WATERLOO COLLECTIVE | mirvac JOHN HOLLAND

WATERLOO METRO QUARTER OVER STATION DEVELOPMENT

Environmental Impact Statement
Appendix K – Solar Reflectivity

SSD-79307765 Second Amending Concept

Detailed State Significant Development
Development Application

Prepared for **WL Developer Pty Ltd**

September 2025

DOCUMENT CONTROL

Version	Status	Date	Prepared By	Reviewed By
1	Initial	12 September 2025	TYT / YCY	GEL
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3	Final – SSDA Submission	22 September 2025	YCY	GEL

NOTE

RWDI

RWDI is a team of highly specialised consulting engineers and scientists working to improve the built environment through three core areas of practice: building performance, climate engineering, and environmental engineering. More information is available at www.rwdi.com.

EXECUTIVE SUMMARY

This Solar Reflectivity Assessment has been prepared by RWDI Australia Pty Ltd (RWDI) to accompany a State Significant Development Application (SSDA) for Waterloo Metro Quarter (WMQ) located at 150 Cope Street, Waterloo ("the Project"). This report pertains to the Second Amending Concept DA (SSD-79307765).

The results and conclusions of the study are summarised as follows:

Thermal Impact on Surrounds

The planar and convex nature of the facades of the Project ensure that multiple reflections will not converge. Therefore, RWDI does not expect any significant thermal impacts (i.e. risks to human safety or property damage) to occur either on the site or in the surrounding neighbourhood.

Visual Glare Impact on Drivers

As with any glazed building, drivers travelling in the vicinity of the Project (i.e. along Botany Rd, Raglan St, Cope St and Cope St Plaza) were predicted to experience reflections emanating from the Project. Based on the detailed results, the predicted reflections falling on one receptor (D6 - westbound driver on Raglan St) was above the veiling luminance threshold of 500 cd/m^2. However, all of the potential glare at this receptor was predicted at times when the sun would also be within the driver's view. This represents a situation where a drive would already experience intense glare from the sun, likely reducing the perceived impact of any reflected light due to both the intensity of the sun compared to the reflection, but also because a driver would already expect glare to occur at that time from that location. All remaining studied driver receptors were predicted to achieve reflections below the veiling luminance threshold of 500 cd/m^2. Based on these findings, no design changes are recommended.

Cumulative Impact Assessment

No additional glare impacts were predicted due to the future Waterloo Park redevelopment as compared to the existing surrounds.

Additional details on when reflections were predicted to occur at the receptors, as well as predicted durations and intensities, can be found in Appendix B.

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1 INTRODUCTION

This report has been prepared by RWDI Australia Pty Ltd (RWDI) on behalf of WL Developer Pty Ltd (the applicant) to accompany a State Significant Development Application (SSDA) for Waterloo Metro Quarter (WMQ) located at 150 Cope Street, Waterloo (the Project). Specifically, this application relates to the Second Amending Concept DA (SSD-79307765).

This report has been prepared to respond to Item 6 of the Planning Secretary's Environmental Assessment Requirements (SEARs) issued by Department of Planning, Infrastructure and Housing (DPHI) on 13 February 2025.

The Second Amending Concept DA is a new concept SSDA made under Section 4.22 of the Environmental Planning and Assessment Act 1979 (EP&A Act). It seeks consent for an amendment to the Waterloo Metro Over Station Development (OSD) Concept DA (SSD 9393) (the Concept DA). As the Concept DA has previously been amended by an Amending Concept DA (SSD 10441) (hereafter referred to as the First Amending Concept DA), the subject amending DA is hereafter referred to as the Second Amending Concept DA.

Whilst the Concept DA relates to the whole WMQ site, the changes now proposed under the Second Amending Concept DA only relate to the Northern and Central Precincts of the overall WMQ site. The image below indicates the land to which the Second Amending Concept DA applies.

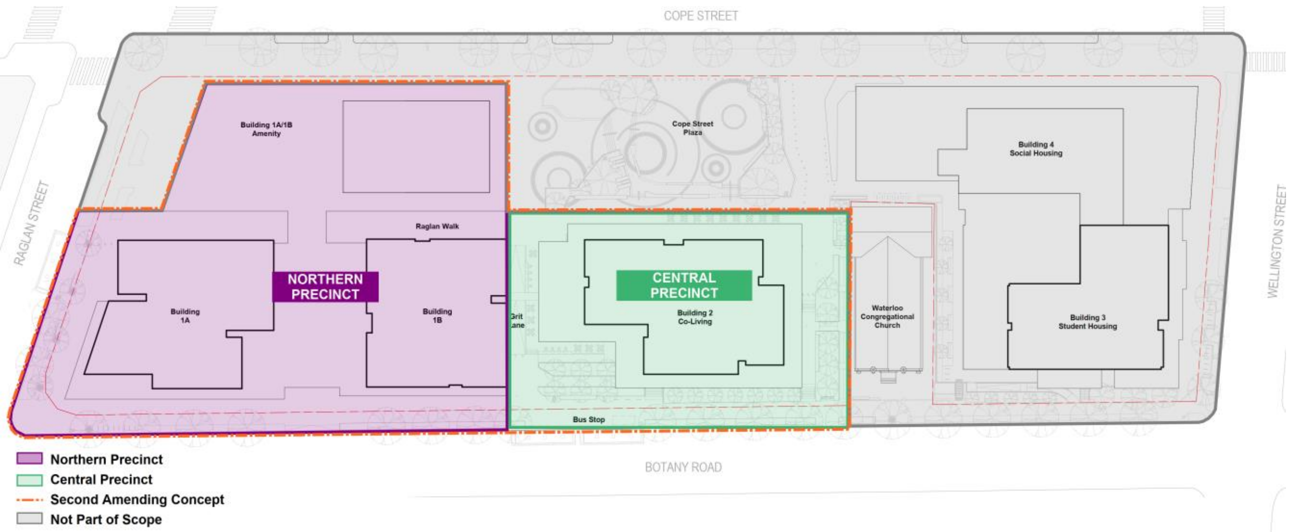


Figure 1: Land to which Scoping Reports Apply

Central Precinct

The Second Amending Concept DA seeks consent to modify the existing concept approval as it relates to the Northern and Central Precincts, by amending the building envelopes to redistribute floor space to suit a new mix of land uses. Specifically, the proposal seeks the following:

- Northern Precinct:
    - Change the approved building envelope, building height and concept land use for the Northern Precinct by replacing the 17-storey commercial office building envelope with a revised envelope for 2 residential apartment towers above a non-residential podium.

    - The residential towers will include market housing, communal facilities and the provision of 5% affordable housing.
- Central Precinct
    - Change the approved building envelope and conceptual land use for the Central Precinct by replacing the residential apartment tower with a co-living housing tower, still above a non-residential podium, comprising retail and a community facility in the form of a childcare.

There will be no change to the maximum permitted GFA, as the floorspace will be redistributed within the revised envelopes. Further, the amended proposal will not exceed the permissible building height for the site under the SLEP 2012. No detailed design or physical works is proposed under this application.

Separate Detailed SSDAs will be submitted for the detailed design, construction and operation of the Northern Precinct (SSD-79307758) and Central Precinct (SSD-79307746) of the WMQ site, to be assessed concurrently with the subject amending Concept DA. The detailed SSDAs have been prepared to be consistent with the Concept SSDA as amended by the subject application.

Separately, a Section 4.55 Modification Application will be submitted to modify the approved detailed Basement SSDA (SSD 10438) relating to the basement levels to buildings within the Northern and Central Precinct.

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 13 February 2025 and issued for the SSDA (79307765). Specifically, this report has been prepared to respond to the SEARs requirement issued below.

Table 1: SEARs Compliance Table

SEARs Request	Response / Location in Report
Item 6 - Environmental Amenity • Address how good internal and external environmental amenity is achieved, including access to natural daylight and ventilation, pedestrian movement throughout the site, access to landscape and outdoor spaces. • Assess amenity impacts on the surrounding locality, including lighting impacts, **reflectivity**, solar access, visual privacy, view loss and view sharing, overshadowing and wind impacts. A high level of environmental amenity for any surrounding residential or other sensitive land uses must be demonstrated. • Provide a solar access analysis of the overshadowing impacts of the development within the site, on surrounding properties and public spaces (during summer and winter solstice and spring and autumn equinox) at hourly intervals between 9am and 3pm, when compared to the existing situation and a compliant development (if relevant). • For applicable developments, provide an assessment of the development against the Housing SEPP and the Apartment Design Guide.	Section 3

2 BACKGROUND

2.1 Understanding Urban Reflections

While a common occurrence, solar reflections from buildings can lead to numerous visual issues including:

Visual Glare

- Impair the vision of motorists and others who cannot easily look away from the source;
- Cause nuisance to pedestrians or occupants of nearby buildings; and
- Create undesirable patterns of light throughout the urban fabric.

Heat Gain

- Affect human thermal comfort;
- Be a safety concern for people and materials, particularly if multiple reflections are focused in the same area; and
- Create increased cooling needs in conditioned spaces affected by the reflections.

The most significant safety concerns with solar reflections occur with concave facades which act to focus the reflected light in a single area. The current design does not feature concave elements. As such, the focusing of energy is not expected from this project.

However, the level of impact of these issues on people and property will be influenced by many other factors that are unique to the reflecting surface(s), the individual(s)/object(s) exposed to reflections and the environment around them. In a complex urban space, these factors are often difficult to reasonably predict, if they can be predicted at all.

As such, it must be acknowledged that there is an element of uncertainty and subjectivity to any reflection analysis, particularly when it comes to visual glare which is inherently a subjective experience and lacks a universally agreed upon quantifiable definition. The metric and threshold used by RWDI (detailed in Appendix A) are based on industry standard approaches in Australia, but as noted above, are subject to a degree of uncertainty/subjectivity. This means that the possibility of reflection impacts from a building can never be completely ruled out through simulation.

2.2 Methodology

The analysis was conducted using RWDI's in-house proprietary *Eclipse* simulation engine. The first phase was a 'Screening Analysis' which predicted the frequency of occurrence of reflections from both Northern Precinct and Central Precinct for every hour of a full calendar year. These values were computed on 'presentation surfaces' located approximately 1.5 m above grade-level for drivers within an approximately 600 m radius of the Project (Figure 3). Note that this analysis included the existing surrounding context and buildings currently under construction (anticipated to be completed at the time of completion of subject development) and excluded proposed developments that are currently under assessment or approved (i.e., not yet under construction).

An additional configuration incorporating future Waterloo Park located immediately east of the Project was also assessed and discussed in Section 4.1. Note that the screening analysis intentionally assumed a very conservative direction in which the viewer is facing (horizontal, but directly towards the building).

A total of two configurations were studied for this assessment:

- **Existing Configuration (Figure 2):** existing surrounds context and buildings currently under construction;
- **Future Configuration (Figure 3):** existing surrounds context and buildings currently under construction, with future Waterloo Park redevelopment located immediately east of the Project included.

Should the potential for glare exist on roadways or other sensitive spaces, multiple 'receptor points' are selected to undergo the second 'Detailed Analysis' phase. This analysis works similarly to the screening simulation, except glare is tested at one-minute increments and a direction of view is explicitly prescribed. This yielded detailed predictions at specific locations of when reflections can occur, how long they can occur for, and the locations of problematic glare sources. The detailed study also provides the level of reflectivity reduction required to comply with local criteria.

As reflections were predicted on sensitive spaces, the detailed assessment was undertaken for this Project. Note that the detailed analysis was not intended to be an exhaustive investigation of all locations where reflections are possible. It was instead intended to provide an understanding of the range of possible reflection characteristics from the Project.

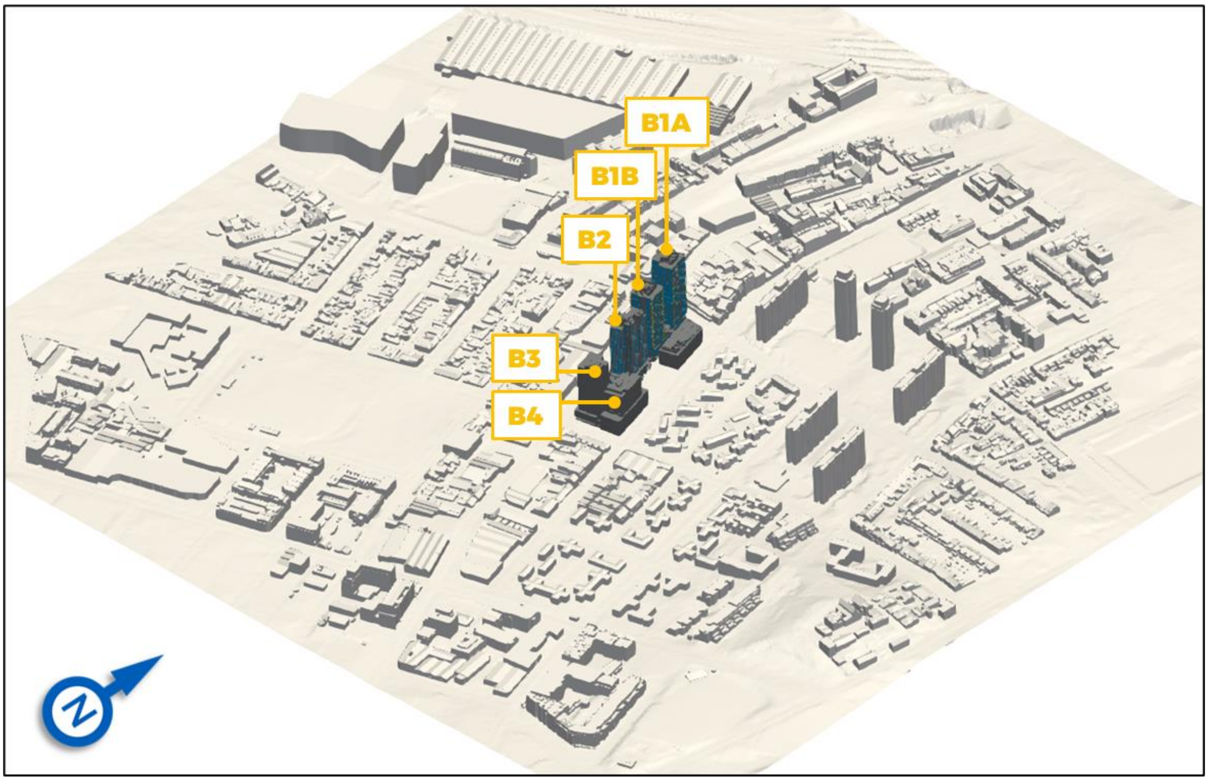
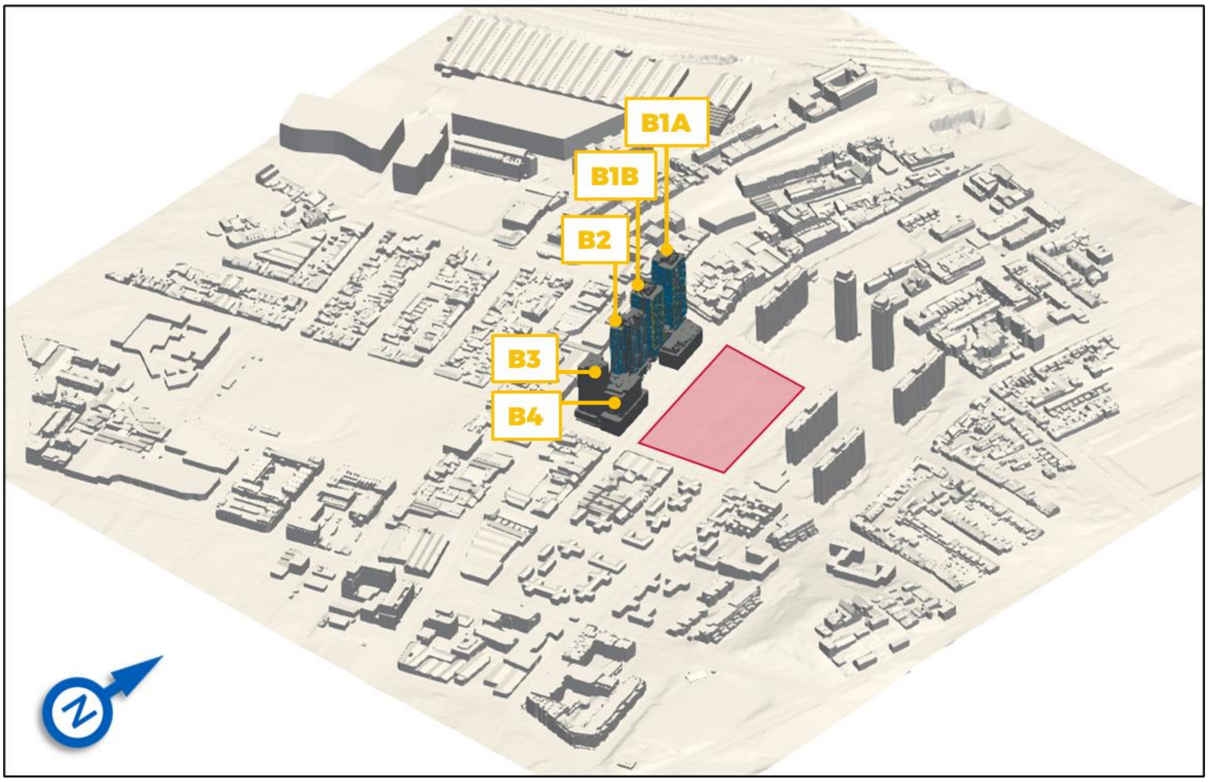


Figure 2: 3D Computer Model of the Project and Existing Surrounding Context



(b)

Figure 3: 3D Computer Model of the Project and Existing Surrounding Context with future Waterloo Park Redevelopment (highlighted in Red)

2.3 Assumptions and Limitations

2.3.1 Meteorological Data

This analysis used 'clear sky' solar data computed at the location of Sydney International Airport using the method promulgated by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE). This approach used mathematical algorithms to derive solar intensity at a given location, ignoring the localised effects of cloud cover. This provides a 'worst case' scenario showing the full extent of when and where glare could ever occur.

2.3.2 Radiation Model

RWDI's analysis is only applicable to the visual impacts of solar radiation (i.e. visible wavelengths only) on people including drivers in the vicinity of the development. It did not consider the impact of the building related to any other forms of radiation, such as thermal energy, cellular telephone signals, RADAR arrays, etc.

2.3.3 Study and Surrounds Models

The analysis was conducted based on 3D models of the Project provided to RWDI on the following dates. This scheme is referred to as the 'Proposed scheme' in this report:

- **Building 1A and 1B:** Woods Bagot Pt Ltd to RWDI on August 11, 2025;
- **Building 2:** Bates Smart to RWDI on August 15, 2025;

At the time this reflectivity study was carried out, the final revision of the architectural drawings had not yet been issued, and the analysis was based on the 3D models available at that time. The design has since remained consistent, with no changes affecting the reflectivity outcomes. Therefore, the results of this report are fully applicable to Appendix E Architectural Drawings Revision 01.

The surrounding model was generated based on publicly available data and previous RWDI projects in the area. This analysis included the existing surrounding context and buildings currently under construction (anticipated to be completed at the time of completion of subject development) and excluded proposed developments that are currently under assessment or approved (i.e., not yet under construction), as this would be conservative on the reflections falling on the public realm. An additional configuration incorporating future Waterloo Park located immediately east of the Project were also assessed (Figure 3b) and discussed in Section 4.1. All data sources were cross-checked against LiDAR data published by the NSW Department of Finance, Services, and Innovation. This dataset was also used to generate the ground surface and has a stated vertical and horizontal accuracy of 0.3m and 0.8m, respectively (both at a 95% confidence interval).

Potential reductions of solar reflections due to the presence of vegetation or other non-architectural obstructions (such as railings) were not included, nor were reflections from other buildings, per standard industry practice. Light that has reflected off several surfaces was assumed to have a negligible impact. As such, only a single reflection from the Project was included in the analysis.

This analysis assumed that all reflective elements are in their as-designed condition, (i.e. clean, free from damage, degradation, distortion, etc.) and that the building envelopes of all buildings are complete and uncompromised (i.e. any elements of the walls/roofs that are not designed to be exposed to sun, are shielded).

The results presented in this report are highly dependent on both the form and materiality of the Project. Should there be any changes to the design, it is recommended that RWDI be contacted and requested to review their potential effects on the findings of this report.

2.3.4 Facade Material Reflectance

The Sydney Development Control Plan (DCP) 2012 Section 3.2.7 stipulates that "generally, light reflectivity from building materials used on facades must not exceed 20%". Therefore, for the purpose of this analysis, all glazing has been conservatively assumed to have a nominal 20% reflectivity for visible light which increases with the angle of incidence as the rays approach perpendicular to the surface. Glass balustrades have been conservatively assumed to have a nominal visible reflectance and transmittance of 20% and 80%, respectively. While the nominal reflectivity values of the Insulated Glass Units (IGU) are noted above, the reflectivity of glass will increase exponentially as light strikes it at increasingly glancing angles. This effect was included in the simulations.

RWDI also notes that only the glazing elements on Buildings 1A, 1B, and 2 have been studied; all other building (including B3 and B4)/facade elements were assumed to be non-reflective. For Buildings 3 and 4 forming part of the overall precinct, these buildings are already approved/constructed, and as relevant reflective surfaces are parallel to those on Buildings 1A, 1B, and 2, reflections would not overlap, and hence have not been included in this assessment.

The locations of the reflective materials on the facades are illustrated in Figure 4.

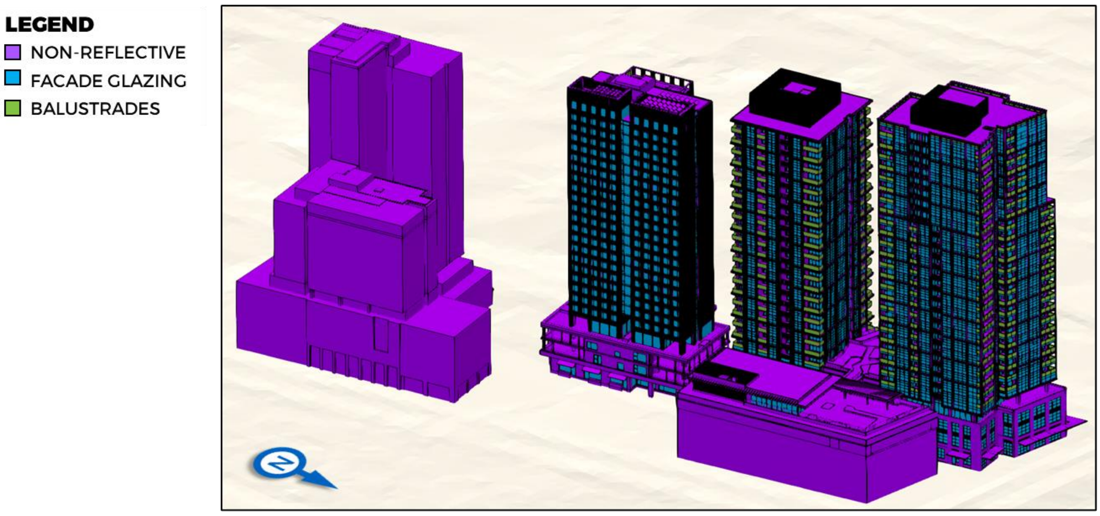


Figure 4: Locations of Reflective Building Elements (Surrounding Context removed for Clarity)

2.3.5 Human Factors

This analysis also assumes reasonable and responsible behaviour on the part of people in the vicinity of the development. A reasonable and responsible person would not purposely look towards a bright reflection, purposely prolong their exposure to reflected light, or otherwise intentionally try to cause discomfort/harm to themselves or others and/or damage to the property.

3 RESULTS AND DISCUSSION

3.1 Screening-Level Analysis

3.1.1 Presentation of Results

This section presents the screening results pertaining to the solar impacts of the Project on the surrounding urban area.

The **Peak Annual Reflected Irradiance** plot (Figure 5a) identifies the maximum intensity of solar energy reflected from the building at any point in the year. The plot identifies any areas where solar energy may be concentrated and create thermal risks. As a reference point, 800 W/m^2 is a typical maximum intensity of direct sunlight.

The **Percentage of Time Above the Veiling Luminance Threshold** plot (Figure 5b) identifies the percentage of day-time hours where the veiling luminance for the existing configuration and future configuration was predicted to exceed the 500 cd/m^2 limit proposed by Hassall (1991) (see Appendix A). *Note that, as a conservative assumption, at each location, it is assumed that the viewer is always facing horizontally towards the source of any reflection that can reach them.*

The veiling luminance-based results present predictions for a 60-year-old viewer. This represents approximately the 80^{th} percentile age of the residents of New South Wales, which means that veiling luminance will be lower than these predictions for 80% of the population.

It is important to understand that the figures do not show a specific moment in time, but rather present aggregated reflection predictions for an entire year.

In order to attain a complete understanding of the impact that reflections may have on people, other factors must be considered, including the duration of the reflections, when they occur and where the viewer is looking. The following plot serves to illustrate the general characteristics of reflections from the Project and informed the locations of the receptor points selected for the detailed phase of work, which analysed these factors in greater detail.

3.1.2 Results – Peak Annual Reflected Irradiance

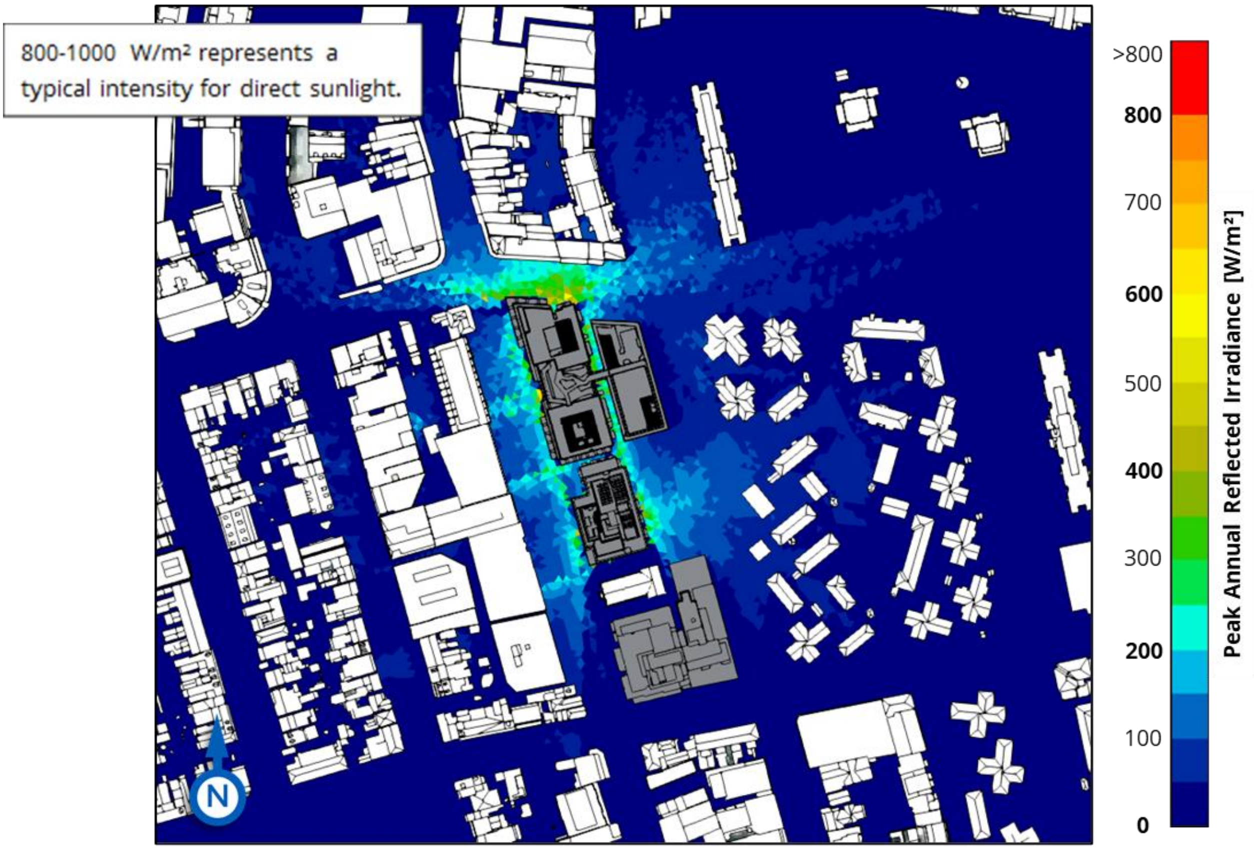


Figure 5a: Maximum Annual Intensity of Reflections at Pedestrian Height

3.1.3 Results – Percentage of Record Above Veiling Luminance Threshold

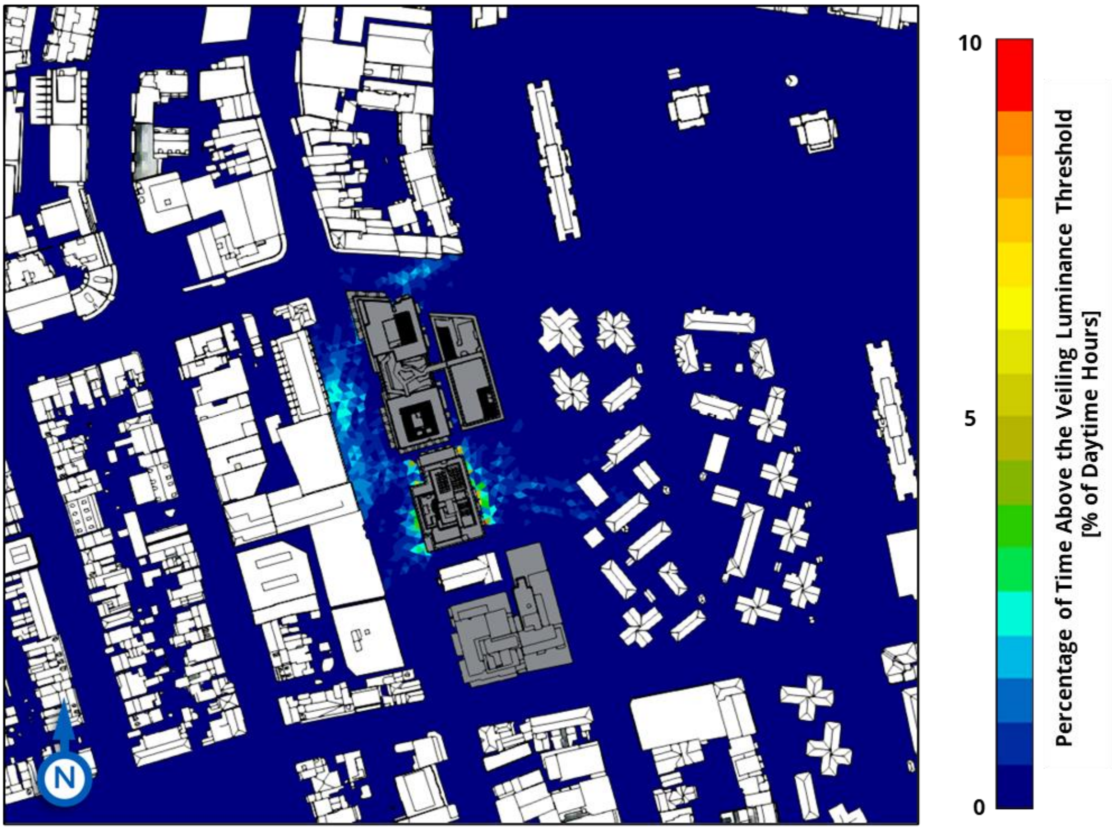


Figure 5b: Frequency (% of Daylit Hours) Where Veiling Luminance Above Threshold were Predicted at Pedestrian Height for an 80th Percentile Resident (Age 60)

3.2 Detailed Analysis

3.2.1 Receptor Locations

Based on the findings of the Screening Analysis, 8 representative points were selected for the Detailed Analysis. These points are described in Table 3 and illustrated in Figure 6. Unless otherwise indicated, all points are located at a height of 1.5m above local grade.

Table 3: Receptor Descriptions

Receptor Number	Receptor Description
D1	Southbound drivers on Cope Street at Raglan Street
D2	Eastbound drivers on Raglan Street at Botany Road
D3	Northbound drivers on Botany Road
D4	Northbound drivers on Cope Street near Cope St Plaza
D5	Eastbound drivers on Henderson Rd turning right onto Botany Rd
D6-D7	Westbound drivers on Ragland St
D8	Southbound drivers on Cope St entering roundabout

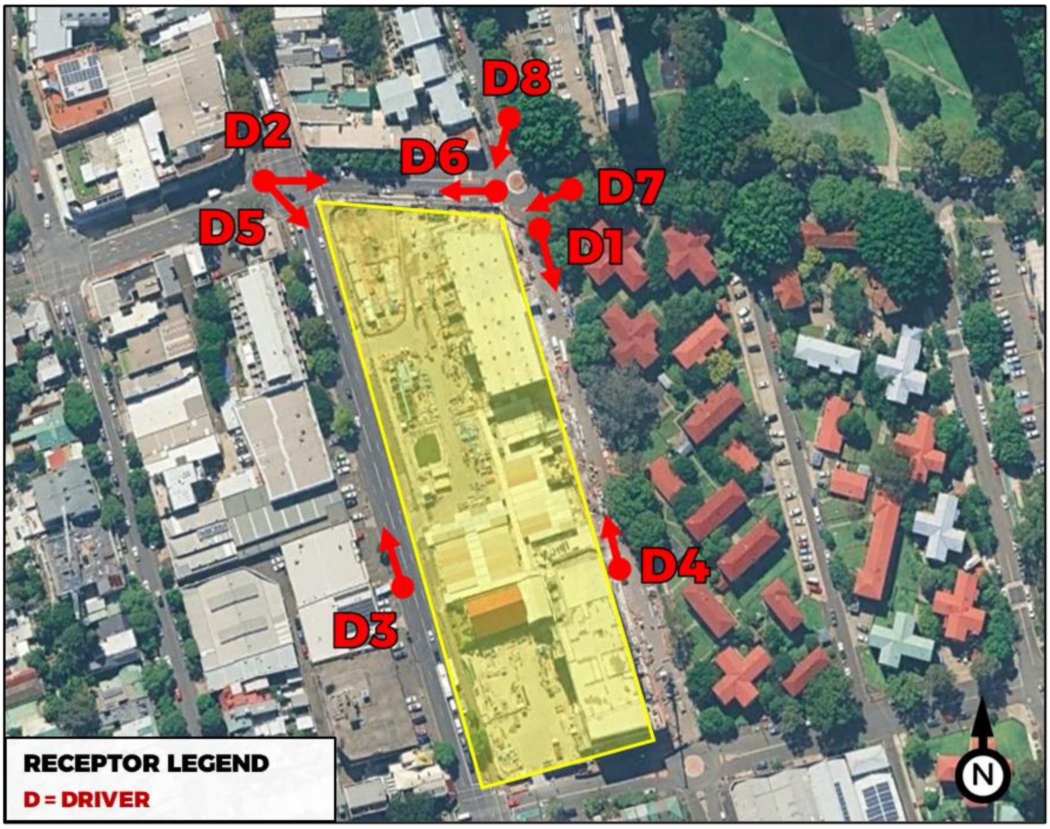


Figure 6: Receptor Locations with Underlay (Map Underlay Credit: Google Earth)

3.2.2 Presentation of Results

Table 4 below summarises the level of visual impact predicted at each of the studied receptors based on the simulation results. The minute-by-minute results for each point are presented as 'Annual Reflection Impact Diagrams' which distil an entire year's worth of data into a single diagram. The diagrams for each receptor, as well as an explanation for how to read the diagrams, are provided in Appendix B.
Additional details of RWDI's criteria are found in Appendix A.

Table 4: Summary of Overall Predicted Impacts on Receptors

Receptor Number	Receptor Type	Max Veiling Luminance (cd/m^2)	Duration / Total Number of Minutes with High Impact Reflection (Veiling Luminance > 500 cd/m^2)	% of High Impacts Where the Sun Is Also Visible
D1	Driver	47	N/A	N/A
D2	Driver	445	N/A	N/A
D3	Driver	234	N/A	N/A
D4	Driver	117	N/A	N/A
D5	Driver	319	N/A	N/A
D6	Driver	875	Average Duration: 1 minutes Total: 5 minutes/year (less than 0.01% of the daytime)	100%
D7	Driver	301	N/A	N/A
D8	Driver	112	N/A	N/A

3.3 Overall Observations

1. Like any contemporary building, the reflective surfaces of the Project (B1A, B1B and B2) are naturally causing solar reflections in the surrounding area.
2. The maximum intensities of the reflected solar energy at ground level were predicted to be low, with the majority having a maximum intensity below 200 W/m^2. Within the proposed development site, the maximum intensities of the reflected solar energy were predicted to be higher, but not in excess of what is commonly seen in an urban area, with a maximum intensity of approximately 680 W/m^2. This indicates that focusing of reflections is not occurring. Thus, RWDI does not anticipate any significant heat gain issues on people or property, nor do we expect the reflections to create significant additional heat loads in adjacent buildings.
3. The screening analysis generally predicted a low potential for visual glare within the surrounding roads, even with its highly conservative assumption that the viewer would always be looking horizontally or upwards towards the source of the reflection. The most frequent reflections were predicted to be confined along the Botany Rd at the area immediately west to the Project where glare was predicted in at most 3% of the daytime hours annually. We would remind that due to the conservative view assumption, this frequency of glare potential would only be possible if drivers were unsafely looking toward the source of the reflection (e.g., at the Project) rather than the road ahead.
4. The detailed analysis, which accounted for more realistic view directions and operated at one-minute increments, predicted that receptor D6 (representing a westbound driver on Raglan St) have the potential for glare. The potential glare at this location was predicted to exist for at most 1 minute per day and occur very infrequently (less than 0.01% of the daytime annually) during the afternoon in mid-March and late September. Furthermore, all of the glare events were predicted at times when the sun would also be within the driver's view. This represents a situation where a driver would already experience intense glare from the sun, likely reducing the perceived impact of any reflected light due to both the intensity of the sun compared to the reflection, but also because a driver would already expect glare to occur at that time from that location. This also means that a driver may have already taken mitigative measures (lowering sun visors, sunglasses, etc.) since the sun would be in their direction of travel.
5. The remaining studied driver receptors (D1-D5 and D7-D8) were predicted to have the potential to be exposed to reflections emanating from the Project. However, none of these reflections were predicted to exceed the veiling luminance threshold of 500 cd/m^2.
6. For further details, refer to the visual impact diagrams for all receptors (D1-D8) as shown in Appendix B.
7. Based on the findings of the detailed assessment, no design changes are recommended, owing to impacts either being below the 500 cd/m^2 criterion (D1-D5, D7-D8), or the sun already being in the driver's field of view during potential impacts (D6).
8. Given the safety risks associated with glare impacts on drivers, RWDI's analysis is intentionally conservative. It assumed clear skies for all daytime hours and ignored the effects of any landscaping, the use of sunglasses, as well as obstructions to reflected light due to the car body.
9. The results presented in this report are highly dependent on both the form and materiality of the Project. Should there be any changes to the design, it is recommended that RWDI be contacted and requested to review their potential effects on the findings of this report.

4 CUMULATIVE IMPACT ASSESSMENT (CIA)

As outlined in the Department of Planning, Housing and Infrastructure's "Cumulative Impact Assessment Guidelines for State Significant Projects" project level cumulative impact assessment (CIA) is considered for the impacts of the proposed Waterloo Metro Quarter development in combination with other reasonably foreseeable and wind significant future projects within the vicinity (See Figure 8). This CIA is also proportionate to the scale and significance of the Proposed Development and the considered future projects.

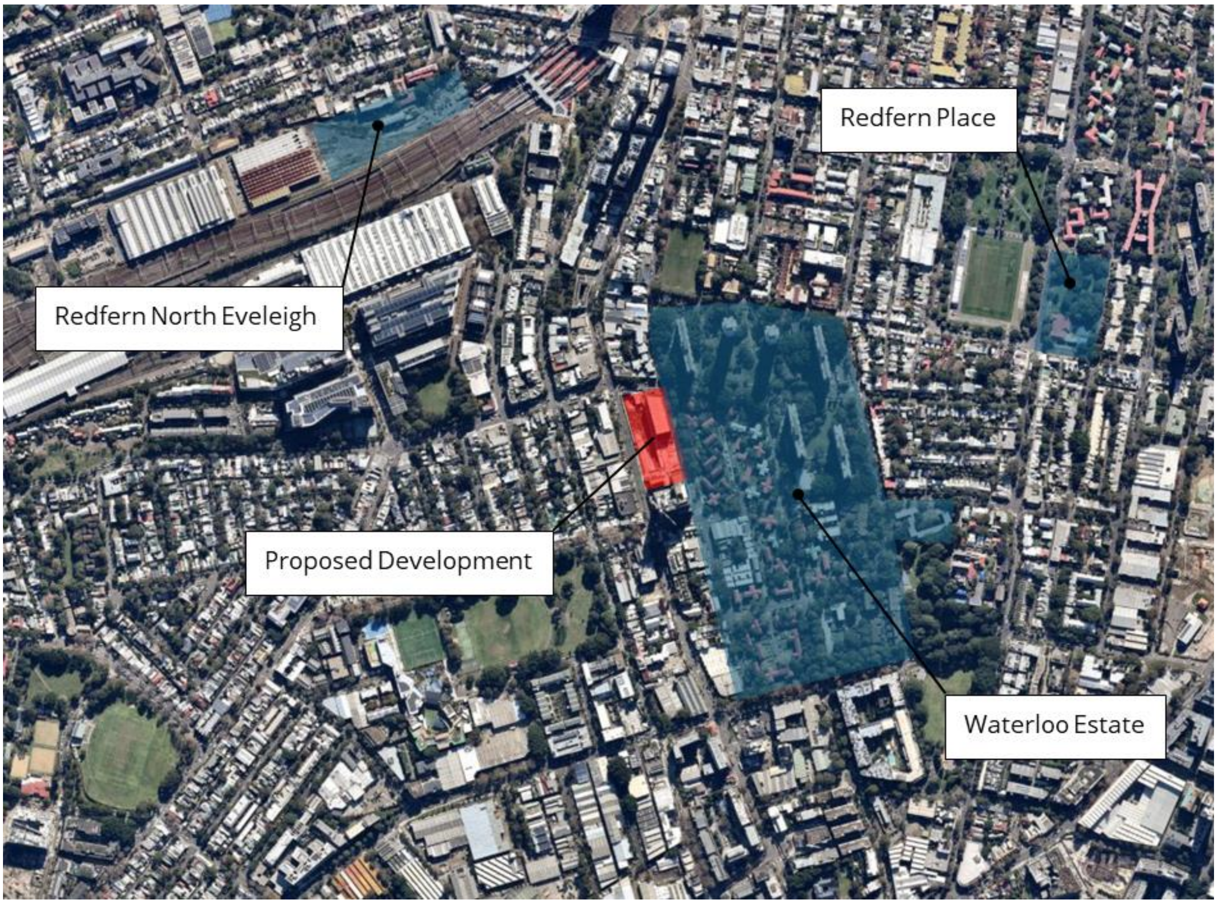


Figure 8: Nearby Future Developments

The development of Redfern North Eveleigh and Redfern Place are located over 500 m away from the proposed development and therefore are not expected to impact or be impacted by reflectivity from the proposed development.

The adjacent re-development of the Waterloo Estate is separated into multiple precincts (See Figure 9). The southern precinct adjacent to the proposed development will be a park (See Figure 10). The northern precinct is understood to be the last to be re-developed, and as such RWDI is not aware that a massing envelope has yet been established. The existing massing in the northern precinct currently overshadows portions of the Central and Northern Precinct buildings of the proposed development until approximately 9 AM on 21 June. The potential impacts on solar reflectivity due to the redevelopment discussed in Section 4.1.

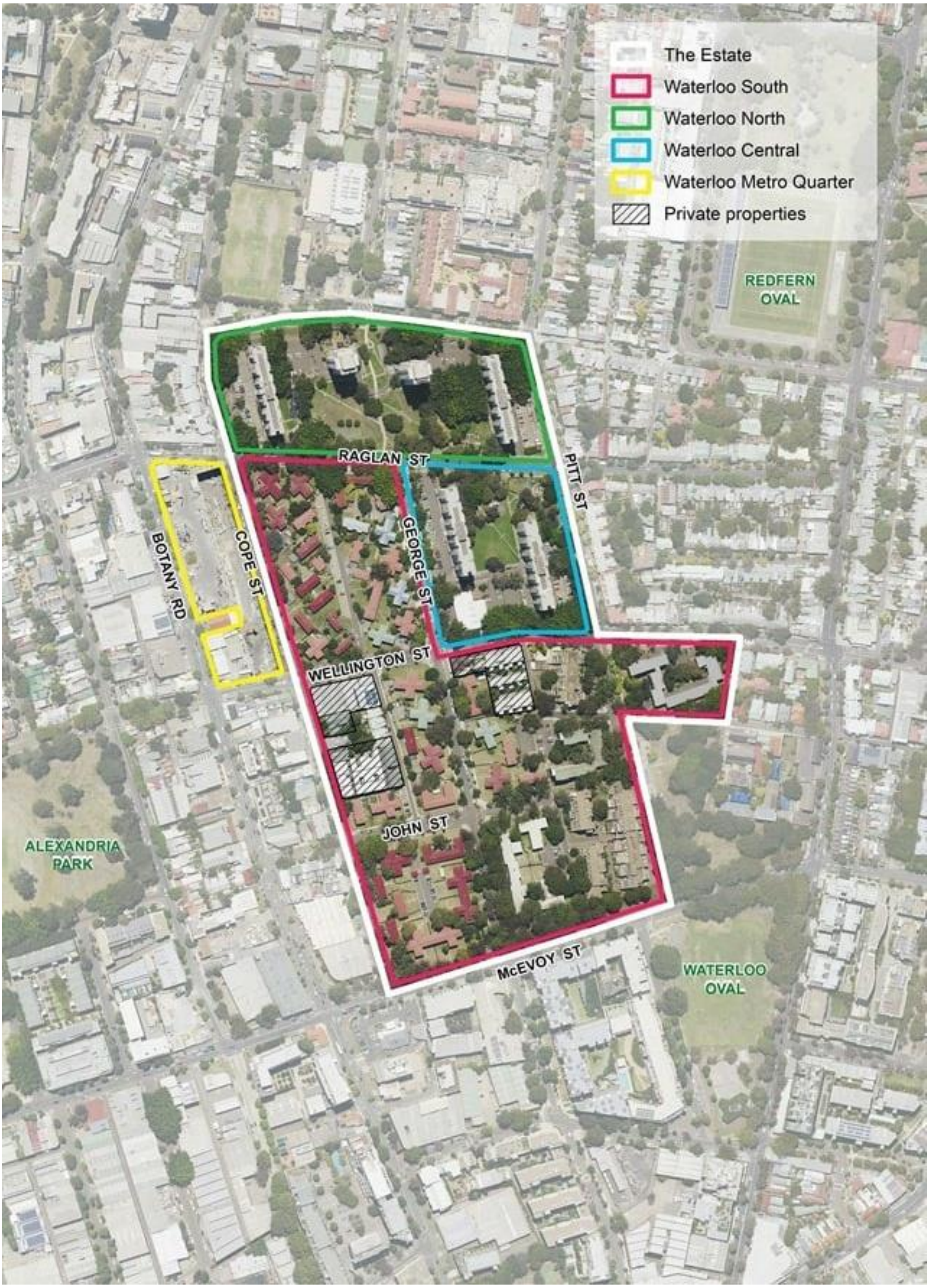


Figure 9: Waterloo Renewal Project Development Areas (Extract from CoS planning proposal webpage)

Figure 10: Waterloo South building heights map (Extract from Planning NSW Waterloo South webpage)

4.1 Future Waterloo Park and Northern Precinct Redevelopment

As undertaken for the Project with existing surrounding, both the screening and detailed simulations were repeated for the surrounding context of the future Waterloo Park and Northern Precinct Redevelopment to understand the solar reflectivity impacts of the Project on the surrounding urban area.

Screening Analysis

- The screening simulations confirmed that the solar reflectivity impacts of the Project due to the future Waterloo Park redevelopment are similar to the existing configuration as indicated by Figures 11a and 11b below.
- Thus, RWDI does not anticipate any significant additional heat gain issues on people or property, nor do we expect the reflections to create significant additional heat loads in adjacent buildings in the future configuration.
- In terms of visual glare on the surrounding roads, the simulation results demonstrated minimal additional impacts with the future Waterloo Park redevelopment in place.

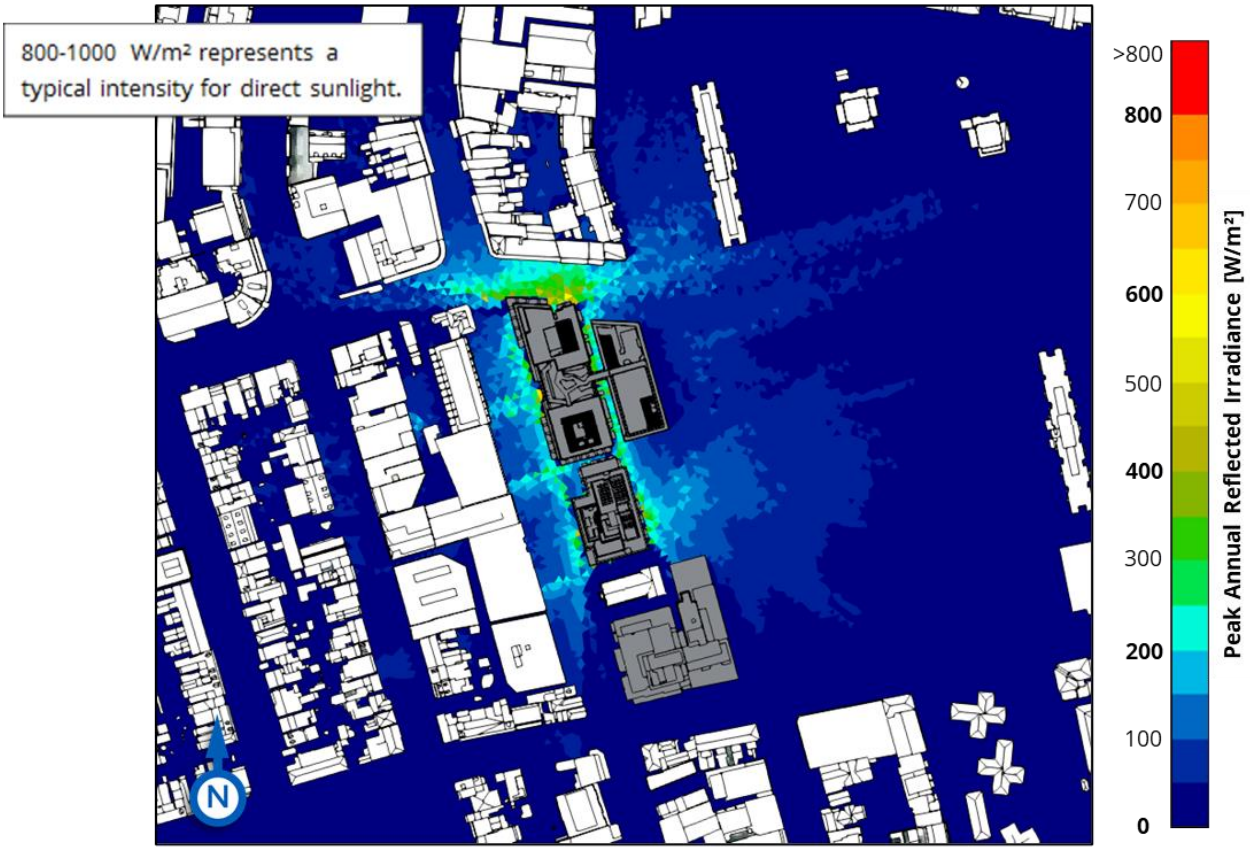


Figure 11a: Maximum Annual Intensity of Reflections at Pedestrian Height

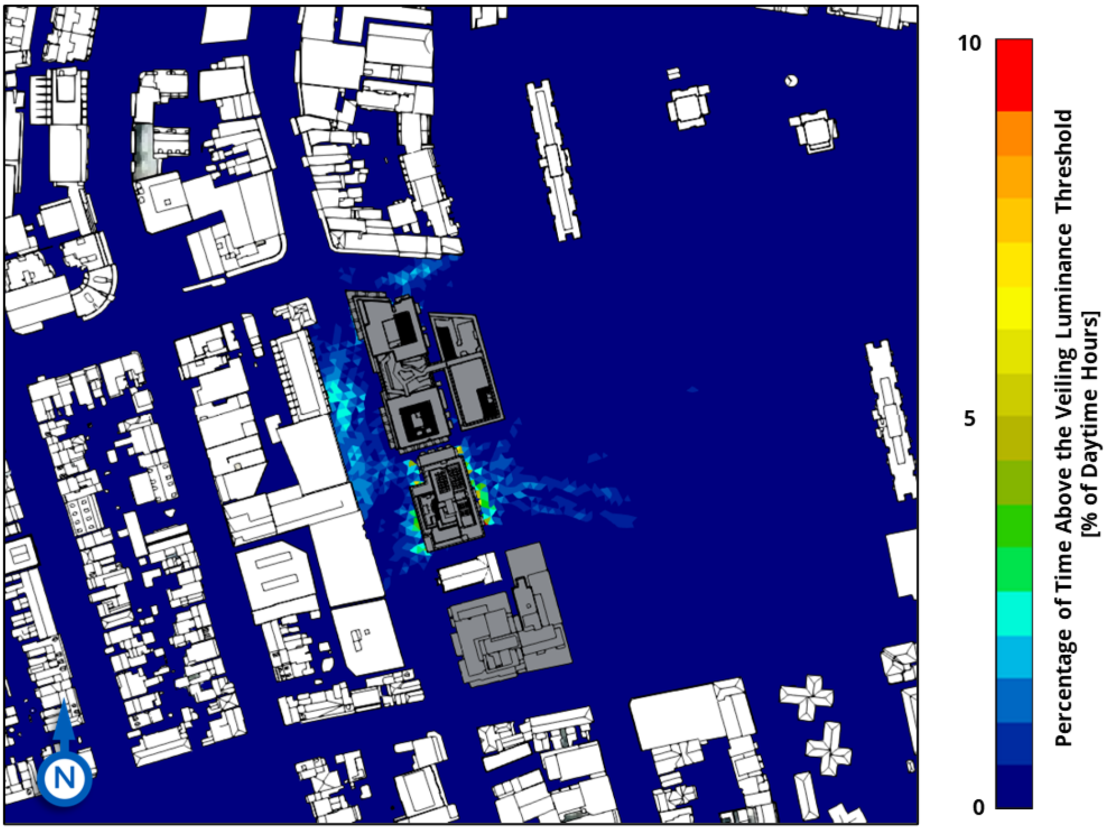


Figure 11b: Frequency (% of Daylit Hours) Where Veiling Luminance Above Threshold were Predicted at Pedestrian Height for an 80th Percentile Resident (Age 60)

Detailed Analysis

- RWDI had also conducted a detailed analysis by repeating the simulations for the same 8 receptor points per Table 3 as these simulations did not identify the potential for glare at any new roadway locations around the location of the park (i.e., that would have been blocked by existing buildings which will be demolished). The results indicated no additional solar reflectivity impacts predicted on all 8 driver receptor points on the surrounding public roads.

5 CONCLUSION

This Solar Reflectivity Assessment has been prepared by RWDI Australia Pty Ltd (RWDI) to accompany a State Significant Development Application (SSDA) for Waterloo Metro Quarter (WMQ) located at 150 Cope Street, Waterloo ("the Project"). This report pertains to the Second Amending Concept DA (SSD-79307765.

The results and conclusions of the study are summarised as follows:

- The maximum intensities of the reflected solar energy at ground level were predicted to be low, with the majority having a maximum intensity below 200 W/m^2. Therefore, RWDI does not expect any significant thermal impacts (i.e. risks to human safety or property damage) to occur either on the site or in the surrounding neighbourhood.
- As with any glazed building, drivers travelling in the vicinity of the Project (i.e. along Botany Rd, Raglan St, Cope St and Cope St Plaza) were predicted to experience reflections emanating from the Project. Based on the detailed results, the predicted reflections falling on receptor D6 (westbound driver on Raglan St) was above the veiling luminance threshold of 500 cd/m^2. That said, all of the potential glare events for receptor D6 were predicted at times when the sun would also be within the driver's view. This represents a situation where a drive would already experience intense glare from the sun, likely reducing the perceived impact of any reflected light due to both the intensity of the sun compared to the reflection, but also because a driver would already expect glare to occur at that time from that location.
- All remaining studied driver receptors were predicted to achieve reflections below the veiling luminance threshold of 500 cd/m^2.
- No additional thermal glare impacts to public spaces or visual glare impacts to the surrounding roads were predicted with the future Waterloo Park redevelopment as compared to the existing surrounds.
- Based on the findings of the detailed assessment, no design changes are recommended.

Given the safety risks associated with glare impacts on drivers, RWDI's analysis is intentionally conservative. It assumed clear skies for all daytime hours and ignored the effects of any landscaping, the use of sunglasses, as well as obstructions to reflected light due to the car body.

The results presented in this report are highly dependent on both the form and materiality of the Project. Should there be any changes to the design, it is recommended that RWDI be contacted and requested to review their potential effects on the findings of this report.

6 GENERAL STATEMENT OF LIMITATIONS

This report entitled *Waterloo Metro Quarter – SSDA Solar Reflection Analysis* was prepared by RWDI Australia Pty Ltd ("RWDI") for WL Developer Ptd Ltd ("Client"). The findings and conclusions presented in this report have been prepared for the Client and are specific to the project described herein ("Project"). The conclusions and recommendations contained in this report are based on the information available to RWDI when this report was prepared.

Because the contents of this report may not reflect the final design of the Project or subsequent changes made after the date of this report, RWDI recommends that it be retained by Client during the final stages of the project to verify that the results and recommendations provided in this report have been correctly interpreted in the final design of the Project.

The conclusions and recommendations contained in this report have also been made for the specific purpose(s) set out herein. Should the Client or any other third party utilise the report and/or implement the conclusions and recommendations contained therein for any other purpose or project without the involvement of RWDI, the Client or such third party assumes any and all risk of any and all consequences arising from such use and RWDI accepts no responsibility for any liability, loss, or damage of any kind suffered by Client or any other third party arising therefrom.

Finally, it is imperative that the Client and/or any party relying on the conclusions and recommendations in this report carefully review the stated assumptions contained herein and to understand the different factors which may impact the conclusions and recommendations provided.

APPENDIX A

RWDI REFLECTION CRITERIA

APPENDIX A: RWDI REFLECTION CRITERIA

Visual Glare

RWDI has extensive experience in the analysis and assessment of the impacts of sunlight and solar energy reflected from buildings[1].

This assessment was conducted in response to the requirements outlined in the Secretary's Environmental Assessment Requirements (SEARs) under Environmental Amenity as reproduced below:

"Assess amenity impacts on the surrounding locality, including lighting impacts, reflectivity, solar access, visual privacy, visual amenity, view loss and view sharing, overshadowing and wind impacts. A high level of environmental amenity for any surrounding residential or other sensitive land uses must be demonstrated. "

However, the SEARs does not provide a description around what constitutes a reflectivity impact or what would be considered a dangerous level of glare from the Project.

In light of the context described above, we have adopted the typical Australian criteria put forth by Hassall (1991)[2], which defines glare as occurring when the veiling luminance of a reflection exceeds 500 cd/m².

Veiling luminance was computed using the CIE General Disability Glare Equation[3]. This equation is a more robust formulation of the classical Stiles-Holladay glare equation that accounts for the effects of age and eye colour when predicting veiling luminance. This formulation remains valid for light sources between 0.1° and 100° away from the direction of view.

RWDI conservatively assumed a light-blue eye colour (pigmentation factor of 1.2) and an observer age of 60 years old for this work. Based on the most recent Australian Census, this age represents approximately the 80th percentile age for the residents of New South Wales. This means that in reality, veiling luminance would be lower than these predictions for 80% of the population.

It should be noted that the 500 cd/m² limit assumes an adaptation luminance corresponding to a dawn or dusk time frame and may be overly conservative during brighter parts of the day.

References

1. Danks, R., Good, J., & Sinclair, R., “Assessing reflected sunlight from building facades: A literature review and proposed criteria.” *Building and Environment*, 103, 193-202, 2016.

2. Hassall, D., “Reflectivity: Dealing with Rogue Solar Reflections” *University of New South Wales, 1991*.

3. Vos, J., et al. "CIE equations for disability glare." *CIE TC Report CIE 146* (2002): 2002.

APPENDIX B

ANNUAL REFLECTION IMPACT DIAGRAMS

Presentation of Results

Results are illustrated using “annual impact diagrams”. These plots condense the minute-by-minute annual dataset into a single image. The vertical axis represents the time of the day, and the horizontal axis indicates the day of the year. A sample of such a diagram is shown in Figure B1.

Please note that the referenced times are in local standard time. When Daylight Saving Time is observed, the time should be shifted by an hour when appropriate.

The colours on this plot indicate when all reflections falling on a specific point were predicted and if the predicted veiling luminance exceeds the disability glare threshold (500 cd/m²) for an 80th percentile resident (60 years old) for New South Wales. Hatching (i.e., dark green areas) indicates when the sun would be within 30° of a motorist's direction of view.

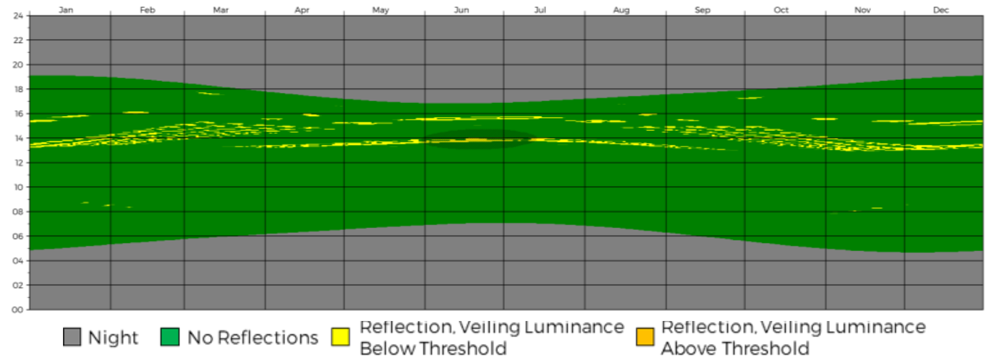


Figure B1: Annual Reflection Impact Diagram for Driver Receptor D3

Driver Receptor D1

Receptor D1 was chosen to assess the visual impact associated with solar reflections affecting southbound drivers on Cope Street at Raglan Street.

The simulations indicated that intermittent reflections may fall on this point from November through January between 9:00 am and 10:00 am AEST. Again on late March, mid-September, November and from mid-January through early February between 1:45 pm and 3:00 pm AEST.

The maximum veiling luminance predicted was 47 cd/m².

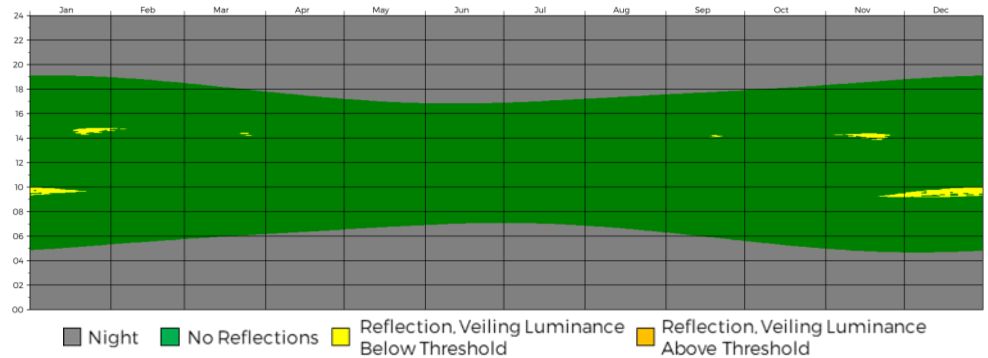


Figure B2: Annual Reflection Impact Diagram for Driver Receptor D1

Driver Receptor D2

Receptor D2 was chosen to assess the visual impact associated with solar reflections affecting eastbound drivers on Raglan Street at Botany Road.

The simulations indicated that intermittent reflections may fall on this point from mid-July through May between 6:30 am and 12:00 pm AEST.

The maximum veiling luminance predicted was 445 cd/m².

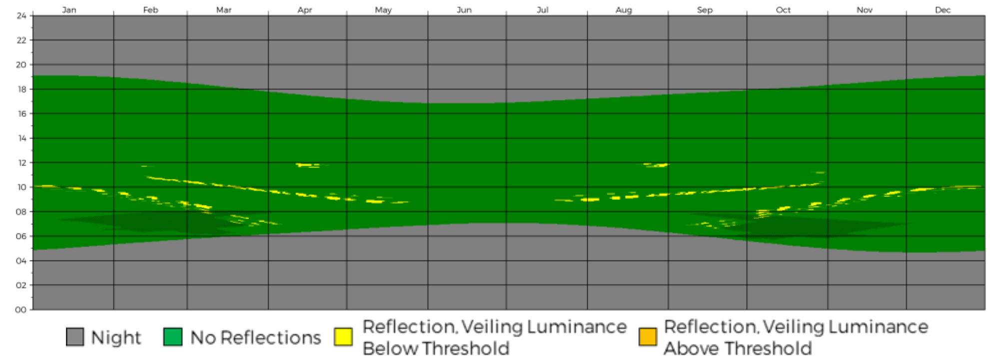


Figure B3: Annual Reflection Impact Diagram for Driver Receptor D2

Driver Receptor D3

Receptor D3 was chosen to assess the visual impact associated with solar reflections affecting northbound drivers on Botany Road.

The simulations indicated that intermittent reflections may fall on this point throughout the year between 12:45 pm and 5:45 pm AEST. Again, from mid-January through early February and from November through early December between 7:45 am and 9:00 am AEST.

The maximum veiling luminance predicted was 234 cd/m².

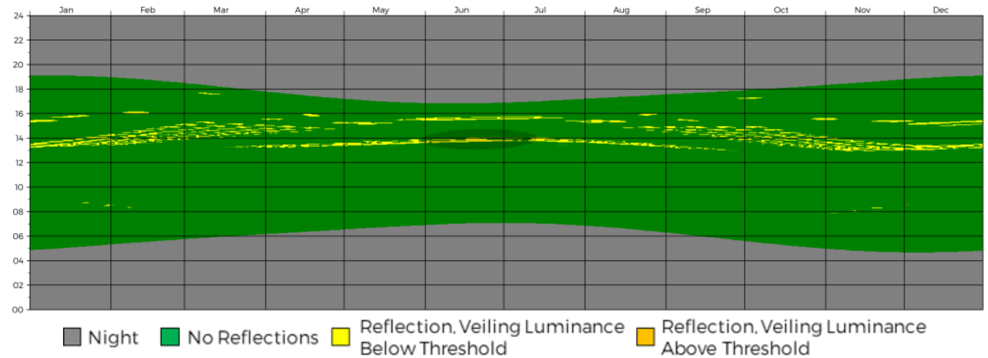


Figure B4: Annual Reflection Impact Diagram for Driver Receptor D3

Driver Receptor D4

Receptor D4 was chosen to assess the visual impact associated with solar reflections affecting northbound drivers on Cope Street near Cope St Plaza.

The simulations indicated that intermittent reflections may fall on this point from late March through mid-September between 10:30 am and 12:15 pm AEST.

The maximum veiling luminance predicted was 117 cd/m².

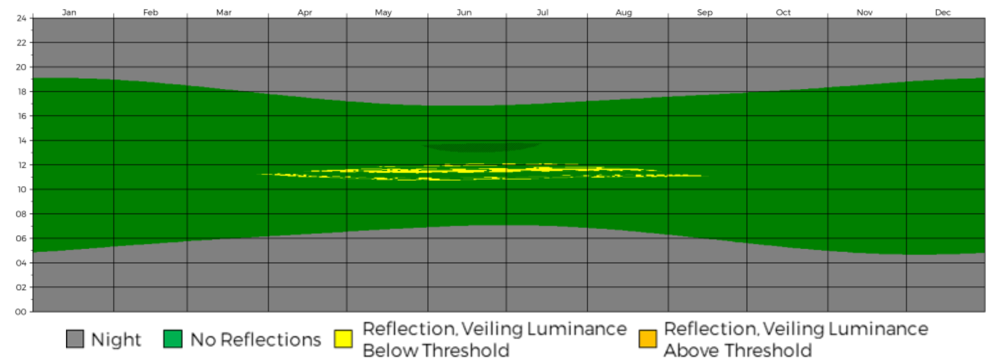


Figure B5: Annual Reflection Impact Diagram for Driver Receptor D4

Driver Receptor D5

Receptor D5 was chosen to assess the visual impact associated with solar reflections affecting eastbound drivers on Henderson Rd turning right onto Botany Rd.

The simulations indicated that intermittent reflections may fall on this point from mid-July through May between 6:30 am and 12:00 pm AEST.

The maximum veiling luminance predicted was 319 cd/m².

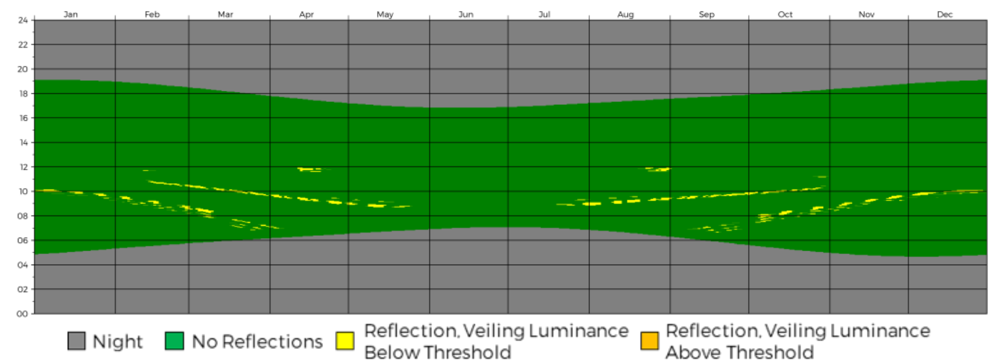


Figure B6: Annual Reflection Impact Diagram for Driver Receptor D5

Driver Receptor D6

Receptor D6 was chosen to assess the visual impact associated with solar reflections affecting westbound drivers on Ragland St.

The simulations indicated that intermittent reflections may fall on this point from late August through April between 6:45 am and 10:45 am AEST. Again, on February and October between 1:30 pm and 3:00 pm AEST. Again, on mid-March and late September between 4:15 pm and 5:00 pm AEST.

Very brief instances where veiling luminance exceeded 500 cd/m² (maximum predicted value was 875 cd/m²) were predicted on mid-March and late September. On average these reflections lasted 1 minutes and were predicted to occur between 4:15 pm and 5:00 pm AEST, totalling 5 minutes per year of potential glare, or less than 0.01% of the daytime.

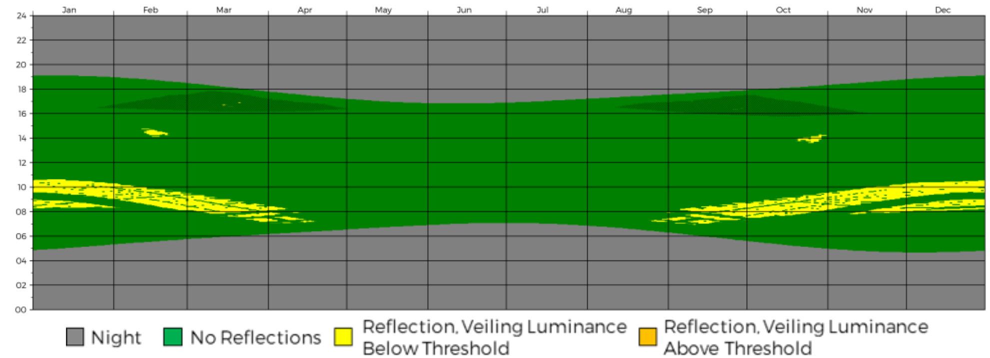


Figure B7: Annual Reflection Impact Diagram for Driver Receptor D6

Driver Receptor D7

Receptor D7 was chosen to assess the visual impact associated with solar reflections affecting westbound drivers on Ragland St.

The simulations indicated that intermittent reflections may fall on this point from August through April between 7:00 am and 10:15 am AEST. Again from late January through March and from mid-September through mid-November between 2:15 pm and 4:30 pm AEST.

The maximum veiling luminance predicted was 301 cd/m².

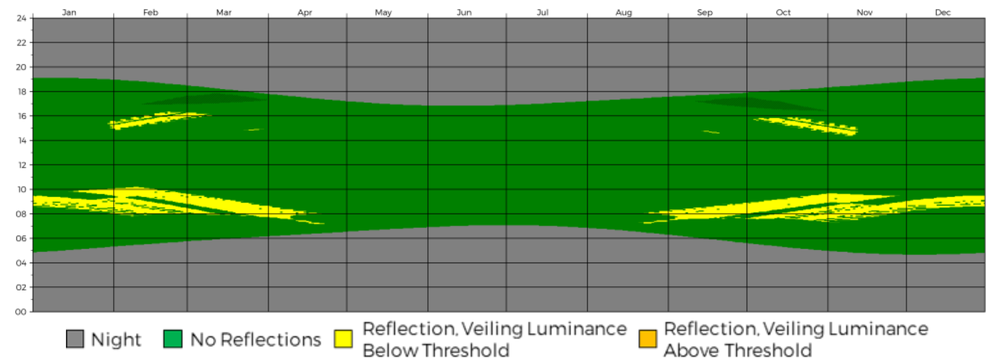


Figure B8: Annual Reflection Impact Diagram for Driver Receptor D7

Driver Receptor D8

Receptor D8 was chosen to assess the visual impact associated with solar reflections affecting southbound drivers on Cope St entering roundabout.

The simulations indicated that intermittent reflections may fall on this point from November through mid-February between 5:45 am and 8:00 am AEST. Again from mid-July through May between 1:15 pm and 5:15 pm AEST.

The maximum veiling luminance predicted was 112 cd/m².

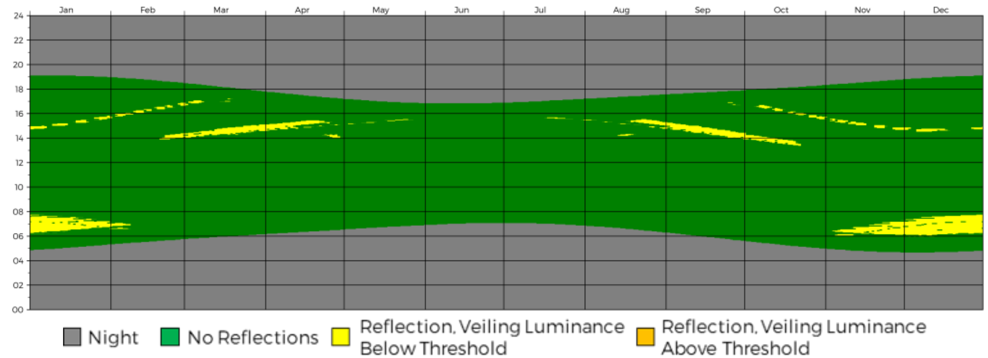


Figure B9: Annual Reflection Impact Diagram for Driver Receptor D8