Standard: Street Lighting For Turtle Nesting Areas

Standard Number: HPC-8DJ-14-0001-2015

Document Control		
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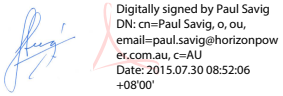
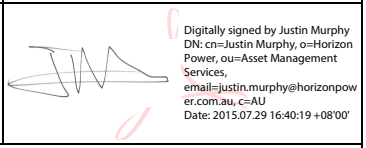
Document Owner *(May also be the Process Owner)*	**Name:** Paul Savig **Position:** Senior Standards Engineer	
Approved By *	**Name:** Justin Murphy **Position:** Manager Asset Management Services	
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** Shall be the Process Owner and is the person assigned authority and responsibility for managing the whole process, end-to-end, which may extend across more than one division and/or functions, in order to deliver agreed business results.*

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**** Frequency period is dependent upon circumstances– maximum is 5 years from last issue, review, or revision whichever is the latest. If left blank, the default shall be 1 year unless otherwise specified.*

Revision Control		
Revision	**Date**	**Description**
0	29/07/2015	Initial Document Creation

STAKEHOLDERS The following positions shall be consulted if an update or review is required:	
Manager Asset Management Services	Manager Engineering and Project Services
Manager Engineering and Project Services	Manager Districts

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1 PURPOSE

This standard seeks to provide suitable street lighting for the safety of road users whilst limiting the impact on Turtle Hatching grounds.

Artificial light is known to deter turtles from nesting and causes disorientation to hatchlings when attempting to reach the sea from the nest, thus greatly increasing the mortality rate of the species.

This document should be read in conjunction with Section 13 of the *Distribution Design Manual Volume 5* [1] and the specification for *LED Street Lighting* [2].

2 APPLICATION

This standard applies to engineers and designers of street lighting near to beach areas. Turtle nesting is known to occur on the Western Australian coast from Shark Bay to the border with Northern Territory [6].

The standard of street lighting recommended in this document reduces light pollution, it does not eliminate it. *Environmental Assessment Guideline* [6] can be used to further reduce the impacts on the environment i.e. reduce the artificial lighting near beaches.

Appendix D contains information about road planning with the goal of minimising artificial light near beaches.—

Table 1: Species Status and Distribution

Species	**Conservation Status**	**Estimated Annual Population of Nesting Females in WA**	**Nesting Area in WA**
Flatback	Vulnerable	1,000 to 10,000	From Exmouth Gulf to NT border
Green	Vulnerable	10,000~30,000	Ningaloo, Barrow Island, Montebellos, Kimberley
Hawksbill	Vulnerable	1,000's	Ningaloo, Lowendal Islands, Dampier Archipelago to Montebello Islands, Kimberley
Leatherback	Endangered	Not known to nest in WA	
Loggerhead	Endangered	1,000's	Ningaloo Coast south to Carnarvon. Islands near Shark Bay. Rookery at Dirk Hartog Island
Olive Ridley	Endangered	Unknown, estimated low	Kimberley Islands

3 NORMATIVE REFERENCES

3.1 Referenced Documents (Horizon Power)

1. *Distribution Design Manual Vol 5 – Overhead Bare Conductor Distribution (HPC-5DC-07-005-2012)*, available from http://www.horizonpower.com.au/2196.html under the *Distribution Design* tab.
2. *Specification – LED Street Lighting (HPC-8DJ-14-0001-2013)*, available from http://www.horizonpower.com.au/2196.html under the *Other* tab.
3. *Standard – Horizon Power Environmental Conditions (HPC-9EJ-01-0001-2013)*, available on request from Horizon Power (CS10 No.: 2302921).

3.2 Referenced Documents (Other)

4. *AS/NZS 1158 (series) Lighting for roads and public spaces*, published by Standards Australia, available from: http://www.saiglobal.com/
5. *Australian Loggerhead Sea Turtle Hatchlings Do Not Avoid Yellow*, K Fritsches, published in *Marine and Freshwater Behaviour and Physiology*, 2012.
6. *Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts*, published by the WA Environmental Protection Authority, November 2010, available at: http://www.epa.wa.gov.au/Policies_guidelines/EAGs/Pages/EAG5.aspx
7. *Sea Turtles and the Environmental Management of Industrial Activities in North West Western Australia*, K Pendoley, Ph.D. thesis, Murdoch University, Perth, 2005.
8. *Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches*, Witherington and Martin, published by the Florida Marine Research Institute, third edition revised 2003, available at: http://www.fws.gov/caribbean/es/PDF/Library%20Items/LightingManual-Florida.pdfhttp://www.fws.gov/caribbean/es/PDF/Library%20Items/LightingManual-Florida.pdf

3.3 Definitions

Carriageway

The portion of the road devoted for vehicles, which includes auxiliary lanes and shoulders.

CFL

Compact Fluorescent Lamp. This lamp is a low-pressure mercury gas discharge lamp, that uses fluorescent powder coating on the tube.

Colour Rendering

The ability of a light source to render the colours of an object, in comparison to what they would be under an ideal light.

Dual Carriageway

A road which has a non-trafficable median strip separating the two carriageways.

Endangered

A description of species that may become extinct if threats continue.

Glare

Discomfort or impairment of vision arising from extreme contrast.

HPS

High Pressure Sodium, a gas discharge lamp that uses sodium vapour at a pressure similar to 1.0 atmosphere.

Illuminance

The amount of light arriving at a surface.

LED

Light Emitting Diode, a solid-state lamp.

LPS

Low Pressure Sodium, a gas discharge lamp that uses sodium vapour at a low pressure (less than 1.0 atmosphere).

Luminance

The brightness of a surface or light-emitting object.

MH

Metal Halide, a gas discharge lamp that uses mercury vapour.

Offset

The distance between the pole alignment and the edge of the carriageway (typically defined by the kerb, or the start of the sealed road shoulder). Also known as pole setback.

Pole Alignment

The distance from the pole alignment to the property boundary.

Setback

The distance between the pole alignment and the edge of the carriageway (typically defined by the kerb, or the start of the sealed road shoulder). Also known as offset.

Threshold Increment

The measure of disability glare, expressed as the percentage increase in contrast required between a standard object and its background (the carriageway) for it to be seen equally as well (with or without the source of glare).

UWLR

Upward Waste Light Ratio, a measure of light spill into the sky causing sky glow. It is the ratio of light flux emitted above a luminaire, compared to the total light flux emitted. The greater the value of this ratio, the more light is spilled.

Vulnerable

A description of species that may become endangered if threats continue.

4 REQUIREMENTS

Street lighting shall be designed to minimise the environmental impact, as well as protect the natural flora and faunæ of regional Western Australia. In addition to new installations Horizon Power staff, are also obliged to apply this standard to existing installations, to minimise environmental footprint in established network areas.

4.1 Artificial Light impact on Turtles

Artificial light impacts on turtle-hatching activity in the following ways:

1) Bright beaches deter adults from nesting
2) Bright lighting disorient hatchlings, preventing them from crawling straight to the ocean, greatly decreasing the survival rate

Artificial light is particularly disruptive due to the colour, intensity, and sky glow.

4.1.1 Light Colour (Wavelength)

Most research to date indicates that turtle hatchlings perceive light differently from humans, with low-wavelength light appearing much brighter than high-wavelength light [6]. Using a 'ROYGBIV' scale, with red at 650 nm and violet at 400 nm, light with a wavelength less than 570 nm (the 'GBIV' part of the scale) appears much brighter. It is therefore an objective to avoid using lamps that emit light in this range.

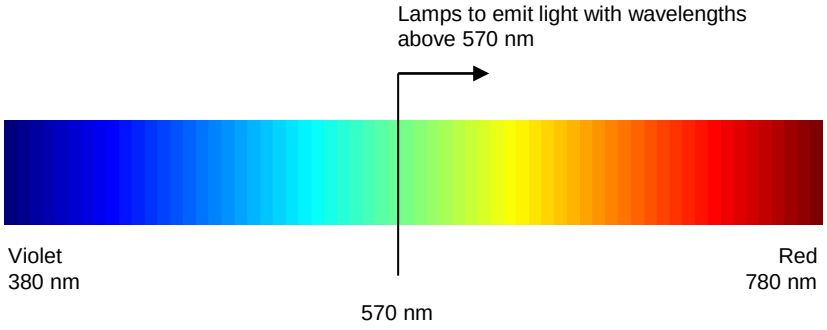

Figure 1: Visible Spectrum and Lamp Wavelength Limit

Scientific papers published over the years describe experiments on a range of species [6, 7, 8]. Results indicate that the decreased sensitivity light of certain wavelength varies between species. These have been summarised below in Table 2.

Table 2: Decreased Sensitivity to Coloured Light by Species

Species	Conservation Status	Decreased Sensitivity to Light of Wavelength (nm)
Flatback	Vulnerable	550~700
Green	Vulnerable	630~700
Hawksbill	Vulnerable	550~700
Leatherback	Endangered	No information
Loggerhead*	Endangered	540~675
Olive Ridley	Endangered	650~700

*Some recent research disputes that yellow light is less attractive for Australian loggerheads, and suggests that limiting light to a certain wavelength may not be an effective measure at increasing hatchling survival [5]. It is clear that more research is required; this standard will be updated according to research outcomes as they develop.

4.1.2 Upward Light Causing Sky Glow

The reflection of moon and celestial light from the ocean surface creates a natural sky glow over the ocean. Artificial light can cause a sky glow over the mainland, and this disorients hatchlings from their normal path to the ocean. The disruption is stronger when cloud coverage is high or the sky is overcast.

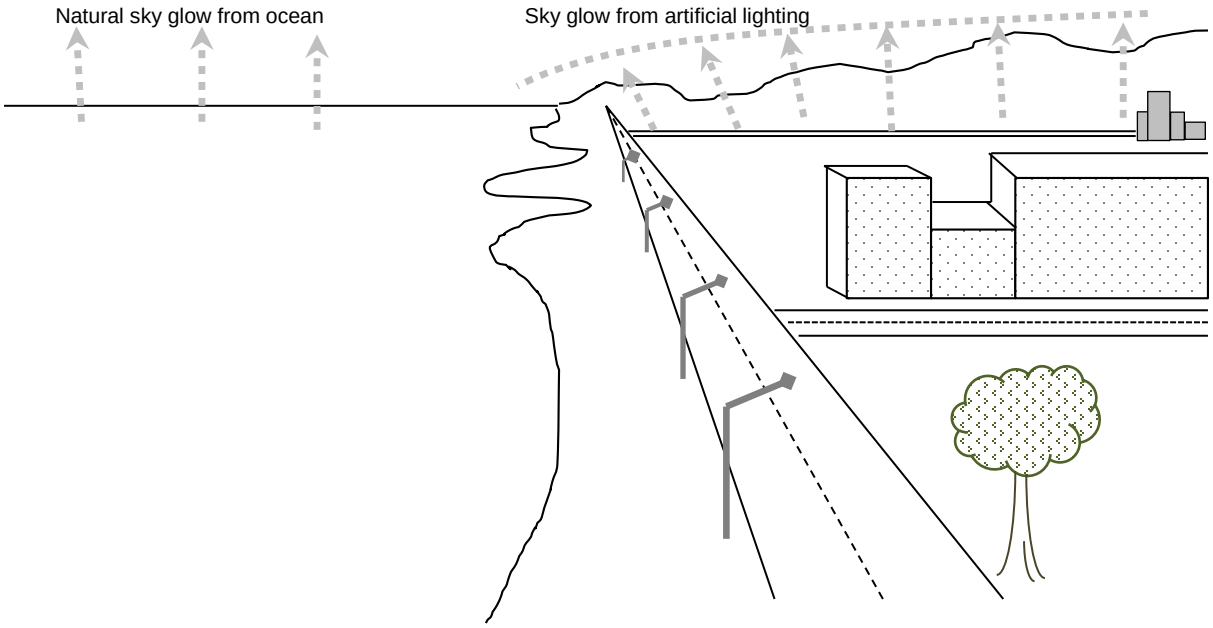

Figure 2: Sky glow from Natural and Unnatural Sources

4.1.3 Placement and Direction of Artificial Light

Luminaires are typically aimed to illuminate the road surface or the entire road reserve. This may be regarded as the target area. The amount of light falling in this target area (as opposed to that spilling outside) is determined by:

- The distribution of light emanating from a luminaire
- The direction in which the luminaire is pointed
- The placement of the luminaire in relation to the target area

Figure 3 shows light spill onto a beach due to poor placement and aim of street light luminaires. Figure 4 shows an improved arrangement resulting in a darker beach.

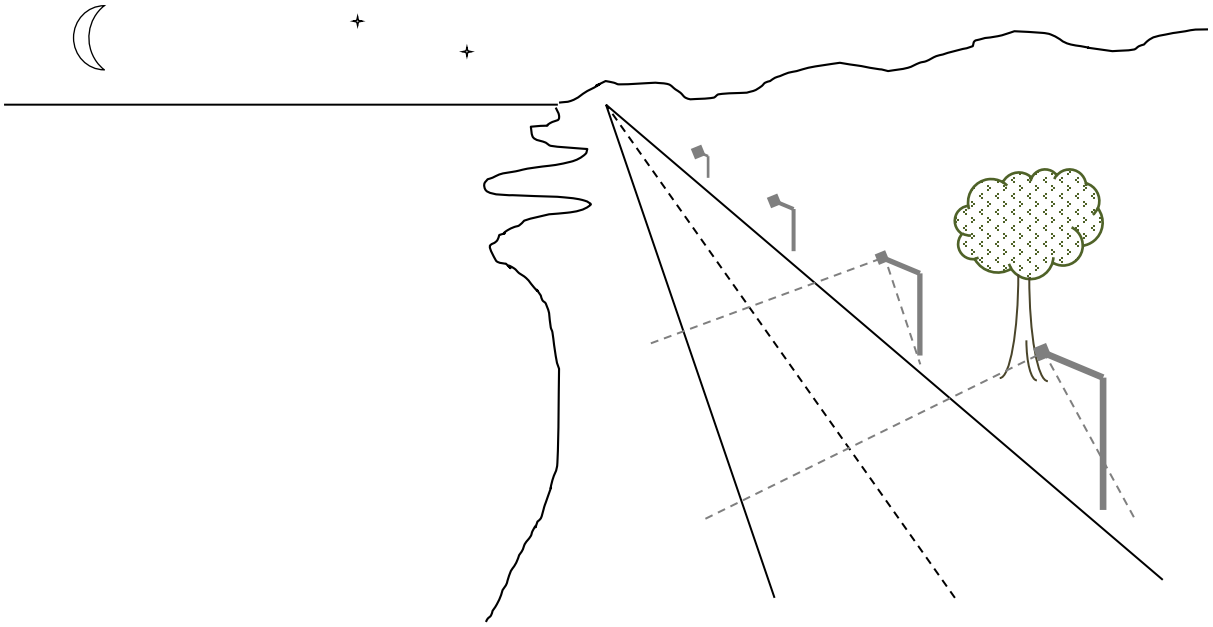

Figure 3: Light Spill onto Beach due to Luminaire Placement and Aim

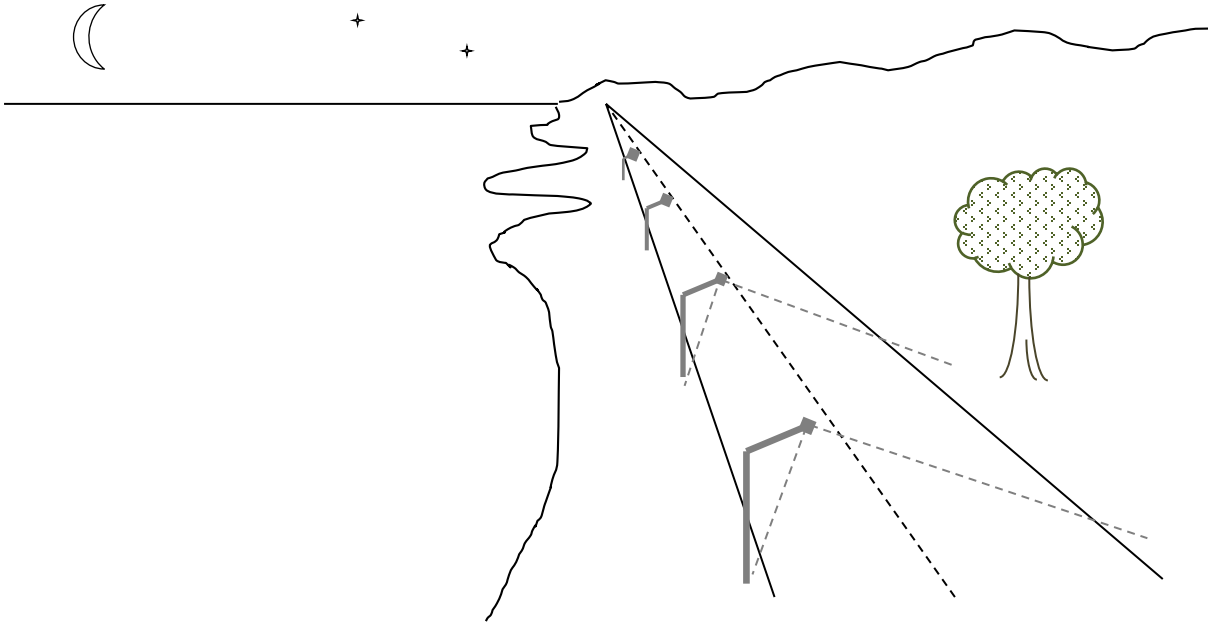

Figure 4: Darker Beach due to Luminaire Placement and Aim

In many situations, a single-sided arrangement away from the beach (as shown in Figure 4) requires a large luminaire upcast to maintain a uniform luminance on the road. This upcast can contribute to sky glow, and so opposing luminaires should be used, as shown in Figure 5.

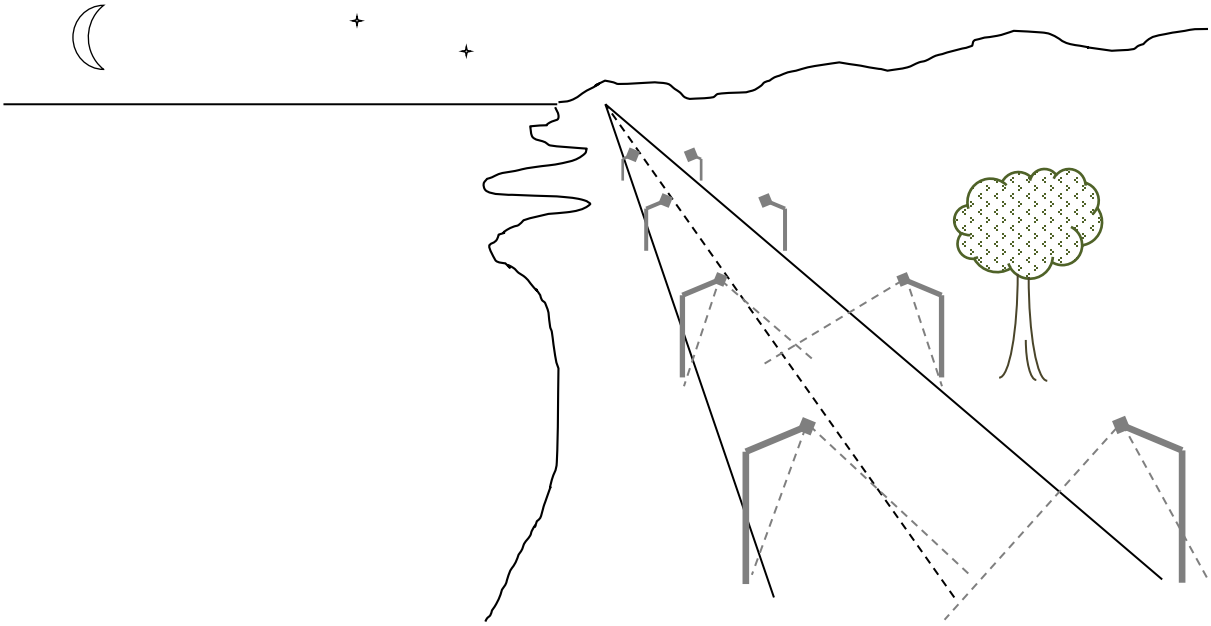

Figure 5: Darker Beach and Reduced Sky glow due to Opposite Luminaire Placement

A staggered arrangement (as shown in Figure 6) should be used with caution, as luminaires may require greater upcast compared to an opposite arrangement. This increased upcast contributes to sky glow and light spilling onto the beach (from the beach-facing luminaires).

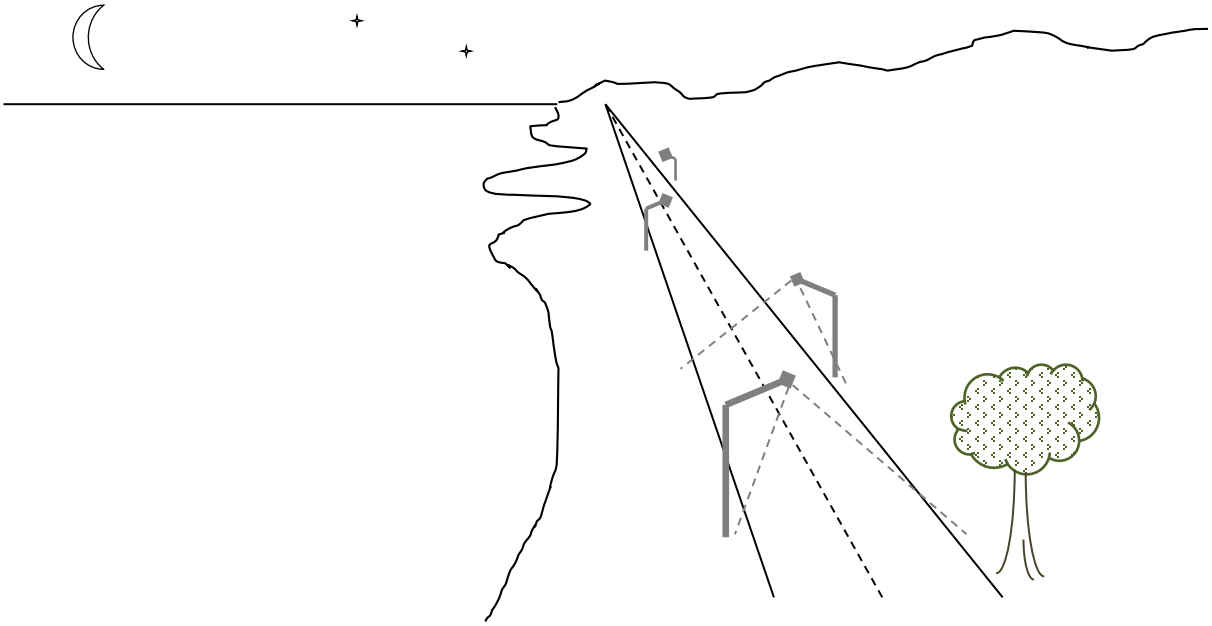

Figure 6: Staggered Luminaire Placement

Where a dual carriage way is used, an opposite arrangement may result in large upcasts in order to reach the uniformity requirement. This upcast may result in unacceptable sky glow, and so a twin opposite arrangement should be used as shown in Figure 7.

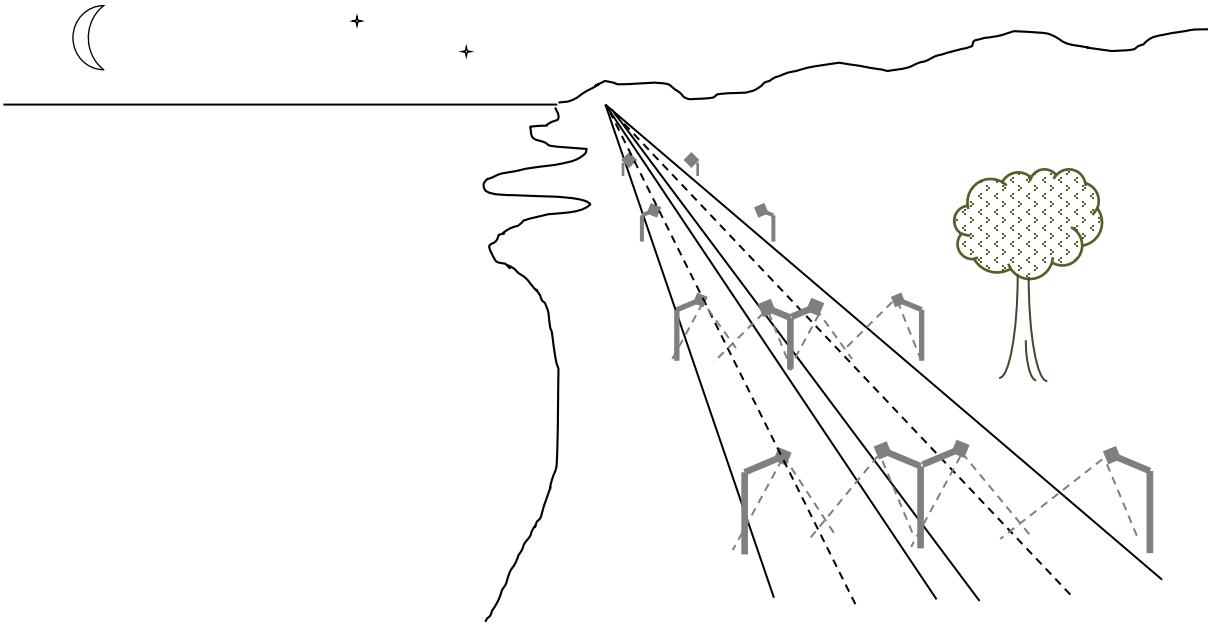

Figure 7: Twin Opposite Luminaire Placement

4.1.4 Height of Luminaires

Luminaires mounted low have a greater chance of being screened from the beach by vegetation or other obstacles. Where no such screening exists, lower luminaires will typically spill less light onto the beach when compared to higher luminaires.

4.2 Design

The primary requirements of lighting for road users are:

- Luminance of the road, and to a lesser extent, the road verge (note that for categories P3 and P4, the entire road reserve is considered)
- Uniformity of luminance
- Upward waste light ratio, to limit sky glow
- Vertical illuminance at pedestrian crossings (or adjacent to intersections where the road lighting is inadequate for safe illumination of pedestrians)

To minimise the environmental impact on turtles, the following design principles are relevant:

- Use lights that emit a long wavelength (see Section 5.1)
- Keep lights low to the road
- Minimise spill by having more lights of lower intensity (rather than fewer lights of higher intensity)
- Where roads are not directly adjacent to beaches, contain light spill in order to maintain a dark zone:
  - of 1.5 km around significant rookeries
  - of 500 m around beaches
- Minimise sky glow (upward waste light)

4.2.1 Lighting Performance Criteria for New Street Lights

Based on the above philosophy, the following requirements apply to new designs:

1) Illuminance, luminance and spill shall meet performance requirements as per Appendix B.
2) Lights shall be LED luminaires with a specific wavelength suitable for the area, as per section 5
3) Pole height, arrangement and spacing shall be as per Section 6

Table 3 and Table 4 below summarise categories for roads and pedestrian crossings. The referenced standards should be consulted for detailed descriptions.

Table 3: Road Categories (V)

Category	Description	Reference
V1	Arterial or main road in central or regional activity centres	T2.1 AS/NZS 1158.1.1 [4]
V2	Arterial roads that carry through traffic from one region to another	T2.1 AS/NZS 1158.1.1 [4]
V3	Freeways, expressways, and also arterial roads	T2.1 AS/NZS 1158.1.1 [4]
V4	Sub-arterial roads, principal roads	T2.1 AS/NZS 1158.1.1 [4]
V5	Sub-arterial roads, principal roads	T2.1 AS/NZS 1158.1.1 [4]

Table 4: Road Categories (P) and Pedestrian Crossing Categories (PX)

Category	Description	Reference
P3	Collector roads or local roads with *medium* pedestrian/cycle activity	T2.1 AS/NZS 1158.3.1 [4]
P4	Collector roads or local roads with *low* pedestrian/cycle activity	T2.1 AS/NZS 1158.3.1 [4]
PX1	Arterial or sub-arterial road with posted speed limit of ≥ 60 km/h	T3.1 AS/NZS 1158.4 [4]
PX2	Local collector or sub-arterial road with posted speed limit of ≤ 60 km/h	T3.1 AS/NZS 1158.4 [4]
PX3	Local road	T3.1 AS/NZS 1158.4 [4]

4.2.2 Lighting Performance Criteria for Existing Street Lights

Existing luminaires shall be replaced in order to comply with the performance requirements of the original design. New luminaires shall comply with the requirements stated in Section 5 and the *LED Street Lighting Specification* [2].

A guide to replacement has been provided below in Table 5. Where the category of lighting is P3 or P4, the replacement luminaire shall be double the input power of that shown.

Table 5: Luminaire Replacement

Original Luminaire Lamp Type	**Original Gas Discharge Lamp Power (W)**	**Replacement LED Luminaire Power (W)**
Compact Fluorescent	42 W	27 W
Mercury Vapour	80 W	27 W
Mercury Vapour	125 W	56 W
Metal Halide	70 W	27 W
High Pressure Sodium	150 W	120 W
High Pressure Sodium	250 W	180 W

5 LUMINAIRES

5.1 Lamp Types

Lamp types shall be LED. Other lamp types such as high pressure sodium, low pressure sodium, metal halide, low-pressure mercury vapour (fluorescent, tubular or compact), and other gas discharge lamps shall not be used.

LED lamps shall be of the colour (wavelength peak), as per Table 6 below for the region applied.

Table 6: LED Types

Colour	Junction Materials	Peak Wavelength (nm)	Area
Amber	aluminium, indium, gallium, phosphide	590 ± 10 nm	Shark Bay and nearby islands, WA coast from Carnarvon up to Kimberley region, including Ningaloo coast, Exmouth and the north-west cape, Port Hedland and Broome.
Red	aluminium, indium, gallium, phosphide	626 ± 10 nm	Barrow Island, Kimberley Region

5.2 Luminaires

LED luminaires shall comply with the *LED Street Lighting* specification [2], with the exception of Section 4.6.3 of that specification (colour temperature and colour rendition index) which shall be disregarded.

5.3 Luminaire Upcast

This Standard does not specify the range of permissible upcast, as it is effectively managed by the performance limit on upward spill (UWLR). In many situations, a large upcast will result in an unacceptable upward spill (exceeding the UWLR performance requirement).

Knuckle adapters that allow high-tilt mounting (tilt ranges up to 45°) may be used providing the luminaire mounted on such adapters are pointed away from the beach, and are not pointed at reflective structures.

6 LIGHT POLES

6.1 Pole Arrangement

In order to limit spill onto beaches and sky glow, only some arrangements may be used. These are shown below in Table 7.

Table 7: Pole and Luminaire Placement Arrangements

Arrangement	Requirement	Comment
Single-sided (facing beach)	Not allowed	
Single-sided (facing inland)	Allowed	This arrangement may fail the UWLR requirement, unless street is narrow or luminance requirement is low
Staggered	Allowed	
Opposite	Allowed	This arrangement may fail the UWLR requirement where the road is dual-carriageway
Twin central	Not allowed	
Twin opposite	Allowed	Only applicable for dual-carriageway roads
Twin staggered	Allowed	Only applicable for dual-carriageway roads

6.2 Pole Height

As a general principle, 6.5 m poles shall be used. Other mounting heights may only be used with Horizon Power written approval.

Where poles are for pedestrian crossings where overhang of the carriageway is necessary, the height shall be sufficient for the clearance of vehicles (a parameter of the road design).

6.3 Typical Pole Spacing

Typical LED luminaires have been used to generate typical pole spacing, as shown in Table 8, Table 9 and

Table 10 below. These spacing's comply with the detailed performance requirements (Appendix B).

Table 8: Typical Pole Spacing's (V category single carriageway)

Lighting Category	Typical Road Description	No. of lanes per carriage-way	Typical LED Lamp Rating (W)	Allowable Pole Height (m)	Typical Carriage-way Width (m)	Typical Pole Arrangement	Pole Spacing Range (m)
V1	Urban arterial or main road	2	120	6.5	14~17	Opposite	24~28
V2	Urban arterial	2	120	6.5	10~13	Opposite	32
V3	Urban freeway	2	120	6.5	12~15	Opposite	26~32
V4	Rural arterial	2	60	6.5	11~14	Opposite	32
V5	Rural arterial	1	60	6.5	7~11	Staggered	16

Table 9: Typical Pole Spacing's (V category dual carriageway)

Lighting Category	Typical Road Description	No. of lanes per carriage-way	Typical LED Lamp Rating (W)	Allowable Pole Height (m)	Typical Carriage-way Width (m)	Typical Pole Arrangement	Pole Spacing Range (m)
V1	Urban arterial	2	120	6.5	14~17	Twin opposite	26~32
V2	Urban arterial	2	120	6.5	10~13	Twin opposite	36~40
V3	Urban freeway	2	120	6.5	12~15	Twin opposite	40

Table 10: Typical Pole Spacing's (P category)

Lighting Category	Typical Road Description	No. of lanes per carriage-way	Typical LED Lamp Rating (W)	Allowable Pole Height (m)	Typical Road Reserve Width* (m)	Typical Pole Arrangement	Pole Spacing Range (m)
P3	Urban access road, parallel parking each side	2	60	6.5	21~25	Staggered	19~20
P3	Urban access road, parallel parking each side	2	30	6.5	21~25	Opposite	20~35
P4	Rural access road, parallel parking each side	2	30	6.5	21~25	Staggered	19~20

*P3 and P4 categories (where a high pedestrian activity is expected) include the entire road reserve as part of the 'design carriageway', to afford greater lighting to the verge area.

6.4 Road Sign Lighting

Section 7.10 of AS/NZS 1158.1.2 [4] states that where monochromatic light is used (e.g. from low-pressure sodium lamps), independent lighting is necessary for the signs to maintain a reasonable colour appearance.

Independent lighting for road signs shall be directed at the road sign from above or the side, and if the latter, pointed away from the beach area. This lighting shall not be situated at the base of the sign, lighting the sign from below, as this creates unacceptable sky glow.

APPENDIX A REVISION INFORMATION

(Informative) Horizon Power has endeavoured to provide standards of the highest quality and would appreciate notification if any errors are found or even queries raised.

Each Standard makes use of its own comment sheet which is maintained throughout the life of the standard, which lists all comments made by stakeholders regarding the standard.

A comment sheet **HPC-9DJ-14-0001-2015-COM** found in CS10# **3278826**, can be used to record any errors or queries found in or pertaining to this standard, which can then be addressed whenever the standard gets reviewed.

Date	Rev No.	Notes
29/07/2013	0	First Issue

APPENDIX B DETAILED PERFORMANCE REQUIREMENTS

Table 11: Performance Requirement for Road User Safety (Category V)

Parameter	Minimum Value	Maximum Value	Reference
Average carriageway luminance (cd/m²)	V1: 1.50 V2: 1.00 V3: 0.75 V4: 0.50 V5: 0.35	V1: 3.1 V2: 3.0 V3: 2.1 V4: 1.4 V5: 2.0	Minimums: T2.2 AS/NZS 1158.1.1 [4] Maximums are requirements of this standard†
Overall uniformity	0.33	None	T2.2 AS/NZS 1158.1.1 [4]
Longitudinal uniformity	0.5	None	T2.2 AS/NZS 1158.1.1 [4]
Threshold increment	20%	None	T2.2 AS/NZS 1158.1.1 [4]
Surround verge illuminance	50%	130% for single carriageway 150% for dual carriageway	T2.2 AS/NZS 1158.1.1 [4] Maximums are requirements of this standard†
Point horizontal illuminance* (lux)	V1: 15.0 V2: 10.0 V3: 7.5 V4: 5.0 V5: 3.5	None	Minimums: T2.2 AS/NZS 1158.1.1 [4]
Illuminance (horizontal) uniformity*	8	None	T2.2 AS/NZS 1158.1.1 [4]
Upward waste light ratio	None	1%	Maximum is a requirement of this standard†

*These values apply to intersections and other specified locations as per the referenced standard. Detailed requirements are described in the referenced standards.

†These maximum values are recommended on the basis of environmental impacts as explained in section 4.1.

Table 12: Performance Requirement for Road User Safety (P Categories)

Parameter	Minimum Value	Maximum Value	Reference
Average horizontal illuminance (lux)	P3: 1.75 P4: 0.85	P3: 6.1 P4: 3.3	Minimums: T2.6 AS/NZS 1158.3.1 [4] Maximums are requirements of this standard†
Point horizontal illuminance (lux)	0.33	None	Minimums: T2.6 AS/NZS 1158.3.1 [4]
Illuminance (horizontal) uniformity	10	None	Minimums: T2.6 AS/NZS 1158.3.1 [4]
Point vertical illuminance (lux)	P3: 0.3 P4: N/A	None	Minimums: T2.6 AS/NZS 1158.3.1 [4]
Upward waste light ratio	None	1%	Maximum is a requirement of this standard†

*These values apply to intersections and other specified locations as per the referenced standard. Detailed requirements are described in the referenced standards.

†These maximum values are recommended on the basis of environmental impacts as explained in Section 4.1.

Table 13: Performance Requirement for Road User Safety (PX Category)

Parameter	Minimum Value	Maximum Value	Reference
Pedestrian crossing point vertical illuminance (lux)	PX1: 32 PX2: 32 PX3: 16	PX1: 150 PX2: 150 PX3: 150	Minimums: T3.2 AS/NZS 1158.4 [4] Maximums are requirements of this standard†
Pedestrian crossing glare control at 90° (cd)	None	PX1: 250 PX2: 250 PX3: 170	T3.2 AS/NZS 1158.4 [4]
Pedestrian crossing glare control at 70° (cd)	None	PX1: 6000 PX2: 6000 PX3: 4000	T3.2 AS/NZS 1158.4 [4]
Upward waste light ratio	None	2%	T2.10 AS/NZS 1158.3.1 [4] T3.2 AS/NZS 1158.4 [4]

†These maximum values are recommended on the basis of environmental impacts as explained in Section 4.1.

APPENDIX C AVAILABLE PRODUCTS FROM VENDORS

Gerard Lighting (Pierlite range)

Gerard have stated that the ‘mine master’ is available with amber LEDs.

Gerard Lighting (Sylvania range)

Gerard have confirmed their product ‘streetled’ 22 W is available with amber LEDs.

Light Sense

Lightsense distribute LED street lights made by BBE. They have confirmed the ‘U’ series (U2A, U2, U4, U6) are available amber and red LEDs. These are powered at 30, 60, 120 and 180 W respectively.

APPENDIX D ROAD PLANNING CONSIDERATIONS

The following recommendations fall outside the scope of street lighting and are provided for information.

- Plan roads such that they are a distance from the beach, especially when they are elevated with regard to the beach. Have only access roads near to the beach, and position local distributors, district, regional, and primary distributors away from the beach.
- Consider planning the road categories such that low lighting will suffice, or no lighting is necessary.
- For unlit roads, road safety may be achieved by other means such as reducing speed limits, introducing speed bumps and other features to reduce traffic speed.
- Preserve natural vegetation as a screen between beach and roads. Where natural vegetation is cleared to necessitate development, implement revegetation programs.
- Use vegetation or buildings as screens (between beach and road) for highly-lit areas such as intersections, round-abouts and pedestrian crossings.
- Road surfaces should be designed to not be highly luminous, and should conform to category R3 as per Table 3.1 of AS/NZS 1158.1.2 [4].