Royal Astronomical Society of Canada

Guidelines for Outdoor Lighting in Dark-sky Preserves (RASC-DSP-GOL)

Adopted by the RASC

March 2008

Revised Summer 2011

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1.0 SCOPE

This document presents Guidelines for Outdoor Lighting (GOL) in Dark-sky Preserves (DSPs, and herein after referred to as Parks) and describes the types of equipment required to satisfy these guidelines.

The goal of the DSP Program is to promote the reduction in light pollution, demonstrate good night-time lighting practices, improve the nocturnal environment of wildlife, protect and expand dark observing sites for astronomy, and provide accessible locations for the general public to experience the naturally dark night sky.

This DSP-GOL has three objectives: to limit glare across the DSP that is visible from within the Park, provide a guide for adequate lighting used for navigation within the Park, and it suggests lighting policies that may be applied to urban areas beyond the Park boundaries. This will protect the DSP from deterioration by surrounding light pollution.

We present in Section 3.0 the rationale for the need for a DSP and the protection of the urban nighttime environment from the excessive use of artificial lighting. To support these guidelines, this document presents references to useful web sites and to general research into the effects of nocturnal lighting on humans, human activity and wildlife.

The general guidelines for outdoor lighting within the Dark-sky Preserve is presented in Section 4. Lighting hardware and signage are described in Section 5 to assist Park managers minimize the impact of artificial lighting on the nighttime environment while maintaining a degree of safety for visitors.

A bibliography provides a set of references and useful websites. Supplementary technical information is provided in the appendices to this document.

2.0 GLOSSARY

2.1 Acronyms

CARS Canadian Aviation Regulations
CF Compact Fluorescent lamps
CO Cut-off luminaires (>0% and <2% up-light)

DSP Dark-sky Preserve

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

GOL Guidelines for Outdoor Lighting

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)

NC Non cut-off (no restriction on up-light)

SCO Semi Cut-off luminaires (<2% and <5% up-light)
SAD Seasonal Affective Disorder

2.2 Definitions

Lux – a measure of the amount of light that falls on a defined area[1]. Examples of levels are provided in Appendix A and C.

Photobiology – the study of the effects of light on biological systems

Photopic Vision – vision that uses the lower sensitivity photoreceptors (cones) that have evolved for daytime vision and high illumination levels

Scotobiology – the study of the effects of darkness on biological systems

Scotopic Vision - vision that uses the higher sensitivity photoreceptors (rods) that have evolved for nighttime vision and low illumination levels.

DSP Buffer - Region within DSP surrounding the Core area under control of the park manager, or others. The Buffer is to prevent glare and light trespass from shining into the Core area

DSP Core - Region within DSP surrounded by a Buffer area under control of the park manager

[1] www.physlink.com/Education/AskExperts/ae409.cfm

3.0 RATIONALE

Most people take artificial nighttime lighting for granted. In cities it is considered to be an acceptable component of our society, and indeed they think it is a necessity for safety and security. Specifications and guidelines for street and roadway lighting[2] address these urban assumptions. This has lead to lighting policies that encourage the illumination of all urban areas to allow the use of human photopic (daytime) vision. (Figure 3.0.1).

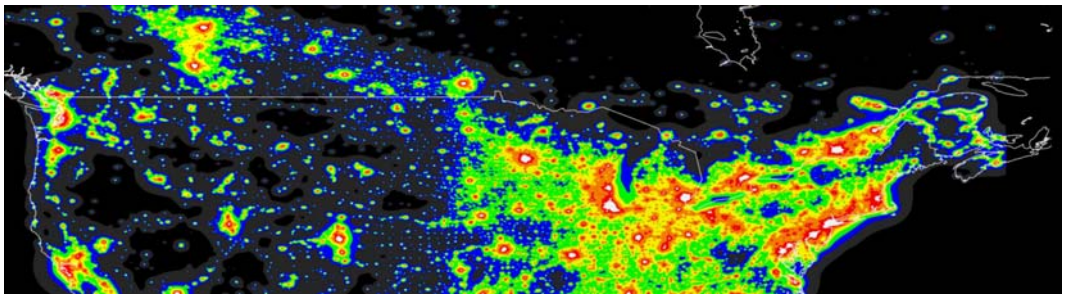

Figure 3.0.1 Mid Latitudes at Night[3]

The availability of electrical energy and efficient lighting fixtures have enabled the current urban lifestyle of non-stop "24-7" activity. Further, the advances in lighting 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 energy. The result is most commercial luminaires are designed for high levels of illumination. Low intensity fixtures are primarily limited to decorative lighting such as Christmas lights.

It is now common in a city to be able to read a newspaper at night under the city's artificial 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. Bright red corresponds to high levels of sky glow (0.010 lux) and green is an intermediate amount (0.00025 lux). The area of Algonquin Park appears black with very dark skies.

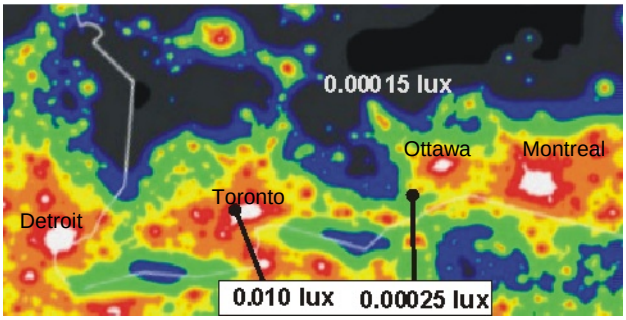

Figure 3.0.2 Light Pollution in Southern Ontario[2]
(Readings were made under clear skies)

In Toronto only the brightest stars are visible. On the Rideau Lake, the Milky Way is easy to see but the sky glow from Ottawa extends halfway up the sky in the northeast and

[2] Illumination Engineering Society of North American (IESNA) Handbook
[3] P. Cinzano, et. al. 2001

with sky glow 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.

3.1 Crime

The most prevalent reason given for nighttime lighting is to reduce crime in cities. This is generally based on the notion that more light improves visibility, and that this visibility discourages criminals. Based on before and after studies of crime statistics, there is no clear evidence that outdoor lighting reduces crime[4]. Although there are anecdotal reports that "improved lighting" (i.e. improved visibility) reduces crime[5], there is no evidence that crime is reduced with "more or brighter lighting"[6]. In some cases crime was simply displaced, or the altered lighting was prompted by or caused a change in use of the streets by "…strengthening informal social control and community cohesion"[7] and this may have affected the pattern of crime.

There are different types of crime. Theft is more prevalent during daytime hours, violent crime occurs more often in the evening and after midnight.[8] Anecdotal studies report that most property crime occurs during the day and violent crime is usually between persons that know each other. The public's belief in the prevalence of random violence is not proven by the research.

There was an unconfirmed report that the brightly lit City of Manila found violent crime was more prevalent after dark and the presence of police was effective at reducing nighttime crime. The city lights were not the deterrent to crime. In a lengthy Report to Congress, by the National Institute of Justice[9] it is stated that there is no evidence that artificial lighting deters crime. It reports that most studies are poorly designed, without controls, which undermines any conclusions to the contrary. They state that: "We can have very little confidence that improved lighting prevents crime". It further reports that lighting can assist in the crime by putting the victim on display. The feeling of safety provided by the light may have the opposite effect.

Vandalism provides an example of the opposite effect of securing lighting than is generally accepted. Studies conclude that lighted areas are more subject to vandalism and graffiti. Anecdotal evidence[10] and more focused studies[11] support the policy of turning lights off when security staff is not around. Apparently, vandals want to see the results of

[4] The Influence of Street Lighting on Crime and Fear of Crime, Prevention Unit Paper No. 28, Stephen Atkins, Sohail Husain and Angele Storey, 1991, ISBN 0 86252 668 X
[5] Effects of Improved Street Lighting on Crime: A Systematic Review, Home Office Research Study 251, by David P. Farrington and Brandon C. Welsh, August 2002
[6] The Indiana Council on Outdoor Lighting Education (ICOLE), P.O. Box 17351, Indianapolis, IN 46217
[7] ibid, page 2.
[8] www.bpap.org/bpap/research/DCA_briefing_dtd.pdf
[9] National Institute of Justice Grant Number 96MUMU0019 (www.ncjrs.gov/works/)
[10] "Darkened Streetlights Fail to Raise Crime Rate", DesMoines Register, T. Alex and T. Paluch, May 6, 2004 www.dmregister.com
[11] Effects of improved street lighting on crime: a systematic review, Home Office Research Study 251, August 2002

the damage and for others to see it. When lights are off, there is less gratification in vandalising an area or painting graffiti.

3.2 Human Lighting Needs

Humans are a daytime species. Although we can see at night, our vision is significantly reduced compared to the daytime. In the past, starlight provided sufficient levels of illumination for most activities. However our modern fast paced and mechanized activity requires better visual acuity for driving cars, bicycles and avoiding urban hazards.

Some level of artificial lighting is required for nighttime activities. But this lighting must be designed to increase visibility. Paradoxically, more light can reduce visibility, especially for persons over 40 years of age[12].

The average age of our population is getting older. Sensitivity to glare increases with age, as does our chances of developing cataracts. In the face of a bright light, our iris closes down letting light into the eye only through the centre of our lens. Since cataracts begin in the centre of the lens, the vision of adults can be severely degraded by glare. With the aging of our population, it is becoming more important to reduce glare in the urban environment.

3.3 Human Health

This proliferation of outdoor lighting has a significant impact on the health and behaviour of humans[13]. "Biological clocks control our sleep patterns, alertness, mood, physical strength, blood pressure, and other aspects of our physiology"[14]. 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. These "repair the damage" we do to our bodies each day. Without the proper release of these hormones, healing takes longer and our bodies are less able to fend off disease[15].

The timing of the circadian rhythm also affects our behaviour. For example, Seasonal Affective Disorder (SAD) is an emotional condition experienced by travellers and others. The symptoms can be reduced with exposure to bright light[16] as it shifts (or entrains) and resets our biological clock. If this entrainment occurs during the late evening or at night due to artificial outdoor lighting, the biochemistry that controls our physiological well-being will also be shifted away from the proper daytime hours.

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[12] **Work, Aging, and Vision: Report of a Conference,** ISBN-10: 0-309-07793-1

[13] Light Research Organization, Electric Power Research Institute, (www.epri.com/LRO/index.html)

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

[15] [15] "Light at night and cancer risk", Schernhammer E, et.al., Photochem Photobiol. 2004 Apr;79(4):316-8.

[16] "Shutting Off the Night", H. Marano, Psychology Today, Sep/Oct 2002

3.4 Environmental 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 planets and animals wherein it plays a similar role[17]. Wildlife depends on the darkness of the night and the study of this dependence is called "scotobiology".

Research into the nocturnal environment is relatively recent compared to research into the daytime environment. Consequently there is far less published literature documenting the sensitivity of the general nighttime ecology to artificial lighting. Most of the research is on specific species in the wild or laboratory studies. However, mounting scientific evidence is documenting the profound impact of artificial light on the ecology of the night.

Plants are affected by the colour and duration of lighting. Whether the effects are considered beneficial or not depends on the desired outcome. Generally, artificial lighting will change the natural growth patterns and may affect the resistance of plants to infestations and disease. Many plants respond to the length of the day and normally recognize it as an indication of the season. By extending light past the evening, may slow the plant's biochemistry from changing to prepare for winter[18]. The various affects of colour, duration, type of plant, etc. makes sweeping conclusions impossible however, they indicate that changing the lighting environment will change the natural ecology of the area.

3.5 Animal Behaviour

Artificial sky glow extends well beyond the city boundaries. Therefore in considering urban outdoor lighting, we must also consider its impact on rural areas in the region.

Exposure to short periods of bright illumination (less than a minute) does not seem to affect the biological rhythm in animals[19]. However, longer exposures to light can shift (or entrain) their circadian rhythm and modify their behavioural patterns. Minimizing the duration of exposure to artificial light is necessary to limit its impact.

Seasonal variations will shift the time of sunset by over four hours (from roughly 16:30 in winter to 21:00 in summer). During the peak of Park activities in summer, the time of sunset can vary by two hours (see Appendix D). In addition to this, dusk can extend the daylight by as much as an hour. Although no references were found in the published literature that documents how wildlife accommodates for this variation, their behaviour has presumably adapted to it.

[17] "Lighting for the Human Circadian Clock", S. M. Pauley, Medical Hypotheses (2004) 63,588–596
[18] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006, Pg. 405
[19] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006, Pg. 24

Artificial lighting changes the nighttime behaviour of species[20]. 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[21].

Predator and prey behaviour depends on the darkness of the night[22]. 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[23]. To put this in context, it is generally recommended by the IESNA that an urban parking lot be lighted to more than 100X 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[24]. They may swarm the light fixture until they are exhausted. The resulting pile of insects must then be cleaned up.

Animals separated from their normal foraging grounds by an illuminated road cannot see the area beyond the lights. They can be temporarily blinded by headlights from passing cars. 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. They may abandon their established foraging patterns for new ones, which will impact other species as they compete for resources[25].

3.6 Shorelines

Historically, waterways have been used for transportation and recreation. However, they are also important ecosystems that support wildlife in the water and on the lands adjacent to the shoreline. Shoreline property is valued by our society and this is causing human developments along rivers and around lakes. An increasing number of properties have shoreline lighting that illuminates the waterway. This impacts the river and lakes in two ways.

From the human stand point; bright lights along the shoreline make it very difficult to navigate the channel. Glare from unshielded shoreline lighting prevents our eyes from becoming adapted to the darkness. At night, a boater will only be able to see the points of light along the shore rendering the channel markers and out-of-channel hazards very difficult to see. Clearly, glare along the shoreline results in a safety hazard that should be corrected.

[20] The Urban Wildlands Group (www.urbanwildlands.org/abstracts.html)
[21] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006, Pg. 28
[22] ibid., Chapter 2
[23] ibid., Chapter 11
[24] ibid., Chapter 13
[25] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006

The second impact is on the fish and aquatic plants[26]. 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.

3.7 Cultural Impact

There is a cultural imperative to protect the darkness of the night sky. Throughout recorded history (about 6,000 years) astronomy has been a 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.

3.8 Summary

Generally there is limited research on the environmental benefits and costs of artificial lighting. In the absence of clear conclusions, the best policy is to minimize its effects on the ecosystem.

Studies have been published that present conflicting conclusions about outdoor lighting and the reduction of crime. The fact that these studies cannot reach a consensus undermines the argument that more light makes a safer environment. It has not been shown that the cost of lamping, or re-lamping, large areas of a city will result in reduced crime. Yet, the cost of lighting an area may cause funds to be redirected away from other more effective measures.

There is growing medical evidence for the degradation of human health with the illumination of the night. The reduction in day-night contrast can uncouple the circadian rhythm from our normal daytime activities that may cause an increase in chronic diseases.

It is clearly shown in published research, that artificial outdoor lighting affects the ecology over the entire food chain. Although the actual mechanism for this disruption is not always clear, this does not weaken the evidence for the damaging impact of artificial light on the ecosystem and the need to minimize it.

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

Education is the key to correcting this degradation of the nocturnal environment by our nighttime culture. As the main source of light pollution, cities are key components in education and solving this problem. Establishing Dark-sky Preserves are an obvious way to help inform the public about the virtues of a dark night.

Artificial lighting that is installed for human activity is altering the natural environment. This environmental degradation continues without resistance and is indeed supported by human nighttime culture. Our civic policies and the legal system is strongly biased in favour of human demands. Unfortunately, we are now discovering how nocturnal lighting degrades both human health and the health of wildlife well outside our cities. Wildlife has no voice in law. Others must act on their behalf. Cities must take action and be their advocate against change in their environment.

4.0 GUIDELINES FOR OUTDOOR LIGHTING

A Dark-sky Preserve (DSP) is defined as an area whose night sky has little or no sky glow and lighting within the DSP is minimized. If there is significant sky glow due to close proximity to an urban area, it may be classified as an Urban Star Park. Persons interested in USP Designations are should refer to the documents: RASC-USP GUIDELINES and RASC-USP-GOL.

There are several facilities that may be within a DSP. The illumination levels for these facilities are summarized in tables for each area and application. The rationales for the limits in these tables are provided in Section 3.

This section provides guidelines that should be followed to minimize light pollution within a Park. Similar fixture hardware is recommended to minimize the inventory for repairs or replacement.

Where necessary for basic safety and navigation:

1. Illumination should be to the minimum practical level,
2. The affected area of illumination should be as small as practical,
3. The duration of the illumination should be as short as practical, and
4. Illumination should minimize the amount of blue colour in the light (avoid white).

What is “practical” depends upon the specific facilities in the area and the technology available at that time.

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 recommended in these guidelines. 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.

These guidelines address the use of the facility and expected pedestrian and vehicle traffic. Eleven specific facilities and areas are identified with a range of lighting conditions that reflect their varied use. Priority is given to respecting and protecting the natural environment.

Park managers have the discretion to assess what levels are most appropriate for each facility within the limits outlined in Section 3 of this document. 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.

“Dark Time” is a term used in some parks 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 parks in southern Canada. Park managers may define Dark Time that is suitable for their facility.

The following tenets have been used in developing these specifications.

1. Buildings require illumination only when open or available to people. 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. To minimize the impact of artificial lighting on the ecosystem, 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. To minimize the extent of light pollution, the area of illumination should be strictly limited.

5. To limit the duration of light exposure on the ecosystem and to save energy, light activated timing circuits should turn off outdoor lighting. The time delay should begin at sunset and should extend to an appropriate time into the evening to permit scheduled activity to end.

6. Where vehicle and pedestrian traffic is at a low speed or infrequent, retro-reflective signage should be used instead of installed lighting fixtures.

4.1 Buildings

This section identifies six types of structures that may require illumination within a park. In all cases, full cut-off (FCO) luminaires should be used and illumination should be controlled to prevent light scattering beyond the immediate area of the light fixture. 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 be a nuisance. Insects are attracted to exterior building lights and interior lighting that shines through windows. In addition to the need for cleaning up dead flies before the building opens in the morning for the public, the light distracts insects from their normal activity.

Illumination levels and luminaire types for various buildings are listed in Table 4.1 at the end of this sub-section. Signage on buildings is discussed in Section 4.6.

This document uses five classifications for buildings:

- Administration Buildings,
- Public Buildings,
- Retail Outlets,
- Vending Machine Enclosures, and
- Toilet and Washroom Facilities.

4.1.1 Administration Buildings

Park administration buildings are defined as those with private offices and 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 in the early spring late autumn and winter. 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.

4.1.2 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 park 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 sunset and off after a period of time specified by Park manager and subject to the building use. Manual reset switches may be used to extend this period.

4.1.3 Retail Outlets

It is assumed retail stores will have higher pedestrian traffic than most other areas while they remain open for business after dark.

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 (FCO) fixtures. All exterior lighting should be turned off within 30 minutes after business hours.

4.1.4 Vending Machines

Vending machines should be located in an enclosed space and their lights should not shine directly outside through doorways or windows. Where practical, these machines

should be enclosed in existing public buildings. Figure 4.1.4 shows an example of a dedicated vending machine enclosure. Only FCO fixtures should be used to illuminate the area outside the entrances. The extent of this outside illuminated ground area is restricted to less than 5 metres 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 to allow the transition for visitors from the bright entrance to the dark surroundings.

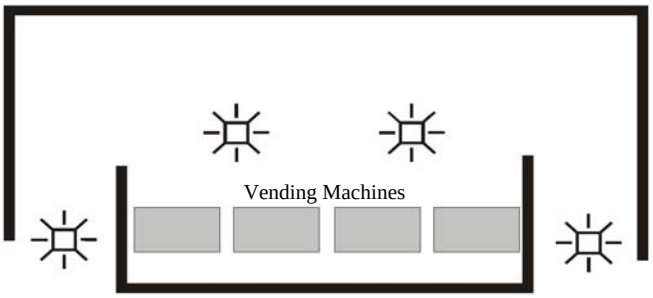

Figure 4.1.4 – Sample Vending Machine

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

Table 4.1 Building Illumination Guidelines (Maximum Values)

4.1 Area	Type	Light	Illumination Level (lux)	Height	Curfew
4.1.1 Administrative Bldgs.	FCO	25 w incandescent, yellow LED	~2 lux	2.5 m	Yes
4.1.2 Public Bldgs.	FCO	25 w incandescent, yellow LED	~2 lux	2.5 m	Yes
4.1.3 Retail Stores	FCO	25 w incandescent, yellow LED	~2 lux	2.5 m	Yes
4.1.4 Vending Machine	FCO	25 w incandescent, yellow LED	~2 lux	2.5 m	Yes
4.1.5 Toilet & Washroom Facilities	Marker (FCO)	25 w incandescent, yellow LED	~2 lux	2 m	No

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

4.1.5 Toilet and Washroom Facilities

Toilet and washroom facilities should be available throughout the night. If illuminated, Full Cut-off (FCO) fixtures should be used to illuminate the entrance and any steps

leading to the doorway. If deemed necessary by Park managers, these structures may have a non-cut-off marker light by the door. This marker light should be the lowest practical wattage. For example, a small 15-watt incandescent bulb can be easily seen for 200 metres.

4.2 Parking lots

Generally, parking lots have less traffic at night than during the day. Parking lots may require lighting due to scheduled after-dusk activities. This lighting will be necessary until gate closure or Dark Time, which ever occurs first.

Where required, pole mounted Full Cut-off (FCO) 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 4.2. If necessary, poles may be located within the parking lot area.

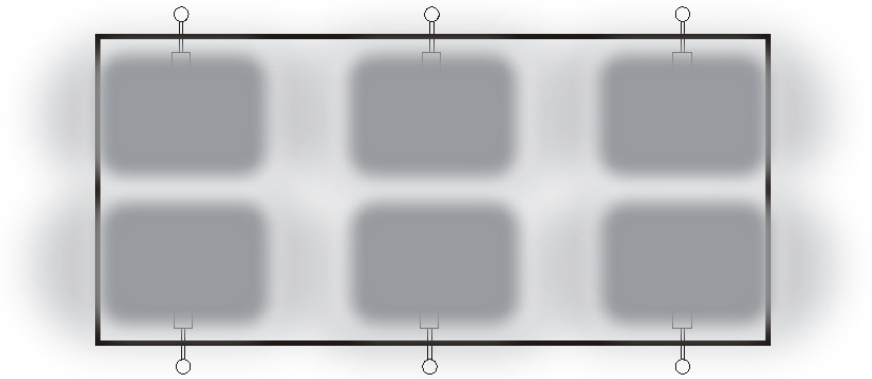

Figure 4.2 Parking Lot

4.2.1 Administration Parking Lots

Administrative 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.

4.2.2 Visitor Parking Lots (Small)

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

4.2.3 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 at the discretion of the Park manager. However illumination levels should not exceed the limits listed in Table 4.2.

Table 4.2 Parking Lot Illumination Guidelines (Maximum Values)

4.2 Parking Area	Type	Light	Illumination Level (lux)	Height	Curfew
4.2.1 Administration Lot	FCO	35 watt HPS	~3	6 m	Yes
4.2.2 Visitor Lot < 10 cars	N/A	None	N/A	N/A	N/A
4.2.3 Visitor Lot > 10 cars	FCO	35 watt HPS	~3	6 m	Yes

N/A – not applicable

4.3 Roadways

Intersections are some of the most dangerous areas for drivers. Drivers of high-speed vehicles require sufficient time to react when they approach an intersection. Therefore, major intersections should be marked with signage or luminaires. Illumination of adjacent areas should be minimized.

4.3.1 Class 1 to Class 3 Roadways

Class 1 to Class 3 roadways are subject to high (Class 1) to medium (Class 3) traffic volumes. Due to the high speed and volume of traffic, marker lighting may be required to alert drives to an intersection.

Where applicable, marker lights should be installed at intersections between Class 1 to Class 3 roadways. To ensure they are visible to approaching traffic, these marker lights should be semi cut-off (SCO) luminaires with a Type II distribution pattern (illumination along the road). They should be oriented with the side area of the “drop glass” lens aimed along the major roadway to minimize illumination beyond the side of the road.

To further minimize the impact of these luminaires on the environment, the luminaire should be mounted no higher than six metres and the bulb should be a 35 watt Low Pressure Sodium (LPS) to minimize the exposure of blue light.

Retro-reflective signage should be used for all other intersections between the Class 1 to 3 roadways and lesser roadways. Illuminated signage should not be permitted (see Section 4.6).

Where applicable, federal and provincial highway standards should take precedence.

4.3.2 Class 4 to Class 6 Roadways

Class 4 to Class 6 roadways have low traffic volumes with class 6 roads seeing occasional and local traffic. These roads provide access to large areas of the Park. Recognizing the infrequent use of these roads and the potential impact they may have on remote areas, these roads and intersections should not be illuminated.

Table 4.3 Roadway Illumination Guidelines (Maximum Values)

4.3 Roadways	Type	Light	Illumination Level (lux)	Height	Curfew
4.3.1 Class 1-3 roadways	None	N/A	N/A	N/A	N/A
4.3.2 Class 1-3 roads & intersections	SCO Marker	35 watt LPS	~3	6 m	No
4.3.3 Class 4-6 Roads & intersections	Signage only	N/A	N/A	N/A	N/A

N/A – not applicable

4.4 Pathways

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

Paths are also used by wildlife. Therefore, pathway lighting should be restricted to only those paths near buildings, parking lots and campgrounds, and only those paths that the Park Manager considers appropriate should be illuminated.

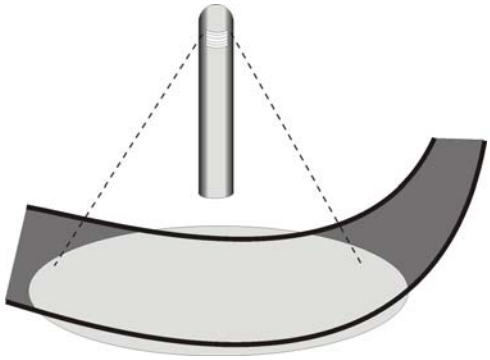

Figure 4.4.1 Bollard Luminaire

Since overhead FCO 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 the path width.

Pathways should use white or light coloured crushed stone (limestone) instead of asphalt to help reflect ambient light. Passive fluorescent markers may also be used to mark the extent and direction of the pathway. These may be mounted on bollards or in the pathway surface.

Generally, individuals walking along a pathway will have left the area after a minute or so (a distance of 30 metres) 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 and LEDs.

1. No pathways in the DSP should be illuminated. If deemed necessary by the Park manager, specific pathways may be illuminated or lined with fluorescent markers.
2. Illuminated pathways should have full cut-off bollard mounted lighting fixtures.
3. Pathway lighting should be turned off at the Dark Time lighting curfew. Retro-reflective markers on the bollards may assist pedestrians after Dark Time.
4. Main pathways leading to night facilities may be illuminated throughout the night at the discretion of the Park manager.

Table 4.4 Pathway Illumination Guidelines (Maximum Values)

4.4 Pathways	Type	Light	Illumination	Height	Curfew
4.4.1 Pathways	None	None	N/A	N/A	N/A
4.4.2 Illuminated Paths	FCO	7 watt incandescent, Yellow LEDs	~1 lux	1 m	Yes
4.4.3 Main Pathways	FCO	7 watt incandescent, Yellow LEDs	~1 lux	1 m	No

N/A – not applicable

4.5 Shoreline Areas

Shoreline areas consist of 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 document provides guidance to Park managers for reducing the impact of lighting along a waterway. These guidelines are relatively general due to the limited authority of Park managers over some of these properties.

1. Park personnel should inform the owners and users of shoreline property of the impact artificial light has on the ecology of the water and adjacent lands.
2. The public should be advised to shield all outdoor lighting to comply with Full Cut-off (FOC) requirements and to turn off this lighting when they go to bed.
3. Shoreline lighting should consist of yellow or red light with minimal content of blue. Blue and white lights should not be permitted.
4. Light fixtures should be prohibited within ten metres of a shoreline unless they are deemed necessary by the Park manager. 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.
5. Where shoreline lighting is permitted, it should have Full Cut-off (FCO) fixtures with low wattage yellow or red light. Shielded bollard lighting with incandescent or LEDs should be used where dock managers have identified their need. High traffic areas and near machinery (lock facilities) may require higher levels of illumination at the discretion of the Park manager.

Table 4.5 Shoreline Illumination Guidelines (Maximum Values)

4.5 Waterways	Type	Light	Illumination Level (lux)	Height	Curfew
4.5.1 General Areas	N/A	None	N/A	N/A	N/A
4.5.2 Dock Bollards	FCO	15 w incandescent, Yellow LEDs	~1 lux	1m	No
4.5.3 Lock Facilities	FCO	35 watt HPS Yellow LEDs	~1 lux	6 m	Yes

N/A – not applicable

4.6 Signage

Signs within a Park are essential to the efficient navigation of the site. They may display three forms of information: names for sites or buildings (usually mounted in proximity to buildings or other structures), directions (located along roadways or pathways and their intersections) and those meant to convey other information (located to the side of roadways and pathways).

Illuminated signs should be prohibited in a DSP. These include, but are not limited to, back illuminated signs, signs illuminated from below and above the sign, and in front of the sign. To improve the visibility of signs after dark, their location, colour scheme, and material should permit reading the sign with flashlights or existing lighting.

Retro-reflective signage should be used to ensure signs are visible only when necessary. Signs may be mounted on or near buildings such that exterior building lighting may provide some illumination, and they should use colours consistent with retro-reflective materials and illumination with flashlights.

Signs should be located so pedestrians can easily see them. Elevated signs are less likely to be illuminated by Fill Cut-off (FCO) luminaires. Pathway and information signs should be located less than one metre above the grade of the path so that they may be found and read by pedestrians with flashlights after dark. All bollards should be marked with retro-reflective material so they may be visible to pedestrians after Dark Time. Signs at a higher level may be missed is flashlights are aimed at the ground. Roadway signs should be mounted in accordance with standard roadway practice.

Table 4.6 Signage Illumination Guidelines (Maximum Values)

4.6 Signage	Type	Light	Illumination Level (lux)	Height	Curfew
4.6.1 Building	Retro-reflective	N/A	N/A	1-2 m	N/A
4.6.2 Navigation	Retro-reflective	N/A	N/A	<1 m	N/A
4.6.3 Information	Retro-reflective	N/A	N/A	1-2 m	N/A

N/A – not applicable

4.7 Tower Navigation Avoidance Beacons

There is a proliferation of communication towers for cell phones and the acceptance of wind turbine power generation. Towers that may have heights of hundreds of metres are being erected in otherwise wilderness areas. Park managers should be aware of the options available for Tower navigation beacons that are regulated by Transport Canada[27]. Park Managers may not have authority over the illumination of these towers so these guidelines are provided as a guide when discussing tower illumination with tower owners and Transport Canada.

Single wind turbine towers less than 90 metres 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 illuminated[28].

There are several types of navigation avoidance beacons that may be used on towers (see Appendix E). 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[29]. 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 or near Parks should not be fitted with nighttime navigation beacons unless strictly required by Transport Canada regulations (CARS 621.19). Communication towers and other structures do not require lighting if their maximum height is less than 90 metres. The brightness of nighttime navigation beacons should be the minimum required by Transport Canada regulations (CARS 621.19). And, all towers requiring nighttime navigation beacons should use red flashing lights.

4.8 "Developed" Properties within Park Facilities

These properties include, but are limited to, privately owned and rental properties and towns within Park boundaries.

Owners of private properties within the Park 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 (FCO) luminaires and replace MH bulbs with either HPS or Low Pressure Sodium (LPS) fixtures. They should be encouraged to turn off all exterior lighting when they are indoors. All municipal lighting should be FCO and illumination levels should be no greater than minimum recommended by Illumination Engineering Society (IESNA) Guidelines.

[27] Canadian Aviation Regulations (CARS) 621.19
[28] Wind Turbine and Windfarm Lighting, CAR621.19 Advisory Circular 1/06 - DRAFT 9, Transport Canada
[29] 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

The outdoor lighting on properties under the control of Park managers should use Full Cut-off (FCO) fixtures. Area lighting fixtures, such as "yard lights" and “dusk to dawn” fixtures or similar luminaires, should not be permitted nor should Metal Halide (MH) or mercury vapour lamps be permitted. These products produce excessive glare and light trespass and emit short wavelength light that affects wildlife.

Use of outdoor lighting on private properties with in Parks should be discouraged 2-hours after sunset, and should be turned off when people are indoors. Outdoor lights should not be permitted to remain on throughout the night.

Table 4.8 Other Properties Illumination Guidelines Maximum Values)

4.8 Other Properties	Type	Light	Illumination Level (lux)	Height	Curfew
4.8.1 Door Lights	FCO	15 watt Incandescent Yellow LEDs	~3	1.5 m	Yes
4.8.2 Yard Lights	FCO	<35 watt HPS, or < 35 watt LPS	~3	6 m	Yes
4.8.3 Municipal Lights	FCO	typically 70 watt HPS	≤ minimum IESNA	TBD	No

4.9 Light Pollution Abatement Beyond Park Boundaries

As with air and water pollution, light pollution has no boundaries. It is only reduced by increasing the distance to the source. Some cities are actively promoting the replacement of luminaires that contribute to sky glow but these policies are not wide spread. Parks may influence the producers of air and water pollution that passes through Parks. This influence should be extended to include light pollution.

- Park managers should introduce and encourage programs of light pollution abatement in municipalities around the Park facilities with the goal of reducing glare across Park boundaries and sky glow from artificial lighting.
- Park managers should approach individuals whose lights shine onto Park facilities. The goal of these contacts is to have those lights shielded, reduced in brightness or removed.

4.10 Historic Sites

The guidelines in this document give priority to wildlife in Parks; but historic sites may be located within urban areas where light pollution is generally so bad that lighting to the above standards will not improve the situation. The philosophy of not over-lighting the area is prudent for better visibility, which leads directly to safety, aesthetics, and it will reduce operating costs.

Outdoor lighting at historic sites should use Full Cut-off (FCO) fixtures and should be lighted to the minimum levels of standards and guidelines in the surrounding area. If

"Period Lighting Fixtures" are used on the site, then the FCO variety should be used where possible.

4.11 Wilderness Areas

Wilderness areas are all "undeveloped" property in their natural state. Although visitors may carry portable lights, they should be advised to use them sparingly. Installation and extended use of outdoor lighting is strictly prohibited.

5.0 LIMITATIONS

No assurance is made regarding the accuracy and completeness of these data. The RASC disclaims responsibility for consequential financial effects on transactions or property values, or requirements for follow-up actions and costs.

This document is based on data and information collected during work undertaken by the RASC. The RASC will not be held responsible for the errors and omissions of work carried out by third parties.

This document provides a professional opinion and, therefore, no warranty is either expressed, implied, or made as to the conclusions, advice and recommendations offered in this document. This document does not provide a legal opinion regarding compliance with applicable laws. With respect to regulatory compliance issues, it should be noted that regulatory statutes and the interpretation of regulatory statutes are subject to change.

6.0 REFERENCES

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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

"Light at Night and Cancer Risk", Schernhammer E, Schulmeister K., Photochem Photobiol. 2004 Apr;79(4):316-8., www.hsph.harvard.edu/faculty/eva-schernhammer/publications/publications.html

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

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Preventing Crime: What Works, What Doesn't, What's Promising National Institute of Justice Grant Number 96MUMU0019

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

6.2 Web Sites

International Dark Sky Association
www.darksky.org

Royal Astronomical Society of Canada (RASC) Light Pollution Abatement Program
www.rasc.ca/lpa/index.shtml

National Crime Prevention Council
www.ncpc.org/ncpc/ncpc/?pg=2088-10802
National Institute of Justice Grant Number 96MUMU0019
www.bpap.org/bpap/research/DCA_briefing_dtd.pdf

Canadian Aviation Regulations (CARS) 621.19
www.tc.gc.ca/CivilAviation/publications/tp14371/AGA/6-0.htm

Shoreline Booklet downloadable from IDA
www.uwsp.edu/cnr/uwexlakes/humanimpact/lighting.pdf

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

Light Pollution by Pierantonio Cinzano
www.lightpollution.it/indexen.html/

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

Psychology Today, Sep/Oct 2002
http://psychologytoday.com/articles/pto-20021002-000003.html

BC Hydro Power Smart Program – 42 watt LED sufficient for urban pathway
http://dmdeng.com/pdf/learning/Power_Smart_Roadway_Lighting,_BCH.pdf

Light Research Organization, Electric Power Research Institute,
www.epri.com/LRO/index.html

The Indiana Council on Outdoor Lighting Education (ICOLE),
P.O. Box 17351, Indianapolis, IN 46217, USA
http://home.att.net/~icole/crime_ref_guide.html

Fatal Light Awareness Program
www.flap.org/new/nestegg_3.htm/

Florida Fish and Wildlife Conservation Commission
www.floridamarine.org/publications/default.asp

Web Sites (continued)

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

Sample of Luminaire Product Sources
http://store.starrynightlights.com/depali.html

LED Landscape Lighting
www.superbrightleds.com/malibu.htm

Astronomy Outreach and Education Materials
www.starlight-thatre.ca

Wildlife Lighting
www.state.hi.us/dlnr/dofaw/fbrp/sos.htm

Work, Aging, and Vision: Report of a Conference, National Academy Press, Washington, DC, 1987, ISBN-10: 0-309-07793-1, http://books.nap.edu/openbook.php?isbn=POD252

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
Open Parking Lot	11-22
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 (SI) unit of illumination equal to 1 candela/m^2 (cd/m^2) = 0.093 foot-candles (fc)

To place these levels in context, people have reported seeing "fine" at full Moon illumination levels in the absence of glare[30].

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

APPENDIX B - Colour from Various Light Sources

There six lights that convey "colour" from bright white to deep yellow. The last light source, LEDs can be designed to provide a range of colour. The accompanying table lists these sources in order from white to yellow.

MH – Metal Halide	They allow very good colour recognition because of the wide spectrum emission (blue to red) from the bulb. It is a "High Intensity Discharge' (HID) bulb that must be warmed up before it can design brightness. The light-emitting region in the bulb is small so lenses and shields can control where the light is projected. The white light gives very good colour recognition.
CF – Compact Fluorescent	These produce white light but their light-emitting region is very large compared to MH so their light is difficult to control with optics and shields. They perform well in cool temperatures and can be used for motion detection systems, but they take several minutes to warm up in sub-zero temperatures.
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.
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
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 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 HID bulbs. In this document they are recommended for use as roadway marker lights.
LEDs - Light Emitting Diodes	These can produce a range of colours but currently (2007) only relatively low illumination levels. However, they produce very directed illumination, which is very desirable for a number of applications identified in this document. They are currently more expensive than the other types of bulbs but their cost is falling quickly.

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	60	0.13	1.2	4.8
15 watt	128	0.28	2.6	10.2
40 watt	342	0.8	6.8	27.2
60 watt	513	1.1	10.2	40.8
100 watt	855	1.9	17.0	68.0
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 (CF)				
9 watt (40 w equivalent)	550	1.2	10.9	43.8
13 watt (60 w equivalent)	850	1.9	17.9	71.6

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

** The luminous efficiency of incandescent light is approximated as 1/10 that of HPS for photopic vision

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

†† Lux is the amount of light illuminating a surface of one metre square

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

References:

IDA Information Sheet 4, Operating Data and Economics of Different Lamps, (08/96)
CAN/CSA-C653-94 (2000) - Performance Standard for Roadway Lighting Luminaires
Mesopic Street Lighting Demonstration, Lighting Research Centre, Jan. 31, 2008, (Rensseaer), Table 2, 5

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[31]

			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	-----	-----
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. WWR

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

APPENDIX F – Summary of RASC Lighting Protocol Dark-sky Preserve / Urban Star Park

This summary applies to all property and structures within the Dark-sky Preserve.

1. No additional light fixtures should be installed.

If additional light fixtures are considered necessary by the park manager, and with approval by the DSP nominators, additional fixtures may be installed. All new fixtures should conform to the requirements of Items 3-8 below.

2. Signage should not use active lighting.

Signage should use retro reflective materials. Pedestrian signs should be mounted at a height suitable for illumination with flashlights (<1 metre from the ground).

3. Only full cut-off (FCO) fixtures should be used.

All existing light fixtures should be replaced with FCO fixtures or shielded to prevent light from shining above the horizon or beyond the immediate area requiring illumination.

4. The illumination level produced by all light fixtures should be as low as practical.

Dusk and nighttime pedestrian and vehicle traffic densities should be used in assessing the level of illumination. For vehicles, typically < 70-watt HPS is sufficient (3 lux) for large parking lots and high traffic density areas where low speed limits are in effect. Major pedestrian routes may be illuminated by typically < 5-watt incandescent light or <1 watt LED (1 lux). Due to the use of vehicle headlights and pedestrian flashlights, lower light wattages can be used with the understanding that they are used only as marker lights. Phosphorescent markers may be used.

5. Structures and barriers should be used to confine illumination to the immediate area.

Illuminated areas should be bordered by trees and bushes or other barriers to prevent the light from shining and scattering beyond the area being illuminated.

6. All light sources should be turned off within 2-hours of sunset

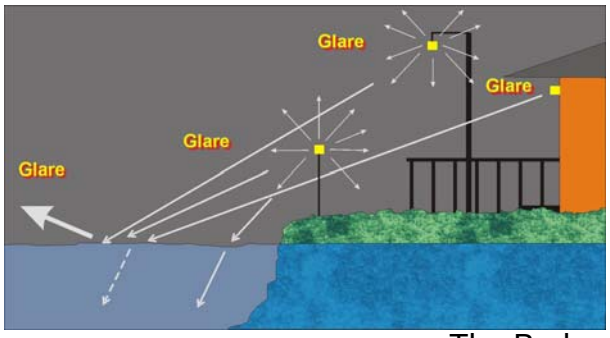
Automatic timers should be used to avoid the need for staff to turn off the lights. The timers should detect nightfall and should turn the lights off within 2-hours. If the park manager considers lights will occasionally be required after this time, the timer should be capable of being reset by staff.

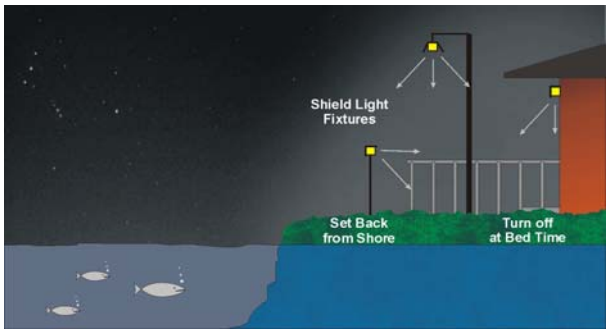
7. Indoor lighting should be prevented from shining through exterior windows.

If interior lights must be used after sunset, window curtains should be closed within 30-minutes of sunset.

8. The colour of all light fixtures should emit a minimum of blue in their spectrum.

“White” light sources such as metal halide lamps and white LEDs should not be used. High-pressure, and low-pressure sodium lamps, incandescent bulbs and “yellow” LEDs may be used.





The Bad and the Good of
Shoreline Lighting

Shielded Bollard and White Stone
for Parkland Pathways

Use Timers
- on at sunset
- off 2-hours later

Use Motion Sensors
- lights on only
  when needed

Use "Warm Light"
- not blue white light