POWERHOUSE PARRAMATTA
ENVIRONMENTAL IMPACT STATEMENT

APPENDIX X
REFLECTIVITY REPORT

Arup

NSW GOVERNMENT

Infrastructure NSW

Powerhouse Precinct Parramatta

Powerhouse SSDA report – Reflectivity

PHM-ARP-REP-FA-0003

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1 Introduction

This report supports a State Significant Development (SSD) Development Application (DA) for the development of the Powerhouse Parramatta at 34-54 & 30B Phillip Street and 338 Church Street, Parramatta. The Powerhouse Parramatta is a museum (information and education facility) that has a capital investment value in excess of $30 million and as such the DA is submitted to the Minister for Planning pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Infrastructure NSW is the proponent of the DA.

2 Background

The Powerhouse is Australia's contemporary museum for excellence and innovation in applied arts and sciences. The museum was established in 1879 in the Garden Palace which emerged from a history of 19th Century grand exhibition halls, including the Grand Palais. It currently encompasses the Powerhouse in Ultimo, Sydney Observatory in The Rocks and the Museums Discovery Centre in Castle Hill. The Powerhouse has occupied the Ultimo site since 1988.

Parramatta, in the heart of Western Sydney, is entering a period of rapid growth. It was identified in 2014's *A Plan for Growing Sydney* as the metropolis' emerging second Central Business District, with the provision of supporting social and cultural infrastructure regarded as integral to its success. The strategic importance of Parramatta as an economic and social capital for Sydney has been subsequently reinforced and further emphasised through its designation as the metropolitan centre of the Central City under the *Greater Sydney Region Plan*.

Powerhouse Parramatta will be the first State cultural institution to be located in Western Sydney – the geographical heart of Sydney. In December 2019, the Government announced the winning design, by Moreau Kusunoki and Genton, for the Powerhouse Parramatta from an international design competition.

Powerhouse Parramatta will establish a new paradigm for museums through the creation of an institution that is innately flexible. It will become a national and international destination renowned for its distinctive programs driven by original research and inspired by its expansive collections. It will be a place of collaboration, a mirror of its communities forever embedded in the contemporary identity of Greater Sydney and NSW.

3 Site Description

The site is located at the northern edge of the Parramatta CBD on the southern bank of the Parramatta River. It occupies an area of approximately 2.5 hectares and has extensive frontages to Phillip Street, Wilde Avenue and the Parramatta River. A small portion of the site extends along the foreshore of the Parramatta River to the west, close to the Lennox Street Bridge on Church Street. The site boundary is identified in Figures 1 and 2. The site excludes the GE Office Building at 32 Phillip Street.

The site is currently occupied by a number of buildings and structures, including:

- Riverbank Car Park – a four-level public car park
- Willow Grove – a two-storey villa of Victorian Italianate style constructed in the 1870s
- St George's Terrace – a two-storey terrace of seven houses fronting Phillip Street constructed in the 1880s
- 36 Phillip Street – a two-storey building comprising retail and business premises
- 40 Phillip Street – a two-storey building comprising retail and business premises
- 42 Phillip Street – a building set back from the street

The immediate context of the site comprises a range of land uses including office premises, retail premises, hotel, serviced apartments and residential apartments. To the north is the Parramatta River and open space corridor, beyond which are predominately residential uses. The Riverside Theatre is located to the north-west across the Parramatta River.

Figure 1- Aerial photograph of the site and its context

Source: Mark Merton Photography

Figure 2 - Site boundary, key existing features, and immediate local context

Source: Ethos Urban

4 Overview of Proposed Development

The Powerhouse was established in 1879, and Powerhouse Parramatta will radically return to its origins through the creation of seven presentation spaces of extraordinary scale that will enable the delivery of an ambitious, constantly changing program that provides new levels of access to Powerhouse Collection. The Powerhouse will set a new international benchmark in experiential learning through the creation of an immensely scaled 360-degree digital space, unique to Australia.

Powerhouse Parramatta will reflect the communities and cultures of one of Australia's fastest growing regions. It will hold First Nations culture at its core and set a new national benchmark in culturally diverse programming. The Powerhouse will be highly connected through multiple transport links, and integrate into the fine grain of the city.

Powerhouse Parramatta will be an active working precinct and include the Powerlab, which will enable researchers, scientists, artists and students from across regional NSW, Australia and around the world to collaborate and participate in Powerhouse programs. The Powerlab will feature digital studios to support music and screen industries alongside co-working spaces, life-long learning and community spaces. Integrated into the Powerlab will be a research kitchen and library that will support a NSW industry development program including archives and oral histories.

This application will deliver an iconic cultural institution for Parramatta in the heart of Sydney's Central City. The SSD DA seeks consent for the delivery of the Powerhouse Parramatta as a single stage, comprising:

- site preparation works, including the termination or relocation of site services and infrastructure, tree removal and the erection of site protection hoardings and fencing;
- demolition of existing buildings including the existing Riverbank Car Park, 'Willow Grove', 'St George's Terrace' and all other existing structures located on the site;
- construction of the Powerhouse Parramatta, including:
    - seven major public presentation spaces for the exhibition of Powerhouse Collection;
    - front and back-of-house spaces;
    - studio, co-working and collaboration spaces comprising the 'Powerlab', supported by 40 residences (serviced apartments) for scientists, researchers, students and artists, and 60 dormitory beds for school students;
    - education and community spaces for staff, researchers and the Powerlab residents, the community, and education and commercial hirers;

  - commercial kitchen comprising the ‘Powerlab Kitchen’ used for cultural food programs, research, education and events;
  - film, photography, and postproduction studios that will connect communities with industry and content that will interpret the Powerhouse Collection;
  - public facing research library and archive for community, industry, students and researchers to access materials; and
  - a mix of retail spaces including food and drink tenancies with outdoor dining.
- operation and use of the Powerhouse Parramatta including use of the public domain provided on the site to support programs and functions;
- maintenance of the existing vehicular access easement via Dirrabarri Lane, the removal of Oyster Lane and termination of George Khattar Lane, and the provision of a new vehicular access point to Wilde Avenue for loading;
- public domain within the site including new public open space areas, landscaping and tree planting across the site; and
- building identification signage.

The project does not seek consent for the carrying out of works outside of the site boundary, and in particular does not involve any alterations to the existing edge of the formed concrete edge of the Parramatta River or to the waterway itself.

5 Assessment Requirements

The Department of Planning, Industry and Environment have issued Secretary's Environmental Assessment Requirements (SEARs) to the applicant for the preparation of an Environmental Impact Statement for the proposed development. This report has been prepared having regard to the SEARs as follows:

SEAR	Where Addressed
9. Environmental Amenity The EIS shall: • include a reflectivity analysis identifying potential adverse glare conditions affecting, motorists, pedestrians and occupants of neighbouring buildings.	Section 7

Table 1 - SEARS Assessment Requirements

6 Assessment of Façade Reflections

6.1 Criteria for Assessment

The method for this study follows that of David N. H. Hassall of the University of New South Wales, which has been widely used to assess reflections off building projects in Sydney. It has been specifically developed for the purpose of reviewing the potential glare impact of solar reflections from facades on traffic in detail, beyond a nominal facade material reflectivity limit.

The term "glare" describes adverse visual effects caused by large ratios of luminance in the visual field. Glare can generally be defined in two ways by its impact on observers (these may coincide):

- Discomfort glare – resulting in psychological annoyance, desire to avert view
- Disability glare –impacting the ability to recognise objects in the visual field and thus ability to carry out visual tasks (such as reading or driving)

It is critical that a driver's view is unaffected by disability glare as this has the potential to cause road accidents, thus the Hassall methodology focuses on prediction of this aspect of glare.

It further singles out veiling glare as the predominant mode of glare that can occur from façade reflections towards traffic. Veiling glare is defined in this context as glare due to the effect of multiple reflection and scattering within the eye of direct light from a bright source. This produces a perception similar to a thin veil being overlaid on the visual scene, and reduces the contrast in the scene, potentially impairing visual tasks. A prerequisite for veiling glare is thus that reflections of the sun are visible relatively close to the direction of view of an observer.

Veiling glare is a form of perceptive effect of glare; whether it leads to discomfort or disability glare depends on the intensity of the effect.

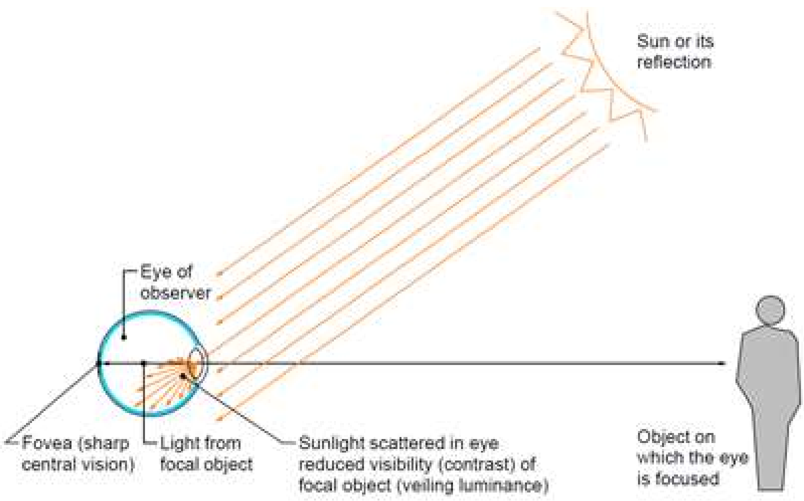


Figure 3 Bright sunlight falling into the eye reduces contrast and visibility of objects. This effect can be quantified by the equivalent veiling luminance measure.

Hassall proposes a workflow to track solar geometry, estimate sun intensity, establish actual façade reflectance, and numerically calculate a measure for the veiling effect. This measure, the equivalent veiling luminance, measured in Cd/m² (candela per metre squared), is a representation of apparent brightness to the human eye corrected for the angular distance of the glare source from the focus of vision, which reduces the veiling effect.

The Hassall methodology further proposes a limit of acceptability of equivalent veiling luminance of façade reflections for traffic of 500Cd/m². Where this is exceeded, solar reflections are considered as potentially causing disability glare.

6.2 Methodology

Arup use in-house developed software to carry out the Hassall calculation based on 3d models, capable of checking for annual worst-case reflections anywhere off the façade towards locations along a stretch of road. We have applied this software to a simplified model of the Powerhouse museum.

This involves several steps, as outlined below:

- The size, orientation and extent of reflective objects on each facade are determined by examination of drawings / 3d models provided by the architect, the site and surrounds, and expected glazing materials.
- Several observer locations are chosen for critical facades, representing locations from which traffic participants may observe the facades.
- Times at which the sun is reflected off the facade are determined, as well as the directions in which it is reflected.
- If the sun is reflected towards any observer, the equivalent veiling luminance in the eye of the observer is calculated and evaluated against the maximum allowed level of 500 Cd/m² according to Hassall. This involves calculations of the strength of solar illumination, the position of the sun in front of the facade, the apparent position of the sun reflected in the facade, and the reflected solar illumination received by the observer.
- If the limit is exceeded, further assessment is carried out to evaluate if other factors such as facade shading make the situation acceptable or not. Within his methodology, Hassall discusses situations where an undesirable amount of veiling glare is experienced but reflections fall outside the cone of sensitive vision and / or can be blocked by sun visor, hand or hat.
- On the multifaceted facades, the sun is only reflected by individual panels at a given time. Observed from a larger distance these do not reflect the full sun disk. In these cases it is reasonable to assume that the intensity of reflections off a panel is proportionally diminished with the percentage of the sun disk solid angle that is reflected by the same panel.

6.3 Assumptions

- Building geometry based on MKG drawings issued 2nd April 2020. Regarding the comment, typically we use the maximum of 20% but we can check with Jorg on Monday morning. Check wording
- All glazed facades have initially been assumed to have a reflectivity of 20% (external specular reflectivity at normal incidence). Where glass reflectivity needs to be limited below this in order to mitigate veiling glare, commentary is provided.
- It is assumed that to carry out the visual tasks required for traffic participation, drivers and pedestrians face parallel to the ground, and parallel to their direction of travel.

6.4 Modelling and Assessment Approach

This reflectivity study has used a digital 3D model of the proposed building and the surrounding context including buildings and topography. The model was developed from the architectural 3D model. Relative road elevation information was taken from available 3D topography.

Facades have been analysed in true elevation angles as provided with 3D model information by MKG. Small scale details such as joints, any expressed framing profiles, downpipes, etc has been omitted from the model. They subtend insufficient angles in the visual field to reflect a large enough portion of the sun disk to cause unacceptable glare.

Whilst the geometry of the trusses is included in the report for reference, the model has been analysed without these, excluding Section 7.4. This is because the size and location of the trusses have not been confirmed in this early stage design phase. The results are thus conservative where they disregard any overshadowing or obscuring effect of these trusses.

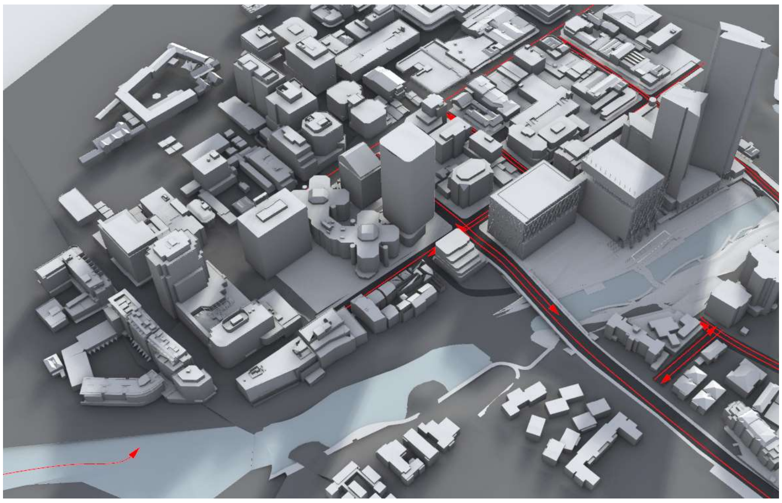


Figure 4: View of 3d model of proposed building and context. Surrounding buildings are included as overshadowing elements.

This model was used to interrogate the view of the building and solar reflections originating from it along the paths shown in Figure 5 and listed in Table 2.

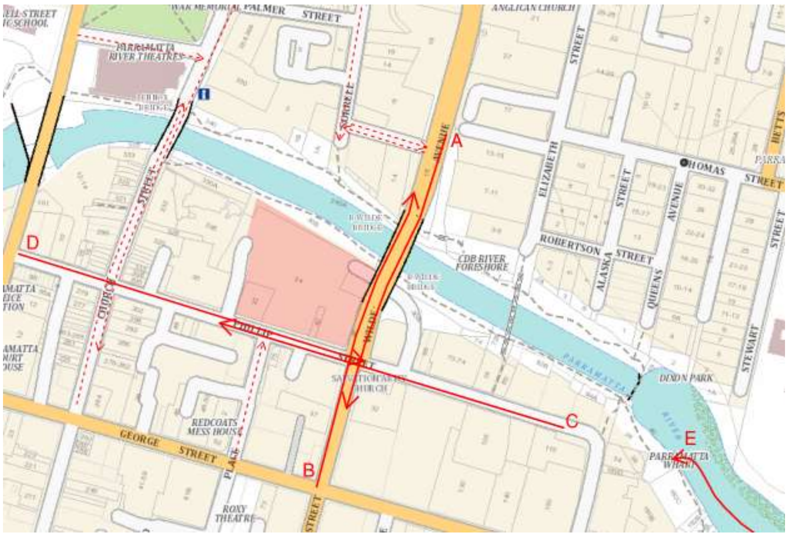


Figure 5: Site map showing observer paths from which glare has been assessed, with the New Powerhouse highlighted in red. Paths dotted in red indicate paths assessed, but not included in report due to negligible glare impact, e.g. New Powerhouse not within field of driver view, or of negligible luminance (less than 500 Cd/m^2).

Table 2: Observer paths assessed for reflected glare

Reference	Road	Dir.
A	Wilde Avenue	South
B	Wilde Avenue	North
C	Phillip Street	East
D	Phillip Street	West
E	Parramatta River – ferry approach	West

7 Results

Sections below comment on the expected impact of reflected glare on traffic by observer path reviewed.

Where reflections from the development can exceed the limit of acceptability set out by Hassall (500 Cd/m²), indicative perspective views are shown for a single viewpoint on these paths. Note however the modelled paths have been reviewed along their entire lengths.

The equivalent veiling luminance of reflections is colour coded in projected facades in perspective views. Façade areas are shown orange to red where reflections exceed the Hassall limit of 500Cd/m² for prevention of disability glare. Reflections off projected façade area shown in blue to cyan are below this limit in intensity.

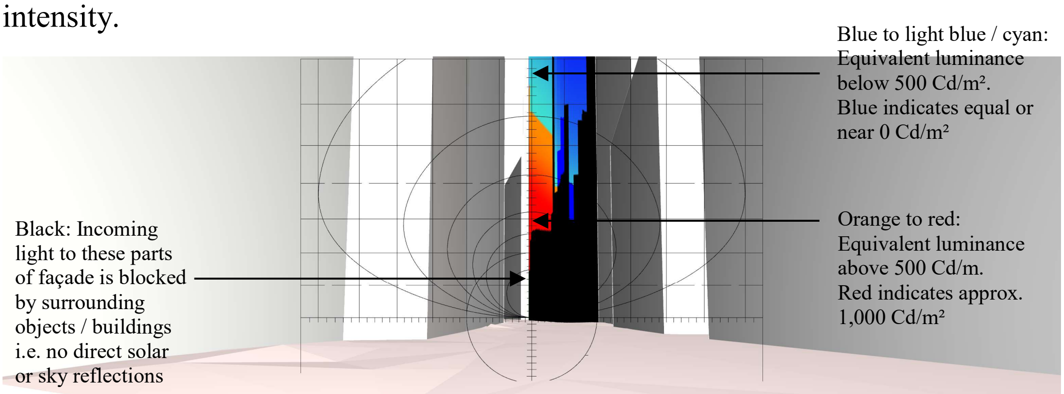


Figure 6: Key of colours indicating reflection intensity per Hassall calculation

7.1 Route A – Wilde Avenue heading south

From this location, solar reflections cast by the south façade remain below the 500 Cd/m2 threshold (up to 130 Cd/m² assuming 20% reflectivity of the glazing) towards drivers.

As a result, reflections are not expected to result in unacceptable glare towards drivers in this location.

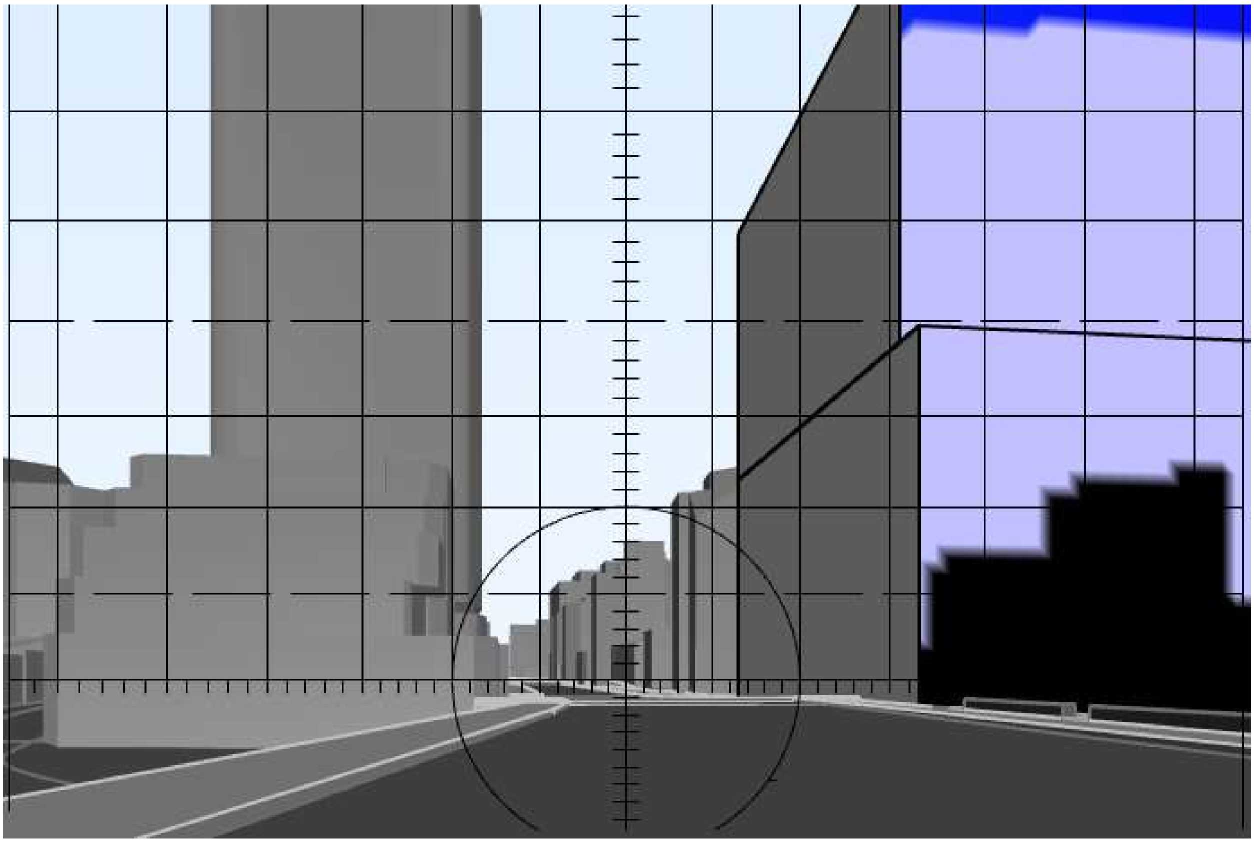


Figure 7: Perspective view from road – Wilde Avenue towards south

7.2 Route B – Wilde Avenue heading north

From this location, solar reflections cast by the south façade remain below the 500 Cd/m^2 threshold towards drivers.

As a result, reflections are not expected to result in unacceptable glare towards drivers in this location.

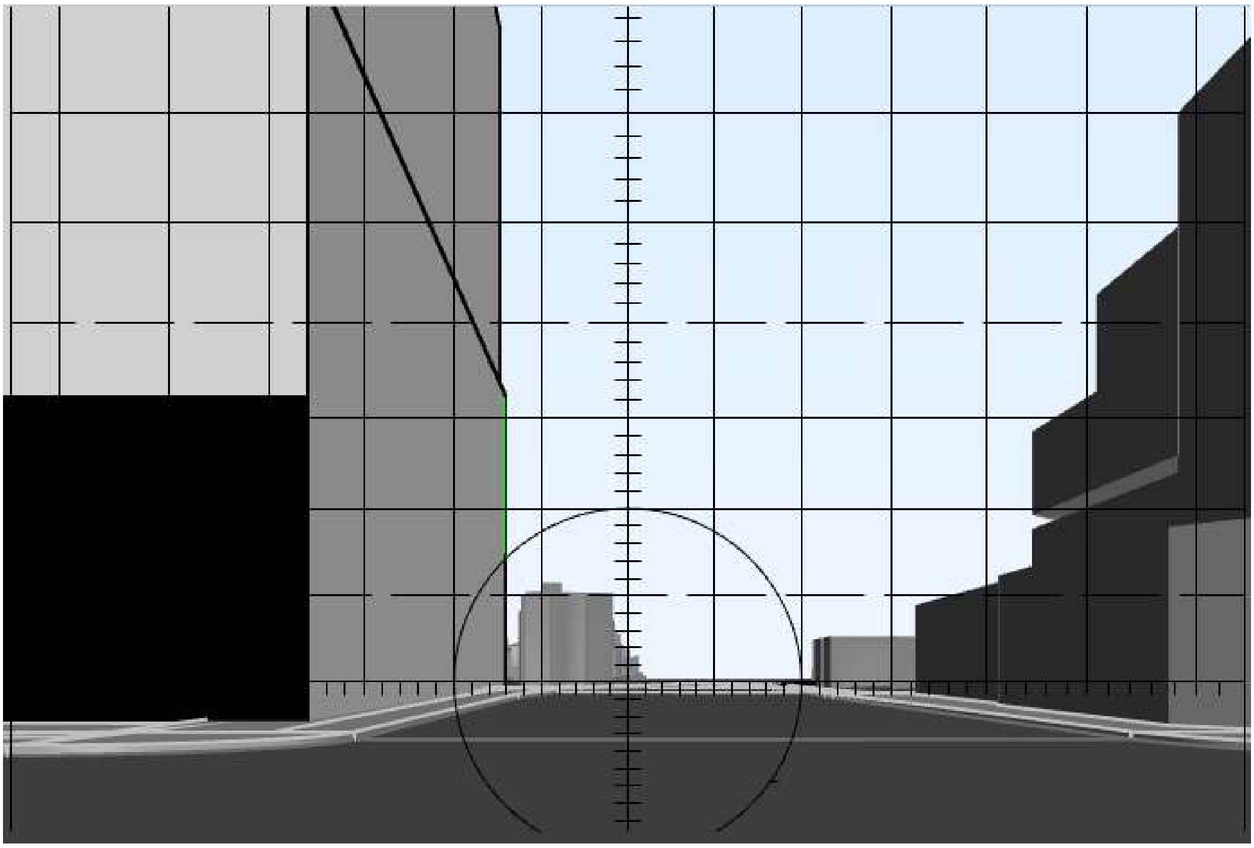


Figure 8: Perspective view from road – Wilde Avenue towards north

7.3 Route C – Phillip Street heading east

From this location, solar reflections cast by the south façade remain below the 500 Cd/m2 threshold (up to 200 Cd/m² assuming 20% reflectivity of the glazing) towards drivers.

As a result, reflections are not expected to result in unacceptable glare towards drivers in this location.

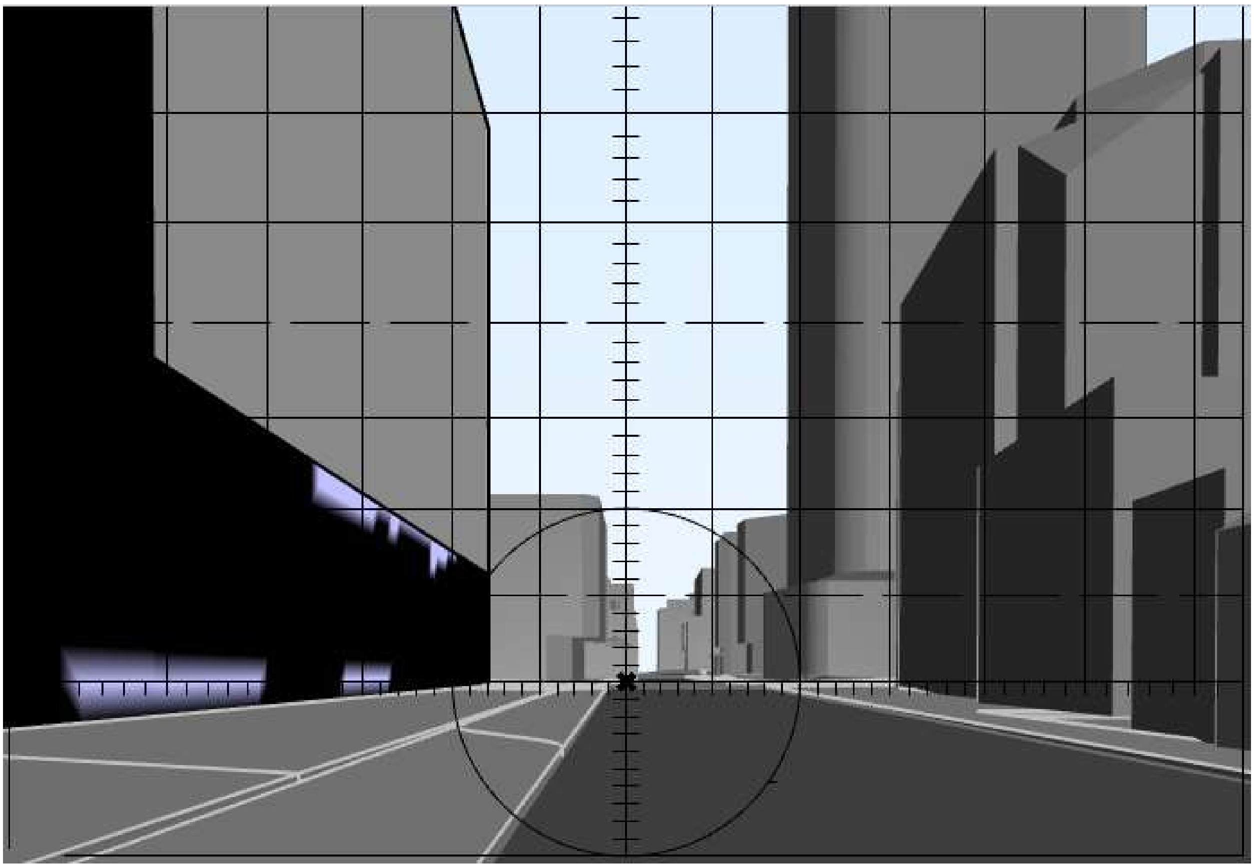


Figure 9: Perspective view from road - Phillip Street towards east

7.4 Route D – Phillip Street heading west

From this location, the south and east facades can cast solar reflections above the 500 Cd/m^2 threshold (up to 1700 Cd/m² assuming 20% reflectivity of the glazing) towards drivers.

When the model is analysed without the truss structure (Figure 8), some reflections are still visible below the 5° sun visor cut off proposed by Hassall. However, with inclusion of the truss structure (Figure 9), these appear to be significantly blocked and/or shaded (indicated by regions of black next to the trusses in Figure 8) such that it is unlikely that the full sun disk reflection is visible below 5°.

Excessive reflections on the south façade that occur above the 5° sun visor cut off proposed by Hassall are considered acceptable. Given that the speed limit on this road is 40km/h, it can be assumed that it is safe for drivers to adjust the sun visor to control glare per the Hassall methodology.

For the above reasons, reflections are not expected to result in unacceptable glare towards drivers in this location.

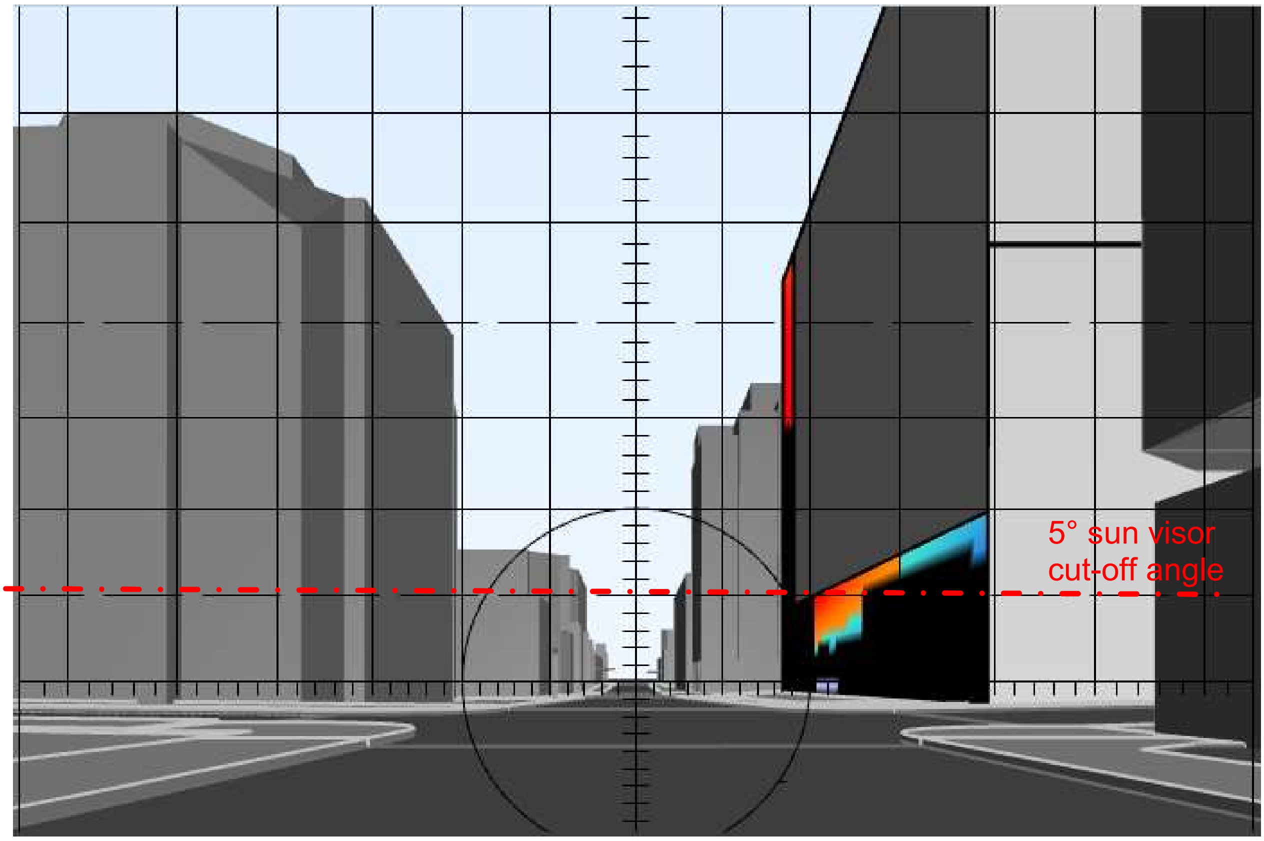


Figure 10: Perspective view from road excluding truss structure - Phillip Street towards west

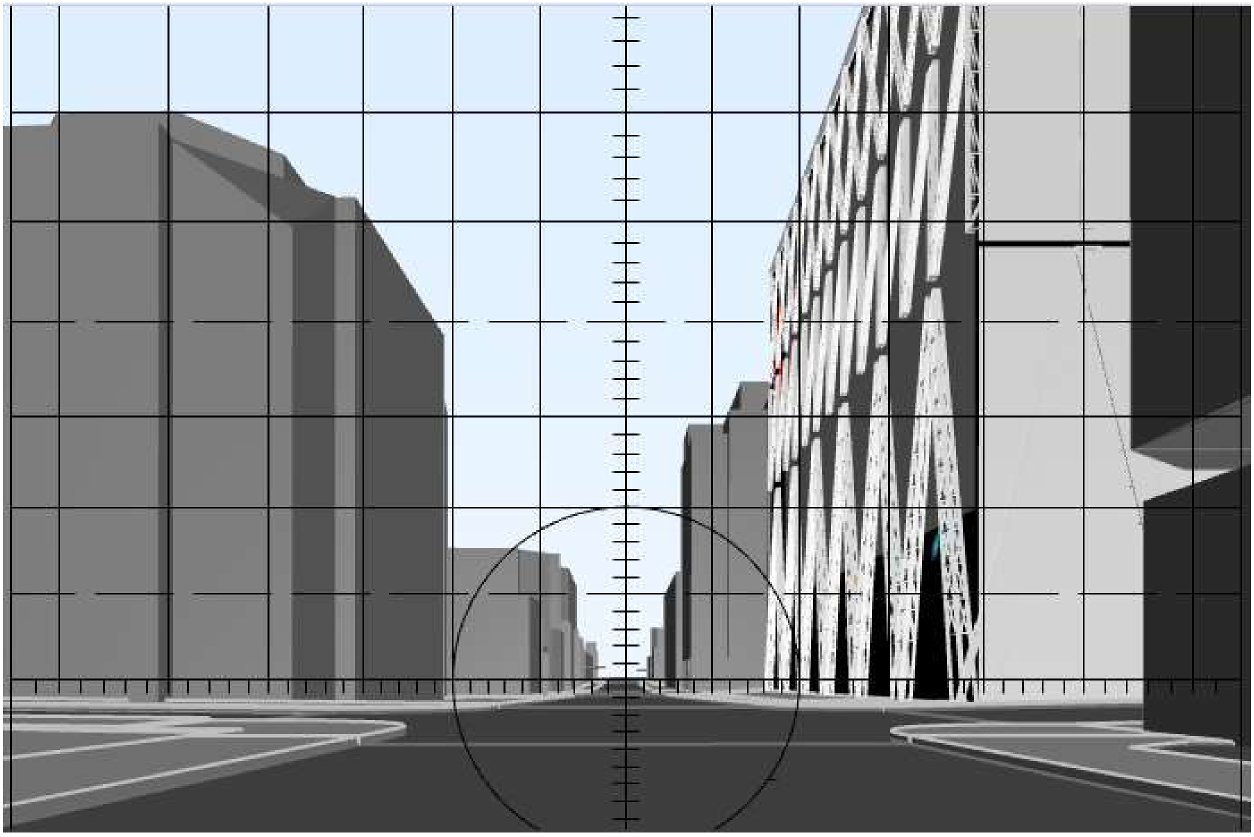


Figure 11: Perspective view from road with the inclusion of the truss structure - Phillip Street towards west

7.5 Route E – Parramatta River ferry approach

Whilst we are not aware of guidance for glare requirements for ferry operators the approach on Paramatta River has been reviewed using the method as for road traffic.

Viewed from the river, the east facades can cast solar reflections above the 500 Cd/m^2 threshold towards ferry operators. This however only occurs at the ferry's turning circle, i.e. when the ferry turns to dock at the wharf (Figure 11). For the majority of the ferry's travel parallel to the river, the reflectance is below the 500 Cd/m2 threshold (Figure 10).

Due to the slow speed of travel of ferries, especially at the turning circle, it can be assumed that analogous to the Hassall methodology assumptions for slower speed roads, ferry operators can adjust their vision to control glare. While the assumption that view follows the travel path is valid for travelling along the river, at this last location, it is likely that ferry operators will need to direct their view towards the wharf rather than towards the building.

It is further noted that a review of existing facades facing the river ferry approach indicates that these also cast reflections exceeding the Hassall threshold at similar angles. The reflections cast by the proposed development thus do not create a new unusual reflected glare situation for ferry drivers.

For the above reasons, reflections are not expected to result in unacceptable glare towards ferry operators in this location.

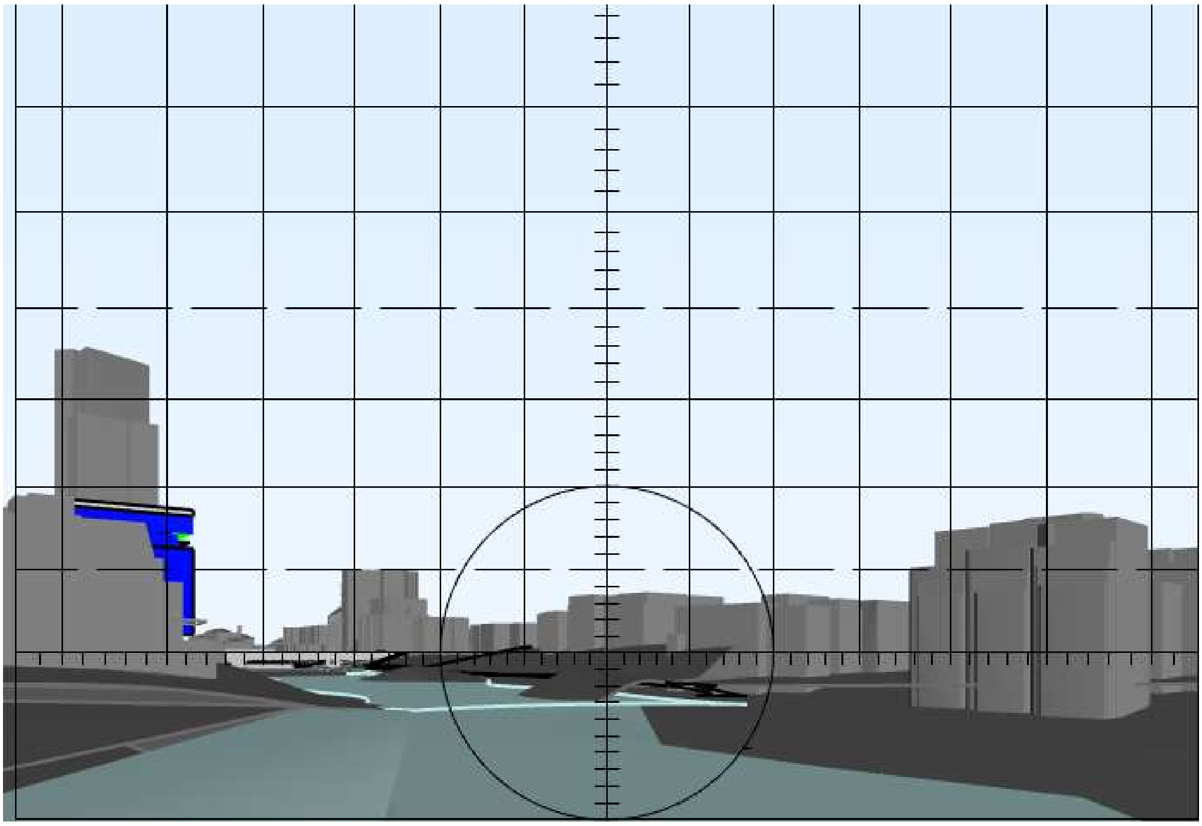


Figure 12: Perspective view from river at ferry's line of travel parallel to the river

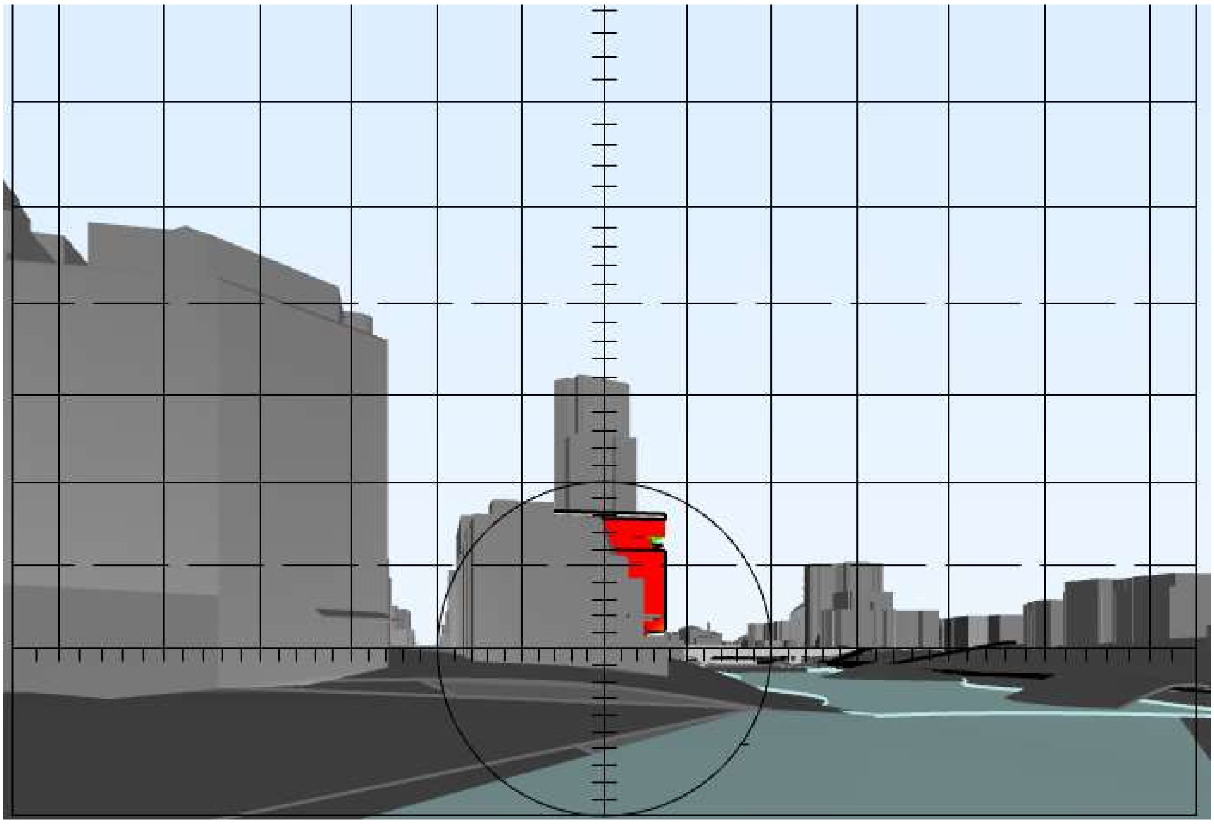


Figure 13: Perspective view from river at ferry's turning circle

7.6 Results Summary

The following table summarises the outcome of the reflectivity assessment for individual roads reviewed:

Ref.	Route	Driving direction	Maximum L_v identified [Cd/m^2]	Note
A	Wilde Avenue	South	< 130 Cd/m^2	Within acceptable requirements
B	Wilde Avenue	North	< 30 Cd/m^2	Within acceptable requirements
C	Phillip Street	East	< 200 Cd/m^2	Within acceptable requirements
D	Phillip Street	West	1700 Cd/m^2	Reflections that occur above the 5° sun visor can be mitigated using sun visor which is deemed acceptable by Hassall for comparable situations. Reflections that occur below the 5° sun visor can be significantly blocked and/or shaded by the truss structure such that it is unlikely that the full sun disk reflection is visible below 5°.
E	Parramatta River – ferry approach	West	< 500 Cd/m^2 (Typically on ferry travel path) 7000 Cd/m^2 (At turning circle)	Reflections that exceed 500 Cd/m^2 occur only at the ferry's turning circle. Due to the slow speed of travel of ferries, ferry operators can adjust their vision to control glare.

Table 3: Summary of roads reviewed for sun reflections.

Reflected glare risk to traffic participants in other locations could be discounted for all visible facades for either of the following reasons:

- The intensity of any reflections will be below the limit of acceptability set out by Hassall (500 Cd/m^2);
- Surrounding buildings and topology or other parts of the building itself will be blocking reflections that could cause glare to drivers; or
- The position of reflections within the visual field is not critical and would allow traffic participants blocking with sun visor.

These findings are valid as long as glazing and cladding reflectivity is kept within the following limits:

- **All glazed facades: 20%**

This result is obtained in spite of worst case assumptions about the extent of reflective facade cladding, and not taking into account obscuring effects from hard to assess smaller façade elements and surrounding vegetation.

7.7 Impact on Traffic in Other Locations

From further afield (e.g. on hill areas in other suburbs) it may be possible that other locations exist where the building can be seen from road level. These would however be at a distance where typical glazing surfaces of the building would subtend angles significantly smaller than the sun disk, and scattering effects from small misalignments (e.g. due to construction tolerances) would reduce the observable intensity of reflections, so that it is not expected to be high enough to create unacceptable glare.

7.8 Impact on Pedestrians

From the perspective of pedestrians moving along roadways, the incidence of reflections from the building is generally similar to the examined road traffic locations. Glare from reflections is therefore expected in similar locations.

Furthermore, pedestrian observers are easily able to adjust their view and thus reduce the glare impact of reflections. They move at a rate significantly slower than that of a vehicle. For this reason it can be assumed that it will be safe for pedestrians to divert their vision in order to avoid glare.

7.9 Impact on Surrounding Buildings

Solar reflections off the facade may reach surrounding buildings in the Parramatta CBD area, as would be expected for any glazed façade in a dense urban context that can be reached by sunlight.

In general, reflections from façades with normal external reflectance below 20% are much less likely to cause discomfort to occupants of surrounding buildings than facades with strongly reflective glazing. The proposed building is targeting a glass reflectance below 20%, which will serve to reduce any potential glare reflections that may occasionally be produced towards pedestrians and other buildings.

8 Conclusion

The reflectivity assessment shows that proposed development is unlikely to result in unacceptable glare under the Hassell methodology on the main traffic routes around the building, pedestrians or surrounding buildings.

While some reflections are above the threshold recommended by Hassell, the above results summary indicates that these may be mitigated. While the view of the Paramatta River ferry approach indicated some strong reflections these only occurred at the point of turning towards the wharf where it is assumed that operators can adjust their view towards the wharf to avoid glare.

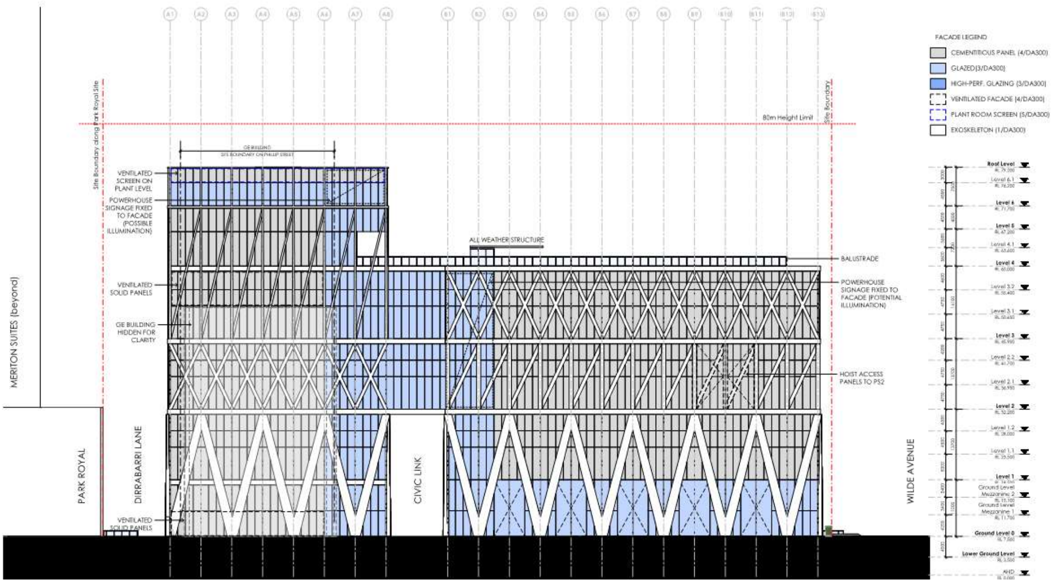
Appendix A

Reference Information

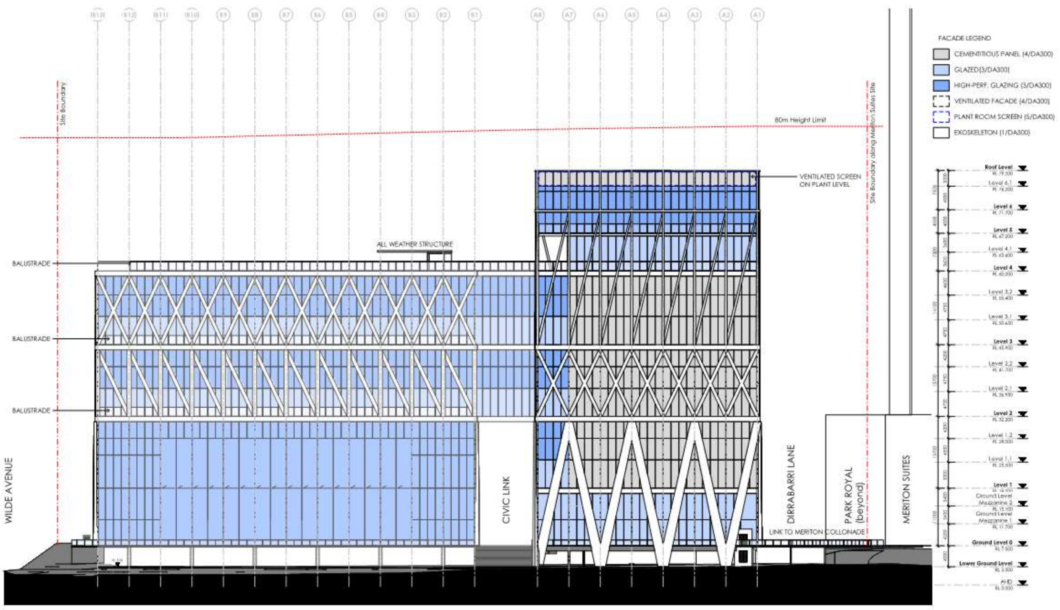
A1 Architectural Drawings

The reflectivity study presented in this report was based on Rhinoceros 3D model information provided by MKG on 3rd March 2020

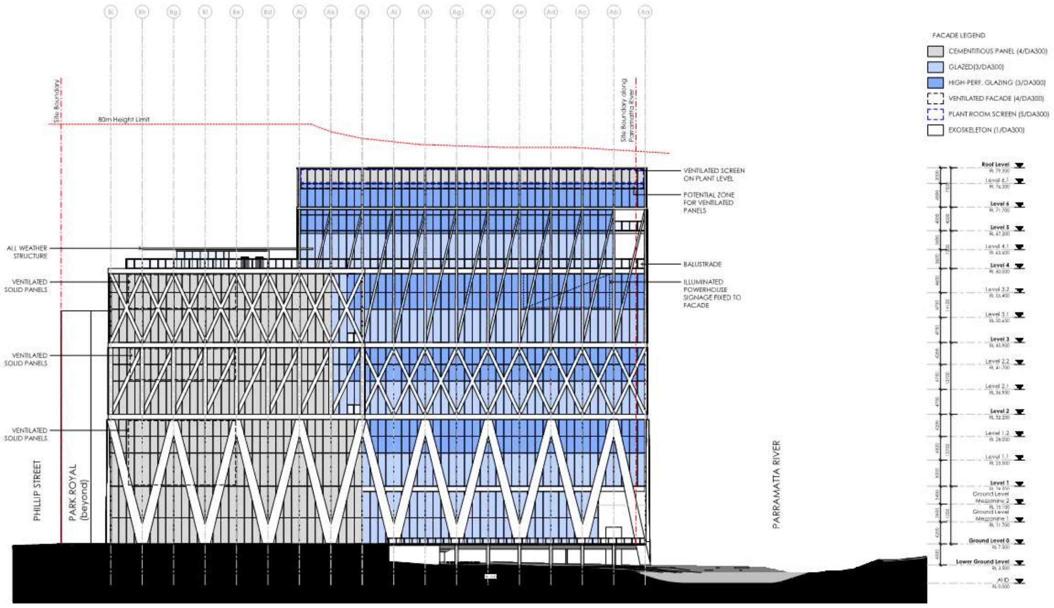
Reference façade elevations for the scheme current as of 2nd April 2020, issued 2nd April 2020 are below.



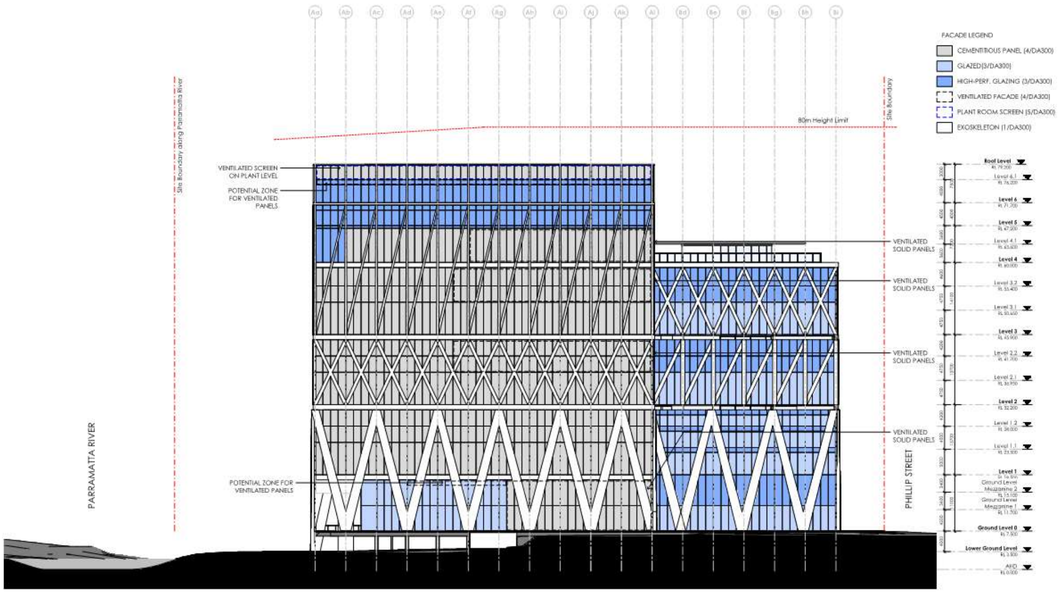
South Façade



North Façade



East Façade



West Façade

Figure 14: Façade elevations by MKG issued 2nd April 2020

A2 References

Hassall, D. N. H. (1991): Reflectivity. Dealing with Rogue Solar Reflections, Faculty of Architecture, University of New South Wales, ISBN 0 646 07086 X