Sydney Metro

State Significant Development,
Development Application (SSD DA)

Report:

External Reflectivity Report

Project:

Pitt Street North Over Station Development (PSN OSD)

For:

Pitt Street Developer North Pty Ltd.

By:

Inhabit Australasia Pty Ltd.

Doc. No: SMCSWSPS-INH-OSN-PL-REP-000001
Date: 2020-07-09
Revision: C
Reason for Issue: Issue for DPIE

Inhabit Group
Office: Level 11, 88 Phillips Street, Sydney, NSW, 2000
T.+61 (0) 2 8003 6333 W.www.inhabitgroup.com E.contact@inhabitgroup.com
Australia | China | Hong Kong | United Arab Emirates | United Kingdom

Table of Contents

Executive Summary 4
1. Introduction 5
1.1 Sydney Metro Description 5
1.2 Updates Since Previous Submission 8
2. Site and Context 9
2.1 Site 9
2.2 Critical Observer Orientations 9
3. Assessment Method 10
4. Modelling Inputs 11
4.1 Sun Path Data 11
4.2 Sky Conditions 11
4.3 Time of Analysis 11
4.4 Software 11
4.5 Model Geometry 11
4.6 Material Properties – Proposed Buildings 11
5. Results 13
5.1 Reflected Glare Impact on Motorists and Pedestrians 13
5.2 Reflected Glare Impact on Occupants of Neighbouring Buildings 20
6. Conclusion 20
7. Appendix 1 - Methodology 21
7.1 Holladay formula 21
7.2 Angular Dependence of Reflectance 21

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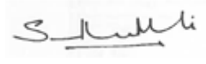
			Prepared by	**Checked by**	**Approved by**
		Name	Sindhu Murali		
		Signature			

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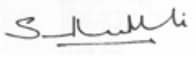
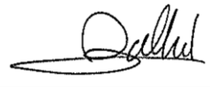
			Prepared by	**Checked by**	**Approved by**
		Name	Sindhu Murali	Danial Nordinson	Pierre-Alexis Galland
		Signature			

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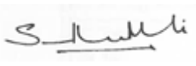
			Prepared by	**Checked by**	**Approved by**
		Name	Sindhu Murali	Jason Gaekwad	Jason Gaekwad
		Signature			

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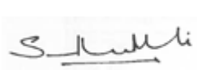
		Signature			

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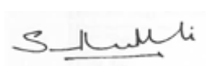
			Prepared by	**Checked by**	**Approved by**
		Name	Sindhu Murali	Pierre-Alexis Galland	Pierre-Alexis Galland
		Signature			

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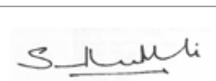
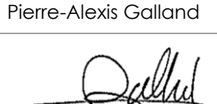
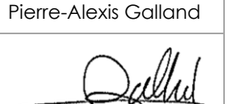
			Prepared by	**Checked by**	**Approved by**
		Name	Sindhu Murali	Pierre-Alexis Galland	Pierre-Alexis Galland
		Signature			

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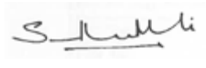
			Prepared by	**Checked by**	**Approved by**
		Name	Sindhu Murali	Pierre-Alexis Galland	Pierre-Alexis Galland
		Signature			

Executive Summary

A detailed external glare study has been undertaken to determine the potential impact of reflected glare on traffic and pedestrians surrounding the proposed mixed-use development Pitt Street North Over Station Development at the corner of Pitt Street, Park Street and Castlereagh Street, Sydney.

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 25 October 2019 and the Condition of Consent for the State Significant Development Concept (SSD 8875) for the OSD.

Points 1 to 7 summarise the criteria adopted, key assumptions and findings of the assessment.

1. The proposed development has been modelled in 3D modelling software Rhino, along with buildings surrounding the site. The analysis has assessed the potential impact of reflected glare on traffic and pedestrians travelling along the following key surrounding roads:

- Pitt Street
- Park Street
- Castlereagh Street

2. Based on the Hassall method, a veiling luminance (LVL) of 500 candelas per square metre (Cd/m^2) has been utilised as the limit to assess the glare affecting motorists.

3. As such, the Hassall method does not specify a criterion to assess the glare impact on pedestrians. A veiling luminance level of 500 Cd/m^2 has been used as a recommended limit to assess the glare affecting pedestrians, however, where this value is exceeded, the associated risk is assessed on a case by case basis based on Inhabit's engineering judgement.

4. Unlike the impact on motorists, reflection from facades on pedestrians do not constitute a hazard and a higher veiling luminance limit is generally acceptable.

5. The assessment has been based on a single external visible light reflectance value of 16% for the proposed building and represents conservative estimations. Where the veiling luminance has been found to exceed the acceptable limit, and the corresponding reflecting surface is not glazing, the veiling luminance has been recalculated based on the reflectivity of the actual material at the location.

6. The following summarise the results of the external glare study to determine the potential impact of reflected glare on motorists and pedestrians:

- Maximum veiling luminance is within the acceptable limit of 500 Cd/m^2 for all four critical observer orientations corresponding to motorists.
- Maximum veiling luminance is within the recommended limit of 500 Cd/m^2 for all six critical observer orientations corresponding to pedestrians.
- The analysis has shown that no glare risk to motorists and pedestrians is predicted, provided, specular reflectance of the proposed façade materials do not exceed the values listed in Table 1; and that, based on the preliminary intent for the various façade materials, compliance is achieved.

Table 1: Summary of compliance requirements

Material	Maximum Allowable External Reflectance (Specular)	Compliance based on Preliminary Finishes Intent
Glazing	16%	✔
Back-painted Cladding	16%	✔
Metal Cladding	3.2%	✔
Stone Cladding	Material is not specularly reflective	N/A
Concrete	Material is not specularly reflective	N/A

1. Introduction

Inhabit has been engaged by Pitt Street Developer North Pty Ltd. to assess the proposed commercial mixed-use Over Station Development (OSD) above the new Sydney Metro Pitt Street North Station for risk of external reflected glare and the potential impact on motorists 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_8875) 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 is 153.5m tall (RL 176.8m) and consists of a total of 38 storeys. The podium levels (L00 – L09) of the development consist of the entrance to the metro station (off Park Street), commercial entrances, end of trip facilities, station areas, retail, commercial and plant areas. Levels 10 – 35 comprise of commercial areas, while levels 36- 38 comprise of plant areas.

Both podium and tower facades consist of vertical and horizontal shading elements. Vertical shading elements at levels L02 – L04 are of stone cladding. Vertical shading elements at all other levels and all horizontal shading elements are of metal cladding.

Figure 1: Architectural render of the development (courtesy: Fosters and Partners Architects)

1.1 Sydney Metro Description

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 – Western Sydney Airport

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 2 below.

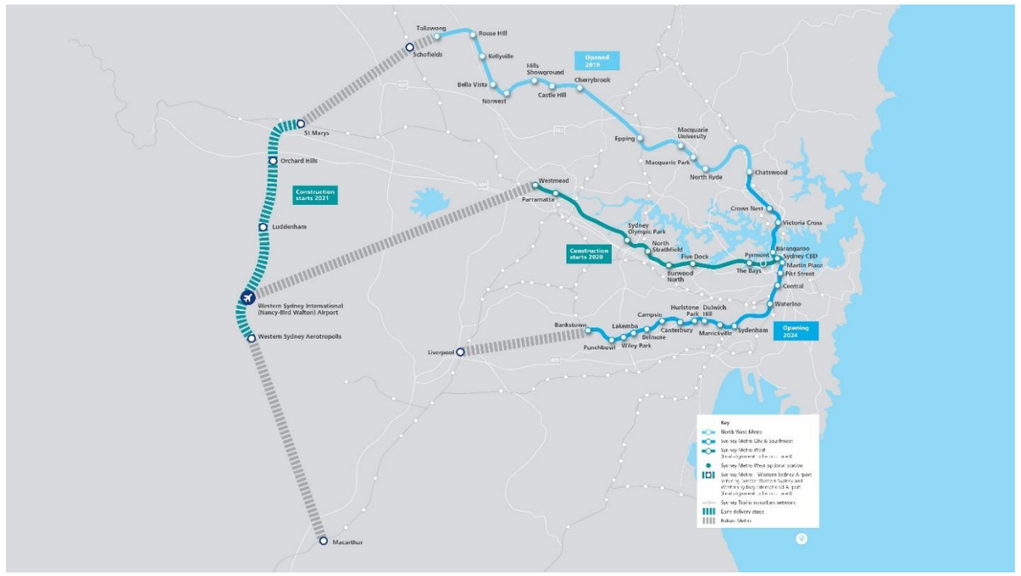


Figure 2: Sydney Metro Alignment Map (Source: Sydney Metro)

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 North 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.

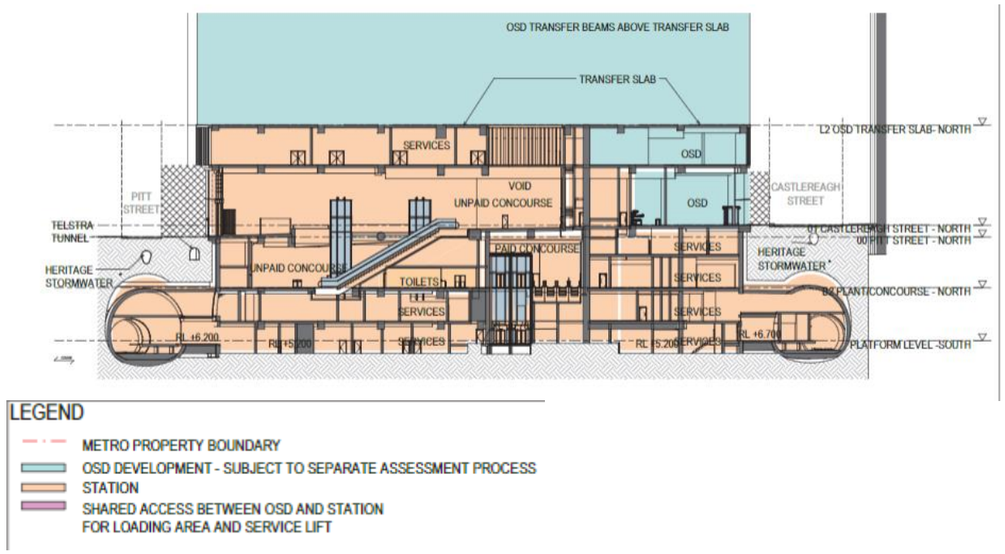


Figure 3: Pitt Street Station – North (East-West Section); (Source: CSSI Preferred Infrastructure Report (TfNSW))

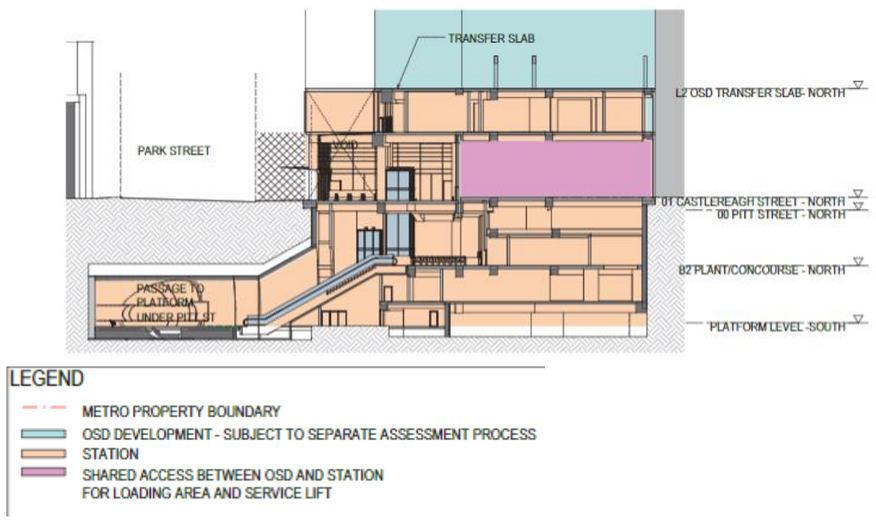


Figure 4: Pitt Street Station – North (North-South Section); (Source: CSSI Preferred Infrastructure Report (TfNSW))

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 North.
- 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 North 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.

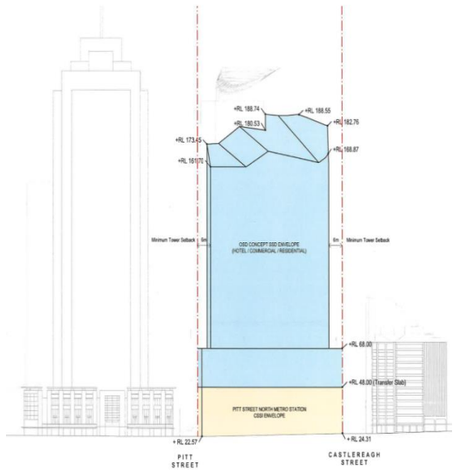


Figure 5: Pitt Street North Concept SSD DA – Envelope – South Elevation (Source: SSD 8875 Concept Stamped Plans)

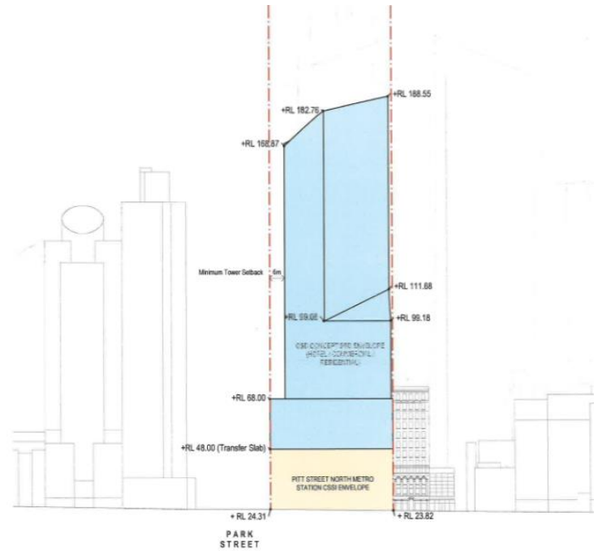


Figure 6: Pitt Street North Concept SSD DA – Envelope – East Elevation (Source: SSD 8875 Concept Stamped Plans)

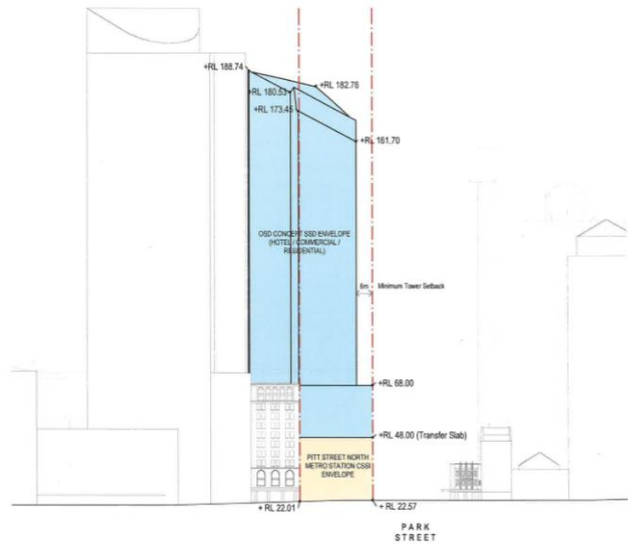


Figure 7: Pitt Street North Concept SSD DA – Envelope – West Elevation (Source: SSD 8875 Concept Stamped Plans)

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 25 October 2019, specifically this report has been prepared to respond to the SEARs requirements summarised in Table 2.

Table 2: 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 2.2 for critical observer orientations considered, section 5 for detailed results and section 6 and section 7 for discussion and conclusion.

This report has also been prepared in response to the following Condition of Consent for the State Significant Development Concept (SSD 8875) for the OSD summarised in Table 3.

Table 3: 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 2.2 for critical observer orientations considered, section 5 for detailed results and section 6 and section 7 for discussion and conclusion.

1.2 Updates Since Previous Submission

This section of the report describes the changes that have been made to this report since Round 1 Submission to Sydney Metro, due to the following reasons:

Table 4: Updates since previous submission

Type of Change	Description of Change	Section Reference (this report)
Addition of new sections	The following sections have been added: • 1.1 Sydney Metro Description; • 1.2 Updates Since Previous Submission	Section 1.1; Page 5 Section 1.2; Page 8
Updated information	Date of issue of SEARs document changed to 25 October 2019	Executive Summary (page 3) and Section 1 (page 4)
Updated information	Update to reduced level (RL) of the proposed development; changed from 175.8m to 176.8m	Section 1, page 4

2. Site and Context

2.1 Site

The site is located within the Sydney CBD. It has three separate street frontages, Pitt Street to the west, Park Street to the south and Castlereagh Street to the east. The site has an approximate area of 3,150.1 m^2 and is legally described as follows:

- 252 Pitt Street (Lot 20 in DP1255509)

The area surrounding the site consists of predominantly commercial high-density buildings and some residential buildings, with finer grain and heritage buildings dispersed throughout.

For the external reflected glare assessment, Pitt Street, Park Street and Castlereagh Street have been assessed as the key roads of focus. Pitt Street and Castlereagh Street are one-way streets while Park Street is a two-way street. Pitt Street is one-way northbound, and Castlereagh Street is one-way southbound. All three streets have a maximum speed limit of 40km/h.

Figure 8: Geographic location of the site

2.2 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/ bearing) of motorists and pedestrians considered in this study are outlined in Figure 9.

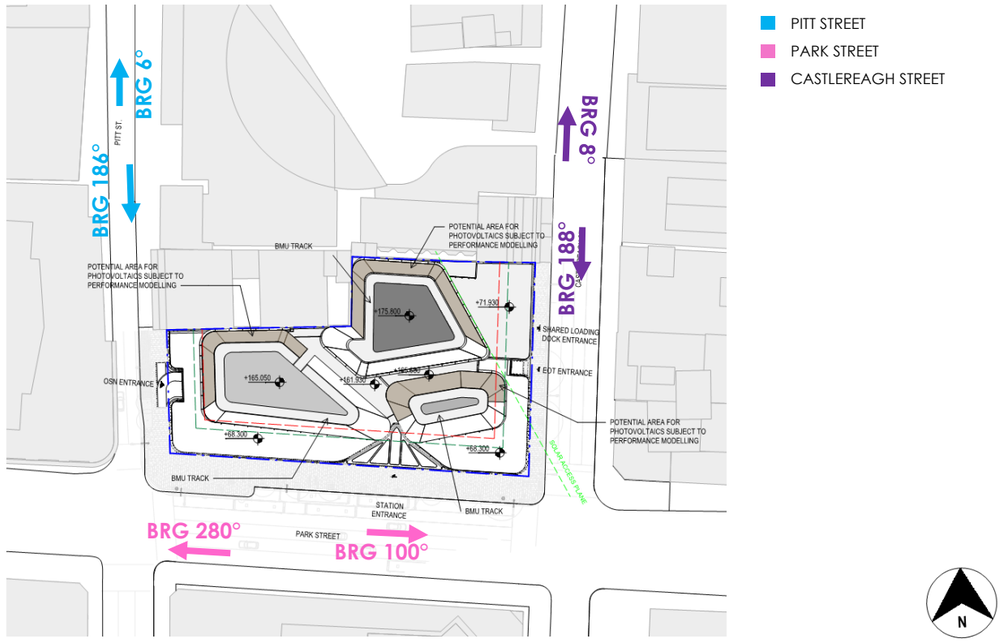


Figure 9: Critical observer view directions- motorists and pedestrians

3. Assessment Method

The proposed development has been modelled in 3D modelling software Rhino, along with buildings surrounding the site.

The Holladay formula has been used to determine the risk of glare due to light reflections from the building. This formula can be found in Reflectivity Dealing with Rogue Solar Reflections published and illustrated by David N. H. Hassall (1991). A veiling luminance (LVL) of 500 candelas per square metre (Cd/m^2) has been utilised as the limit. Refer to section 7 of this report for detailed assessment methodology.

The assessment 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 sun's azimuth is either +/- 90˚ of the various aspects of the proposed development i.e it cannot be calculated when the sun is behind the facade.

Further, the equivalent veiling luminance is only calculated for periods of the day when the sun's azimuth is not within the observer's field of view (i.e. within 60˚ on either side of the BRG). During periods when the sun is within the field of view, the glare from the real sun is much higher than the glare from the reflected sun and for these reasons the reflected glare will not be a 'surprise'.

An example of this is illustrated in Figure 10 and Figure 11 which show locations where a veiling luminance due to reflected glare from the proposed building is expected for a westbound travel along Park Street at 4pm on January 21st. Green points in the image correspond to a veiling luminance within the acceptable level of 500 Cd/m^2. Red points correspond to a veiling luminance of exceeding the acceptable level of 500 Cd/m^2. The image also shows that the sun's azimuth is within the observer's field of view. Therefore, although the veiling luminance due to glare from the reflected sun exceeds the acceptable level of 500 Cd/m^2 at certain locations, this is expected to be much less in comparison to the glare from the real sun.

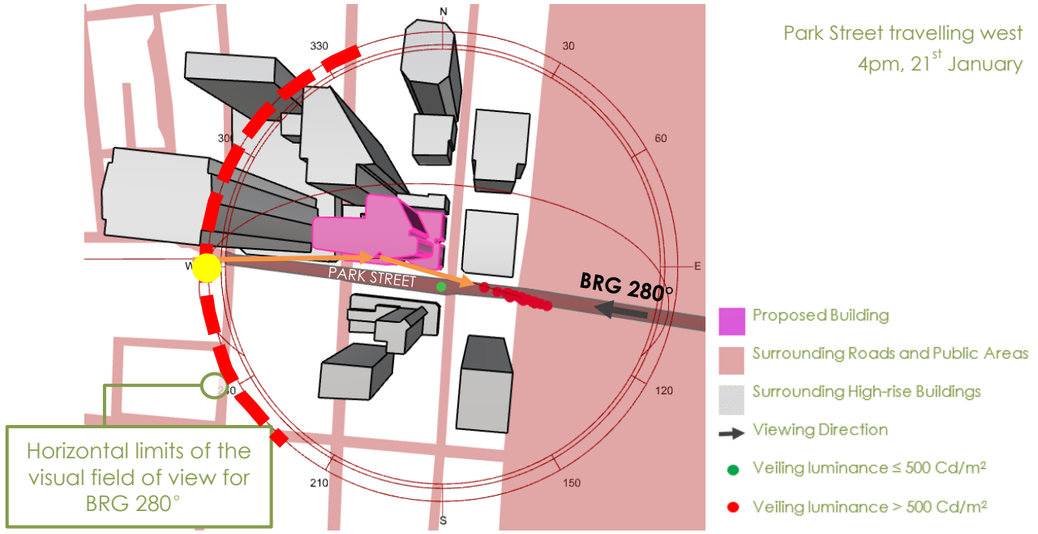


Figure 10: Example illustrating veiling luminance due to reflected glare for a period when the real sun (a more severe source of glare) is also in the driver's field of view- plan view

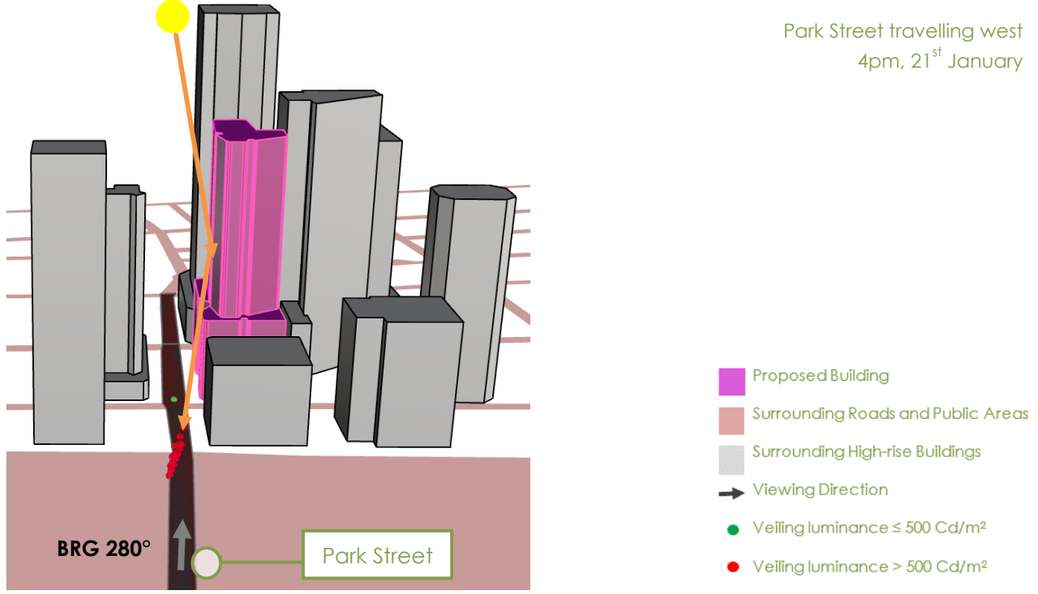


Figure 11: Example illustrating veiling luminance due to reflected glare for a period when the real sun (a more severe source of glare) is also in the driver's field of view- perspective view

4. Modelling Inputs

4.1 Sun Path Data

The assessment has used the sun's positions (azimuths and altitudes) based on the the Reference Meteorological Year (RMY) file for Sydney (947680), the closest data set to the site.

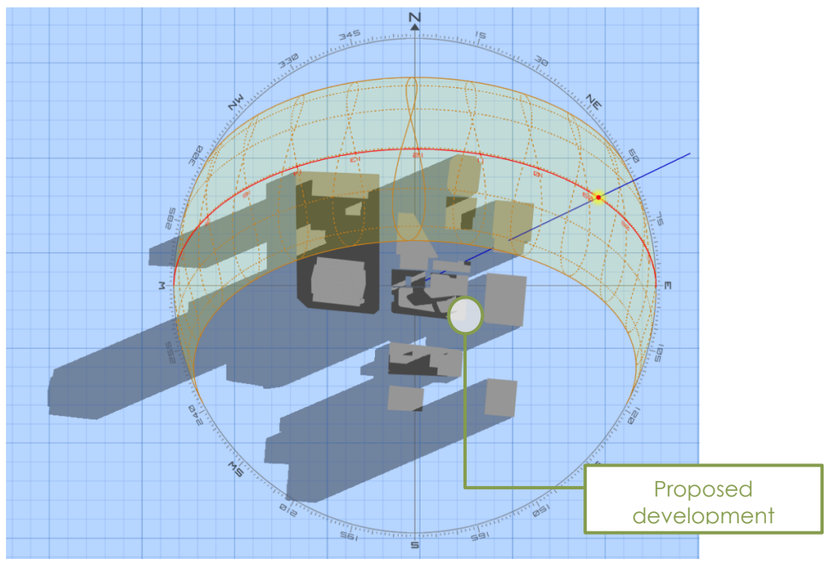


Figure 12: Annual sun path, Sydney

4.2 Sky Conditions

A sunny clear sky condition has been used in the glare analysis, which represents a conservative scenario for the risk of glare. An overcast (or polluted) sky will reduce the intensity of direct solar reflections thereby reducing the risk of glare.

4.3 Time of Analysis

Assessment has been carried out for hours 5am to 7pm, on the 21st day of each month of the year. The 21st has been considered to account for the summer and winter solstices. All months have been assessed to account for differences in façade orientations and sun location. This time resolution provides an adequate representation on the impact of glare across the year.

4.4 Software

Rhinoceros - and its generative modelling plugin, Grasshopper, along with environmental modelling plug-ins Ladybug and Honeybee have been used. Ladybug allows the import of standard EnergyPlus weather files into Grasshopper. The model uses ray-tracing for accurate analysis.

4.5 Model Geometry

A simple 3D massing model of the proposed development has been built based on the following Preliminary SSDA Drawings issued by Foster + Partners:

- Site Plan: SMCSWSPS-FOS-OSN-AT-DWG-910013 (Revision P1)
- GA Plans: SMCSWSPS-FOS-OSN-AT-DWG-910014 to SMCSWSPS-FOS-OSN-AT-DWG-939513 (Revision P1)
- Elevations: SMCSWSPS-FOS-OSN-AT-DWG-960001 to SMCSWSPS-FOS-OSN-AT-DWG-960004 (Revision P1)

The results of the reflected glare assessment are only valid for the architectural model assessed. Any changes to the façade and architectural model will require additional assessments.

Shading fins have been excluded in the model due to their relatively small projected dimensions. A single material property (that of glazing) has been considered for the entire model mass. Both model simplifications are expected to result in conservative outcomes.

Neighbouring buildings have been included for a more accurate model and to provide context. Massing of neighbouring buildings is coarse and based on the site plan and elevation drawings provided. As with the proposed building, shading fins, if any, have been excluded from the model.

4.6 Material Properties – Proposed Buildings

4.6.1 Glazing

The assessment has been based on a maximum external reflectance of 16% and represents conservative estimations based on the thermal (Section J) and Visual Light Transmittance (VLT) requirements of the project. The glass specification extracted from CSG's datasheets and as shown in Table 6 has been used in the assessment.

Table 5: Glazing Properties

Make-up	Visiblel Light			AFRC Winter U-value	AFRC SHGC
	Transmittance	Reflectance			
		Outdoor	Indoor		
6 LB52S on low Iron + 12A + 6 Low Iron	53%	16%	15%	≤ 3.6 W/m^{2}K	≤ 0.51

It is to be noted that the outdoor reflectance figures specified in the table above corresponds to that of normal incidence (i.e. the incident ray is perpendicular to the surface of the glazing). Reflectance of specularly reflective elements is a function of the angle of incidence. This has been accounted for in the assessment.

4.6.2 Metal Cladding

The intent for the metal cladding is of powder coated finish with a bronze coloured appearance. Corresponding specular reflectivity values are typically below 3.2% based on products currently available in the market. This value has been used in the assessment.

5. Results

5.1 Reflected Glare Impact on Motorists and Pedestrians

5.1.1 Pitt Street, Travelling North

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

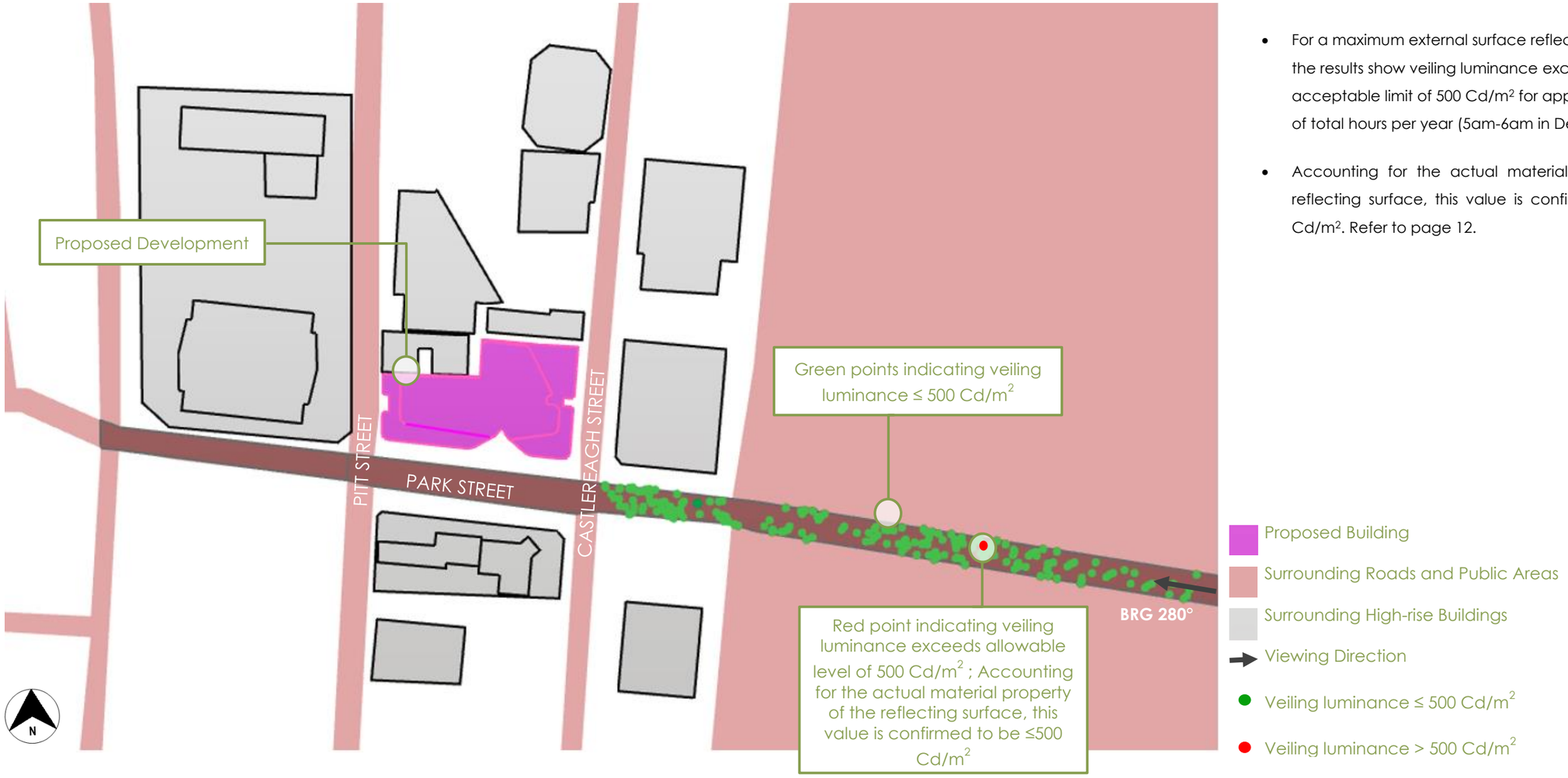
- For a maximum external surface reflectance of 16%, the results show veiling luminance below the acceptable limit (500 Cd/m^2) over the course of the year.
- The small number of receiver points indicate that the facades acting as a 'glare source' for this particular viewing direction receives minimal direct solar radiation.

5.1.2 Pitt Street, Travelling South (pedestrians only)

- For a maximum external surface reflectance of 16%, the results show veiling luminance below the recommended limit (500 Cd/m^2) over the course of the year.
- The small number of receiver points indicate that the facades acting as a 'glare source' for this particular viewing direction receives minimal direct solar radiation.

Figure 14: Veiling luminance results- Pitt Street, travelling south

5.1.3 Park Street, Travelling West



- For a maximum external surface reflectance of 16%, the results show veiling luminance exceeds the acceptable limit of 500 Cd/m^2 for approximately 0.5% of total hours per year (5am-6am in December).
- Accounting for the actual material property of the reflecting surface, this value is confirmed to be ≤500 Cd/m^2. Refer to page 12.

Figure 15: Veiling luminance results- Park Street, travelling west

Figure 16 below illustrates the location of the reflecting facades ('glare source') and the receiver point at 5am on 21st December. The location of the reflecting surface is at an elevation of 8.5m. As per the elevation drawings, this corresponds to the location of the metal cladding. Based on the current intent for the metal cladding (maximum specular reflectance of 3.2%), the maximum veiling luminance will be within the acceptable limit of 500 Cd/m^2.

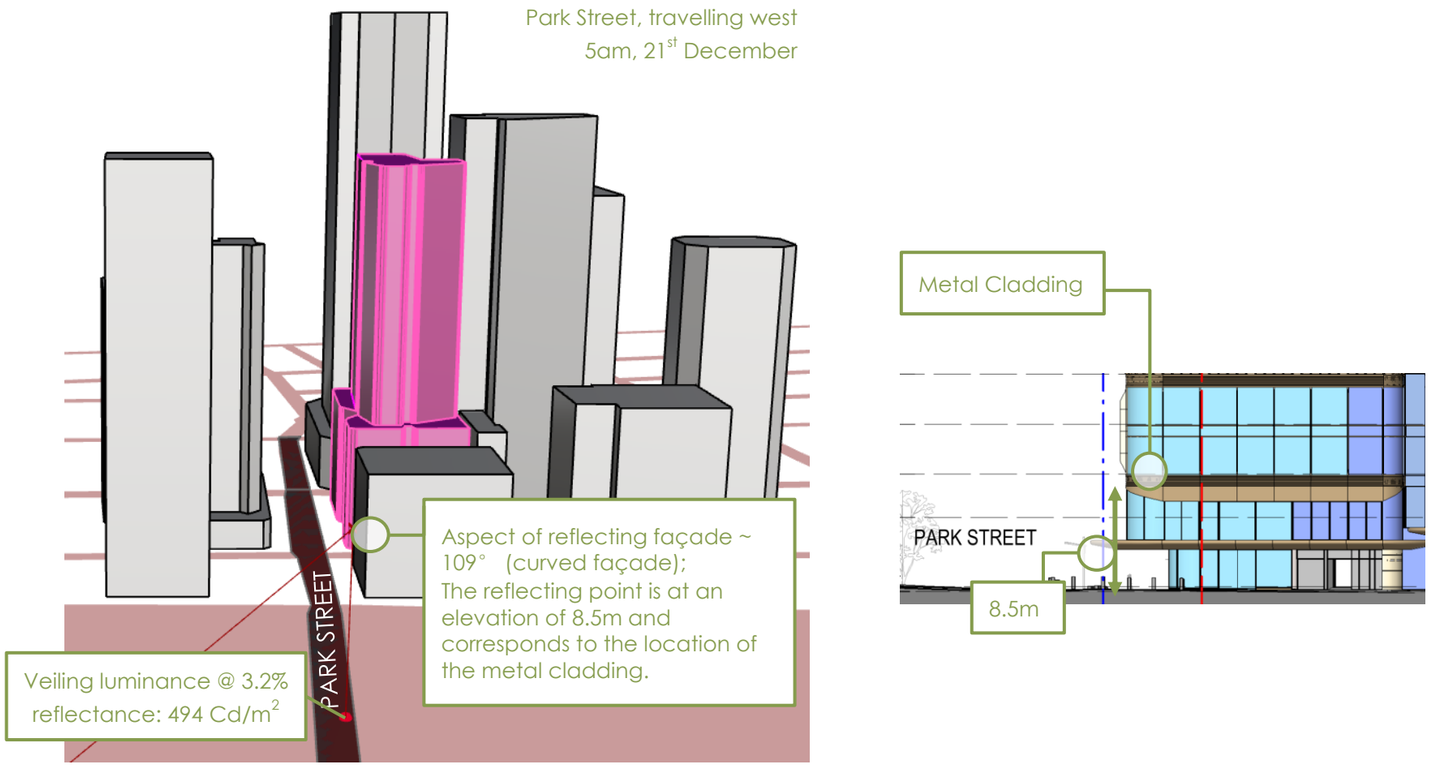


Figure 16: Veiling luminance results- Park Street, travelling west (5am @ 21st December)

5.1.4 Park Street, Travelling East

- For a maximum external surface reflectance of 16%, the results show veiling luminance below the acceptable limit (500 Cd/m^2) over the course of the year.
- The small number of receiver points indicate that the facades acting as a 'glare source' for this particular viewing direction receives minimal direct solar radiation.

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

5.1.5 Castlereagh Street, Travelling South

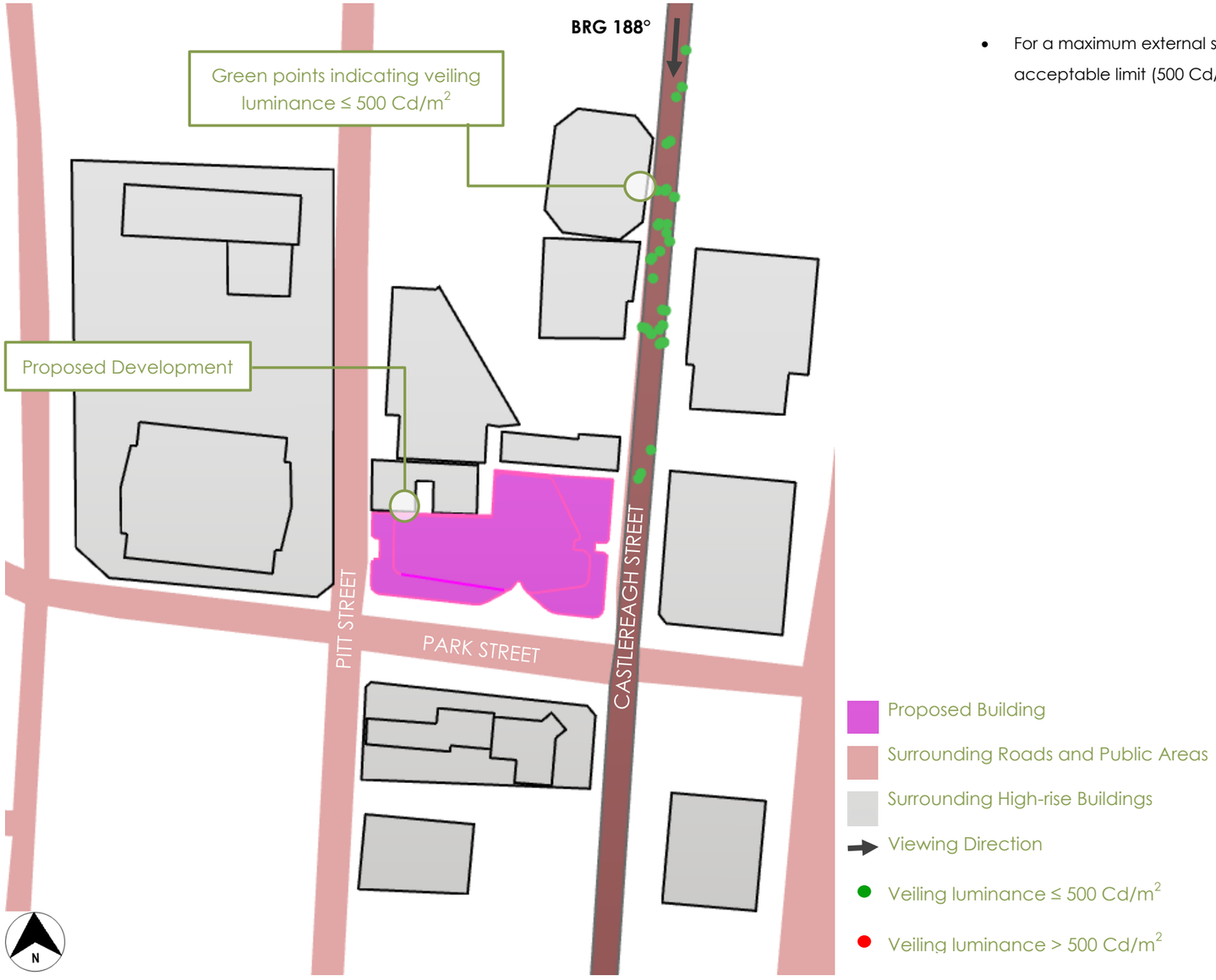


Figure 18: Veiling luminance results- Castlereagh Street, travelling south

- For a maximum external surface reflectance of 16%, the results show veiling luminance below the acceptable limit (500 Cd/m²) over the course of the year.

5.1.6 Castlereagh Street, Travelling North (pedestrians only)

Figure 19: Veiling luminance results- Castlereagh Street, travelling north

- For a maximum external surface reflectance of 16%, the results show veiling luminance below the acceptable limit (500 Cd/m^2) over the course of the year.

Table 6 summarises the results of the assessment.

Table 6: Summary of results- based on a maximum external reflectance of 16%

Travel Direction	User Type	% Total Hours/ Year Above Practical Limit [1]	Maximum Veiling Luminance (Cd/m^2)
Pitt Street, Travelling North	Motorists and pedestrians	0%	≤500
Pitt Street, Travelling South	Pedestrians only	0%	≤500
Park Street, Travelling West	Motorists and pedestrians	~0.5% [2] 0% based on reflectance ≤3.2%	≤500 based on reflectance ≤3.2%
Park Street, Travelling East	Motorists and pedestrians	0%	≤500
Castlereagh Street, Travelling South	Motorists and pedestrians	0%	≤500
Castlereagh Street, Travelling North	Pedestrians only	0%	≤500

NOTES-

[1] The assessment is based on hourly intervals. Given the constant change in the sun's position, a glare impact is only expected for a few minutes a day. Therefore, the actual % total hours per year above the practical limit of 500 Cd/m^2 is expected to be much less than the reported figures.

[2] Based on an external reflectance of 16%, a veiling luminance greater than 500 Cd/m^2 has been identified. The location of the façade causing a glare greater than 500 Cd/m^2 corresponds to the metal cladding at an elevation of 8.5m. With the current intent for the metal cladding (bronze coloured powder coated finish with a maximum specular reflectivity of 3.2%), compliance is achieved.

5.2 Reflected 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 5am-7am), which are outside of typical office hours. It is to be noted that this is not considering the use of internal block-out blinds which are generally provided for office buildings and offer protection against glare.

6. Conclusion

The analysis has shown that no glare risk is predicted provided specular reflectance of the proposed façade materials do not exceed the values listed in Table 7; and that based on the preliminary intent for the various façade materials, compliance is achieved.

Table 7: Summary of compliance requirements

Material	Maximum Allowable External Reflectance (Specular)	Compliance based on Preliminary Finishes Intent
Glazing	16%	✔
Back-painted Cladding	16%	✔
Metal Cladding	3.2%	✔
Stone Cladding	Material is not specularly reflective	N/A
Concrete	Material is not specularly reflective	N/A

7. Appendix 1 - Methodology

7.1 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/m^2, 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 20 shows some of the approximate values of luminance for several sources of light. The maximum tolerable luminance by direct observation is 7,500 Cd/m^2.

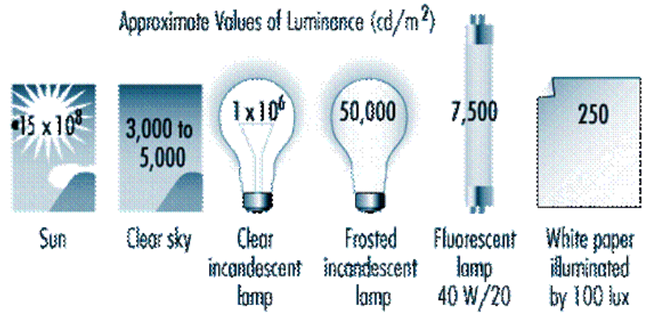


Figure 20: Approximate values of luminance

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.

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

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. It is calculated using the following formula.

$$EG = E.R.\cos\theta \qquad \textbf{Equation 2}$$

where E is the solar illumination (lux) on the surface, calculated as a product of solar power (W/m^2) and luminous efficacy (lumens/W). Solar power is calculated as a function of the altitude (ALT) of the sun and is as per the following formula.

for ALT ≤ 10°, solar power (W/m^2) = ALT*50

ALT ≥ 10°, solar power (W/m^2) = 500 + (ALT – 10)*15 **Equation 3**

A luminous efficacy of 150 lumens/W corresponding to clear sky conditions has been used.

R is the angular dependent reflectance of the surface.

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 (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.

This assessment 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.

Further, the equivalent veiling luminance is only calculated for periods of the day when the sun's azimuth is not within +/- 60˚ of the viewing direction. During periods when the sun is within the field of view, the glare from the real sun is much higher than the glare from the reflected sun and for these reasons the reflected glare will not be a 'surprise'.

7.2 Angular Dependence of Reflectance

Reflectance of specularly reflective elements is a function of the angle of incidence.

- For solar incidence angles less than 40°, the reflectance is generally similar to the reflectance value measured at an incidence angle normal to the glazing element.
- For incidence angles greater than 40°, the reflectance values increase drastically with the angle of incidence.
- For a 90° incident angle (i.e. incident solar rays striking near parallel to the façade plane), the reflectance is equal to 100%.

This is depicted in Figure 21 below.

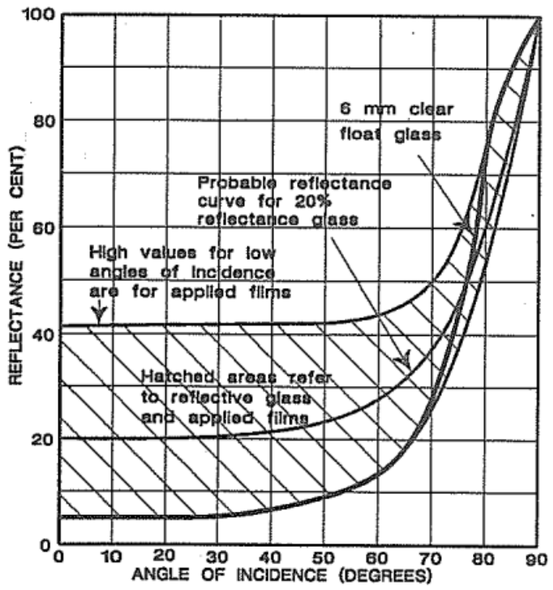


Figure 21: Reflectance versus angle of incidence (image extracted from the publication 'Reflectivity-Dealing with Rogue Solar Reflections' written by David N. H. Hassall)