Sydney Metro

State Significant Development, Development Application (SSD DA)

Report:

N - External Reflectivity Assessment

Project:

Pitt Street South Over Station Development (PSS OSD)

For:

Pitt Street Developer South Pty Ltd.

By:

Inhabit Australasia Pty Ltd.

Doc. No: SMCSWSPS-INH-OSS-PL-REP-000001
Date: 2020-05-19
Revision: C
Reason for Issue: Issue for SSD DA

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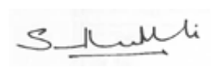
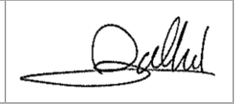
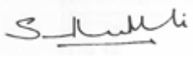
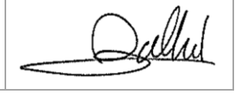
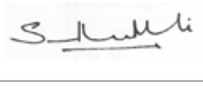
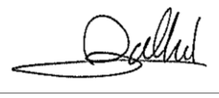
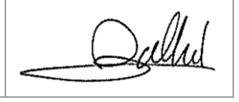
00	2020-01-17	**Description**	Preliminary Issue for Comments		
			Prepared by	**Checked by**	**Approved by**
		Name	Sindhu Murali	Samantha Anderson	Pierre-Alexis Galland
		Signature			

Revision	**Date**	**Filename**	10762-RPT-ES0001(01) External Reflectivity Assessment- Pitt Street South		
01	2020-02-10	**Description**	Amended Report based on Client Feedback Issued 2020-01-24		
			Prepared by	**Checked by**	**Approved by**
		Name	Sindhu Murali	Pierre-Alexis Galland	Pierre-Alexis Galland
		Signature			

Revision	**Date**	**Filename**	SMCSWSPS-INH-OSS-PL-REP-000001 External Reflectivity Assessment- Pitt Street South		
B	2020-04-06	**Description**	Issue for Landowner's Consent		
			Prepared by	**Checked by**	**Approved by**
		Name	Sindhu Murali	Pierre-Alexis Galland	Pierre-Alexis Galland
		Signature			

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C	2020-05-19	**Description**	Issue for SSD DA		
			Prepared by	**Checked by**	**Approved by**
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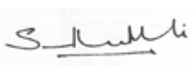
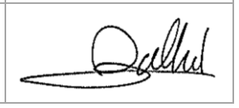
		Signature			

Executive Summary

An external reflectivity analysis has been undertaken on the proposed mixed-use development Pitt Street South Over Station Development at 125-129 Bathurst Street, Sydney, NSW. A study has been carried out to assess the potential impact of reflected glare on traffic and pedestrians travelling along the following key roads of concern:

- Pitt Street
- Bathurst Street
- Castlereagh Street

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 28 October 2019, specifically this report has been prepared to respond to the SEARs requirements summarised in Table 1.

Table 1: SEARs requirements

Item	Description of Requirement	Section Reference (this report)
SEARS 5	Provide a reflectivity analysis identifying potential adverse glare conditions affecting motorists, pedestrians and occupants of neighbouring buildings.	Refer to section 3.3 for critical observer orientations considered, section 4 for detailed results and Table 4 for summary of results.

This report has also been prepared in response to the following Condition of Consent for the State Significant Development Concept (SSD 8876) for the OSD summarised in Table 2.

Table 2: Concept approval of Conditions of Consent

Item	Description of Requirement	Section Reference (this report)
DC B23	Reflectivity analysis demonstrating that the external treatments, materials and finishes of the development do not cause adverse or excessive glare.	Refer to section 3.3 for critical observer orientations considered, section 4 for detailed results and Table 4 for summary of results.

The Holladay formula has been used to determine the risk of glare due to light reflections from the building. A veiling luminance (LVL) of 500 candelas per square metre (Cd/m^2) has been utilised as the limit. A maximum external specular reflectance of 20% (for all angles of incidence) has been considered for the assessment. The results indicate that all facades can achieve compliance with a maximum specular reflectance of 20% to the whole façade (100%) without causing adverse discomfort glare to the surrounding roads.

Table 3: Summary of results

Façade Orientation	Hours Above Practical Limit (20% external reflectance)	Maximum Acceptable Reflectivity Limit (for all angles of incidence)	% Façade Spectrally Reflective	Acceptability (SEARs 5 and DC B23)
ASP 6°– North Façade	0	20%	100%	✔
ASP 96°– East Façade	0	20%	100%	✔
ASP 186°– South Façade	0	20%	100%	✔
ASP 276°– West Façade	0	20%	100%	✔

1. Introduction

Inhabit has been engaged by Pitt Street Developer South Pty Ltd. to assess the proposed residential Over Station Development (OSD) above the new Sydney Metro Pitt Street South Station for risk of solar reflectance glare and the potential impact on drivers and pedestrians. This report has been prepared to accompany a detailed State Significant Development (SSD) development application (DA) for the proposed development. The detailed SSD DA is consistent with the Concept Approval (SSD 17_8876) granted for the maximum building envelope on the site, as proposed to be modified.

The Minister for Planning, or their delegate, is the consent authority for the SSD DA and this application is lodged with the NSW Department of Planning, Industry and Environment (NSW DPIE) for assessment.

The proposed development has a maximum building height of RL 171.6 and consists of a total of 39 storeys. The lower levels of the development consist of the entrance to the metro station (off Bathurst Street), amenities and back of house areas. Levels 07 – 36 comprise of residential units and Levels 37 and 38 comprise of the mechanical plantrooms.

Upper levels of all four principal elevations of the development consist of Glass Reinforced Concrete (GRC) cladding elements and the podium levels consist of precast and GRC cladding elements, both materials are non-reflective and offer some amount of shading to the adjacent glazed façade elements.

Figure 1: Architectural render of the development (courtesy: Bates Smart Architects)

2. Modelling Details

2.1 Basis of Simulation

The analysis has been based on the following preliminary SSDA drawings issued by Bates Smart Architects:

- Site Plan: SMCSWSPS-BAT-OSS-AT-DWG-910041 (Revision P3)
- GA Plans: SMCSWSPS-BAT-PSS-AT-DWG-930041 to SMCSWSPS-BAT-PSS-AT-DWG- 939542 (Revision P2)
- Elevations: SMCSWSPS-BAT-OSS-AT-DWG-960001 to SMCSWSPS-BAT-OSS-AT-DWG-960004 (Revision P3)

3. Site and Context

3.1 Local Traffic Conditions

The site is located within the Sydney CBD, on the corner of Bathurst Street and Pitt Street. The site has an approximate area of 1,710m^2 and is now known as Lot 10 in DP 1255507. The street address is 125 Bathurst Street, Sydney.

The site is bounded by Bathurst Street to the north, Pitt Street to the west, Princeton Apartments to the south and low-rise Euro tower and City of Sydney Fire Station to the east. The site is surrounded by several high-rise buildings including 262 Pitt Street, 329 Pitt Street and the proposed apartment tower 'Castle Residences' to the north, 570 George Street, Century Tower and the proposed apartment tower 'Greenland' to the west.

For the external reflectivity assessment, Pitt Street, Bathurst Street and Castlereagh Street have been assessed as the key roads of concern. All three streets are one-way streets with a maximum speed limit of 40km/h. Pitt Street is one-way northbound, Bathurst Street is one-way eastbound, and Castlereagh Street is one-way southbound.

Figure 2: Geographic location of the site

3.2 Sydney Metro

Sydney Metro is Australia's biggest public transport program. A new standalone railway, this 21st century network will revolutionise the way Sydney travels.

There are four core components:

1. Sydney Metro Northwest (formerly the 36km North West Rail Link)

This project is now complete and passenger services commenced in May 2019 between Rouse Hill and Chatswood, with a metro train every four minutes in the peak. The project was delivered on time and $1 billion under budget.

2. Sydney Metro City & Southwest

Sydney Metro City & Southwest project includes a new 30km metro line extending metro rail from the end of Metro Northwest at Chatswood, under Sydney Harbour, through new CBD stations and southwest to Bankstown. It is due to open in 2024 with the ultimate capacity to run a metro train every two minutes each way through the centre of Sydney.

Sydney Metro City & Southwest will deliver new metro stations at Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, Waterloo and new underground metro platforms at Central Station. In addition, it will upgrade and convert all 11 stations between Sydenham and Bankstown to metro standards.

In 2024, customers will benefit from a new fully-air-conditioned Sydney Metro train every four minutes in the peak in each direction with lifts, level platforms and platform screen doors for safety, accessibility and increased security.

3. Sydney Metro West

Sydney Metro West is a new underground railway connecting Greater Parramatta and the Sydney CBD. This once-in-a-century infrastructure investment will transform Sydney for generations to come, doubling rail capacity between these two areas, linking new communities to rail services and supporting employment growth and housing supply between the two CBDs.

The locations of seven proposed metro stations have been confirmed at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock and The Bays.

The NSW Government is assessing an optional station at Pyrmont and further planning is underway to determine the location of a new metro station in the Sydney CBD.

4. Sydney Metro Greater West

Metro rail will also service Greater Western Sydney and the new Western Sydney International (Nancy Bird Walton) Airport. The new railway line will become the transport spine for the Western Parkland City's growth for generations to come, connecting communities and travellers with the rest of Sydney's public transport system with a fast, safe and easy metro service. The Australian and NSW governments are equal partners in the delivery of this new railway

The Sydney Metro Project is illustrated in Figure 3 below.

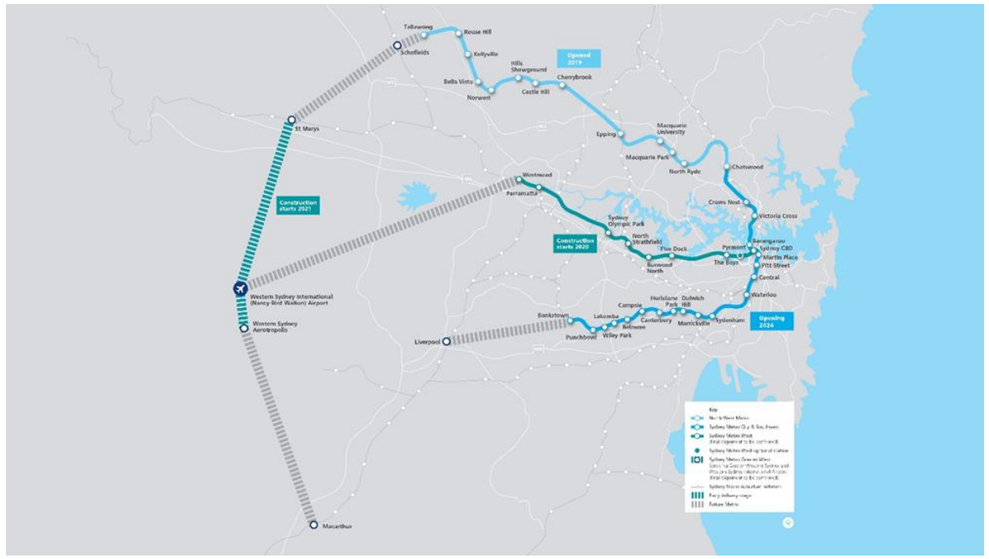


Figure 3: Sydney Metro Alignment Map (Source: Sydney Metro)

On 9 January 2017, the Minister for Planning approved the Sydney Metro City & Southwest - Chatswood to Sydenham project as a Critical State Significant Infrastructure project (reference SSI 15_7400) (CSSI Approval). The terms of the CSSI Approval includes all works required to construct the Sydney Metro Pitt Street Station, including the demolition of existing buildings and structures on both sites (north and south). The CSSI Approval also includes construction of below and above ground works within the metro station structure for appropriate integration with over station developments.

The CSSI Approval included Indicative Interface Drawings for the below and above ground works at Pitt Street South Metro Station site. The delineation between the approved Sydney Metro works, generally described as within the "metro box", and the Over Station Development (OSD) elements are illustrated below. The delineation line between the CSSI Approved works and the OSD envelope is generally described below or above the transfer slab level respectively.

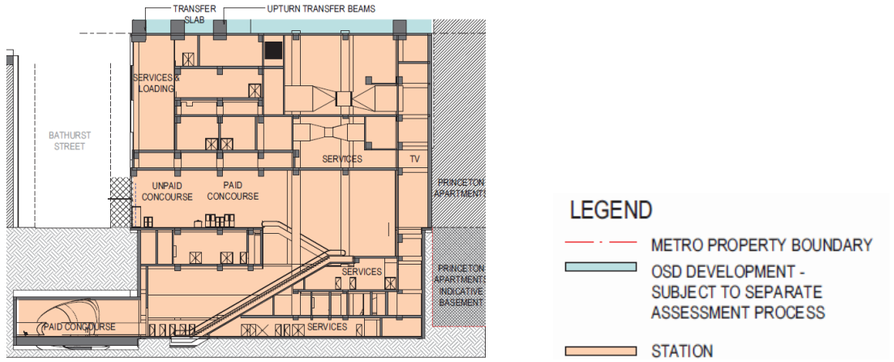


Figure 4: Pitt Street Station - North-South Section (Source: CSSI Preferred Infrastructure Report (TfNSW))

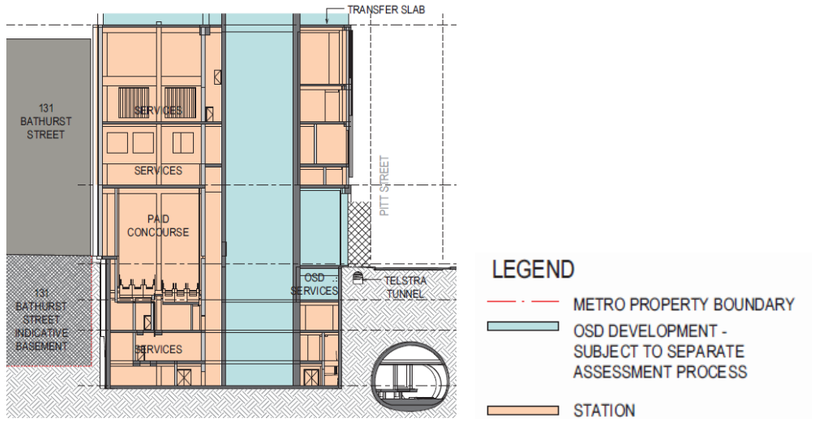


Figure 5: Pitt Street Station -East-West Section (Source: CSSI Preferred Infrastructure Report (TfNSW))

The Preferred Infrastructure Report (PIR) noted that the integration of the OSD elements and the metro station elements would be subject to the design resolution process, noting that the detailed design of the "metro box" may vary from the concept design assessed within the planning approval.

As such in summary:

- The CSSI Approval provides consent for the construction of all structures within the approved "metro box" envelope for Pitt Street South.
- The CSSI Approval provides consent for the fit out and use of all areas within the approved "metro box" envelope that relate to the ongoing use and operation of the Sydney Metro.

- The CSSI Approval provides consent for the embellishment of the public domain, and the architectural design of the "metro box" envelope as it relates to the approved Sydney Metro and the approved Pitt Street South Station Design & Precinct Plan.
- Separate development consent however is required to be issued by the NSW DPIE for the use and fit-out of space within the "metro box" envelope for areas related to the OSD, and notably the construction and use of the OSD itself.

As per the requirements of clause 7.20 of the Sydney Local Environmental Plan 2012, as the OSD exceeds a height of 55 metres above ground level (among other triggers), development consent is first required to be issued in a Concept (formerly known as Stage 1) DA. This is described below.

3.3 Pitt Street South Over Station Development (OSD)

Development consent was granted on 25 June 2019 for the Concept Development Application (SSD 8876) for Pitt Street South OSD including:

- A maximum building envelope, including street wall and setbacks for the over station development.
- A maximum building height of RL171.6.
- Podium level car parking for a maximum of 34 parking spaces.
- Conceptual land use for either one of a residential or commercial scheme (not both). NO maximum Gross Floor Area was approved as part of SSD 8876.

The building envelope approved within the Concept SSD DA provides a numeric delineation between the CSSI Approval "metro box" envelope and the OSD building envelope. As illustrated in the figures below, the delineation line between the two projects is defined at RL 58.25 (Level 7).

For the purposes of the Detailed (Stage 2) SSD DA, it is noted that while there are two separate planning applications that apply to the site (CCSI and SSD DA), this report addresses the full development across the site to provide contextual assessment.

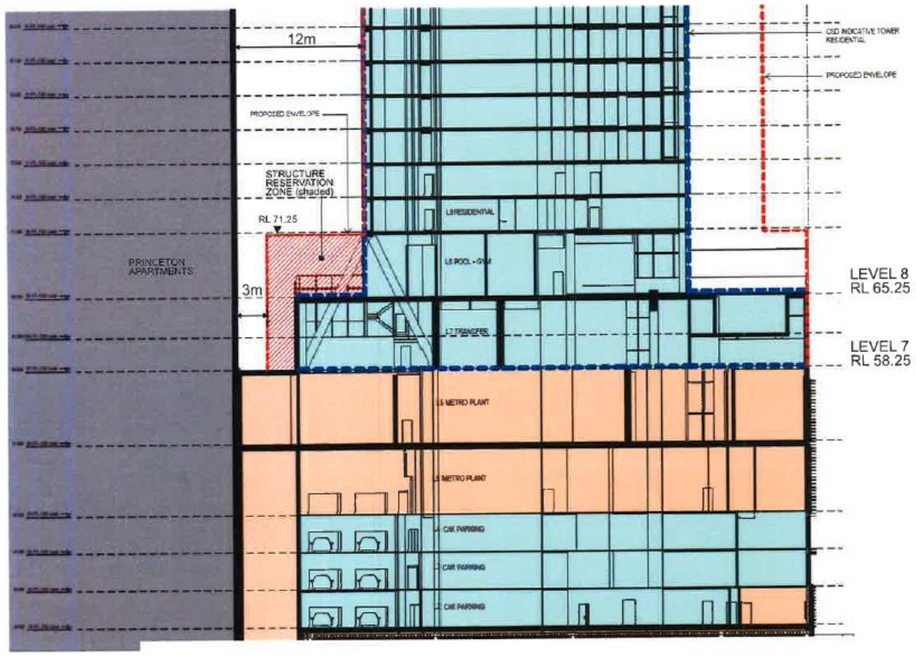


Figure 6: Pitt Street South Concept SSD DA – Building Section (Source: SSD 8876 Concept Stamped Plans)

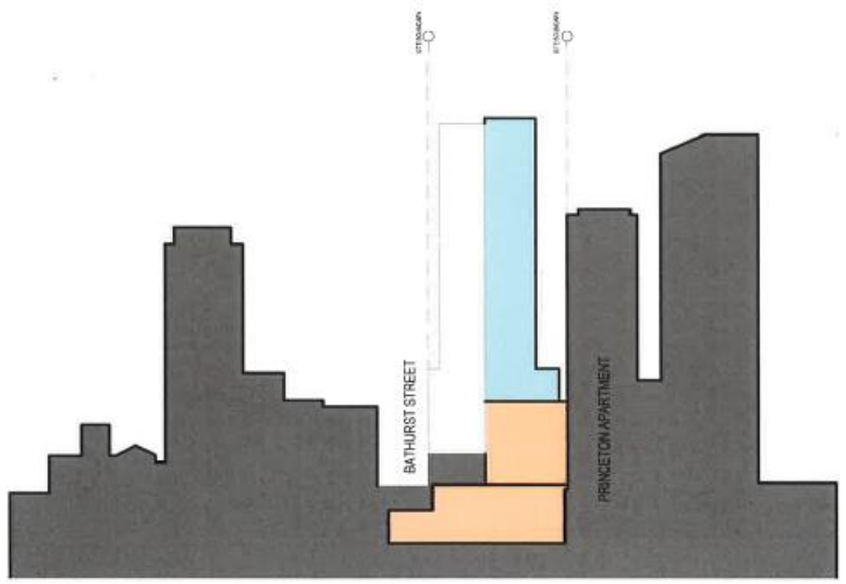


Figure 7: Pitt Street South Concept SSD DA – North South Section (Source: SSD 8876 Concept Stamped Plans)

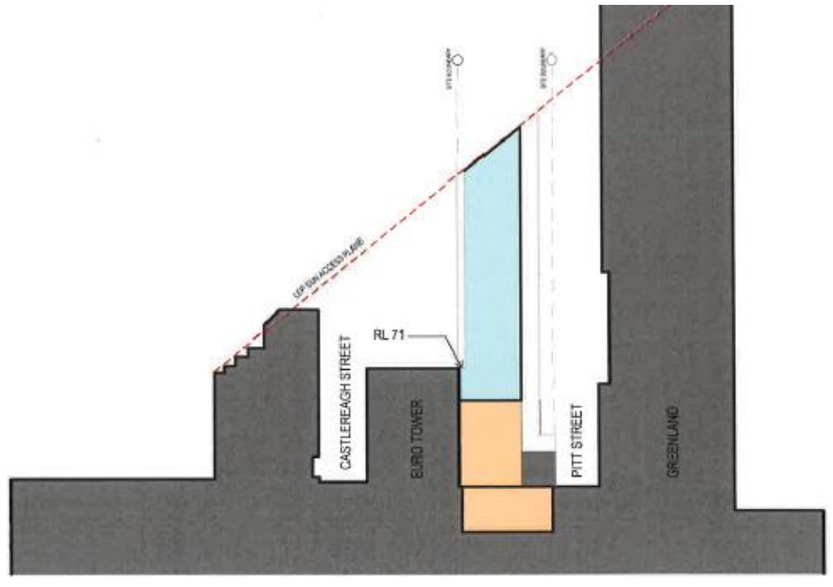


Figure 8: Pitt Street South Concept SSD DA – East West Section (Source: SSD 8876 Concept Stamped Plans)

3.4 Climate and Weather Data

The location in Sydney CBD classifies the project under Climate Zone 5 and the Reference Meteorological Year (RMY) file for Sydney (947680). The closest data set to the site, has been utilised for the analysis.

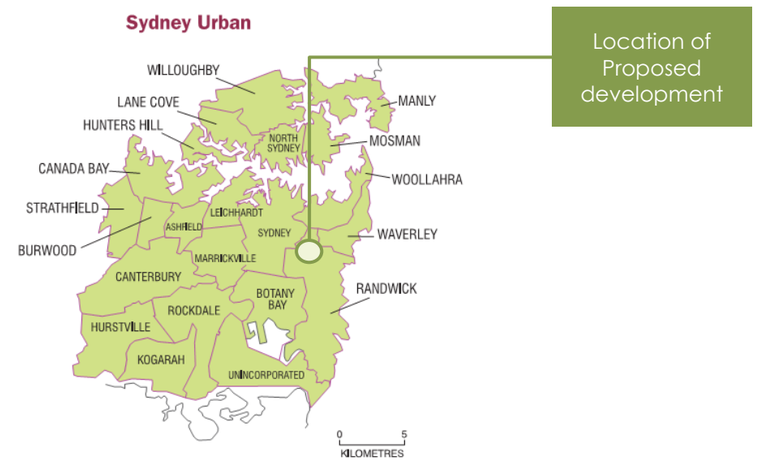


Figure 9: Location of site

3.5 Critical Observer Orientations

The likelihood of veiling luminance glare is dependent on the critical angles of the observer and the building façade in relation to the sun. The critical observer viewer directions (BRG) considered in this study are outlined in Figure 10.

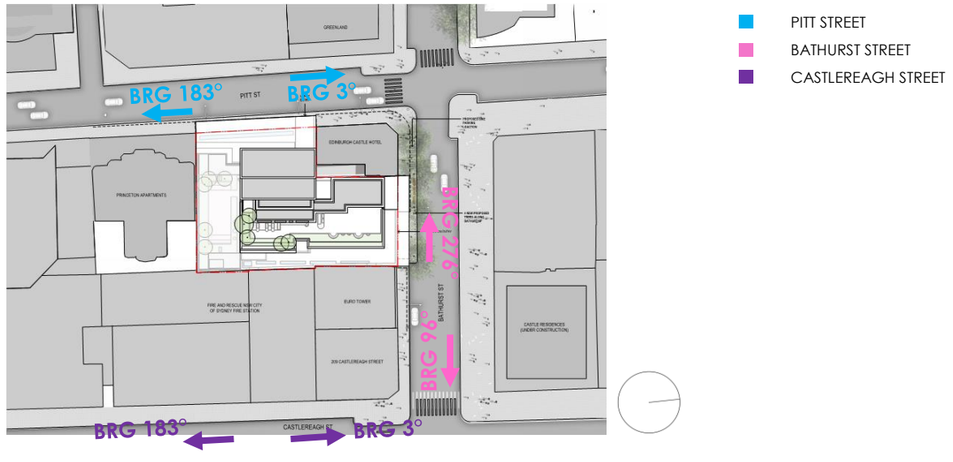


Figure 10: Critical observer view directions (pedestrians and motorists)

The orientations of the façade are represented by ASP angles, and are shown in Figure 11.

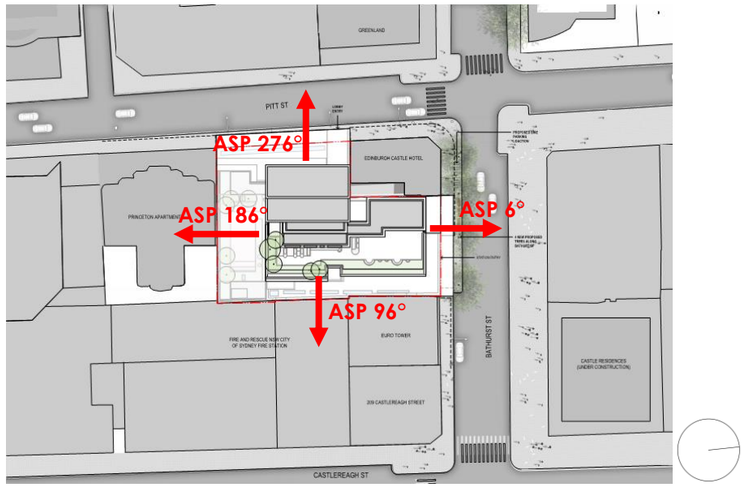


Figure 11: Aspect ratio of facade reflecting surfaces

4. Results

4.1 Pitt Street, Travelling North

The results for Pitt Street travelling north are shown in Figure 13, based on façade orientations of 186° (south) and 276° (west). For a maximum external surface reflectance of 20%, the results show veiling luminance below the acceptable limit (500 Cd/m^2) over the course of the year.

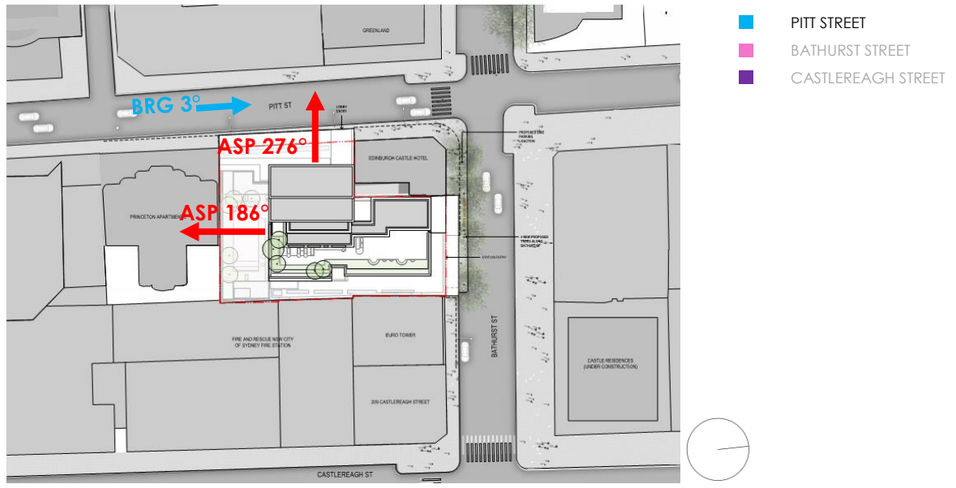


Figure 12: Summary of assumptions- Pitt Street, travelling north

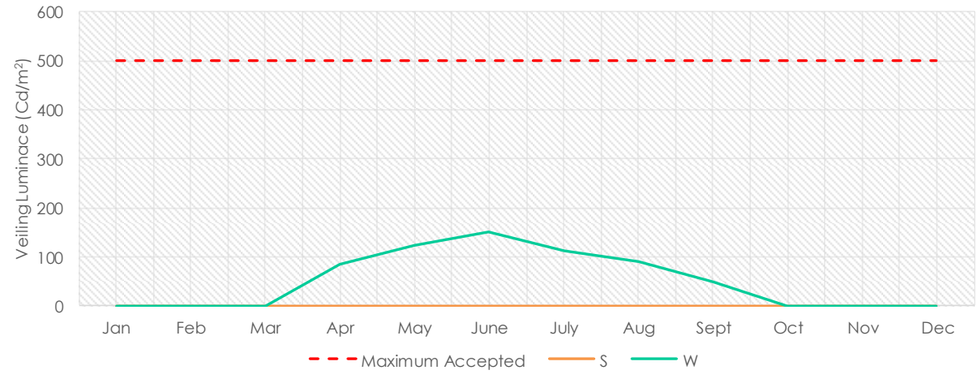


Figure 13: Veiling luminance results- Pitt Street, travelling north

4.2 Pitt Street, Travelling South (pedestrians only)

The results for Pitt Street travelling south are shown in Figure 15, based on façade orientations of 6° (north) and 276° (west). For a maximum external surface reflectance of 20%, the results show veiling luminance below the acceptable limit (500 Cd/m^2) over the course of the year.

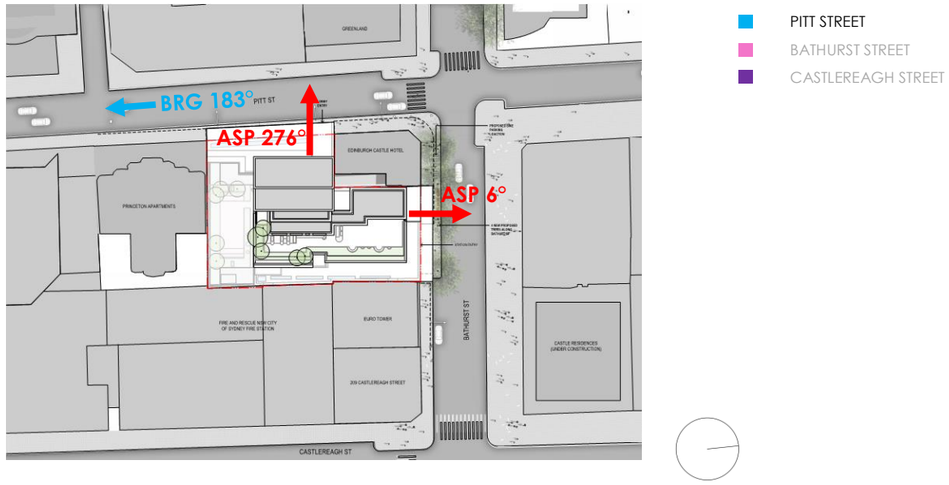


Figure 14: Summary of assumptions- Pitt Street, travelling south

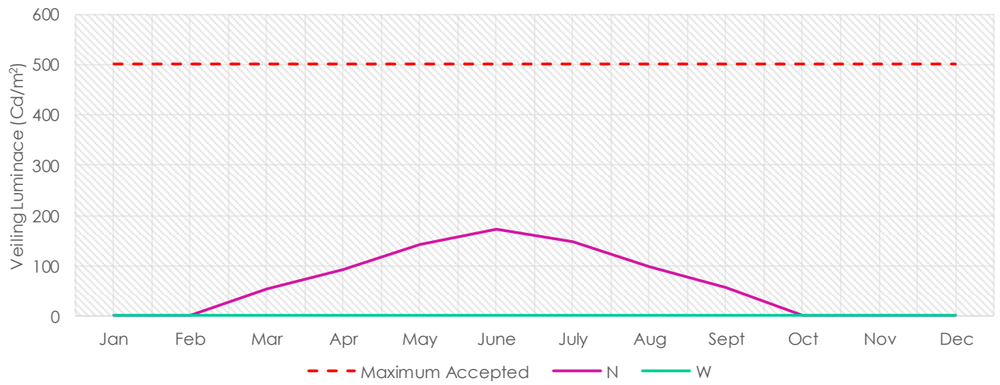


Figure 15: Veiling luminance results- Pitt Street, travelling south

4.3 Bathurst Street, Travelling East

The results for Bathurst Street travelling east are shown in Figure 17, based on façade orientations of 276° (west) and 6° (north). For a maximum external surface reflectance of 20%, the results show that the veiling luminance at the west facade exceeds the acceptable limit (500 Cd/m^2) for 61 hours a year (5pm-6pm during March and September) and that at the north façade exceeds the acceptable limit for 15.5 hours a year (6am-6.30am in October).

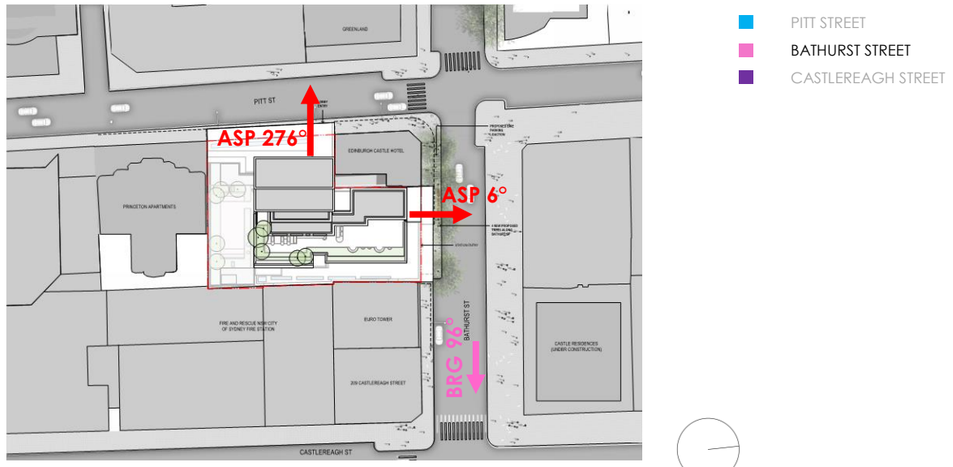


Figure 16: Summary of assumptions- Bathurst Street, travelling east

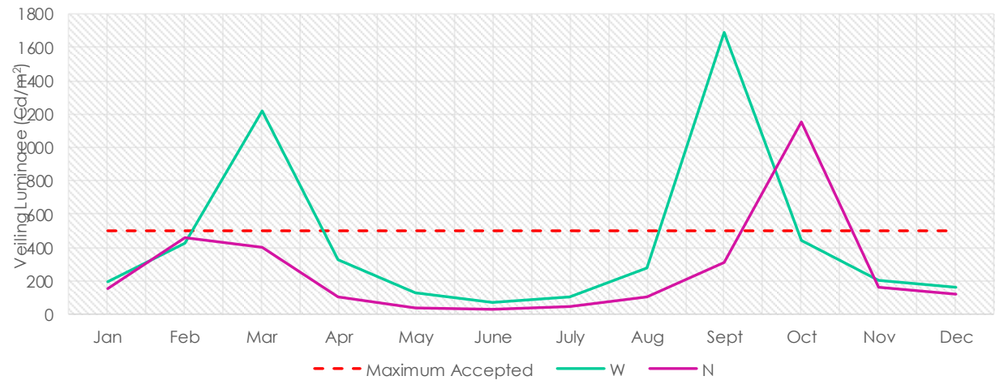


Figure 17: Veiling luminance results- Bathurst Street, travelling east

Although a glare risk is predicted by using Hassall methodology, since the building is shaded by high-rise buildings to the west and north, in reality, negligible risk due to discomfort glare is expected. Shading analysis considering the surrounding buildings as well as self-shading from the precast cladding has been carried out for the durations when a glare risk is identified by Hassall Methodology. Figure 18 shows the shading on the west facade at 5.30pm on a typical September day. It can be observed that during this period, majority of the west façade will be shaded by the adjacent towers to the west. The image shows that a small portion of the western façade is not shaded; this portion of the façade is approximately 35m from Bathurst Street and is expected to be outside the field of the driver's vision and therefore doesn't present a glare risk.

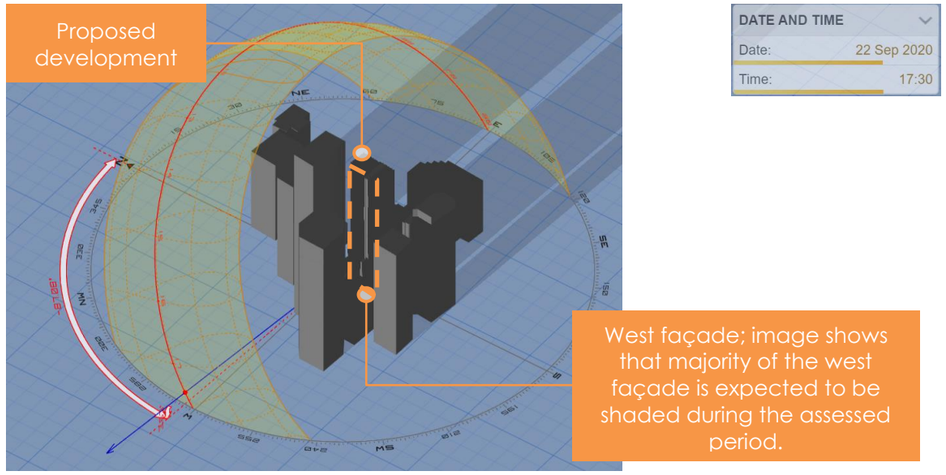


Figure 18: Shading expected at 5.30pm on a typical September day

Figure 19 shows the shading on the north facade at 6.15am on a typical October day. It can be observed that during this period, then north façade will be completely shaded. As such, no risk due to glare is therefore expected.

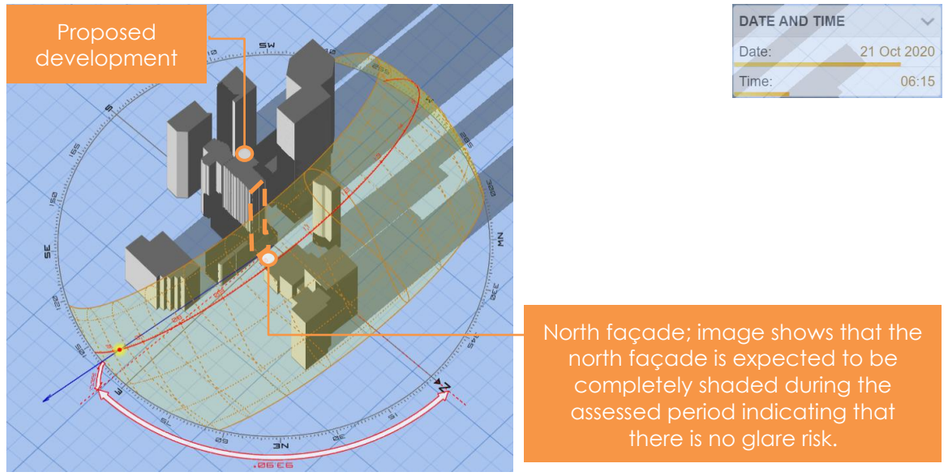


Figure 19: Shading expected at 6.15am on a typical October day

4.4 Bathurst Street, Travelling West (pedestrians only)

The results for Bathurst Street travelling west are shown in Figure 21, based on façade orientations of 96° (east) and 6° (north). For a maximum external surface reflectance of 20%, the results show that the veiling luminance at the east façade exceeds the acceptable limit (500 Cd/m^2) for 59 hours a year (6am-7am during February and 5.30am-6.30am during October).

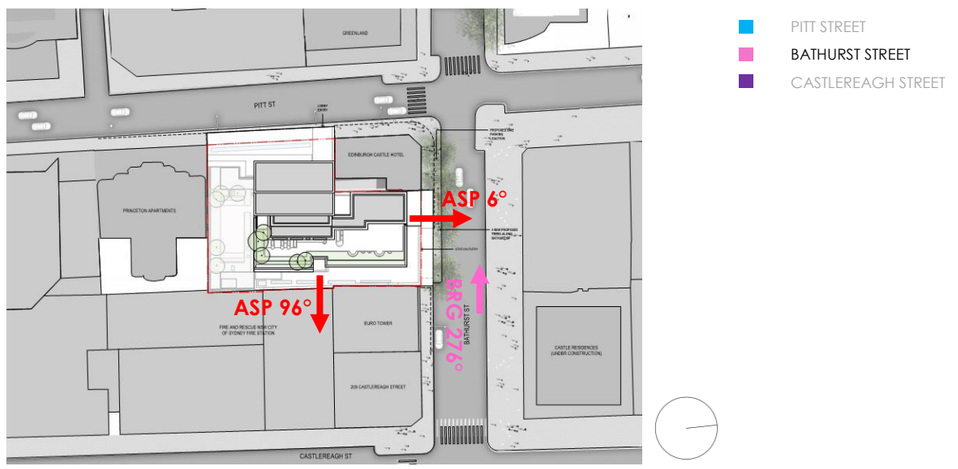


Figure 20: Summary of assumptions- Bathurst Street, travelling west

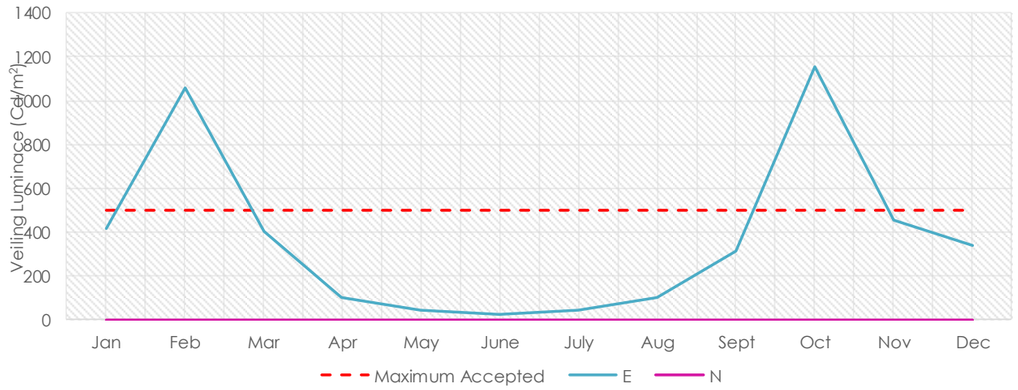


Figure 21: Veiling luminance results- Bathurst Street, travelling south

As with the previous case, shading analysis has been carried out for the durations when a glare risk is identified. Figure 22 shows the shading on the east facade at 6am on a typical February day. It can be observed that during this period, the lower levels of the east façade will be completely shaded by the adjacent 229-249 Elizabeth Street ('Telstra House') to the east.

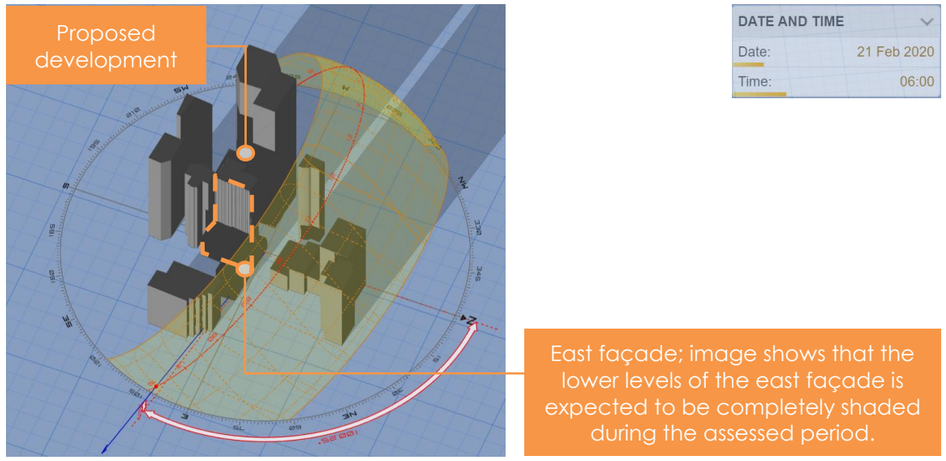


Figure 22: Shading mask expected at 7am on a typical March day

Additionally, although the upper levels of the eastern façade, (roughly 70m onwards from the ground level) will be exposed to direct solar radiation, this portion of the façade is not expected to be in the line of sight of the pedestrian (the Hassall method assumes that the angular extent of the human binocular field of view extends upwards by 60°; based on this the pedestrian needs to be at least 80.8 m east of the proposed development to see the exposed portion of the east façade. As such, no risk due to glare is therefore expected.

4.5 Castlereagh Street, Travelling North (pedestrians only)

The results for Castlereagh Street travelling north are shown in Figure 24, based on façade orientations of 96° (east) and 186° (south). For a maximum external surface reflectance of 20%, the results show veiling luminance below the acceptable limit (500 Cd/m²) over the course of the year.

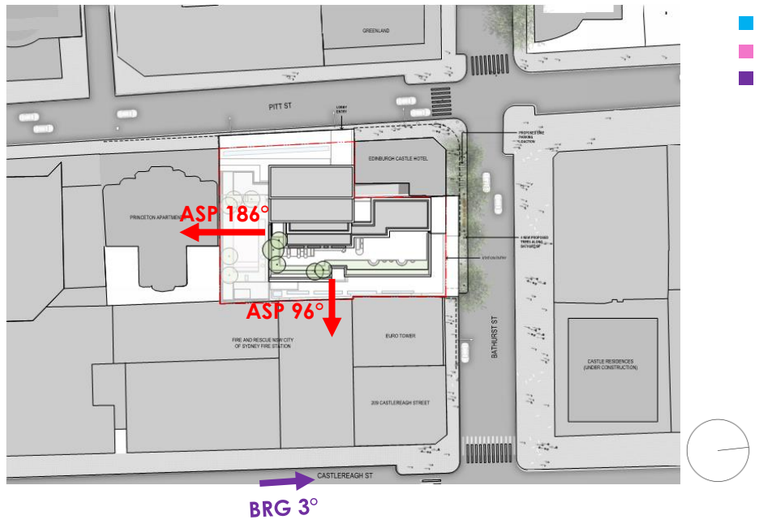


Figure 23: Summary of assumptions- Castlereagh Street, travelling north

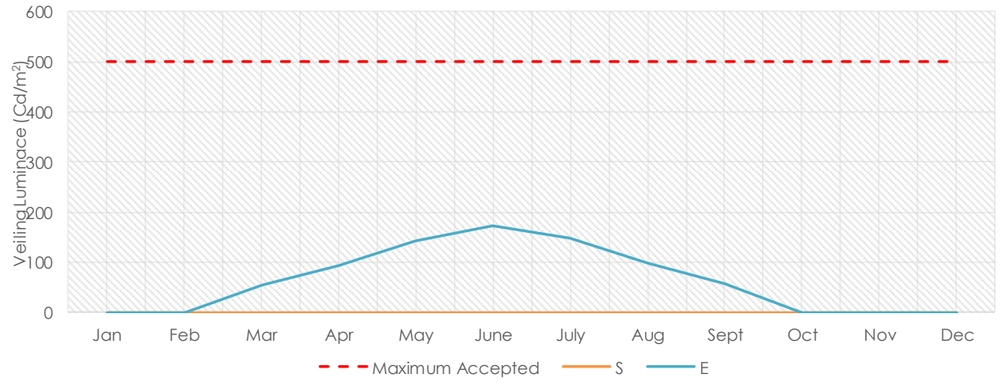


Figure 24: Veiling luminance results- Castlereagh Street, travelling north

4.6 Castlereagh Street, Travelling South

The results for Castlereagh Street travelling south are shown in Figure 26, based on façade orientations of 6° (north) and 96° (east). For a maximum external surface reflectance of 20%, the results show veiling luminance below the acceptable limit (500 Cd/m²) over the course of the year.

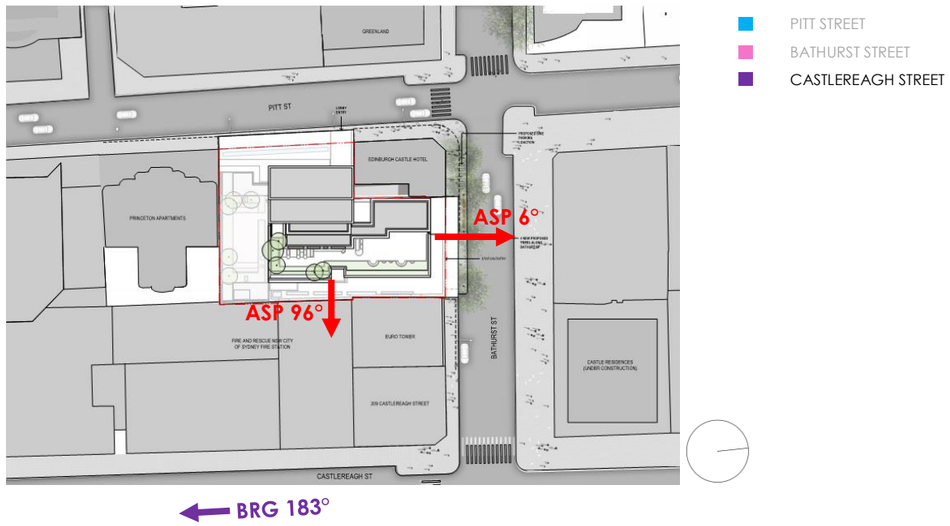


Figure 25: Summary of assumptions- Castlereagh Street, travelling south

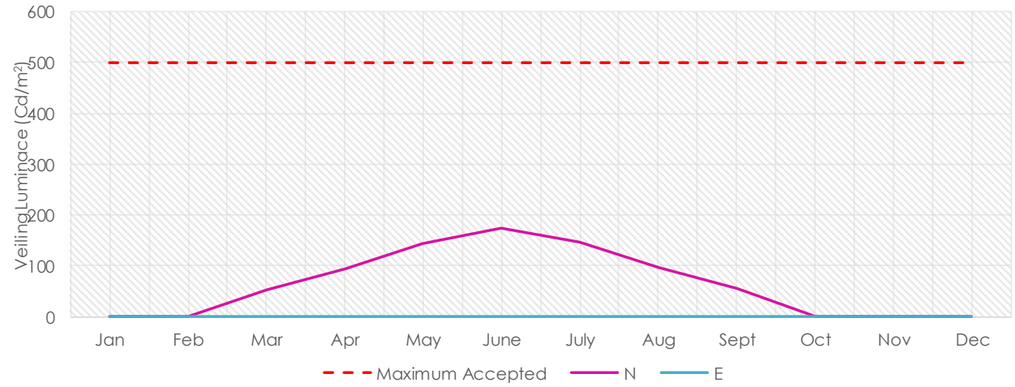


Figure 26: Veiling luminance results- Castlereagh Street, travelling south

4.7 Glare Impact on Occupants of Neighbouring Buildings

Unlike motorists, reflection from facades on occupants do not constitute a hazard, however, we have verified this using the same criteria used to assess the glare impact on motorists. This is a conservative approach.

Due to the location of the site amidst several high-rise towers, the proposed project is overshadowed for a large part of the year, which minimizes the total hours of glare impact on occupants of neighbouring buildings.

During periods when the proposed building is not shielded from the sun, maximum veiling luminance levels is expected during the early morning hours (between 5.30am-7am), which are outside of typical office hours. It is to be noted that this is based on conservative assumptions for the visual light transmittance (VLT) of the neighbouring buildings and not considering the use of internal block-out blinds which offer protection against glare and are generally provided for office and residential buildings.

5. Discussion and Conclusion

This analysis has shown that all façades can achieve compliance with a specular reflectance of 20% to the whole façade (100%) without causing adverse discomfort glare to the surrounding roads.

Table 4: Summary of results

Façade Orientation	Hours Above Practical Limit (20% external reflectance)	Maximum Acceptable Reflectivity Limit (for all angles of incidence)	% Façade Spectrally Reflective	Acceptability
ASP 6°– North Façade	0	20%	100%	✔
ASP 96°– East Façade	0	20%	100%	✔
ASP 186°– South Façade	0	20%	100%	✔
ASP 276°– West Façade	0	20%	100%	✔

6. Appendix 1 - Methodology

6.1 Holladay formula

The modelling was calculated using the Holladay formula. This formula can be found in Reflectivity Dealing with Rogue Solar Reflections published and illustrated by David N. H. Hassall (1991).

The limiting veiling luminance figure of 500 Cd/m2, as calculated by the Holladay formula, has been suggested as a practical limit to the amount of reflected solar glare to which a driver should be exposed. In meeting this criterion for vehicle drivers, conditions will also be satisfactory for pedestrians. Figure 2 shows some of the approximate values of luminance for several sources of light. The maximum tolerable luminance by direct observation is 7,500 Cd/m2.

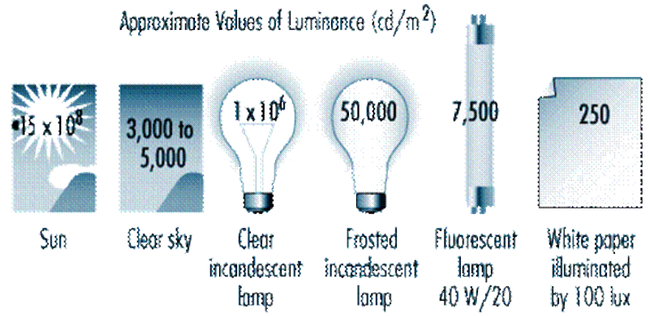


Figure 27: Approximate values of luminance

The Holladay formula calculates the equivalent veiling luminance or glare. It assesses the acceptability of solar reflections that fall within a driver's field of view. It suggests an answer to the question 'how much glare is too much?'

The equivalent veiling luminance for the façade is calculated using the following formula.

$$L_v\left(\frac{Cd}{m^2}\right) = \frac{10 \cdot EG}{\theta^2} \qquad \textbf{Equation 1}$$

Lv is the equivalent veiling luminance or 'glare.

EG is the illumination on the observer's eye produced by the glare source in the plane perpendicular to the line of sight in lux.

θ is the angle between the centre of the glare source and the line of sight. It is valid from 1.5˚ to 60˚.

The issue of solar glare and its effect on human vision is very complex and one for which science has not so far provided a definitive answer. One of the main problems is the great variation in individual human response to a given amount of glare. One person's slight inconvenience is another's blinding light

The equivalent veiling luminance method models the sun path in relation to the proposed building development. Reflection conditions are modelled for all daylight hours throughout the year. This method is more accurate as it depends on the power of the solar radiation (W/m^2) for various altitudes, luminous efficiency for such rays (lumens/watt), sun position (azimuth and altitude) for various times of the day, observer's viewing direction (BRG), aspect of reflecting surface, reflectivity of glass and fraction of solid wall which is spectrally reflective. The equivalent veiling luminance method was chosen over the glare protractor since the glare protractor is not numerically calculated, but requires the transparency to be placed over either a photograph or computer plot of the view from the driver's position. This process is more susceptible to human error. The angular scale of the protractor and of the photograph or plot must be the same and there is a process that needs to be observed when taking photographs. However the glare protractor can be used to justify the acceptability of a glare source once problematic dates and times have been identified.

This report assumes specular type reflective façade surfaces, where the reflected ray angle is equal to the incident solar ray angle. It assumes that the equivalent veiling luminance is only calculated for periods of the day when the suns azimuth is either +/- 90˚ of the various aspects of the proposed development i.e. it cannot be calculated when the sun is behind the wall.

6.2 Glare Acceptability Criteria

Once potential glare sources have been identified for various dates and times, the glare protractor can then be used to locate the position of the glare source and to assess the acceptability of the glare. This will determine whether a reflective surface falls within a critical area boundary of the glare protractor and its magnitude of discomfort. Table 2 outlines the angular limits for each critical area, methods to mitigate the glare source and roads which can accept the glare source.

In addition to the glare protractors, a site plan with the areas affected by the glare sources is used to identify affected roads. This is used to contextualise the glare protractor in respect to surrounding road. It is then used to assess the acceptability of the glare with respect to overshadowing from surrounding buildings.

7. Appendix 2 - Glossary of Terms

Veiling Luminance (Glare) – veiling luminance is the "threshold" of contrast for an object, where any additional light superimposed on the retina will cause an object to become invisible?

Glare- is difficulty seeing in the presence of bright light such as direct or reflected sunlight

Disability Glare- impairs the vision of objects without necessarily causing discomfort

Discomfort Glare- results in an instinctive desire to look away from a bright light source or difficulty in seeing a task

BRG- View Direction- Angle of the direction of travel of the vehicle,

ASP- Building Aspect- Angle of the building aspect to be assessed.

EG- illumination at the observer's eye.

Luminance- is an objective parameter, is the amount of light being reflected from a surface towards the eye.

Contrast- Contrast is defined as the ration of the difference between and object and its background and the luminance of a background

Shading Coefficient (SC) – The ratio of total solar heat gain through a specific glazing system to the total solar heat gain through 3mm clear glass under the same set of conditions. 3mm ordinary clear glass typically has a SC of 1.0.

Solar Radiation- Energy from the sunn arriving at the surface as a direct, diffuse and effected component measured in W/m^2.

Luminous Efficacy- refers to the numbers of lumens/watt in sunlight which varies with solar altitude.

Azimuth- The direction of the sun in plan, measure in degrees for north or from south depending ion the hemisphere you are in.

Altitude- The angle between the horizontal plane and the sun

Reflectance- The ration of the amount of energy striking a surface to the amount of energy reflected.