates that the area is still vacant. When someone approaches the machine, the sensor sends a signal to turn the lights and other electronic components back on, and the compressor runs a cooling cycle if needed.

If these options are not feasible, then where possible vending machines should be located in an enclosed space such as an existing public building so their lights do

not shine directly outside through doorways or windows. Figure 6.1.4 shows an example of a dedicated vending machine enclosure. Only full cut-off fixtures should be used to illuminate the area outside the entrances. The extent of this outside illuminated area is restricted to less than 5 meters from the entrance.

Light from vending machines is usually from a number of fluorescent tubes behind the translucent display and may emit significant amounts of blue light. This light undermines dark adaptation. Therefore, the illumination levels outside these enclosures may be higher than for other buildings.

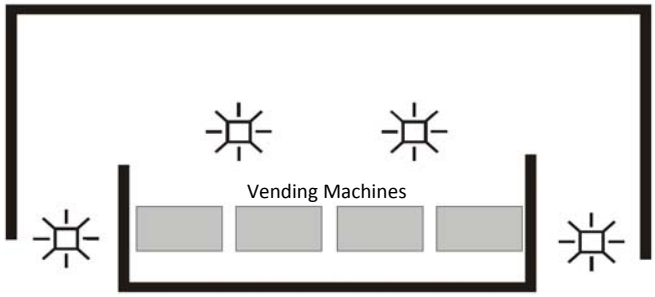

Figure 6.1.4 – Sample Vending Machine Enclosure

Doorway lighting should be turned off within two hours of sunset. Interior lighting may remain on at the owner's discretion.

6.1.5 Toilet and Washroom Facilities

Toilet and washroom facilities will be available throughout the night. Full cut-off fixtures may be used to illuminate the entrance and any steps leading to the doorway. If deemed necessary, these structures may have a marker light by the door.

Table 6.1 Building Illumination Specifications

6.1 Area	Type	Light*	Illumination Level (lux)	Height	Curfew
6.1.1 Administrative & Operational Bldgs.	FCO	Incandescent, Amber CFL or LED	~2 lux	2.5 m	Yes
6.1.2 Public Bldgs.	FCO	Incandescent, Amber CFL or LED	~2 lux	2.5 m	Yes
6.1.3 Retail Stores	FCO	Incandescent, Amber CFL or LED	~2 lux	2.5 m	Yes
6.1.4 Vending Machine	FCO	Incandescent, Amber CFL or LED	~2 lux	2.5 m	Yes
6.1.5 Toilet & Washroom Facilities	Marker (FCO)	Incandescent, Amber CFL or LED	~2 lux	2 m	No

*The wattage for individual lamp type are not specified due to differences in efficacy, Managers should consult Appendix C for guidance in meeting the recommended illumination level in all tables in Section 4.

Note: 2 lux = illumination of dusk about 20 minutes after sunset

6.2 Parking Lots

Generally, parking lots have less traffic at night than during the day. Parking lots may require lighting after Dark Time due to special after-dusk activities.

Where required, pole mounted full cut-off luminaires should be placed one pole-height from the extreme corners of the parking lot and distributed evenly along the perimeter with an approximate pole spacing of no less than 4-times the luminaire height. Their light distribution pattern should be “full forward” and aimed into the lot. This is symbolically shown in Figure 6.2. If necessary, poles may be located within the parking lot area.

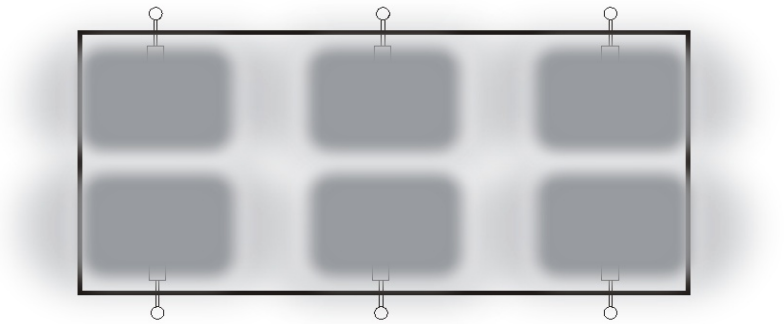

Figure 6.2 Parking Lot

6.2.1 Administration Parking Lots

Administration personnel will generally leave when offices close. Luminaires in administration parking lots should be turned off within 30 minutes of the office closure. A timing circuit should control the lights with a manual reset for employees working late.

6.2.2 Visitor Parking Lots (Small)

Generally small lots (less than 10 cars) experience little traffic and should not be illuminated.

6.2.3 Visitor Parking Lots (Large)

Larger parking lots (spaces for approximately more than 10 cars) may require better visibility than smaller lots. These lots may be illuminated.

Table 6.2 Parking Lot Illumination Specifications

6.2 Area	Type	Light*	Illumination Level (lux)	Height	Curfew
6.2.1 Administration Lot	FCO	LPS, HPS or amber LED	~3	6 m	Yes
6.2.2 Visitor Lot < 10 cars	N/A	None	N/A	N/A	N/A
6.2.3 Visitor Lot > 10 cars	FCO	LPS, HPS or amber LED	~3	6 m	Yes

*The wattage for individual lamp type are not specified due to differences in efficacy, Managers should consult Appendix C for guidance in meeting the recommended illumination level in all tables in Section 4.

N/A – not applicable

6.3 Roadways

6.3.1 Class 1 to Class 3 Roadways

Class 1 to Class 3 roadways (Parks Canada classification) are subject to high (Class 1), to medium (Class 3) traffic volumes. They are defined as highways and are part of a larger highway network. Parks Canada's policy for these types of roadways is to adopt provincial highway standards.

6.3.2 Class 4 to Class 6 Roadways

Class 4 to Class 6 roadways (Parks Canada classification) have low traffic volumes with class 6 roads being park service roads, providing primarily access to administrative and operational uses and purposes. Recognizing the limited use of these roads and the potential impact they may have on remote areas, illumination should be minimized or avoided entirely.

6.4 Pathways

Pathways and sidewalks provide a relatively level surface for pedestrian traffic, and aid in navigation around the site. Visibility of the site is necessary for navigation but excessive illumination will prevent pedestrians from seeing off the path. Although some visitors use flashlights (i.e. campgrounds), additional lighting along pathways may be required to guide visitors to public facilities.

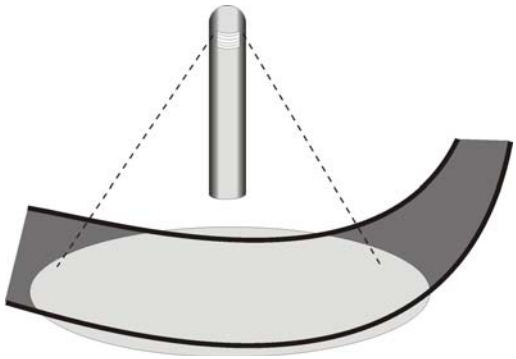

Figure 6.4.1 Bollard Luminaire

Since overhead full cut-off luminaires will illuminate areas much wider than the path, low wattage bollard lighting should be used such that the bollard-mounted lights are directed down to the path. The fixture should be shielded such that the illumination pattern is approximately limited to within the path width.

Generally, individuals walking along a pathway will have left the area after a minute or so (a distance of 30 meters) unless they remain for an activity. To minimize unnecessary light exposure, motion detectors may be used to turn on the string of

lights and timing circuits to turn them off after a few minutes. Detectors may be installed at the entrances to pathways.

The closeness of the luminaires to the ground necessitates very low intensity lights. This limits the current products available to low wattage incandescent bulbs, compact fluorescent (CFL) and light emitting diodes (LED).

Paths are also used by wildlife. Therefore, pathway lighting should be restricted to areas like those near buildings, parking lots and campgrounds, and only those paths that are considered appropriate should be illuminated.

Illuminated pathways should have shielded bollard mounted lighting fixtures. Pathway lighting should be turned off after the Dark Time lighting curfew. Retro-reflective markers on the bollards should assist pedestrians after Dark Time.

Table 6.4 Pathway Illumination Specifications

6.4 Pathways	Type	Light	Illumination Level (lux)	Height	Curfew
6.4.1 Pathways	none	None	N/A	N/A	N/A
6.4.2 Illuminated Paths	FCO	Incandescent Amber CFL or LED	~1 lux	1 m	Yes
6.4.3 Main Pathways	FCO	Incandescent Amber CFL or LED	~1 lux	1 m	No

*The wattage for individual lamp type are not specified due to differences in efficacy, Managers should consult Appendix C for guidance in meeting the recommended illumination level in all tables in Section 4.

N/A – not applicable

6.5 Shoreline Areas

Shoreline areas consist of canals, docks, jetties, lock facilities, boat launching areas, beaches, homes, cottages and undeveloped lands. The direct illumination of the shallow water near shore alters the behaviour of aquatic species and the foraging patterns of landed species and insects.

This specification provides guidance for reducing the impact of lighting along a waterway. Shoreline lighting should consist of amber or red light with minimal content of blue. White lights should not be permitted.

Light within 10 meters of a shoreline should be prohibited unless it is deemed necessary. Overhead luminaires that shine into the water should not be permitted. Where applicable, the illumination level and colour should minimize their impact on the ecosystem.

Where shoreline lighting is permitted, it should have full cut-off fixtures with low wattage amber light. Shielded bollard lighting with incandescent, compact fluorescent (CFL) or amber light emitting diodes (LED) should be used where their needs have been identified. High traffic areas and near machinery (lock facilities) may require higher levels of illumination.

Table 6.5 Shoreline Illumination Specifications

6.5 Waterways	Type	Light	Illumination Level (lux)	Height	Curfew
6.5.1 General Areas	N/A	None	N/A	N/A	N/A
6.5.2 Docks Bollards	FCO	Incandescent, amber CFL or LED	~1 lux	1m	No
6.5.3 Lock Facilities	FCO	LPS, HPS, amber CFL or LED	~1 lux	6 m	Yes

*The wattage for individual lamp type are not specified due to differences in efficacy, Managers should consult Appendix C for guidance in meeting the recommended illumination level.

N/A – not applicable

6.6 Signage

Signage plays an essential role by facilitating access to, and navigation within, our national parks, national historic sites and national marine conservation areas. Parks Canada has developed new standards (Exterior Signage: Standards and Guidelines, 2007) to facilitate the consistent application and implementation of signage across the system with a goal to ensure signs function within the context of their environment. The new signage standards require that all signs, both vehicular and pedestrian, be retro-reflective in order to ensure safe navigation both at night and during the day and therefore do not require added illumination. Some vehicular signs, such as signs mounted to overhead structures, may require illumination to ensure increased visibility. Parks and sites should be aware of any provincial/territorial traffic control standards that would require roadway signs to be illuminated.

6.7 Tower Navigation Avoidance Beacons

Communication towers and wind turbines are often erected in wilderness areas that may have heights of hundreds of meters. Personnel should be aware of the options available for tower navigation beacons that are regulated by Transport Canada18.

Single wind turbine towers less than 90 meters high do not have to be lighted unless specifically identified by Transport Canada as a hazard to aviation. For wind farms with several towers, the towers on the edge of the array and the central tower must be illuminated19.

There are several types of navigation avoidance beacons that may be used on towers (see Appendix E). Those less likely to cause bird casualties seem to be flashing red lights20. Birds are not attracted to red light as much as white light and they appear to be less able to orient themselves to the flashing beacons compared to non-flashing types. One beacon in the list of those approved by Transport Canada consists of a collimated rotating beam (CL864 in Appendix E). In principal, its luminous intensity can be lower than other types of beacons and would emit less light into the air.

Communication towers erected on Parks Canada property should not be fitted with night time navigation beacons unless strictly required by Transport Canada regulations (Canadian Aviation Regulations 621.19). The brightness of night time navigation beacons should be the minimum required by Transport Canada regulations (Canadian Aviation Regulations 621.19). And, all towers requiring night time navigation beacons should use red flashing lights.

6.8 Development on Parks Canada Lands

These developments include buildings, structures and site development on leased and licensed lands in national parks and national historic sites and municipal infrastructure in townsites within national park boundaries. Lessees and municipalities within national parks should be informed of the impact of artificial lighting on wildlife. They should be encouraged to remove “dusk to dawn” lights, replace "yard lights” with full cut-off luminaires and replace metal halide bulbs with either high pressure sodium or low pressure sodium. All municipal lighting, including street lighting, should be full cut-off and illumination levels should be no greater than minimum recommended by Illumination Engineering Society Guidelines.

[18] Canadian Aviation Regulations (CARS) 621.19

[19] Wind Turbine and Windfarm Lighting, CAR621.19 Advisory Circular 1/06 - DRAFT 9, Transport Canada

[20] Gehring, J. Aviation Collision Study for the Michigan Public Safety Communications System (MPSCS): Summary of Spring 2005 Field Season, Central Michigan University, August 12, 2005

Use of outdoor lighting on leased and licensed lands in national parks and national historic sites and within municipalities in national parks should be discouraged 2 hours after sunset (as per "Dark Time" definition in section 6.0), and should be turned off.

Table 6.8 Other Properties Illumination Specifications

6.8 Other Properties	Type	Light*	Illumination Level (lux)	Height	Curfew
6.8.1 Door Lights	FCO	Incandescent, amber CFL or LED	~3	1.5 m	Yes
6.8.2 Yard Lights	FCO	LPS, HPS, amber CFL or LED	~3	6 m	Yes
6.8.3 Municipal Lights (including street lights)	FCO	LPS, HPS, amber CFL or LED	≤ minimum IESNA	TBD	No

*The wattage for individual lamp type are not specified due to differences in efficacy, Managers should consult Appendix C for guidance in meeting the recommended illumination level.

6.9 Light Pollution Abatement Beyond Parks Canada Boundaries

As with air and water pollution, light pollution has no boundaries. It is only reduced by distance from its source. Some cities are actively promoting the replacement of luminaires that contribute to sky glow but these policies are not wide spread. Parks Canada influences the producers of air and water pollution that passes through parks. This influence could be extended to include light pollution by introducing and encouraging programs of light pollution abatement in municipalities around Parks Canada facilities with the goal of reducing glare across Parks Canada boundaries and sky glow from artificial lighting.

7.0 REFERENCES

Aviation Collision Study for the Michigan Public Safety Communications System (MPSCS): Summary of Spring 2005 Field Season, Gehring,J. Central Michigan University, August 12, 2005.

Darkened Streetlights Fail to Raise Crime Rate, DesMoines Register, T. Alex and T. Paluch, May 6, 2004.

Ecological Consequences of Artificial Lighting, T. Longcore, C. Rich Island Press, 2006 ISBN 1-55963-129-5.

Environment and Crime in the Inner City, Environment and Behavior, Vol. 33, No. 3, 343-367 (2001).

FMRI Technical Report TR-2, B. E. Witherington, R. E. Martin, Florida Fish and wildlife Conservation Commission, Second Edition 2000.

Handbook, Illumination Engineering Society of North American (IESNA).

Influence of Street Lighting on Crime and Fear of Crime, S. Atkins, S. Husain and A. Storey, Crime Prevention Unit Paper No. 28, Home Office Crime prevention, Unit, 50 Queen Anne's Gate, London SW1H 9AT.

Lighting for the Human Circadian Clock, S. M. Pauley, Medical Hypotheses (2004) 63,588–596.

Observers Handbook, Royal Astronomical Society of Canada, Patrick Kelly, Ed. 2007, ISBN 0-9738109-3-9.

Pierantonio Cinzano 2001, University of Padova, Italy.

Preliminary Recommendations: Outdoor Lighting at Highlands Center, Cape Cod National Seashore, Chad Moore, March 25, 2006.

Shutting Off the Night, H. Marano, Psychology Today, Sep/Oct 2002.

Tested Strategies to Prevent Crime: A Resource for Municipal Agencies and community Groups, National Crime Prevention Council, Copyright © 1995.

Wind Turbine and Windfarm Lighting, CAR621.19 Advisory Circular 1/06, DRAFT 9, Transport Canada.

8.0 WEB SITES

International Dark Sky Association
www.darksky.org

Royal Astronomical Society of Canada (RASC) Light Pollution Abatement Program
http://www.rasc.ca/light-pollution-abatement

National Crime Prevention Council
http://www.ncpc.org/

Canadian Aviation Regulations (CARS) 621.19
https://www.tc.gc.ca/eng/acts-regulations/regulations-sor96-433.htm

Ecology of the Night Conference Proceedings
www.muskokaheritage.org/ecology-night/

Light Pollution by Pierantonio Cinzano
http://www.lightpollution.it/cinzano/en/index.html

WebMD, March 06, 2007
www.webmd.com/cancer/news/20040908/light-at-night-may-be-linked-to-cancer

Fatal Light Awareness Program
http://www.flap.org/

Florida Fish and Wildlife Conservation Commission
http://myfwc.com/research/publications/scientific/

The Urban Wildlands Group
www.urbanwildlands.org/abstracts.html

Astronomy Outreach and Education Materials
http://www.starlight-theatre.com/

APPENDIX A - Reference Illumination Levels

Condition	Illumination Levels* (lux)**
Clear night sky (no Moon)	0.000 05
Clear Urban Sky with Light Pollution	0.015
Twilight	0.1
Overcast Urban Sky with Light Pollution	0.15
Full Moon	1 max. (0.2 typical)
Urban Road Artificial Illumination	2
Car Dealership Lot	200
Full Sunlight	100,000

* Clarity of the atmosphere is highly variable over hours and days. These values are presented to provide only a rough guide to approximate illumination levels.

** “lux” is a Système internationale unit of illumination equal to 1 candela/m2 = 0.093 foot-candles

To place these levels in context, people have reported seeing “fine” at full Moon illumination levels in the absence of glare[21].

[21] Preliminary Recommendations: Outdoor Lighting at Highlands Center, Cape Cod National Seashore, Chad Moore, March 25, 2006.

APPENDIX B - Colour from Various Light Sources

These six light types convey “colour” from bright white to deep yellow. The last light source, light emitting diodes, can be designed to provide a range of colour. The accompanying table lists these sources in order from white to amber.

MH- Metal Halide	It is a “High Intensity Discharge’ (HID) lamp that must be warmed up before it can reach full brightness. The white light gives very good colour recognition. MH has high blue spectral content, produces a significant amount of UV and therefore its use should be avoided in all DSPs.
Incandescent bulbs	These emit a yellowish light and are available in a very wide range of light outputs but they have very low energy efficiency. Two characteristics make them desirable for some applications. They can be turned off and on very quickly so they can be used for motion detection systems. Very low wattage bulbs are readily available if low illumination levels are required. Incandescent should only be considered if amber LED or amber CFL lamps are not available with low enough brightness.
HPS - High Pressure Sodium	These are bright yellow and allow fair colour recognition. A HPS bulb has a small light-emitting region for very good control over where the light is focused. As a HID source, they require a few minutes to heat up before they reach their design brightness.
Amber CF – Compact Fluorescent Lamps	These produce filtered light and are commercially sold as bug and party lights. They may be identified as yellow and orange but their colour and quality vary greatly. Choose darker yellow and orange whenever possible to avoid flying insect attraction. They typically do not perform as well in cold temperatures and may take several minutes to warm up in sub-zero temperatures.
LPS - Low Pressure Sodium	Deep yellow light is virtually a single colour offering very poor colour recognition. It is the most energy efficient of the above lamps. They are so efficient that even low wattages may produce too much light our purposes. The light-emitting

	region in the bulb is quite large compared to other high pressure sodium bulbs. In this document they are recommended for use as roadway marker lights.
LED - Amber and Red Light Emitting Diodes	These are available in a range of colours, amber and red LEDs minimizes their impact on the environment. They can produce very focused illumination, which is very desirable for DSP applications. For DSP purposes “Amber” is defined as light in the wavelength of 500 – 700 nm and “Red” is 600 - 660nm. White LEDs emit short wavelength blue light and are not recommended.

APPENDIX C - Light Output from Typical Bulbs for Comparison Purposes

Bulb Types	Lumens∀ (Intensity)	Lux∀∀ at 6 m (no losses*)	Lux∀∀ at 2 m (no losses*)	Lux∀∀ at 1 m (no losses*)
Incandescent				
7 watt	46	0.1	0.9	3.7
15 watt	112	0.25	2.3	9.1
40 watt	365	0.8	7.3	29.0
60 watt	740	1.4	12.7	50.9
100 watt	1530	3.8	34.0	136.1
Metal Halide - MH				
70 watt	3,000	6.6	59.7	238.7
100 watt	5,800	12.8	115.4	461.6
High Pressure Sodium - HPS				
35 watts	2025	4.5	40.3	161.1
50 watts	3600	8.0	71.6	286.5
70 watts	5450	12.1	108.4	433.7
100 watts	8550	18.9	170.1	680.4
Low Pressure Sodium - LPS				
18 watts	1570	3.5	31.2	124.9
35 watts	4000	8.8	79.6	318.3
55 watts	6655	14.7	132.4	529.6
Compact Florescent				
9 watt (40 w equivalent)	550	1.2	10.9	43.8
13 watt (60 w equivalent)	850	1.9	17.9	71.6

Light Emitting Diode - LED**				
1 watt (White) ***	100	2.8	25	100
1 watt (amber) ***	75	2.	19	75
3 watt amber A19	90	0.5	4.0	12
3 watt amber PAR16	90	1.8	16	50
7 watt amber PAR30	200	5.5	50	200
13 watt amber PAR38	400	11	100	400

* The fixture and bulb degradation before cleaning or replacement may decrease these to as low as 50%.

** Supplied by IDA

*** Assumes a 1 steradian illumination angle and no external optics, typical for 2011

∀ Lumens is the total amount of light emitted in all directions (over 4 steradians)

∀∀ Lux is the amount of light illuminating a surface of one-meter square

$$1 \text{ lux} = \frac{1 \text{ Lumen}}{4 \text{ dist}^2} \quad \text{(where distance is in meters)}$$

APPENDIX D - Approximate Times of Sunset for Areas in Southern Canada

The time of sunset depends on the time of year and the latitude for a site. The following table lists the approximate time of sunset (DST) for latitude of about +50 degrees from May to the end of September.

May 1	8:17
8	8:29
15	8:38
22	8:48
29	8:57
June 1	9:00
8	9:08
15	9:11
22	9:13
29	9:13
July 1	9:13
8	9:09
15	9:04
22	8:57
29	8:48
August 1	8:42
8	8:31
15	8:19
22	8:06
29	7:50
September 1	7:45
8	7:30
15	7:15
22	6:59
29	6:44

From the Royal Astronomical Society of Canada

Observers Handbook

APPENDIX E - Navigation Light Photometric Distribution[22]

			Minimum Intensity (candelas) (a)				Intensity (candelas) at given elevation angles when the light is levelled (c)				
Light Type	Colour	Signal type	day	Twilight	night	Vert. beam spread (b)	- 10deg (d)	- 1deg (e)	± 0deg (e)	+ 2.5deg	+12.5deg
CL810	red	fixed	N/A	32min	32min	10deg	-----	-----	-----	32 min	32 min
CL864	red	flashing 20-40fpm	N/A	N/A	2,000 ±25%	3 deg min	-----	50% min 75% max	100% min	-----	-----
CL865 (f)	white (f)	flashing 40fpm	20,000 ±25%	20,000 ±25%	2,000 ±25%	3 deg min	3% max	50% min 75% max	100% min	-----	-----
CL866	white	flashing 60fpm	20,000 ±25%	20,000 ±25%	2,000 ±25%	3 deg min	3% max	50% min 75% max	100% min	-----	-----
CL885 Catenary	red	flashing 60fpm	N/A	N/A	2,000 ±25%	3 deg min	-----	50% min 75% max	100% min	-----	-----
CL856	white	flashing 40fpm	270,000 ±25%	20,000 ±25%	2,000 ±25%	3 deg min	3% max	50% min 75% max	100% min	-----	-----

[22]Wind Turbine and Windfarm Lighting, CAR621.19 Advisory Circular 1/06 - DRAFT 9, Transport Canada

CL857 Catenary	white	flashing 60fpm	140,000 ±25%	20,000 ±25%	2,000 ±25%	3 deg min	3% max	50% min 75% max	100% min	-----	-----

a) Effective intensity, as determined in accordance with External Transport Canada Document

b) Beam spread is defined as the angle between two directions in a plane for which the intensity is equal to 50% of the lower tolerance value of the intensity shown in columns 4, 5 and 6. The beam pattern is not necessarily symmetrical about the elevation angle at which the peak intensity occurs.

c) Elevation (vertical) angles are referenced to the horizontal.

d) Intensity at any specified horizontal radial as a percentage of the actual peak intensity at the same radial when operated at each of the intensities shown in columns 4, 5 and 6.

e) Intensity at any specified horizontal radial as a percentage of the lower tolerance value of the intensity shown in columns 4, 5 and 6.

f) In the case of rotating type CL865 one third of the flash display should be red in colour. e.g. WWRWW