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# Western Sydney Zoo Masterplan Lighting Concept Report

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for

**Sydney Zoo**



## Table of Contents

1.	INTRODUCTION .....	1
2.	EXTENT AND LOCATION OF THE LIGHTING .....	1
2.1	Carparks .....	1
2.1.1	Primary Carpark .....	1
2.1.2	Staff Carpark .....	1
2.2	Internal Pathways.....	1
2.2.1	Destinations .....	2
2.2.2	Primary Circulation Path .....	2
2.2.3	Australian Animals Circulation Path .....	2
2.2.4	Elevated Boardwalk .....	2
2.3	Back of House Areas.....	3
2.3.1	Service Roads .....	3
2.3.2	Service Yard .....	3
2.4	Emergency Lighting and Exit Signage .....	3
2.5	Signage .....	4
2.6	Animal Exhibits .....	4
2.7	Picnic Areas.....	4
3.	LIGHTING CONTROL .....	4
4.	OBTRUSIVE LIGHTING IMPACT.....	4
5.	SKY GLOW IMPACT.....	5
6.	APPENDICES.....	6



## 1. INTRODUCTION

The Western Sydney Zoo is proposed to be open to the public till 10:00pm. As a result external lighting will be required to assist access through the site and to facilitate viewing of the animals.

This report addresses the areas that are proposed to be lit and the type of lighting appropriate for the task, the impact of the lighting on the surrounding environment and the implications on sky glow.

There is an Australian Standard for public lighting; AS/NZS1158.3.1 Pedestrian area (Category P) lighting – Performance and design requirements. Although the standard may have some relevance to some of the spaces, e.g. carpark lighting, the basis of the standard is both safe movement and reduction of the risk of crime in public spaces. As the internal spaces in the zoo are not public, there is assumed that there would be a low risk of crime compared to a public park and there is the overriding requirement of the comfort and the visibility of the animals, then the majority of the spaces would not comply with all the recommendations of the standard.

## 2. EXTENT AND LOCATION OF THE LIGHTING

We have reviewed the masterplan design and in proposing the areas to be lit we have made assumption with respect to the night time operation of the facility. If some of these assumptions are not accurate it may affect the lighting recommendations and we have assumed that they will be reviewed by the zoo.

### 2.1 Carparks

There is a primary carpark and an overflow carpark. The primary carpark is sealed and the overflow carpark is a gravel surface. We have assumed that the night attendance will be lower than the day attendance and therefore only proposed to light the primary carpark. The carpark is an external public space and should therefore be compliant with the Australian Standard.

#### 2.1.1 Primary Carpark

The Australian Standard recommends several different levels of lighting depending on the level of usage and risk of crime. We have included the assessment criteria as Appendix A. We believe that the appropriate category would be P11b. Accessible car-parking spaces within the illuminated carpark should be lit to Category P12.

As it is proposed to have lines of trees along the dividers, this means that the vertical illumination cannot be achieved with floodlights on the carpark boundaries. As a result poles will need to be mounted on the median strips with lights on outreaches on both sides. This will have the advantage of creating an environment by day and night that is less visually obtrusive.

#### 2.1.2 Staff Carpark

Due to the staff leaving work after dark, it would be necessary to provide safe access to their cars. We would therefore propose that the staff carpark be lit to P11c. The lighting could be controlled by motion sensors so that the light is only activated when required.

In addition the pathway and road between the entry and the service facilities should be lit to P4 category. The criteria and recommended levels for paths are included in Appendix B.

### 2.2 Internal Pathways

The internal pathways have to provide guidance to direct people throughout the space, illuminate the ground sufficiently to reduce the likelihood of trips and falls, while not



obstructing the visibility of the animals. We have assumed that there would be a very low risk of crime in the area.

The Australian Standard would normally require the lighting to provide illumination in the vertical plane 1.5 metres above the ground. This is designed to assist facial identification as a safety and security measure. To achieve this with minimal glare this would normally be provided by post mounted luminaires. We believe that this is inappropriate for this situation for several reasons:

- The eye changes its sensitivity based on the ambient light. In dark conditions this is commonly referred to as dark-adaptation. Providing vertical illumination on people's faces will reduce their dark-adaptation level thereby making it more difficult to see the animals.
- We assume that there will be minimal risk of crime within the zoo and as a result the facial illumination is secondary to the visibility of the animals.
- It should be noted that the light levels that are recommended are based on residential street lighting and are well below the levels recommended for lip reading. Minimum lip reading levels are between 40 and 60 lux. To light to this level would require that the animal enclosures were increased to a comparative level. This would effectively increase the energy and lighting by a factor of 10.

### **2.2.1 Destinations**

An important part of wayfinding and people maintaining their orientation and sense of location is to have visual destinations in the space. These are generally a lit visual object at the end of a line of travel. This can be an artwork, a characteristic tree, a significant sign or the like. They provide an object for people to aim for so that the path does not appear endless. In addition it provides reference points so people recognise where they are and where they have been. It assists in people finding their way back to the entry particularly where the exit to an exhibit is in a different area to the entry.

It is also useful if these icons are lit in emergency conditions as they are often better reinforcement of people's locations than signage.

### **2.2.2 Primary Circulation Path**

The lighting of the primary pathway should provide adequate light for wayfinding and reveal obstructions but it should not compete with the viewing of the animals. We would propose that the paths be lit to Category P4 level to AS1158.3.1. This gives a level of light equivalent to a minor residential street without the need for the vertical illumination requirement. This can be achieved with a series of low level directional bollards that light the path without throwing light back into the animal enclosures. Because of the reduced height the spacing of the bollards will be closer than would be the case for post top luminaires.

### **2.2.3 Australian Animals Circulation Path**

The Australian Animal Circulation path is a less formal path than the primary circulation path and is within an animal enclosure. We would propose to light the path to a lower level consistent with Category P5 to AS1158.3.1. Again the path can be illuminated by low bollards or ground mounted fittings. The fittings should be animal proof.

### **2.2.4 Elevated Boardwalk**

The elevated boardwalk is a continuation of the primary pathway and should be lit to the same level. As the boardwalk has a balustrade the lighting can be provided by lights mounted in the underside of/within the handrail.



## 2.3 Back of House Areas

The need to light the service roads that surround the site will depend on the operational requirements of the zoo. If maintenance and servicing of enclosures is to operate out of hours then there may need to be some lighting provided. This may not be necessary if the traffic is only vehicular, however if there is pedestrian traffic at night then the road should be lit.

### 2.3.1 Service Roads

Service roads are not to be lit.

### 2.3.2 Service Yard

The service yard would need to be lit in case it was needed at night. This could be achieved using pole mounted lights on the perimeter of the yard. As it would not be required all night, every night we would propose that it be controlled by motion sensors or timers so that it is only used when needed. This will reduce the energy usage as well as the environmental effects.

## 2.4 Emergency Lighting and Exit Signage

There are several scenarios where emergency evacuation may be required at night. The principal ones are:

- Loss of Power
- Fire
- Act of Aggression
- Escaped Animal

Although there is a standard for emergency evacuation lighting and exit signs for interiors, there is no equivalent standard for external installations and the interior standard is not particularly relevant.

In all cases it is important that the lighting performs the following requirements:

- Adequate lighting is maintained to allow people to efficiently evacuate the site
- The lighting allows people to maintain their orientation in the site and find their way to the exits and their car
- Provide clear signage to direct people to the exits.
- Provide lighting in the specific emergency exit routes that either runs at all times or is operated in emergency situations.

The interior lighting standard has a requirement that emergency lights must achieve 10% output within 1 second and 80% output within 15 seconds. This is designed to minimise panic and precludes the use of diesel generators as they take too long to start.

With interior lighting the emergency evacuation lighting is normally provided by low power battery operated stand-alone lights. These would be ineffectual in the large area of the site and as batteries are temperature sensitive, the life of the fittings would be low when subjected to the summer sun.

For EXPO88 in Brisbane it was decided that if the lighting failed there would be no difference to being outside and would not experience the total darkness that can occur in an interior space. As a result diesel generators were used to provide the emergency lighting as it was considered more important that people be provided with meaningful lighting to maintain their orientation in the space rather than instant light. With LED lighting there is no restrike time so that once the diesel is up to speed the lighting can be instantly provided. It would not be necessary to maintain the lighting of the animal enclosures, only the pathway lighting.



## 2.5 Signage

Lighting needs to be located so that direction and information signage is legible at night or alternatively internally illuminated signage should be used. The signage must still be visible in emergency mode.

## 2.6 Animal Exhibits

The animal exhibits will need to be lit to see the animals. The lighting level should be low so that people are viewing the animals in a night mode rather than extend the daytime appearance and behaviour. It is important that the light be moderately uniform throughout the enclosure. If only part of the enclosure is lit the animals may choose to stay in the dark area and the lighting will raise the adaptation of the people's eyes so that they will not be able to see them. Consideration should be given to lighting the enclosures with blue light as it will give a night appearance to the space.

We would recommend a level of around 5 lux. The lighting should be pole mounted at the front of the enclosure looking into the space. The higher the light pole the better the uniformity throughout the animal enclosure. With larger enclosures there may be a need to provide intermediate poles in the space.

With the elevated walkway it would be possible to install lighting on the underside to light the surrounding area.

## 2.7 Picnic Areas

If the picnic areas are to be used at night then the areas will need to be lit. The lighting levels in these areas will need to be higher than the access ways as people will need to prepare the food and will need adequate facial illumination to communicate. We would recommend an average illuminance of 40 lux for these areas.

## 3. LIGHTING CONTROL

The flexibility and intelligence of lighting control has improved dramatically in recent years, particularly with the introduction of LED lighting that no longer has a warm up or restrike time. There are now wireless systems available that enable individual control of each fitting or light poles. This will enable lighting on empty enclosures to be switched off. The wireless system can also monitor the performance of each light and flag failures. Alternatively conventional switching at switchboards can be implemented, with a dedicated cable for each light switching group. With this arrangement should a light need to be switched with another group of lights then re-wiring is required to implement the change.

It is also possible to have presence sensors on the lighting of a particular enclosure so that it only comes on when there are visitors present.

## 4. OBTRUSIVE LIGHTING IMPACT

There is an Australian Standard for obtrusive light impact, AS4282: Control of the obtrusive effect of outdoor lighting. The standard acknowledges that there is an inherent amount of light trespass that is a consequence of living in an urban environment and recommends limits of what a person can reasonably expected to tolerate. The standard has three criteria for assessment:

- ***Illuminance in the vertical plane*** at the property boundary of residential properties
- ***Luminous intensity*** of the light source. This is a measure of the glaring impact of the lighting.
- ***Threshold increment***. This is a measure of the effect that the lighting has on the visual performance of drivers on surrounding roads.

The standard recommends different limits based on the ambient light in the area and the time of operation.



The standard has different limits for before and after 11:00pm. The curfew levels are significantly lower. As the Zoo is not proposed to be open after 11:00 pm then the installation only needs to comply with the pre-curfew limits. The recommended limits are included in Appendix C.

The standard has different recommendations for ambient light levels. These are categorised as 'Commercial', 'Residential – Light Surrounds' and 'Residential –Dark Surrounds'. It could be argued that, given the surrounding usage, the site could be classified as 'Commercial', the highest level; however the installation will easily comply with 'Residential-Dark Surrounds' the most conservative level.

The illuminance reduces proportional to the distance squared. The site has a buffer zone in all directions provided by the park, the highway and the natural bushland. Given the buffer and the fact that the illumination levels on the site are low we believe that the vertical illuminance at the residential property boundaries will be negligible. When the lighting design is completed this can be calculated to confirm this. The light emanating from this site will be negligible compared with the light from the adjacent sports fields.

As all the lights to be selected are to be full cut-off fittings that emit no light in or above the horizontal plane the light sources should not be visible from outside the site so we believe that the luminous intensity external to the site will be negligible. This can again be confirmed by calculation when the lighting design is completed.

The threshold increment will not be a problem as the highway is offset from the site and the carpark lights will have a controlled cut-off. Again this can be confirmed by calculation when the lighting design is completed.

## **5. SKY GLOW IMPACT**

Sky Glow is a result of light directed into the sky reflecting off particles on moisture and dust in the atmosphere. It is an inherent consequence of an urban environment. As the cumulative Sky Glow increases it is more difficult to see the stars.

Sky glow is made up of two components, the light from the fitting that is directed into the sky and the light that is reflected from other surfaces.

There is no quantitative standard for the control of sky glow, although there is comments in AS4282 that highlight the need to control the upward light output. There are some specific requirements for specific locations near international observatories.

The lights proposed for the site will emit no light above the horizontal plane so there will be no direct contribution to sky glow from the site.

The reflected contribution depends on the illumination level and the reflective properties of the surface. Reflected light is a significant problem with tennis courts and other sports installations where the illumination levels are high. The illumination levels in this site will be around 1% of those used in sporting installations. In addition the ground finishes in the zoo will be natural and have a relatively low reflectivity.

The contribution of the site to sky glow will be minimal.



## 6. APPENDICES

### APPENDIX A – AS/NS1680.3.1 Carpark Assessment Criteria

**TABLE 2.5**  
**LIGHTING CATEGORIES FOR OUTDOOR**  
**CAR PARKS**  
**(INCLUDING ROOF-TOP CAR PARKS)**

1	2	3	4	5
	Selection criteria <sup>a)</sup>			
Type of area	Night time vehicle or pedestrian movements	Night time occupancy rates (NTOR)	Risk of crime <sup>b)</sup>	Applicable lighting subcategory <sup>c)</sup>
Parking spaces, aisles and circulation roadways	High	>75%	High	P11a
	Medium	≥25%, ≤75%	Medium	P11b
	Low	<25%	Low	P11c
Designated parking spaces specifically intended for people with disabilities	N/A	N/A	N/A	P12

<sup>a)</sup> The selection criteria of Columns 2 to 4 should be separately evaluated. The highest level of any of the selection criteria that is deemed appropriate for the area type will determine the applicable lighting subcategory.

<sup>b)</sup> The risk levels 'High', 'Medium' and 'Low' correspond to the classifications of the same names in HB 436.

<sup>c)</sup> Providing a lighting scheme that meets the requirements of more than one subcategory by the use of switching is permitted.



**APPENDIX B – AS/NS1680.3.1 Pathway Criteria and Recommendations**

**TABLE 2.1  
LIGHTING CATEGORIES FOR ROAD RESERVES IN LOCAL AREAS**

1	2	3	4	5	6
Type of road or pathway		Selection criteria <sup>a,b)</sup>			Applicable lighting subcategory <sup>c,d)</sup>
General description	Basic operating characteristics	Pedestrian/cycle activity	Risk <sup>f)</sup> of crime	Need to enhance prestige	
Collector roads or non-arterial roads which collect and distribute traffic in an area, as well as serving abutting properties	Mixed vehicle and pedestrian traffic	N/A	High	N/A	P1
		High	Medium	High	P2
		Medium	Low	Medium	P3
		Low	Low	N/A	P4
Local roads or streets used primarily for access to abutting properties, including residential properties	Mixed vehicle and pedestrian traffic	N/A	High	N/A	P1
		High	Medium	High	P2
		Medium	Medium	Medium	P3
		Low	Low	N/A	P4
		Low	Low	N/A	P5 <sup>e)</sup>
Common area, forecourts of cluster housing	Mixed vehicle and pedestrian traffic	N/A	High	N/A	P1
		High	Medium	High	P2
		Medium	Low	Medium	P3
		Low	Low	N/A	P4

- a) The selection criteria of Columns 3 to 5 should be separately evaluated. The highest level of any of the selection criteria that is deemed appropriate for the road will determine the applicable lighting subcategory.
- b) Refer to Appendix C for guidance on choosing the applicable level of each selection criteria for the environment and purpose of a lighting scheme.
- c) Lighting categories P3, P4 and P5 apply across the whole of the road reserve width, including the footpath. Lighting categories P1 or P2 may be selected where there is a significant risk of crime or need to enhance the prestige of the area, however, such lighting only applies over the physical extent of any formed pathway.
- d) Refer to the footnotes to Table 2.6 regarding modified sub-categories P3R and P4R for use in New Zealand.
- e) Discretionary use of subcategory P5.  
Generally, subcategory P5 shall only be applied to the replacement of existing luminaires installed on existing electricity distribution poles or for the initial application of a lighting scheme where the cost to re-configure these poles limits or precludes compliance with category P4.  
It is recognized however that for some authorities, category P4 could be deemed as being excessive in terms of providing adequate level of service and meeting with community expectations. In this case subcategory P5 may be used.
- f) The risk levels ‘High’, ‘Medium’ and ‘Low’ correspond to classification of the same names in HB 436.

**TABLE 2.6**  
**VALUES OF LIGHT TECHNICAL PARAMETERS AND PERMISSIBLE**  
**LUMINAIRE TYPES FOR ROADS IN LOCAL AREAS AND FOR PATHWAYS**

1	2	3	4	5	6
Lighting subcategory	Light technical parameters				Permissible luminaire type (see Table 2.10)
	Average horizontal illuminance <sup>a,b)</sup> ( $\bar{E}_h$ ) lux	Point horizontal illuminance <sup>a,b)</sup> ( $E_{ph}$ ) lux	Illuminance (horizontal) uniformity <sup>c)</sup> Cat. P ( $U_{E2}$ )	Point vertical illuminance <sup>a,b)</sup> ( $E_{pv}$ ) lux	
P1	7	2	10	2	Type 4 where part of a road reserve or Types 2, 3, 4 or 6 elsewhere
P2	3.5	0.7	10	0.7	
P3 <sup>e)</sup>	1.75	0.3	10	0.3 <sup>d)</sup>	
P4 <sup>e)</sup>	0.85	0.14	10	N/A	
P5 <sup>e)</sup>	0.5	0.07	10	N/A	

**TABLE 2.1**  
**RECOMMENDED MAXIMUM VALUES OF LIGHT TECHNICAL PARAMETERS**  
**FOR THE CONTROL OF OBTRUSIVE LIGHT**  
**(See Clause 2.7)**

1	2	3	4	5
Light technical parameter	Application or calculation conditions (see also Figure 2.1 and Section 5)	Recommended maximum values		
		In commercial areas or at boundary of commercial and residential areas*	Residential areas	
			Light surrounds†	Dark surrounds‡
Illuminance in vertical plane ( $E_v$ )	<i>Pre-curfew:</i> Limits apply at relevant boundaries of nearby residential properties, in a vertical plane parallel to the relevant boundary, to a height commensurate with the height of the potentially affected dwellings. Values given are for the direct component of illuminance	25 lx	10 lx	10 lx
	<i>Curfewed hours:</i> Limits apply in the plane of the windows of habitable rooms of dwellings on nearby residential properties. In the absence of development (i.e. vacant allotment), the limits apply on the potentially affected property, in a vertical plane parallel to the relevant boundary, at the minimum setback permitted for a dwelling, to a height commensurate with land use zoning provisions. Values given are for the direct component of illuminance	4 lx	2 lx	1 lx
Luminous intensity emitted by luminaires ( $I$ )	<i>Pre-curfew:</i> Limits apply to each luminaire (irrespective of the number on a head frame) in the principal plane, for all angles at and above the control direction, when aimed in accordance with the installation design	Limits as determined from Table 2.2. Alternatively, the limits and method of assessment associated with curfewed hours may be applied, at the discretion of the designer (see Clauses 2.7.1 and 2.7.2)		
	<i>Curfewed hours:</i> Limits apply in directions where views of bright surfaces of luminaires are likely to be troublesome to residents, from positions where such views are likely to be maintained, i.e. not where momentary or short-term viewing is involved	2 500 cd	1 000 cd	500 cd
Threshold increment ( $TI$ )	Limits apply at all times where users of transport systems are subject to a reduction in the ability to see essential information. Values given are for relevant positions and viewing directions in the path of travel	20% based on adaptation luminance ( $\bar{L}$ ) of 10 cd/m <sup>2</sup>	20% based on adaptation luminance ( $\bar{L}$ ) of 1 cd/m <sup>2</sup>	20% based on adaptation luminance ( $\bar{L}$ ) of 0.1 cd/m <sup>2</sup>

\* Applies to residential accommodation in commercial areas or at the boundary between commercial and residential areas. The term 'commercial' is used as a generic description for zoning which provides for urban uses other than residential.

† Where the affected property abuts roads that are lit to Category V5 or higher in accordance with AS/NZS 1158.1.1.

‡ Where the affected property abuts roads that are lit to Category B1 or lower in accordance with AS 1158.1, or where there is no lighting.

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**TABLE 2.2**  
**MAXIMUM LUMINOUS INTENSITY PER LUMINAIRE**  
**FOR PRE-CURFEW OPERATING TIMES**  
**(See Table 2.1)**

1	2	3	4
Area description		Maximum luminous intensity from each luminaire*	
Size of area	Controlling dimension (Figure 5.1)	Level 1 control (Note 1)	Level 2 control (Note 2)
Large	>75 m	7 500 cd	100 000 cd
Medium	≥25 m ≤75 m	7 500 cd	50 000 cd
Small	<25 m	2 500 cd	25 000 cd

\* Limits apply to each luminaire (irrespective of the number on a head frame) in the principle plane, for all angles at and above the control direction, when aimed in accordance with the installation design (see Clause 5.3.2.1).

**NOTES:**

1 Level 1 control is appropriate for development control of environmentally sensitive areas, i.e. where the existing environment is of high quality, where abutting properties are close to the installation, where they are residential in nature, where the existing ambient light levels are low and where the community requires the best available environmental safeguards to be applied.

As the use of Type C cut-off luminaires† is likely to be necessary for Level 1 control, the implementation of this level of control will normally be possible only for lighting applications that require relatively high illuminances over areas that are small to medium in size, e.g. lighting for tennis courts or hockey fields. However, Level 1 control may also be suitable for larger areas where lower illuminances are appropriate, e.g. for car parks and outdoor storage areas.

2 Level 2 control will permit the use of a wide range of currently used lighting techniques but will limit intensities in the control direction to what might reasonably be expected by careful attention to design and the selection and aiming of luminaires, especially for applications involving Type A luminaires†.