



MOOREBANK  
INTERMODAL  
COMPANY

# Moorebank Intermodal Terminal Project Environmental Impact Statement

## Volume 9

October 2014



**PARSONS  
BRINCKERHOFF**





# Technical Paper 13 Light Spill Impact Assessment





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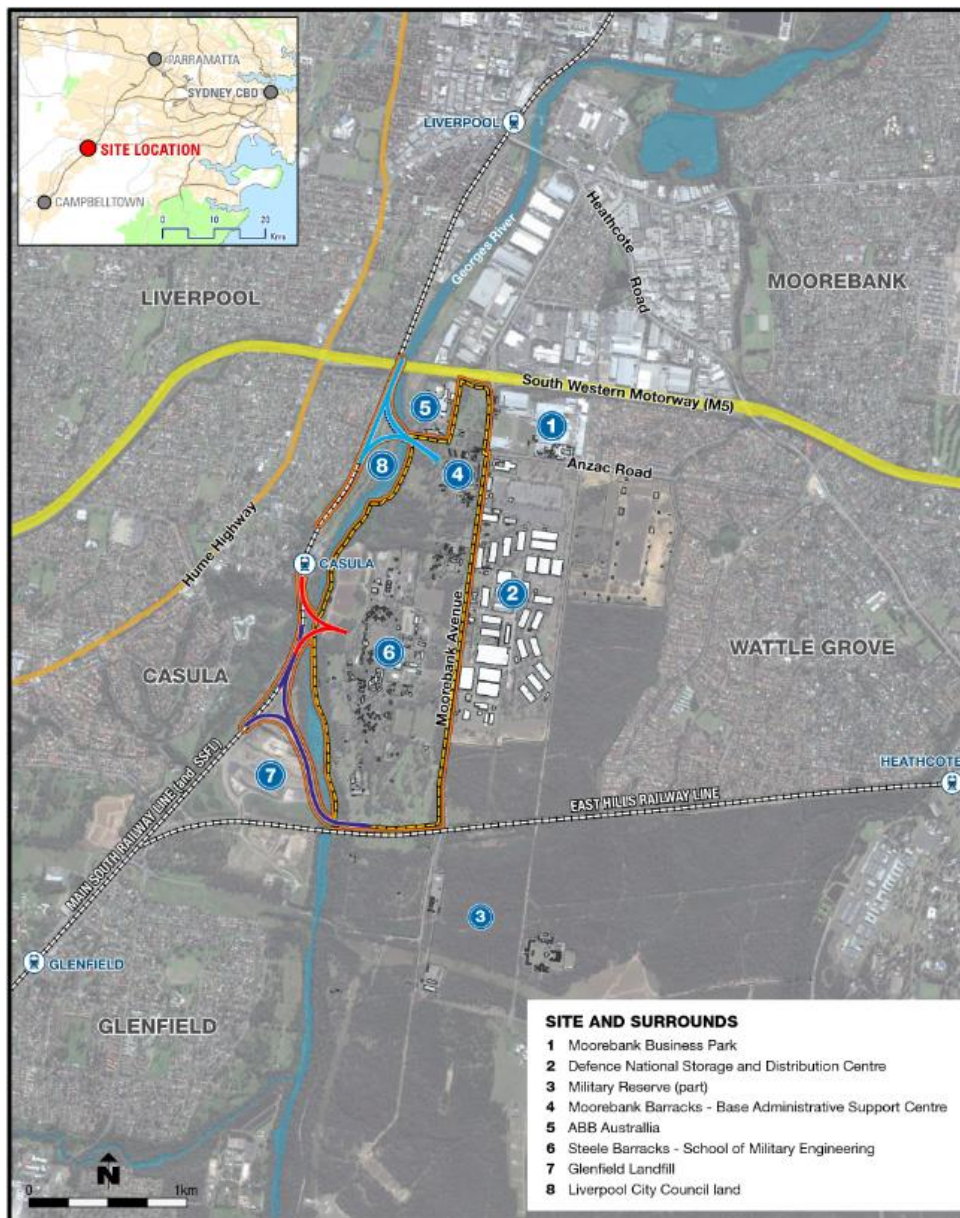
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# Light Spill Impact Assessment

## Moorebank Intermodal Terminal



## Light Spill Impact Assessment

Moorebank Intermodal Terminal

Client: Moorebank Intermodal Company

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E	27-May-2014	Addressing Rail Entry/Exit Options and changes in warehousing space	Tim Shotbolt Associate Director	
F	13 June 2014	Addressing revision feedback	Tim Shotbolt Associate Director	



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## Executive Summary

The purpose of this Technical Paper and the overall Environmental Impact Statement (EIS) is to seek approval for the Moorebank IMT Project 'concept' under both the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as a controlled action; and the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act), as a Stage 1 state significant development (SSD).

The Moorebank Intermodal Terminal Project ('Moorebank IMT') involves the development of freight terminal facilities linked to Port Botany and the interstate freight rail network by rail. It also includes associated commercial infrastructure, the three options for connecting the site to the planned Southern Sydney Freight Line (SSFL) and road entry and exit points from Moorebank Avenue.

The Project Site is approximately 220 hectares (ha) in area, and is located within a locality that includes the residential suburbs of Casula, Wattle Grove and North Glenfield, as well as industrial, commercial and Defence National Support and Distribution (DNSDC) land. The Project would provide connectivity to Port Botany by rail, and would connect to major regional and interstate roads and highways via the M5 and M7 Motorways.

The assessment of light spill from the Moorebank IMT project involves three separate actions. Measurement of existing environment conditions with respect to light spill; calculation of the potential light spill from the proposed lighting design; and assessment of the likely impact in specific sensitive receptor areas identifying mitigation measures as or if necessary.

Measurement of the existing lighting conditions in the general area involved night-time surveys. Dates and times were selected to eliminate influence of moonlight. Locations were selected surrounding the IMT Project site based on observation and site analysis to provide a general all-round perspective. The surveys consisted of measured lighting values for existing conditions and photographs.

The potential light spill from the Moorebank IMT was calculated using industry standard AGi32, version 2.31, lighting design software. The preliminary concept site lighting design for the Moorebank IMT was provided to AECOM and that design information was imported directly into the modelling software. The reference design is full build operations (Stage 1A (IMEX freight terminal development), 1B (Warehousing development) and 2 (Interstate freight terminal development) all together) so that the potential worst case scenario of impacts is calculated. Calculation grids were established in the different areas surrounding the Moorebank IMT site and calculation undertaken using the imported lighting design information

The Moorebank IMT preliminary concept site lighting design utilises luminaires that effectively prevent any direct light spill into the night sky. The light source proposed, high pressure sodium, is the most energy efficient for the application and the warmer colour of light contributes less to the overall brightness of the area.

The site (phases A, B and C) is large and the existing environment from most viewpoints is relatively dark. The reference lighting design would contain any direct light spill quite effectively with respect to adjacent residential areas as noted in this report. Also it would be possible to provide additional shielding to any specific luminaire should there be an issue.

There will be reflection of light from the general pavement areas and this will contribute to sky glow effects. There is no known industry accepted algorithms to calculate sky glow and sky glow is dependent on particulates and moisture in the atmosphere. Calculation shows that the amount of light reflected into the night sky from the pavement can be influenced by the reflectance characteristics of the pavement surface itself.

Calculation also shows that there will be direct light affecting the proposed conservation area adjacent to the Moorebank IMT site as well as the Georges River. Literature indicates that electric light may affect fauna and this aspect would be further considered during detailed design.

To put the calculated values into perspective using a natural benchmark, the calculated values for light spill from the Moorebank IMT towards various locations are an order of magnitude below that from a full moon, that is less than 0.03 lux, or equivalent to the light from the moon only on the days after or the days before a new moon.

For some of the residential locations that overlook the Moorebank IMT site there will be a noticeable change in brightness of that area on a clear night. In foggy conditions the brightness may be less but there would still be a strong local sky glow effect.

Transitory lighting such as train headlights would affect some residential locations in Casula particularly for the Northern access option upon exit from the Moorebank IMT site. There would be a minimal affect for residents

from train headlights when exiting the Moorebank IMT via the Southern access option where the minimum distance to residential boundaries from the approach is greatest. However consideration should be given to reducing the effect of train headlights similar to that for residential areas close to Port Botany.

## 1.0 Introduction

### 1.1 The Moorebank Intermodal Terminal Project

The Moorebank Intermodal Terminal (IMT) Project (the Project) involves the development of approximately 220 hectares (ha) of land at the Project site (refer to Figure 1) for the construction and operation of an IMT and associated infrastructure, facilities and warehousing. The Project includes a rail link connecting the Project site to the Southern Sydney Freight Line (SSFL) and road entry and exit points from Moorebank Avenue.

The primary function of the IMT is to be a transfer point in the logistics chain for shipping containers and to handle both international IMEX cargo, and domestic interstate and intrastate (regional) cargo. The key aims of the Project are to increase Sydney's rail freight mode share including: promoting the movement of container freight by rail between Port Botany and western and south-western Sydney; and reducing road freight on Sydney's congested road network.

The Project proponent is Moorebank Intermodal Company (MIC), a Government Business Enterprise set up to facilitate the development of the Project.

The Project site is currently largely occupied by the Department of Defence's (Defence) School of Military Engineering (SME). Under the approved Moorebank Units Relocation (MUR) Project, the SME is planned to be relocated to Holsworthy Barracks by mid-2015, which would enable the construction of the Project to commence.

The key features/components of the Project comprise:

- *an IMEX freight terminal* – designed to handle up to 1.05 million TEU per annum (525,000 TEU inbound and 525,000 TEU outbound) of IMEX containerised freight to service 'port shuttle' train services between Port Botany and the Project;
- *an Interstate freight terminal* – designed to handle up to 500,000 TEU per annum (250,000 TEU inbound and 250,000 TEU outbound) of interstate containerised freight to service freight trains travelling to and from regional and interstate destinations; and
- *warehousing facilities* – with capacity for up to 300,000 square metres (m<sup>2</sup>) of warehousing to provide an interface between the IMT and commercial users of the facilities such as freight forwarders, logistics facilities and retail distribution centres.

The proposal concept described in the main EIS provides an indicative layout and operational concept for the Project, while retaining flexibility for future developers and operators of the Project. The proposal concept is indicative only and subject to further refinement during detailed design.

### 1.2 Rail access options and layouts

The Project is intended to connect to the SSFL, which was commissioned in January 2013 within the Main South Railway Line corridor. The SSFL connects Port Botany to west and south-western Sydney, and would provide a direct route for freight trains from Port Botany to the Project site.

Three separate rail access options are included as part of the proposal concept as detailed in this EIS, as shown in Figure 1 (and included in Appendix A). These options comprise:

*northern rail access option* — with rail access from the north-western corner of the IMT site, passing through the former Casula Powerhouse Golf Course (which is currently owned by Liverpool City Council (LCC)) and crossing the Georges River and floodplain;

*central rail access option* — with rail access from the centre of the western boundary of the IMT site, passing through Commonwealth land on the western bank of the Georges River (referred to as the 'hourglass land'); and

*southern rail access option* — rail access from the south-western corner of the IMT site, passing through the Glenfield Landfill site (owned by Glenfield Waste Services) and crossing the Georges River and floodplain.

In order to maintain flexibility for future developers and operators of the Project, the proposal concept, as presented in this EIS, provides three indicative IMT internal layouts; one for each of three proposed rail access options. Once the selected developer/operator has been appointed, the Project would progress to the detailed design phase and one of the three rail access options identified above would be selected.

### 1.3 Project Delivery

The Project would be developed generally in accordance with development phasing as noted in Table 1. This proposes a staged approach for delivery (construction and operation) of the Project. The Project design has only been developed to a concept level at this stage and would be subject to further detailed design processes and planning approval (see Section 1.4).

Development of the Moorebank IMT would occur in three phases, as outlined in Table 1 below.

### 1.4 Planning and Assessment Process

The project requires assessment under both the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as a controlled action; and the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act), as a Stage 1 state significant development (SSD).

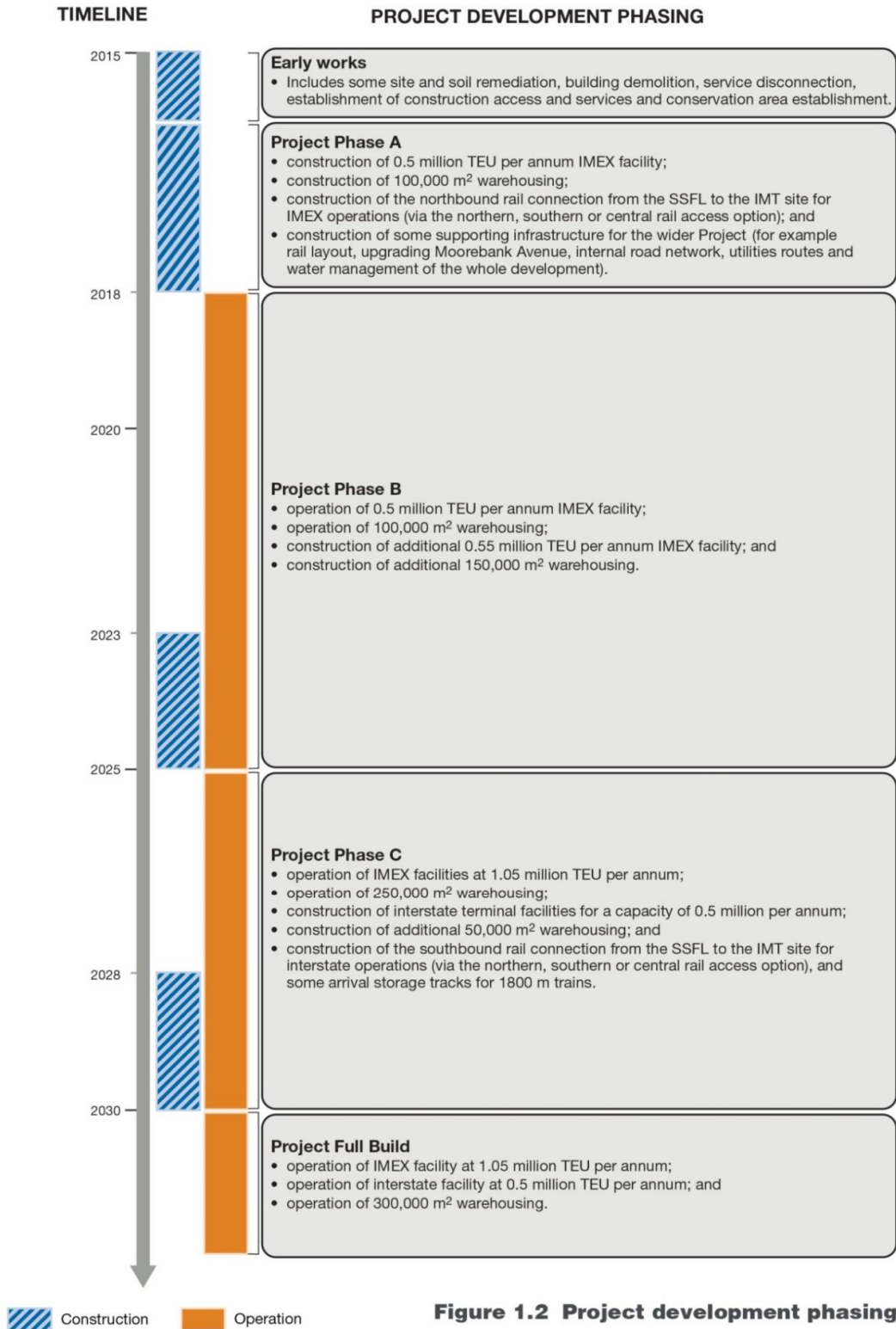
In seeking approval, MIC is seeking to establish a staged approval process, whereby successive stages of development on the Project Site would be subject to further environmental assessment and separate planning approval once further detailed Project information is developed. That is, the MIC is currently seeking approval for the Project 'concept' (i.e. the broad parameters of the Project), sufficient to satisfy both:

- a Stage 1 SSD development application under the NSW EP&A Act
- Commonwealth EPBC Act requirements for the Project, in relation to impacts of the proposed controlled action on matters protected under the EPBC Act (which comprise listed threatened specials and communities and impacts on the environment by a Commonwealth agency).

Therefore, this Technical Paper and the EIS assess the impacts of all three proposed development phases of the Project (A, B and C) to a concept level, but with more detailed assessment of matters protected under the EPBC Act. Further details of the Project would be the subject of future development applications under the NSW EP&A Act as those details are developed, with environmental impact assessments to be conducted in detail at that time. Impacts and mitigation measures would be confirmed following detailed design.



**Table 1** Development of Moorebank IMT



**Figure 1.2** Project development phasing

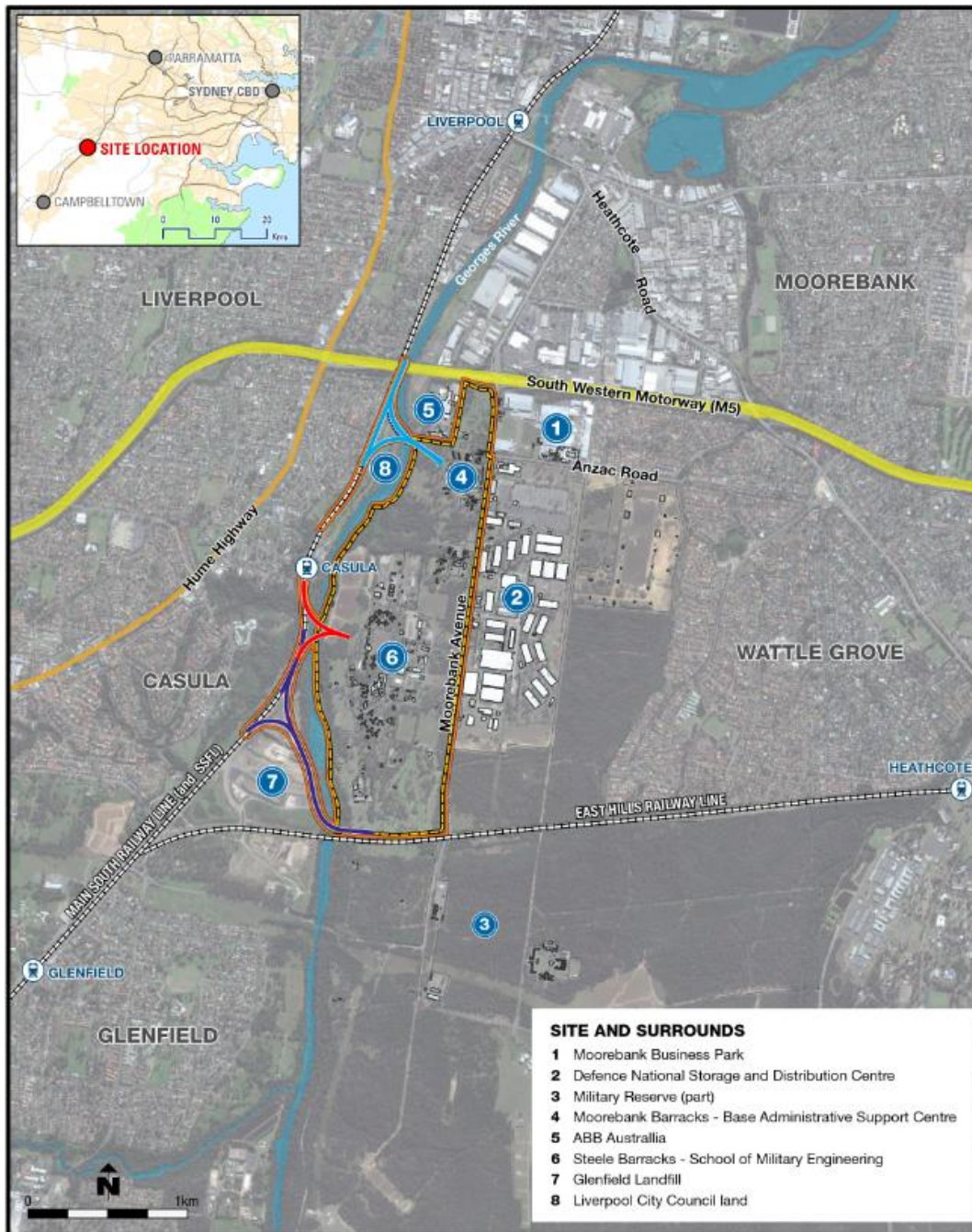


Figure 1 Moorebank Intermodal Terminal site and local context

## 1.5 Environmental Impact Assessment Requirements

This Technical Paper has been prepared by AECOM Australia Pty Ltd to address environmental impact assessment requirements of both the Commonwealth Government under the EPBC Act (the 'Final EIS Guidelines'); and the NSW Government under the EP&A Act ('the Director-General's Requirements (DGRs)'). Specifically this Technical Paper addresses the requirements outlined in the Table 2.

**Table 2** EIS requirements addressed within this Technical Paper

Requirement	Where addressed in this technical paper
<b>EPBC Act – Final EIS Guidelines</b>	
<b>Description of the Environment and matters of NES</b> – provide a discussion of the current light environment at the proposed site and surrounding area. Identify the location of all sensitive receivers to light in the local area.	Sections 2 to 4 inclusive
<b>Impacts to Listed Threatened Species and Communities</b> – discussion of the known threats to the species or communities, with reference to threats posed by the proposed action.	Sections 4 to 7 inclusive
<b>Impacts to the Environment by a Commonwealth Agency</b> – analyse and describe the contribution and impacts of the proposed facility on light spill at the local scale. The analysis should include (but not be limited to) details of the height of any proposed lighting and regimes for when lighting will be operating.	Sections 2 to 7 inclusive
<b>NSW EP&amp;A Act - DGRs</b>	
<b>Biodiversity</b> – an impact assessment of threatened terrestrial and aquatic (including groundwater dependent) species, populations and endangered ecological communities and/or critical habitat under both State and Commonwealth legislation, including the Cumberland Plain Woodland	Sections 4 to 7 inclusive
<b>Visual and Urban Design</b> – analyse and describe the contribution and impacts of the proposed facility on light spill at the local scale and to sensitive receivers.	Sections 2 to 7 inclusive

## 2.0 Assessment Approach

### 2.1 Methodology

The assessment of light spill from the Moorebank IMT project involves three separate actions. Measurement of existing environment conditions with respect to light spill; calculation of the potential light spill from the proposed lighting design; and assessment of the likely impact in specific sensitive receptor areas identifying mitigation measures as or if necessary.

#### 2.1.1 Existing environment

Measurement of the existing lighting conditions in the general area involved night-time surveys. Dates and times were selected to eliminate influence of moonlight. Locations were selected surrounding the Moorebank IMT site based on observation and site analysis to provide a general all-round perspective. The surveys consisted of measured lighting values for existing conditions and photographs.

The quantity of light received at a specific point (i.e. illuminance – measurement unit lux) may vary with any small change in location and any change in angle that the illuminance meter is held. The highest likely illuminance measurement is always in a vertical plane directly towards the direction where the Moorebank IMT will be built. Illuminance on the horizontal plane (i.e. ground) was only measured where it might be relevant as some locations were well screened by various objects including woodland and any light on the horizontal at that point would only ever come from an adjacent streetlight. At some locations only vertical illuminance was relevant. Illuminance values were measured with an illuminance meter (Yokogawa 510 illuminance meter, certified by Queensland University of Technology).

Photographs were taken with a digital SLR camera and the images selected represent the visual impression of the environment on the night the images were recorded.

Together, the illuminance measurements and the photographs form an impression of the existing general environment at night.

#### 2.1.2 Calculation of the potential light spill from the Moorebank IMT

The potential light spill from the Moorebank IMT was calculated using industry standard AGi32, version 2.31, lighting design software. The preliminary concept lighting design for the Moorebank IMT was provided to AECOM and that design information was imported directly into the modelling software. The preliminary concept design is full build operations (phase D) so that the potential worst case scenario of impacts is calculated. Calculation grids were established in the different areas surrounding the Moorebank IMT site and calculation undertaken using the imported lighting design information.

#### 2.1.3 Assessment of likely impact and identifying mitigation measures

The difference between the results of the existing environment measurements (2.1.1) and the calculated potential light spill (2.1.2) form the basis of assessments of likely impacts to the general environment. The potential results from 2.1.2 will be cumulative to the results from 2.1.1, however, it is the difference between the two environments that may also be important.

## 2.2 Lighting Standards

The impact of lighting on people is controlled by AS 4282-1997 Control of the obtrusive effects of outdoor lighting. Under AS 4282, public lighting as covered in the AS/NZS 1158 (road lighting) series of Standards is exempt from compliance with AS 4282. For this project that would mean lighting of Moorebank Avenue is exempt from assessment, however the main site would be subject to assessment. There are no relevant guidelines or standards in relation to impacts on fauna.

AS 4282 provides for two different sets of lighting criteria: pre-curfew and curfew. Curfew criterion applies after a specific time at night to reduce the potential impacts. The pre-curfew and curfew criterion vary depending whether the residential areas are adjacent commercial areas (includes industrial applications), light surrounds (i.e. abuts a category V5 road or higher lighting requirements (AS/NZS 1158.1.1)), or dark surrounds (i.e. abuts roads that are lit to B1 or less lighting requirements (AS/NZS 1158.3.1)) or where there is no lighting. The criterion includes both light received at a property (illuminance) and the luminance ('brightness') of lights as viewed from those properties. Pre-curfew the limiting criterion applies at the boundary of adjacent properties whilst during curfew the limiting criterion applies at windows facing the proposed development.



Where a residence is adjacent to an industrial or commercial business, more light is permissible compared to the opposite situation such as a darker parkland environment. Industrial includes all types of business not otherwise classified as commercial. Both circumstances of the lighting environment exist in the vicinity of the proposed IMT development and variations in between both circumstances also exist depending on the location of the observer.

## 3.0 The Moorebank IMT

### 3.1 Operational hours

The Moorebank IMT would operate 24 hours per day, 7 days per week and therefore require adequate lighting to provide for safe operation during night hours.

### 3.2 Preliminary concept lighting design

The preliminary conceptual site lighting design has been provided by Parsons Brinckerhoff. A summary of the design criteria is as follows, with the full details in Appendix B.

Function	Illuminance	Uniformity (min:ave)
Container handling areas	30lux	0.5
Regular vehicle traffic, road and gate areas	20lux	0.4
Container storage	10lux	0.25
Rail yards – continuous operation	15lux	0.4
Maintenance areas	20lux	0.25
Security lighting for CCTV surveillance	see notes below	
Other		
Moorebank Ave	30lux	

The preliminary concept design identifies that the majority of the open container storage and circulation areas would be lit from 30m high masts with the masts spaced nominally at 100m centres and any one mast supporting two to six 1000W high pressure sodium (HPS) luminaires mounted on a headframe. The luminaires will be full cut off type to limit site glare and spill light towards residences. Roads, gate areas, vehicle parking, movement and rail maintenance areas would utilise 20m poles with full cut off type luminaires. The lighting along Moorebank Avenue is proposed to be mounted at 15m height. General security surveillance lighting is to be provided on 10.5m poles spaced at 40m with a CCTV camera mounted every second pole. Further detail on the preliminary concept lighting design is provided in Appendix A.

### 3.3 Trains as a source of lighting

Trains would enter and leave the site anytime during operational hours. Trains at night would use headlights unless approaching a station or some similar sensitive area.

Three approaches from the SSFL to the Moorebank IMT are being considered. These are the Northern, Central and Southern approaches as indicated in Figures 29, 30 and 31 respectively in Appendix B

For all considered approaches, trains would leave the Moorebank IMT via a rail bridge crossing and their headlights would be pointing directly at some residents during their progress around the radius that takes them on to the SSFL. The effect at any one time is transitory however the headlights provide a peak intensity of 200,000 candela which translates to 2.2 lux at 300 metres distance from the locomotive.

For the Northern approach the minimum distance from the locomotive to the nearest residential boundary when exiting the Moorebank IMT is approximately 150m for both a northerly and southerly direction of travel along the SSFL. For the Central approach these minimum distances increase to approximately 220m and 600m for a northerly and southerly direction of travel respectively along the SSFL. For the Southern approach the approximate distances are 450m and 750m respectively when exiting the Moorebank IMT. These minimum distances for the Southern approach are across existing bushland.



### 3.4 Other sources of lighting

Trucks arriving and departing will use headlights at night although that is most likely to be on low-beam. Other vehicles on site will be forklifts and rail mounted gantries which will have working lights that are normally directed downwards plus flashing amber warning lighting. Also there may be a number of staff site vehicles and maintenance vehicles that will also have headlights and flashing amber warning lighting.

## 4.0 Existing Environment

### 4.1 Description of the environment

The surrounding environment includes many different areas associated with human activity such as military areas, industrial areas, commercial areas and residential areas, as well as areas of woodland, forest and Georges River. The Moorebank IMT Ecological Impact Assessment lists endangered, vulnerable and migratory fauna and the likelihood of occurrence in the area. Figure 2 shows the locations where existing lighting was assessed and the results are provided in the following parts of section 4.

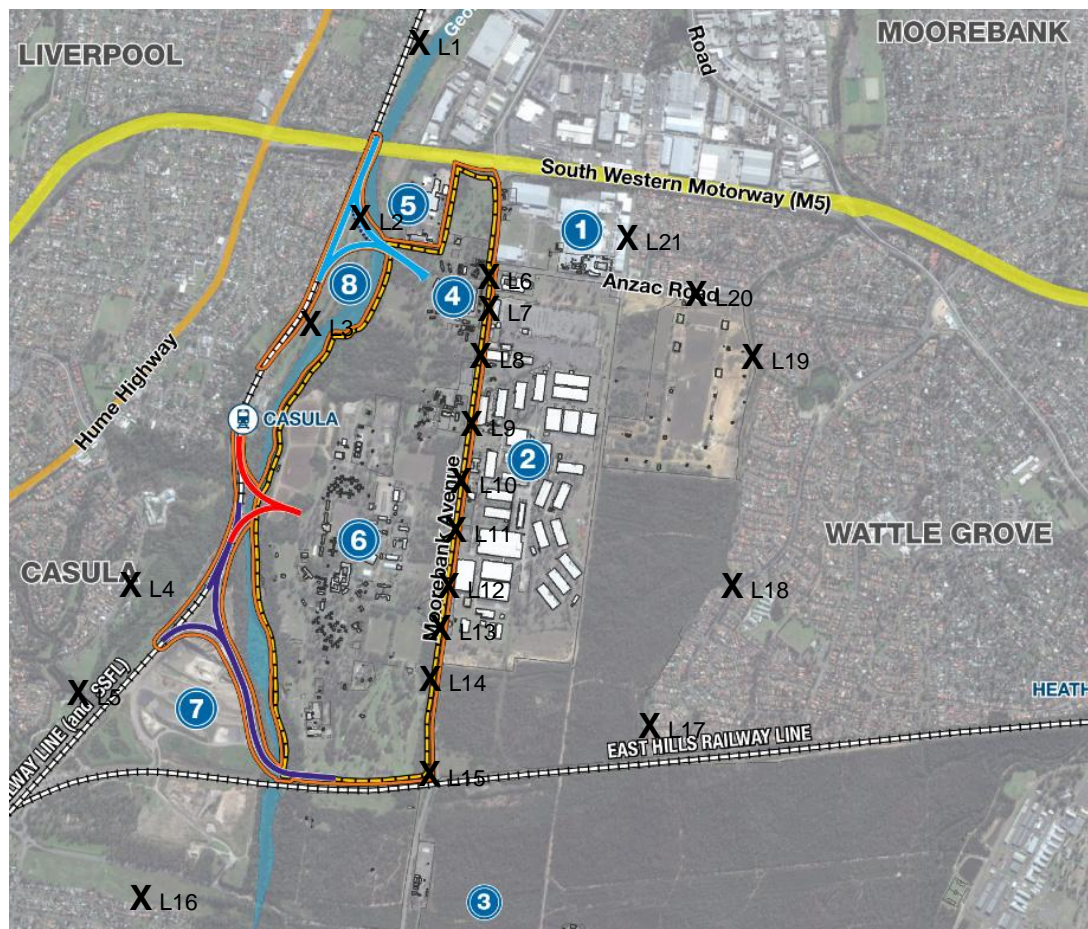


Figure 2 Location of lighting observation and measurement points (L1 etc) adjacent the Moorebank IMT site.

## 4.2 Night-time survey results

Existing night-time conditions were recorded by illuminance measurement at selected locations and the general view of existing conditions at those locations recorded by photograph. This required new moon conditions or moon phases and times when the moon had either already set or not yet risen. The measurements and photographs in Casula were recorded on 20 September 2012 which was a waxing crescent moon which provides very little light and also sets early; 16 October 2012 for Moorebank Avenue was a new moon providing no moonlight contribution; and 11 November 2012 for Wattle Grove was a waxing crescent moon which provides very little light and also rises late. The moon was not visible during the times of survey.

### 4.2.1 Existing lighting environment for residents in Liverpool facing the proposed IMT Moorebank development.

Residents located immediately west of the Main South Railway Line in Liverpool and north of the M5 South Western Motorway are at a similar level to the Moorebank IMT site.

Position	GPS co-ordinates	Comments	Ev (lux)	Eh (lux)
L1	S33° 56.062' E150° 55.253'		Ev=0.04	Eh= 0.03

**Table 3** Positions of lighting assessment and measured illuminance values for the Liverpool area as shown in Figure 2. Illuminance (E) has been measured in a vertical plane towards the Moorebank IMT (Ev) as noted in Table 3 and also on a horizontal plane (Eh) in situations where there is direct line-of-sight to the Moorebank IMT site.

Figure 3 is an image from location L1 in Liverpool in a direction towards the proposed Moorebank IMT. Figure 4 is a night-time image from the same location in Liverpool in a direction towards the proposed Moorebank Moorebank IMT to provide an overall impression of the existing lighting environment. The illuminance values recorded at location L1 is shown in Table 3

### 4.2.2 Existing lighting environment for residents in Casula.

Residents located immediately west of the Southern Sydney Freight Line mostly overlook the proposed IMT site as these residences are elevated above the general level of the IMT development, the height differential being 4 to 26 metres depending on location. The appearance of the proposed IMT site environment is relatively dark as technically defined in AS 4282 (refer section 2.2).

Figures 5 and 7 are daytime photographs of receiver locations. Figures 6, 7, 8, 10 and 11 are night-time images from those locations in Casula in directions toward the proposed Moorebank IMT to provide an overall impression of the existing lighting environment. The illuminance values recorded at the locations are shown in Table 4. Illuminance (E) has been measured in a vertical plane towards the Moorebank IMT (Ev) as noted in Table 4 and also on a horizontal plane (Eh) in situations where there is direct line-of-sight to the Moorebank IMT site.

Position	GPS co-ordinates	Comments	Ev (lux)	Eh (lux)
L2	S33° 56.580' E150° 54.996'	$v_C$ = centre towards IMT site, $v_L$ is left of direction towards site and $v_R$ is right of direction towards site from measurement location.	$E_{v_L}=0.05$ $E_{v_C}=0.03$ $E_{v_R}=0.02$	Eh= 0.03
L3	S33° 56.766' E150° 54.785'	A vertical measurement was taken towards mercury vapour street light ( $E_{v_{MV}}$ ) in Buckland Rd, Casula for comparison purposes.	$E_{v_L}=0.02$ $E_{v_R}=0.03$ $E_{v_{MV}}=0.08$	Eh= 0.02
L4	S33° 57.383' E150° 54.397'		$E_v=0.02$	Eh= 0.04
L5	S33° 57.749' E150° 54.144'		$E_v=0.03$	Eh= 0.02

**Table 4** Positions of lighting assessment and measured illuminance values for the Casula area as shown in Figure 2.



**Figure 3** Location L1 view towards Moorebank IMT site which will be the other side of the M5 Motorway



**Figure 4** Location L1 night-time view towards Moorebank IMT site. The M5 Motorway is located in the forefront of the photo and the IMT Project would be located on the other side of the M5. Orange glow is from high pressure sodium lighting associated with Moorebank Business Park and ABB Australia on the opposite side of the M5. The white glow is a combination of more distant glow from lighting associated with the Campbelltown area and also the Powerhouse Arts Centre (PAC) and the construction yard security lighting adjacent the PAC.



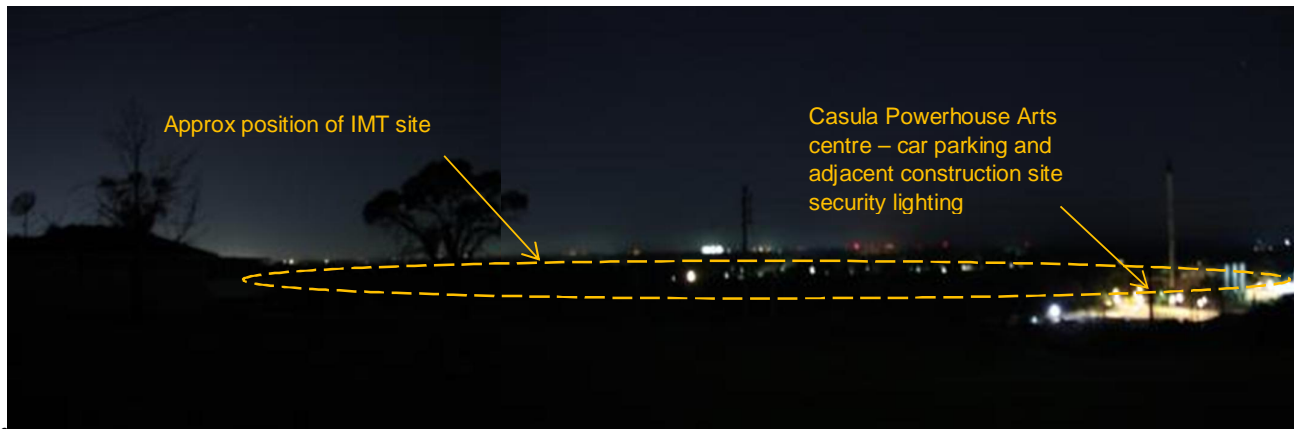
**Figure 5** Location L2 (receivers) Residences in Casula overlooking the proposed Moorebank IMT site approximately in the area of the potential rail link



**Figure 6** Location L2 Night-time view 20<sup>th</sup> September 2012 towards IMT Project site – view taken from receiver point (fence line of rail corridor Figure 5)



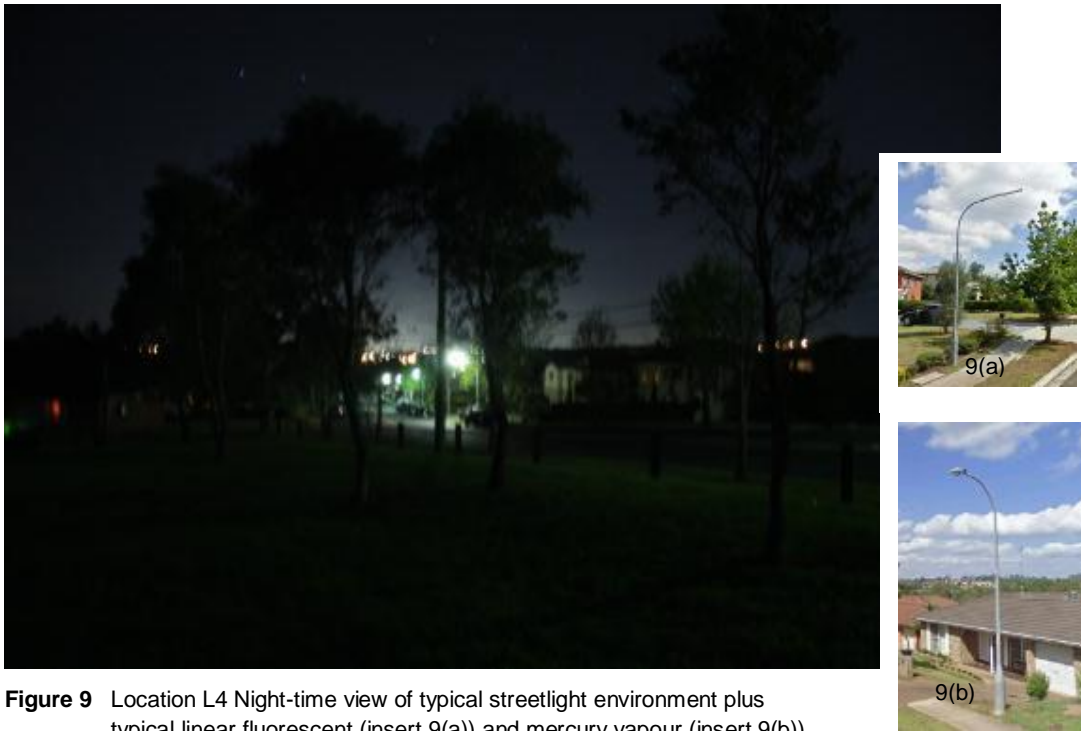
**Figure 7** Location L3 residences in Casula (receivers) on high ground overlooking the proposed Moorebank IMT site



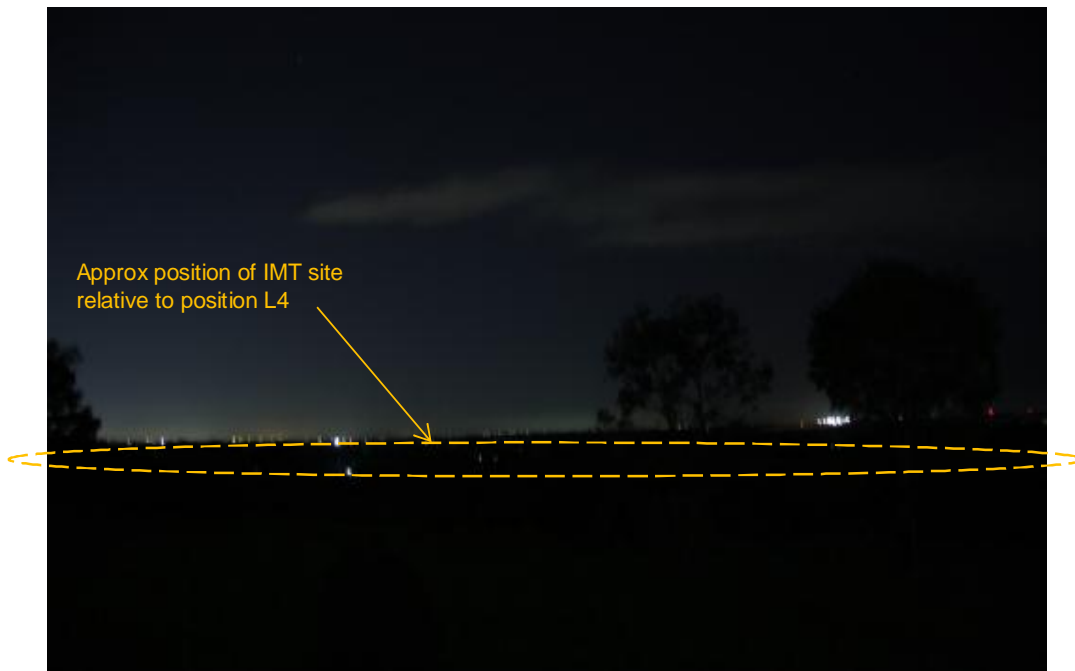
**Figure 8** Location L3 Night-time view from high ground receiver point overlooking the proposed Moorebank IMT site

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**Figure 9** Location L4 Night-time view of typical streetlight environment plus typical linear fluorescent (insert 9(a)) and mercury vapour (insert 9(b)) street lighting that produces that night-time effect.



**Figure 10** Location L4 (receiver point) night-time view from park across Moorebank IMT site.



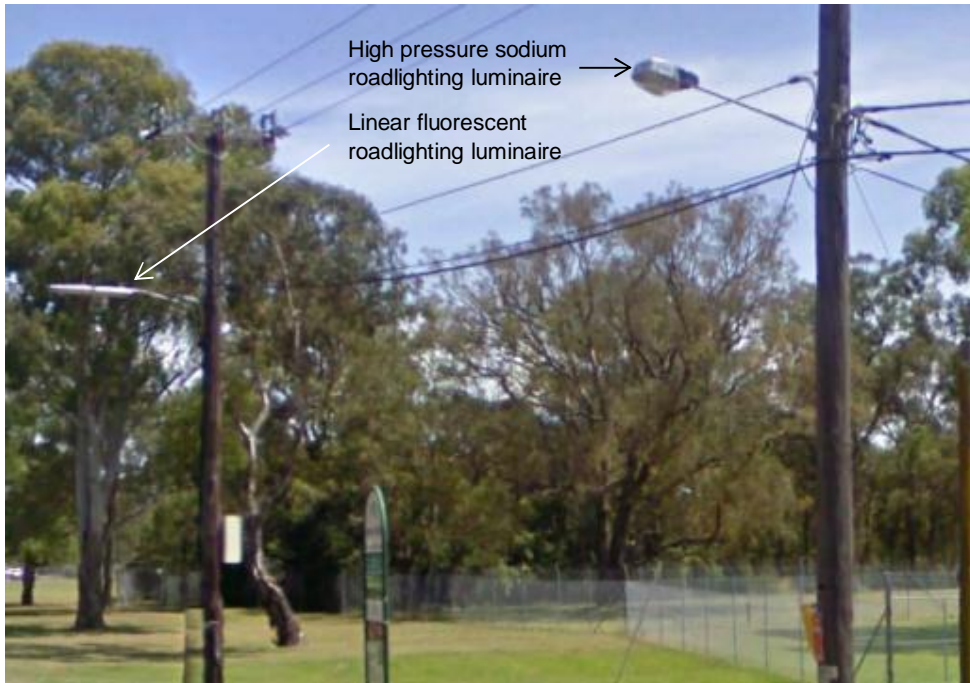
**Figure 11** Location L5 Night-time view of sky from park (receiver point) towards Moorebank IMT site

#### 4.2.3 Existing lighting environment along Moorebank Avenue.

Moorebank Avenue is currently flanked on both sides by military areas. The military areas vary from very dark lighting environments to quite bright lighting environments with multiple buildings and vehicle parking areas etc. Moorebank Avenue can experience quite high traffic and is lit by a combination of high pressure sodium light and fluorescent light in road lighting luminaires (refer Figure 12) and some road side car park areas are lit with metal halide light from floodlights.

Position	Comments	$E_v$ (lux)
L6	Street light contributing	$E_v = 0.18$
L7	2 x 18W fluorescent on saw-tooth roof	$E_v = 0.15$
L8	No measurement taken (Photo only)	
L9	Street light contributing twin lamp linear fluorescent	$E_v = 0.22$
L10	Floodlit visitor car park and twin lamp linear fluorescent	$E_v = 0.78$
L11	Low level lighting on buildings in the distance	$E_v = 0.06$
L12	Low level lighting on buildings off to left	$E_v = 0.12$
L13	At corner of fence approx. 50m from closest Moorebank Ave road lighting luminaire.	$E_v = 0.08$
L14	View towards RAE golf course and trees	$E_v = 0.04$
L15	Over rail line – no light except signal lamps	$E_v = 0.01$

**Table 5** Position of lighting assessments and measurements at receiver points for Moorebank Avenue, Moorebank. Illuminance ( $E$ ) has been measured in a vertical plane at receiver points and facing towards the Moorebank IMT ( $E_v$ ).



**Figure 12** Typical existing road lighting luminaires on Moorebank Avenue – semi cut-off high pressure sodium luminaires and a twin lamp linear fluorescent luminaire mounted on short outreach arms fixed to timber poles beneath overhead power.



**Figure 13** Location L6 night-time view in west direction towards IMT site.



**Figure 14** Location L7 night-time view in west direction towards IMT site



**Figure 15** Location L8 night-time view in west direction towards IMT site



**Figure 16** Location L10 night-time view in west direction towards IMT site



**Figure 17** Location L15 night-time view in west direction towards IMT site (gold dashed line).



**4.2.4 Existing lighting environment for residents in Glenfield.**

Illuminance (E) has been measured in a vertical plane towards the Moorebank IMT (E<sub>v</sub>) as noted in Table 6 and also on a horizontal plane (E<sub>h</sub>) in situations where there is direct line-of-sight to the Moorebank IMT site.

Position	GPS co-ordinates	Comments	E <sub>v</sub> (lux)	E <sub>h</sub> (lux)
L16	S 33° 58.205' E150° 54.522'	Mercury vapour streetlights adjacent (B22 type)	E <sub>v</sub> =0.02	E <sub>h</sub> = 0.06

**Table 6** Position of lighting assessments and measurements for Goodenough Street, Glenfield.



**Figure 18** View towards Moorebank IMT site (gold dashed line) from receiver point located in the cul-de-sac at end of Goodenough Street (L16), Glenfield.



**Figure 18A** – Goodenough Street cul-de-sac, glass bowl B22 Sylvania luminaire with mercury vapour light source

#### 4.2.5 Existing lighting environment for residents in Wattle Grove.

Illuminance (E) has been measured in a vertical plane towards the Moorebank IMT (Ev) as noted in Table 7 and also on a horizontal plane (Eh) in situations where there is direct line-of-sight to the Moorebank IMT site.

Position	GPS co-ordinates	Description	Ev (lux)	Eh (lux)
L17	S 33° 57.661' E150° 55.939'	Mercury vapour streetlights adjacent (B22 type)	Ev=0.01	Eh= 0.08
L18	S 33° 57.418' E150° 56.162'	Mercury vapour streetlights adjacent	Ev=0.05	Eh= 0.17
L19	S 33° 56.891' E150° 56.255'	Behind houses on concrete path	Ev=0.07	Eh= 0.07
L20	S 33° 56.711' E150° 56.040'	High pressure sodium street lighting and metal halide floodlights	Ev=0.31	Eh= 0.33
L21		Road access does not exist (gated) – no access		

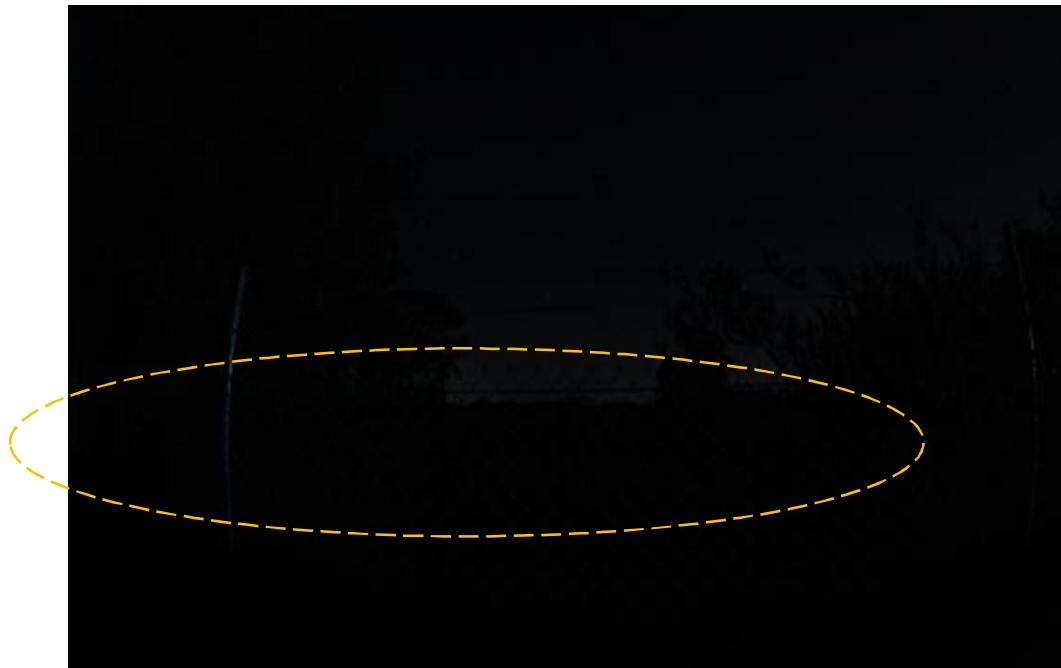
**Table 7** Position of lighting assessments and measurements for Wattle Grove.



**Figure 19** View towards Moorebank IMT site (gold dashed line) from receiver point in cul-de-sac at end of Corryton Circuit (L17), Wattle Grove.



**Figure 20** View towards Moorebank IMT site (gold dashed line) from receiver point in park off Larra Circuit and Wattle Grove Drive (L18), Wattle Grove. Insert shows Sylvania B22 mercury vapour luminaire Larra Circuit – typical in the area.



**Figure 21** View towards Moorebank IMT site (gold dashed line) from path off Lomond Circuit (L19), Wattle Grove.



**Figure 22** View towards Moorebank IMT site (gold dashed line) from receiver point on the road side off Anzac Road (L20), Wattle Grove.



**Figure 22A** Typical lighting along Anzac Road. High pressure sodium semi cut-off roadlighting luminaire on an outreach arm plus area floodlight mounted to the rear of pole and directed across the field.

## 5.0 Impact Assessment

### 5.1 Calculation of Light Spill from Proposed Moorebank IMT Lighting Design

#### 5.1.1 General Area: Light spill in a vertical plane towards the Moorebank IMT lighting

The following sections provide an impact assessment of the full build (phaseD) on the surrounding environment. This assessment is based on the concept plan for the three proposed rail alignments. The impacts and proposed mitigation measures would be confirmed at subsequent detailed design stages and through subsequent planning and assessment process.

##### 5.1.1.1 Some assumptions behind calculated values

Each value calculated and shown in Figure 24 is a vertical illuminance value that is as if an illuminance meter is aimed directly towards the centre of the Moorebank IMT. This technique is more accurate over large distances and is better the more the distance from the assumed central point. Assumptions included in the values shown include:

- Generally no maintenance factor – that is the values shown are the highest values likely as the lamps are new.
- A maintenance factor of 1.5 for luminaires in the vicinity of warehouse areas. This is an assumed value that takes into consideration any additional lighting above that provided in the Lighting Design (Refer Appendix A for details)
- There is no allowance for the 3D landform profile or unknown blocking effects of vegetation or other objects, therefore the values are the maximum likely.
- 240v and/or 415v nominal electrical supply to the luminaires is the basis of standard light output of all luminaires. Over voltage may increase the lighting values 10 to 15 percent and under voltage reduce the values 10 to 20 percent if no power control device such as 'active reactor' is used.
- To produce a single diagram that summarises vertical illuminance at all grid locations throughout the area shown requires some simplification. A single central point is chosen at the point towards which each calculation value is aimed. To maximise the likely value a point equivalent to the height of the highest luminaires is used, that is 30 metres height.

##### 5.1.1.2 General area calculation results

Figure 23 shows calculated values for vertical illuminance with values at specific grid locations on a 200 metre by 200 metre grid and isolux lines that interpolate between those calculated values to show the overall distribution pattern. A value calculated to two decimal places could be -0.006 to 0.004 of the value shown (e.g. 0.02 lux could be 0.015 to 0.024 lux and still show as 0.02 lux). The vertical illuminance from a full moon is likely to be in the range 0.25 to 0.35 lux depending on time of the year and position of the moon relative to Earth and the Sun (reference 1).

The outer blue isolux curve represents 0.01 lux, the green isolux curve is 0.1 lux, the orange isolux curve 0.5 lux and the red isolux curve 1 lux.

##### 5.1.2 Casula: Light spill in a vertical plane towards the Moorebank IMT lighting

Calculation of vertical illuminance at specific grid locations and accounting for up to 26 metre height differential with the Moorebank IMT high mast lighting resulted in no significant change to that shown in Figure 23. The large distances involved, combined with the height of many of the Casula residences facing the Moorebank IMT being only a few metres below the actual height of the high mast luminaires means that the calculated values shown in Figure 24 are marginally overstated as there may be an angle change up to 5 degrees.

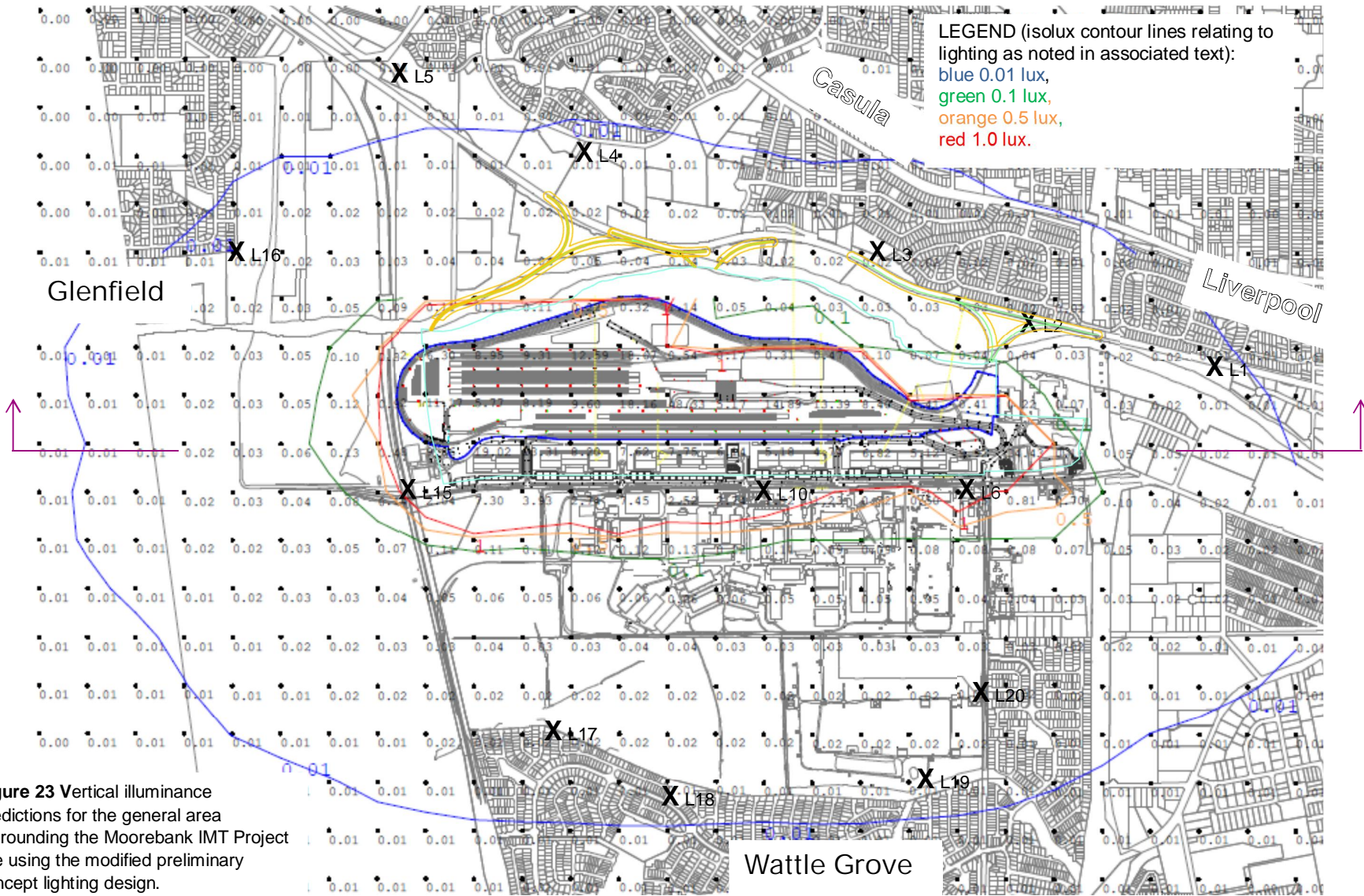
The values vary from 0.01 to 0.02 lux where residences are above and adjacent the main southern rail line L2 to L5 (also refer Section 4.2.2 for existing conditions).

##### 5.1.3 Moorebank Avenue: Light spill in a vertical plane towards the Moorebank IMT lighting

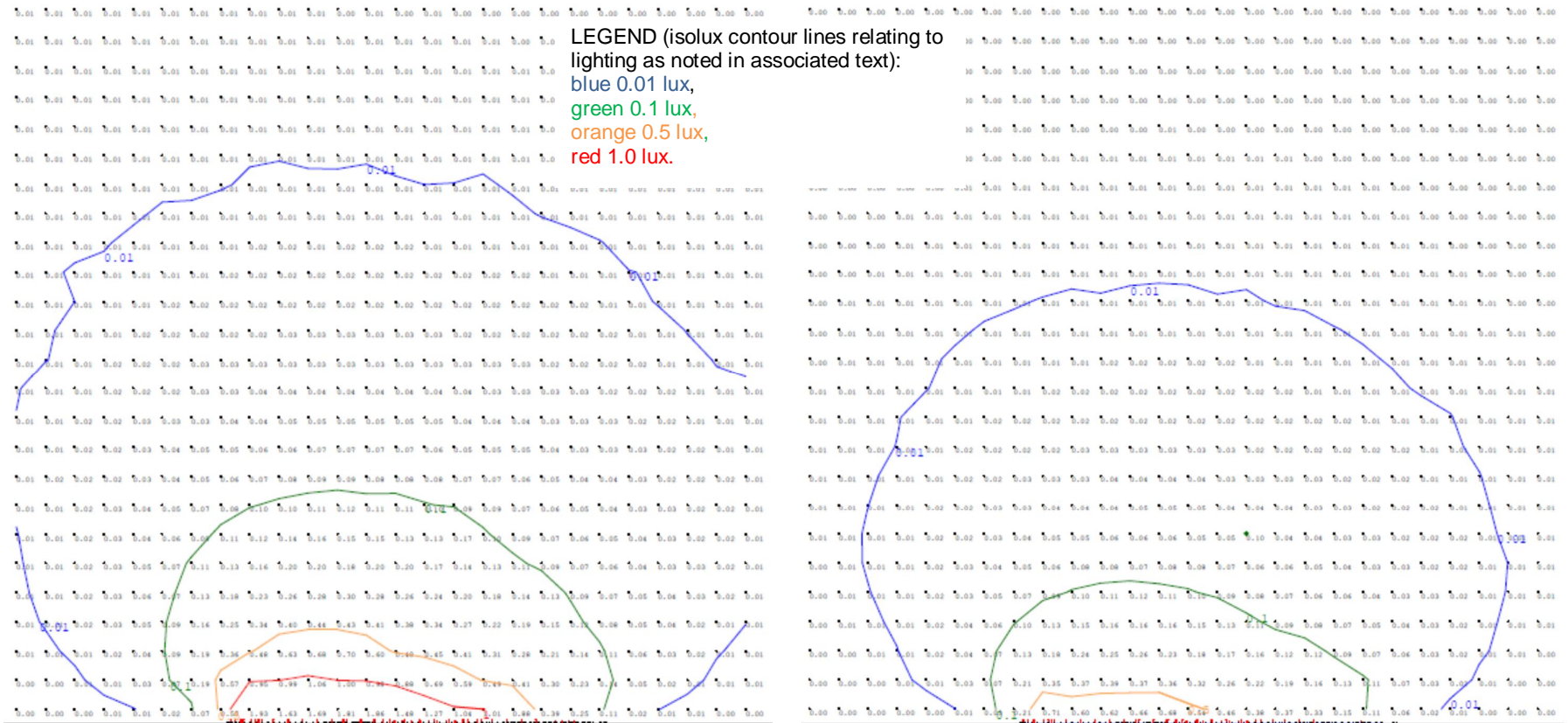
Light spill from roadlighting is exempt from consideration under AS 4282 as noted in section 2.2, however, notwithstanding that exemption, additional calculations in the vertical plane at sample sections along Moorebank Avenue in alignment with the chain wire fence of the military area indicate maximum values ranging from 5.1 to 10.7 lux. Currently the military has no residential buildings adjacent Moorebank Avenue and the future of that

military area may be another intermodal terminal which means under AS 4282 the area is classified commercial which has an allowable limit of 25 lux. As the chosen roadlighting luminaires are full cut-off type (similar to those used adjacent airports) there is absolutely no direct effect further afield in any of the residential areas.





**Figure 23** Vertical illuminance predictions for the general area surrounding the Moorebank IMT Project site using the modified preliminary concept lighting design.

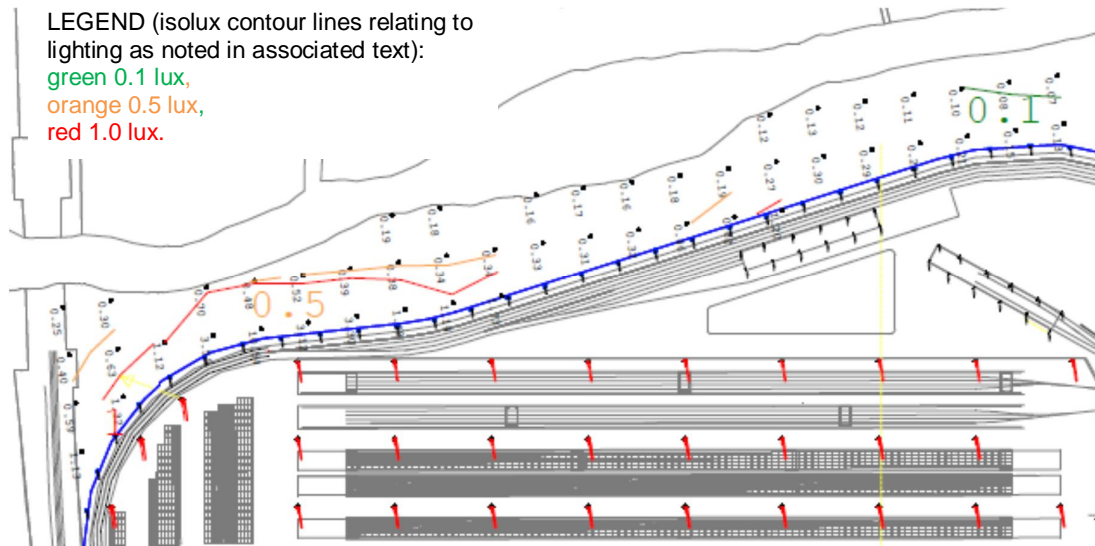


**Figure 24** A vertical section through Moorebank IMT project site to a height of 5km indicating the distribution of light reflected from a 30% reflecting pavement and a 10% reflecting pavement. Whether or not that translates into sky glow will depend on a number of factors including the moisture and particulate content of the atmosphere at the time and observer position.



### 5.1.3.1 Riparian Forest Area: Light spill in a vertical plane towards the Moorebank IMT lighting

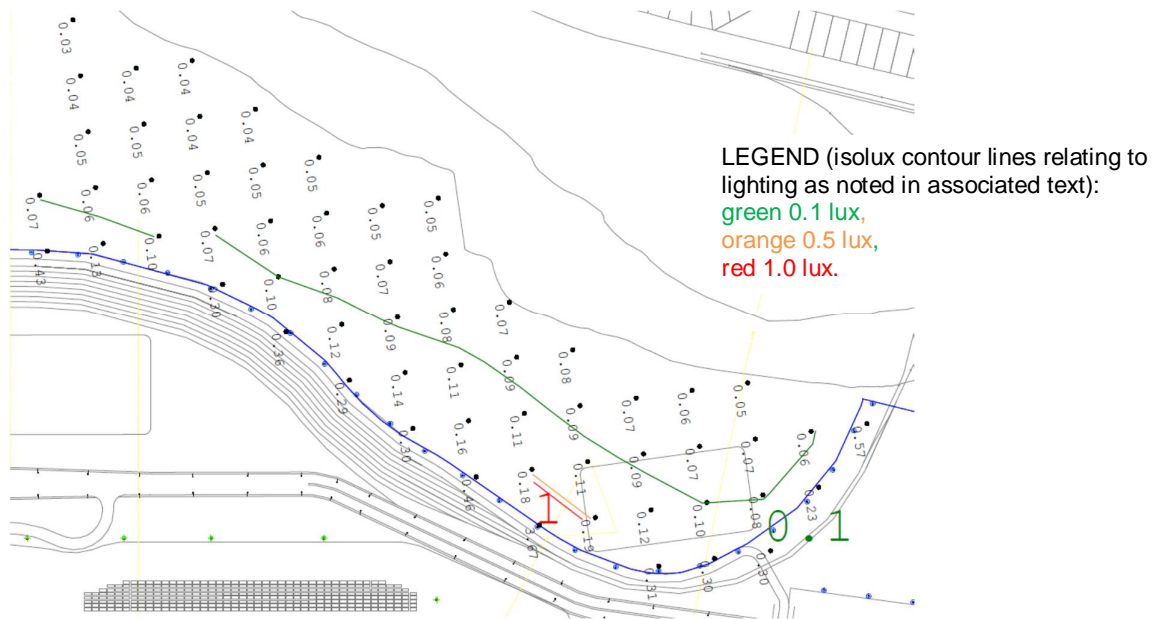
This calculation is a more detailed calculation in the riparian forest area and for an average height of 10m above the general pavement. Where the pavement area is lit with high mast lighting and is adjacent the riparian forest area the vertical illuminance values are highest. The values in Figure 25 below vary from 0.07 lux to 10 lux.



**Figure 25** Potential light spill calculated for the riparian forest area based on 30% reflectance average for the site pavement area

### 5.1.3.2 Woodland: Light spill in a vertical plane towards the Moorebank IMT lighting

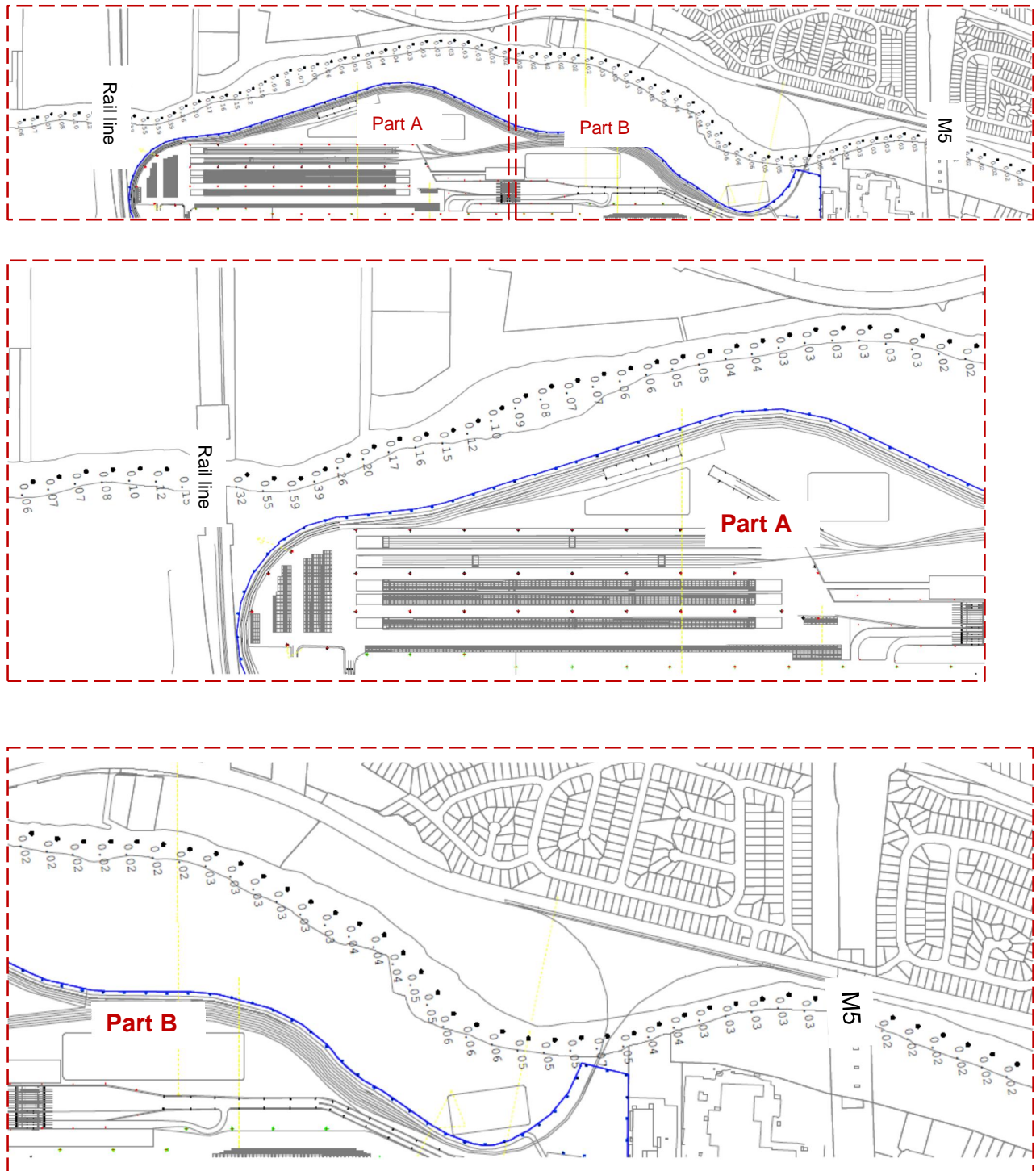
This calculation is a more detailed calculation in the woodland area and for an average height of 10m above the general pavement. Where the pavement area is lit with high mast lighting and is adjacent the riparian forest area the vertical illuminance values are highest. The values in Figure 26 below vary from 0.03 lux to 3.67 lux.



**Figure 26** Potential light spill calculated for woodland area based on 30% reflectance average for the site pavement area.

**5.1.3.3 Georges River: Light spill in a vertical plane towards the Moorebank IMT lighting**

The assumption for these calculations is that there is no shielding by the riparian forest trees or woodland trees. The values vary from 0.02 lux on the other side of the M5 Motorway in Liverpool to 0.59 lux adjacent the current



**Figure 27** Potential light spill calculated for Georges River based on 30% reflectance average for the site pavement area.

rail bridge over the Georges River where the Moorebank IMT site is closest to the Georges River.

#### 5.1.4 Wattle Grove: Light spill in a vertical plane towards the Moorebank IMT lighting

The calculated values in Figure 23 show that vertical illuminance is predicted to be 0.01 to 0.03 lux. Locations such as L17 to L19 will be shielded by trees as indicated in Section 4.2.1, Figures 19 to 21 inclusive.

#### 5.1.5 Sky Glow

Sky glow is a function of the particulates and/or moisture in the air, the amount of light striking those airborne particles and the location from where the effect is being viewed. The closer an observer to the Moorebank IMT site, the more dense the fog or dust content or pollution that is required for the proposed installation to have a perceived sky glow. Strong direct upward light would be noticeable close to the site compared to less intense indirect reflected light. Generally sky glow is more visible from a distance.

There is no known acceptable method of calculating sky glow with any accuracy. An indication of illuminance at different theoretical grid points in a vertical section through the Moorebank IMT site is used to indicate upward contributions from the proposed lighting design. This calculation result is shown in Figure 24.

Controlling the direct lighting component contributing to sky glow effect is achieved by the appropriate selection of floodlights and roadlighting luminaires. This project lighting design incorporates an appropriate luminaire selection whereby the front glass of the luminaires is horizontal and thereby directing all light directly downward below the horizontal. Floodlights would have asymmetric light distribution and roadlighting luminaires would be aero screen type. Any security surveillance lighting would need to adopt the same style of luminaires with appropriate wattage.

Calculating the potential reflected indirect effect requires many assumptions including the reflectivity of the Moorebank IMT site and that the site is completely empty which excludes the shielding effect of container stacks, trains and other vehicles. Assuming an overall average ground reflectance of pavement of 30 percent, the resulting effect on a vertical section calculation is shown in Figure 24 and a comparison for a pavement reflectance of 10 percent is also shown.

#### 5.1.6 Train Headlights

Trains leaving the Moorebank IMT site from any of the proposed northern, central and southern access options will directly face various residences respectively.

The southern access option appears to provide minimum potential impact which is due to the greater distance between the train and the likely affected residences. In addition the light is directed predominantly across existing bushland which will have a further screening affect to varying degrees depending on the density of foliage. The illuminance from train headlights operating under high beam at the residential boundary without any screening by foliage will vary from 0.35 lux to 0.98 lux. This assumes a clear night with no sky-glow.

Trains leaving the Moorebank IMT via the proposed central access option will directly face some residents in Casula and the use of headlights on high beam will be an issue, more so if the trains are heading north than if they are heading south. Potential illuminance at the residential boundary may be 4.1 lux and 0.47 lux respectively. This assumes a clear night with no sky-glow.

Trains leaving the Moorebank IMT via the proposed northern access option will directly face some residents in Casula and the use of headlights on high beam will be an issue. Potential illuminance may be 8.8 lux at the residential boundary at a distance of 150m from a train using high beam lighting.

## 6.0 Net Effects

The net effect is directly linearly additive numerically; however, seeing as a sense responds more logarithmically, that is, doubling or close to doubling the number does not double the perceived effect, however, tripling a number means there would be a just perceptible difference if both conditions (before/after) could be simultaneously viewed side by side. For instance; the measured illuminance at L17 was 0.01 lux in the vertical towards the Moorebank IMT site. The calculated vertical illuminance from the Moorebank IMT site is 0.02 lux providing a linearly additive net value of 0.03 lux but that will not be a doubling or tripling of perceived brightness but rather a just perceived change in brightness if both conditions could be viewed simultaneously side by side.

However, if the relative humidity is high or there is considerable dust or pollution there may well be a perceived increase in sky brightness or sky glow from Location L17.

The net values would be as indicated in Table 8 below. Except for locations such as Moorebank Avenue (L6, L10, and L15) the net increase is small. As indicated in Section 2.2, roadlighting is exempt from inclusion in obtrusive light assessment and the increased roadlighting along Moorebank Avenue is not included in this assessment.

Location	Existing vertical Illuminance Ev (lux)	Calculated Moorebank IMT Illuminance Ev (lux)	Net Illuminance Ev (lux)
L1	0.04	0.01	0.05
L2	0.05	0.02	0.07
L3	0.03	0.02	0.05
L4	0.02	0.01	0.03
L5	0.03	0.01	0.04
L6	0.18	0.50	0.68
L10	0.78	1.92	2.70
L15	0.01	2.04	2.05
L16	0.02	0.01	0.03
L17	0.01	0.02	0.03
L18	0.05	0.01	0.06
L19	0.07	0.01	0.08
L20	0.31	0.02	0.33

**Table 8** Net illuminance values at specific locations (not including any sky-glow component).

## 7.0 Discussion

### 7.1 Light spill containment

The preliminary concept design utilises luminaires which do not have any direct upward light component and have asymmetric type light distribution which means the light is directed specifically to the task with minimal direct light spill to the surrounding area. It also means that any direct views of bright floodlights will be minimised. Together this minimises the disturbance to the surrounding environment as there will be a strong cut-off similar to that shown in Figure 28. The installation in Figure 28 is a major sports lighting installation with well over 10 times the average illuminance proposed for the Moorebank IMT, yet, with asymmetric type distribution luminaires and luminaires aimed such that front glasses are horizontal the excellent cut-off of light spill can be seen. The same effect would occur on the Moorebank IMT and the light source is not white but more golden colour as shown in the roadlighting of Figure 28.



**Figure 28** Belconnen soccer facilities, Canberra



## 7.2 Light spill calculated values

To place this in perspective by using a natural benchmark, that is moonlight, the calculated values for light spill from the Moorebank IMT at various locations (Lx) are an order of magnitude below that expected from a full moon, that is less than 0.03 lux or equivalent to the light from the moon only days after or before new moon (reference 1).

## 7.3 Anticipated appearance of the Moorebank IMT site

Figure 8 provides an indication of the appearance of the completed Moorebank IMT (Phase D). Figure 8 shows the Casula Powerhouse Arts Centre (converted power station) complex against the general background of the area for that observer location. Towards that location the whole of the Moorebank IMT site (approximated by the dashed orange line) would appear to have a similar brightness on a clear night. In foggy conditions the brightness may be less but there would be local sky glow.

## 7.4 The effect of electric light on fauna

Changing a relatively dark environment to a brighter environment would change the existing natural situation surrounding the Moorebank IMT site. Electric light throughout the night would have an influence on behaviours such as foraging, predation, and mating, depending on the species. More evidence is emerging of the influence of light on fauna (reference 2) although sometimes factual information such as lighting thresholds that would trigger behavioural change is difficult to find.

This aspect would be further considered in detailed design.

## 8.0 Mitigation and Compensation Measures

### 8.1 On-going Monitoring

Design is a process from original concepts and options to the selection of the preferred option and detailed design of the preferred Moorebank IMT option. Light spill prediction is sensitive to the installation and aiming of each luminaire which means light spill prediction will depend on the final detail design. Ensuring that the final predictions are achieved will be a process of monitoring the tendering and purchasing phase so that the specified luminaires and mounting arrangements are provided. Further, during commissioning the luminaires should be aimed as per the approved lighting design. The final process would be to use the locations (Figure 2) for illuminance measurements and photographs for comparison and compliance and adjustment purposes if necessary.

### 8.2 Individual Luminaires

Where there arises an issue with the 'brightness' of a specific luminaire towards a particular observer location and the luminaire is already of the appropriate asymmetric distribution and the front glass is horizontal, the only other option is to fit a bespoke shield to that luminaire.

### 8.3 General Reduction in Sky Glow

The most effective mitigation measure is to select asymmetric light distribution type floodlights and ensure they are mounted such that the front glass is horizontal. This is an integral part of the proposed lighting design.

The only other reduction possible is to consider reducing the reflectance characteristics of the pavement surface such as the top surface being bitumen colour compared to a light cured concrete colour. The choice, however, may affect the perceived brightness and contrast of detail providing safe working visual conditions whereby a more reflective pavement surface may provide superior visual conditions compared to a perceived darker pavement surface with reduced reflection.

## 8.4 Avoiding Over Design

The potential sensitivity of the general environment would commend that the lighting design meet required Standards and safe work practice without excessively exceeding the minimum requirements of that criteria. An area that could be reviewed may be the proposed lighting of Moorebank Avenue as the current road lighting design parameters exceed those normally associated with the major roads classified as V1 in Australian Standard AS/NZS 1158 and therefore may be reduced if required.

## 8.5 Reduction in Lighting (dimmed) in Areas Where There is No Activity for Prolonged Periods

Not all parts of the Moorebank IMT site may be active at the same time. Reducing the quantity of light and therefore energy consumption in those areas is technically possible without switching out any areas - hence retaining aspects of safe operation. Light reduction to 70 percent of full operation (which would equate to 80 percent of full operation energy consumption) is possible with high pressure sodium lamp and control gear technology with step dimming and also 'active reactor' electronics.

## 8.6 Train Headlights

Trains leaving the Moorebank IMT site from any of the proposed northern, central and southern access options will directly face various residences respectively.

Trains leaving the Moorebank IMT via the proposed access options will directly face some residents in Casula and most notably the northern access option and the use of headlights on high beam will be an issue. Modifying that practice of headlights on high beam in this zone until trains are running on the SSFL is recommended.

## 9.0 Conclusions

The Moorebank IMT reference lighting design utilises luminaires that effectively prevent any direct light spill into the night sky. The light source proposed, high pressure sodium, is the most energy efficient for the application and the warmer colour of light contributes less to the overall brightness of the area.

The site (phases A, B and C) is large and the existing environment from most viewpoints is relatively dark. The preliminary concept lighting design would contain any direct light spill quite effectively with respect to adjacent residential areas as noted in this report. Also it would be possible to provide additional shielding to any specific luminaire should there be an issue.

There will be reflection of light from the general pavement areas and this will contribute to sky glow effects. There is no known industry accepted algorithms to calculate sky glow and sky glow is dependent on particulates and moisture in the atmosphere. Calculation shows that the amount of light reflected into the night sky from the pavement can be influenced by the reflectance characteristics of the pavement surface itself.

Calculation also shows that there will be direct light affecting the conservation area adjacent to the Moorebank IMT site as well as the Georges River. Literature indicates that electric light may affect fauna, although the actual effect on the fauna listed in the EIS is uncertain at this time.

The calculated values for light spill from the Moorebank IMT at various locations are an order of magnitude below that from a full moon, that is, less than 0.03 lux, or equivalent to the light from the moon only on days after or on days before new moon.

For some residential locations that overlook the Moorebank IMT site there will be a noticeable change in brightness of that area on a clear night. In foggy conditions the brightness may be less but there would be a local sky glow effect.

Transitory lighting effects such as train headlights would affect some residential locations in Casula with the proposed Northern access option and trains travelling in a north direction from the central access option when exiting the Moorebank IMT and consideration should be given to reducing the effect of train headlights similar to that for residential areas close to Port Botany. There would be a minimal affect for residents from train headlights when exiting the Moorebank IMT via the Southern access option and when heading in a southerly direction from the central access option where the minimum distance to residential boundaries from the approach is greatest.

## 10.0 References

1. Shotbolt, T, and Cowling, I, Moonlight as a Reference for Environmental Assessment (technical paper as part of PhD research soon to be released for publication)
2. Rich, C. and T. Longcore, Eds. (2006). Ecological Consequences of Artificial Night Lighting. Washington DC, Island Press.

## Appendix A – Preliminary Concept Lighting Design

### Moorebank IMT – preliminary concept lighting design

#### Background

The proposed preliminary concept lighting design has been provided by Parsons Brinkerhoff for purposes of light spill assessment. This was provided for assessment within Revision C of this report. For purposes of light spill assessment in current Revision E (this report), an increased maintenance factor of 1.5 has been applied to luminaires in the vicinity of the increased warehouse area of the site. This has been done within the previously supplied preliminary concept lighting design. The overall site boundary is unchanged between Revisions C and E of this report.

#### Lighting description

The Moorebank IMT facility will require functional lighting on a 24/7 basis. Energy efficient lighting will be required for all working, storage maintenance and roadway areas.

#### Lighting design reference standards

- CIE129 Lighting for Outdoor work spaces,
- IES of North America
- AS4282 Control of the obtrusive effects of outdoor lighting

#### Lighting design values adopted

Function	Illuminance	Uniformity
Container handling areas	30lux	0.5
Regular vehicle traffic, road and gate areas	20lux	0.4
Container storage	10lux	0.25
Rail yards –continuous operation	15lux	0.4
Maintenance areas	20lux	0.25
Security lighting for CCTV surveillance	see notes below	

#### Other

Moorebank Ave 30lux

(Illuminance levels are minimum average, uniformity levels minimum to average)

#### Rail storage and container yard lighting:

Container handling area lighting will be from 30m masts at 100m nominal spacing. 30m. high masts will carry two, three, four, five or six 1000w HPS luminaires as required to illuminate the designated spaces. Luminaires on 30m masts will be serviced by using masts of a type with raising and lowering rings, hinged base or of a fixed type requiring access by climbing or from an EPV. Luminaires will be full cut type off to limit site glare and spill light towards residences. All luminaires shall be set for zero upward waste light. All functional area light sources will be high pressure sodium selected for maximum efficacy, lumen maintenance and sustainability.

#### Roads, gate areas, vehicle parking, movement and rail maintenance areas:

Lighting required will be at mounting heights of 20m or lower height appropriate to the dimensions and lighting function.

#### Security lighting and perimeter fence lighting:

Security lighting will be co-ordinated with camera requirement for illuminance towards camera, colour temperature and glare control. Since cameras can be balanced down to 2000 kelvin colour temperature high pressure sodium lamps will be an acceptable light source for security lighting. Lighting provided for the perimeter road and CCTV surveillance lighting will be from 10.5m poles spaced at 40m. Since each camera has a range of 80m; a camera will generally be mounted on every second pole. An illuminance footprint has been provided for options of lamp power to assist the selection of camera and surveillance criteria.

Along the warehouse access roadway, shared poles will carry roadway lighting, perimeter fence lighting and CCTV cameras.

Moorebank Avenue:

Lighting is to be upgraded along Moorebank Rd Avenue to an objective 30 lux. To limit obtrusive light onto residences on the eastern side, pole height has been restricted to 15m. Lighting levels will therefore be reduced on the eastern carriageway with low overall uniformity.

Obtrusive and upward waste light control:

On the western boundary there is extensive residential development elevated above the Moorebank IMT. It is anticipated that the residents will have concerns over potential obtrusive light and glare into residences. Considering the amount of exterior lighting applied on site it is also anticipated there will be significant interest from amateur and professional astronomer's concerned over the elevation of sky glow levels. To meet these concerns the following measures have been employed:

1. All luminaires will be full cut off type with horizontal glass visors to stop light emission above the horizontal.
2. Maximum height of masts used in the installation is 30m.

While the final site levels are still undecided, properties nearest to the western boundary will be approximately 10 to 26m below the level of the highest masts. Preliminary calculations indicate that some floodlights aimed towards these properties may need supplementary shielding or aiming adjustment to meet AS4282 requirements.

Sustainability review considerations:

Exterior lighting

High pressure sodium (HPS) lamps are currently the most energy efficient light sources available. For the 30m high mast lighting applications, they are also optically efficient and the best suitable to long throw projection from luminaires. Utilising the maximum HPS lamp size of 1000w contains the quantity, weight and windage of luminaires on each mast, which in turn reduces the installation cost. HPS lamps are also employed at lower mounting heights applicable to road ways and vehicle parking spaces.

Other energy saving measures will be integrated into the control system for the exterior lighting e.g.

- Switching lighting down to a security level during periods of low night time activity.
- Use of an active reactor system to run the lamps at reduced power (80%) ramping up the power to nominal output as the lamp ages.

Interior lighting

Will be required for all buildings including administration, customs, services, substations, workshop and associated undercover car parks to the requirements of the Building Code of Australia, This reference design report indicates that energy saving measures (applicable for power and lighting) will be incorporated. The energy saving measures identified for this purpose are:

1. Efficient lighting (2 Watt/Sq. m. /100 lux in office spaces)
2. Lighting control using motion sensor and photo sensor
3. All individual spaces are individually switched
4. All multi-switch panels to be clearly labelled
5. Spaces with intermittent or variable occupancy separately zoned
6. Efficient after hour lighting control.

## Appendix B Proposed Rail Entry/Exit Options

Figures 29, 30 and 31 below indicate the proposed Northern, Central and Southern rail connections to the Moorebank IMT. The minimum distances to residential boundaries from the approaches upon exit from the site are indicated.

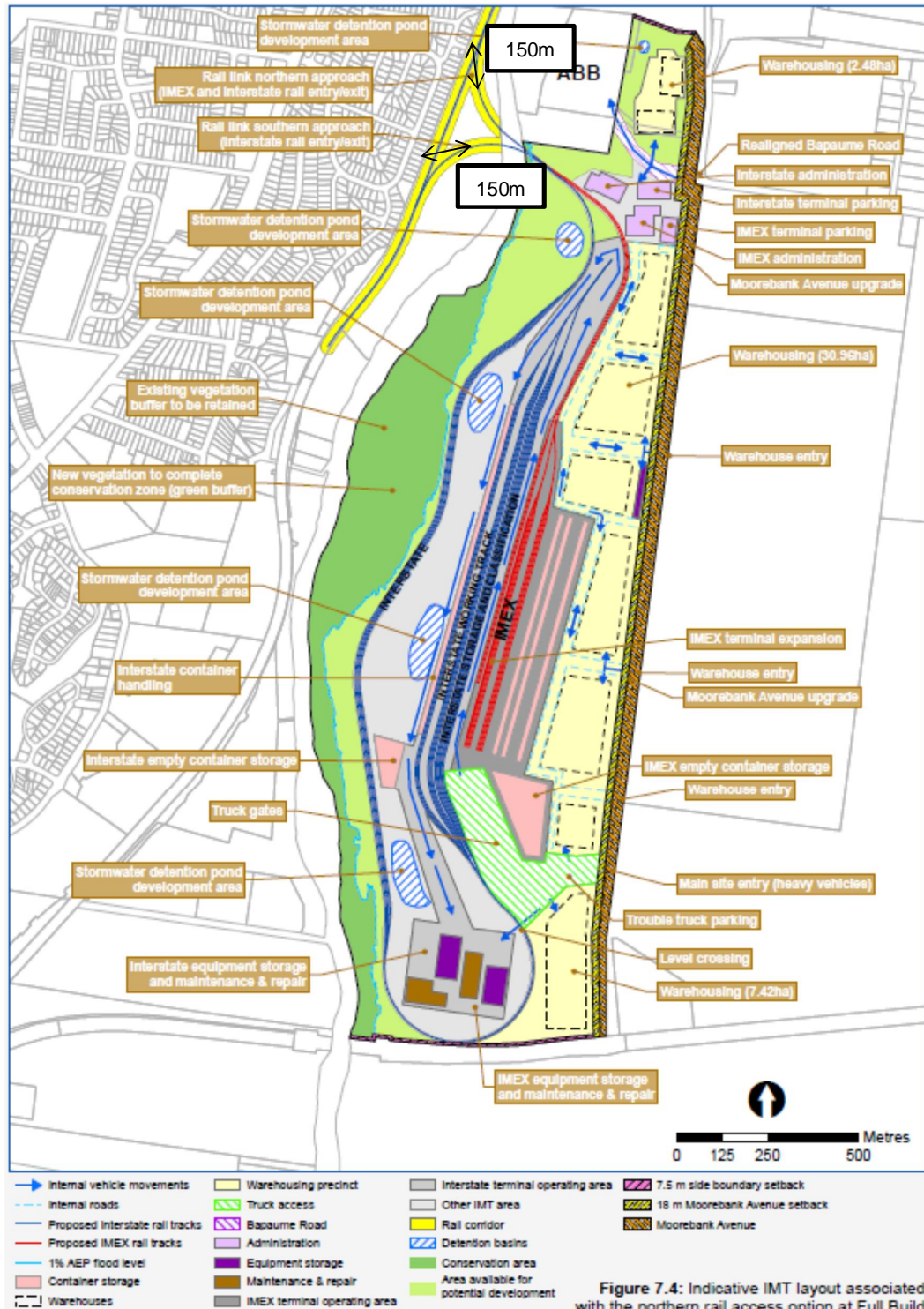




Figure 29 Northern rail connection

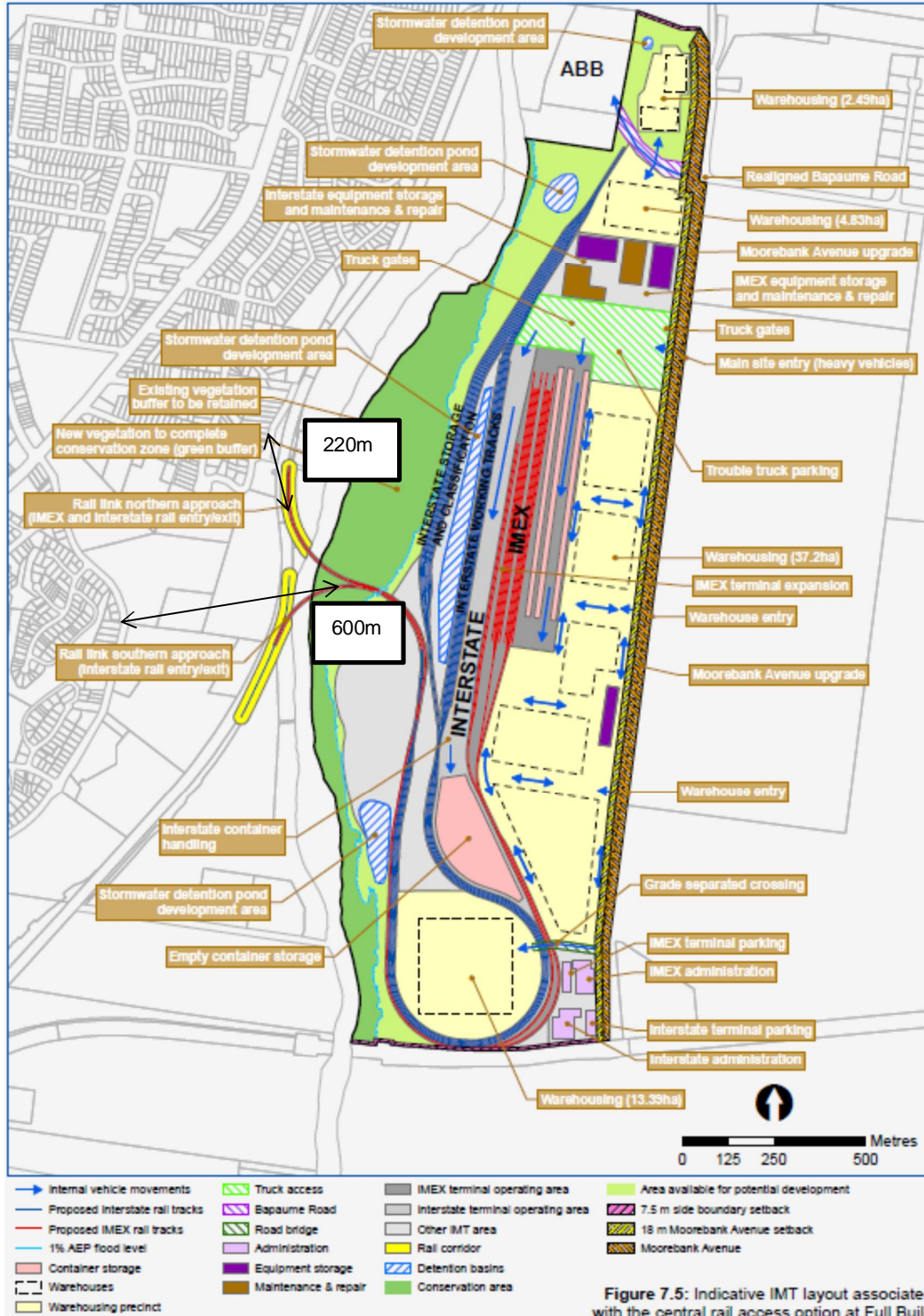


Figure 30 Central rail connection



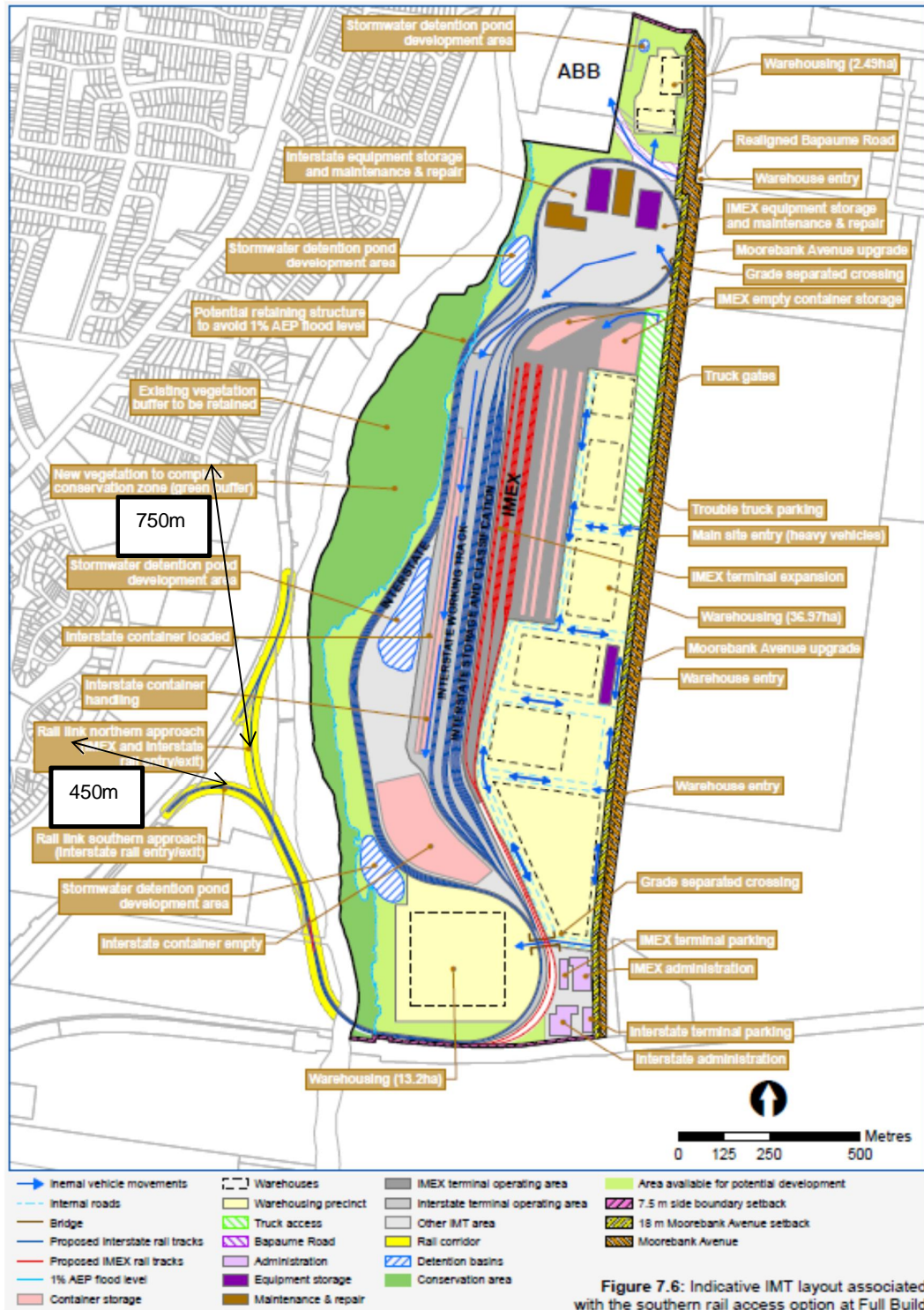


Figure 31 Southern rail connection