REPORT

TOGA CENTRAL

SYDNEY, NSW

SOLAR REFLECTION SCREENING ANALYSIS

RWDI PROJECT #1902973
JULY 21, 2022

SUBMITTED TO

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EXECUTIVE SUMMARY

This Solar Reflections Screening Analysis report has been prepared by RWDI Consultants Pty Ltd to accompany a detailed State significant development (SSD) development application (DA) for the mixed-use redevelopment proposal at TOGA Central, located at 2 & 8A Lee Street, Haymarket (the site). The site is legally described as Lot 30 in Deposited Plan 880518, Lot 13 in Deposited Plan 1062447 and part of Lot 14 in Deposited Plan 1062447. The site is also described as 'Site C' within the Western Gateway sub-precinct at the Central Precinct.

This report has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) issued for the SSD DA (SSD 33258337).

This report concludes that the proposed mixed-use redevelopment is suitable and warrants approval subject without the need for any mitigation measures applied to the proposed design.

INTRODUCTION

This report has been prepared to accompany a SSD DA for the for the mixed-use redevelopment proposal at TOGA Central, located at 2 & 8A Lee Street, Haymarket.

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 and Environment (DPE) for assessment.

The purpose of the SSD DA is to complete the restoration of the heritage-listed building on the site, delivery of new commercial floorspace and public realm improvements that will contribute to the realisation of the Government's vision for an iconic technology precinct and transport gateway. The application seeks consent for the conservation, refurbishment and adaptive re-use of the Adina Hotel building (also referred to as the former Parcel Post building (fPPb)), construction of a 45-storey tower above and adjacent to the existing building and delivery of significant public domain improvements at street level, lower ground level and within Henry Deane Plaza. Specifically, the SSD DA seeks development consent for:

- Site establishment and removal of landscaping within Henry Deane Plaza.
- Demolition of contemporary additions to the fPPb and public domain elements within Henry Deane Plaza.
- Conservation work and alterations to the fPPb for retail premises, commercial premises, and hotel and motel accommodation. The adaptive reuse of the building will seek to accommodate:
    - Commercial lobby and hotel concierge facilities,
    - Retail tenancies including food and drink tenancies and convenience retail with back of house areas,
    - 4 levels of co-working space,
    - Function and conference area with access to level 7 outdoor rooftop space, and
    - Reinstatement of the original fPPb roof pitch form in a contemporary terracotta materiality.
- Provision of retail floor space including a supermarket tenancy, smaller retail tenancies, and back of house areas below Henry Deane Plaza (at basement level 1 (RL12.10) and lower ground (RL 16)).
- Construction of a 45-storey hotel and commercial office tower above and adjacent to the fPPb. The tower will have a maximum building height of RL 202.28m, and comprise:
    - 10 levels of hotel facilities between level 10 – level 19 of the tower including 204 hotel keys and 2 levels of amenities including a pool, gymnasium and day spa to operate ancillary to the hotel premises. A glazed atrium and hotel arrival is accommodated adjacent to the fPPb, accessible from Lee Street.

- 22 levels of commercial office space between level 23 – level 44 of the tower accommodated within a connected floor plate with a consolidated side core.
- Rooftop plant, lift overrun, servicing and BMU.

- Provision of vehicular access into the site via a shared basement, with connection points provided to both Block A (at RL 5) and Block B (at RL5.5) basements. Primary access will be accommodated from the adjacent Atlassian site at 8-10 Lee Street, Haymarket, into 4 basement levels in a split-level arrangement. The basement will accommodate:
  - Car parking for 106 vehicles, 4 car share spaces and 5 loading bays.
  - Hotel, commercial and retail and waste storage areas.
  - Plant, utilities and servicing.
- Provision of end of trip facilities and 165 employee bicycle spaces within the fPPb basement, and an additional 72 visitor bicycle spaces within the public realm.
- Delivery of a revitalised public realm across the site that is coordinated with adjacent development, including an improved public plaza linking Railway Square (Lee Street), and Block B (known as 'Central Place Sydney'). The proposal includes the delivery of a significant area of new publicly accessible open space at street level, lower ground level, and at Henry Deane Plaza, including the following proposed elements:
  - Provision of equitable access within Henry Deane Plaza including stairways and a publicly accessible lift.
  - Construction of raised planters and terraced seating within Henry Deane Plaza.
  - Landscaping works within Henry Deane Plaza.
- Utilities and service provision.
- Realignment of lot boundaries.

INTRODUCTION

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 17 December 2021 and issued for the SSD DA. Specifically, this report has been prepared to respond to the SEARs requirement issued below.

Item	Description of requirement	Section reference (this report)
6. Environmental Amenity	▪ 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.	Screening Analysis Results

THE SITE

The site is located within the City of Sydney Local Government Area (LGA). The site is situated 1.5km south of the Sydney CBD and 6.9km north-east of the Sydney International Airport within the suburb of Haymarket.

The site is located within the Western Gateway sub-precinct, an area of approximately 1.65ha that is located immediately west of Central Station within Haymarket on the southern fringe of the Sydney CBD. Immediately north of Central Station is Belmore Park, to the west is Haymarket (including the University of Technology, Sydney and Chinatown), to the south and east is rail lines and services and Prince Alfred Park and to the east is Elizabeth Street and Surry Hills.

Central Station is a public landmark, heritage building, and the largest transport interchange in NSW. With regional and suburban train services, connections to light rail, bus networks and to Sydney Airport, the area around Central Station is one of the most-connected destinations in Australia.

The site is located at 2 & 8A Lee Street, Haymarket and is legally described as Lot 30 in Deposited Plan 880518, Lot 13 in Deposited Plan 1062447 and part of Lot 14 in Deposited Plan 1062447. The land that comprises the site under the Proponent's control (either wholly or limited in either height or depth) comprises a total area of approximately 4,159sqm.

The location of the TOGA Central site is illustrated in Figure 1.

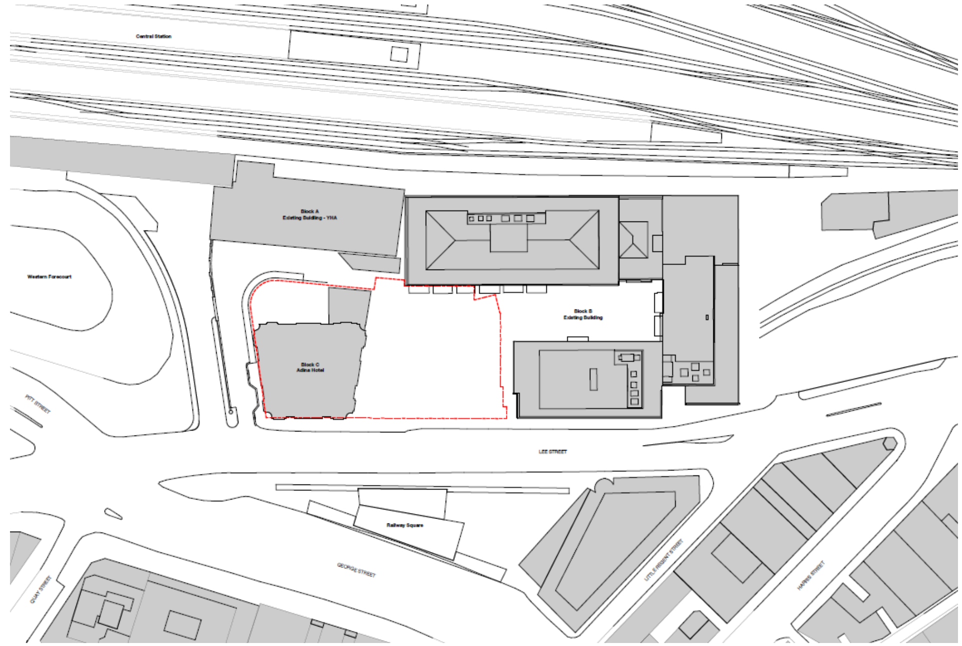

Figure 1: Site Identification Plan (Source: Bates Smart)

THE SITE

The site currently comprises the following existing development:

- Lot 30 in Deposited Plan 880518 (Adina Hotel building): the north-western lot within the Western Gateway sub-precinct accommodates a heritage-listed building which was originally developed as the Parcels Post Office building. The building has been adaptively re-used and is currently occupied by the Adina Hotel Sydney Central. The eight-storey building provides 98 short-stay visitor apartments and studio rooms with ancillary facilities including a swimming pool and outdoor seating at the rear of the site.

- Lot 13 in Deposited Plan 1062447 and part of Lot 14 in Deposited Plan 1062447 (Henry Deane Plaza): the central lot within the Western Gateway sub-precinct adjoins Lot 30 to the south. It accommodates 22 specialty food and beverage, convenience retail and commercial service tenancies. The lot also includes publicly accessible space which is used for pop-up events and a pedestrian thoroughfare from Central Station via the Devonshire Street Tunnel. At the entrance to Devonshire Street Tunnel is a large public sculpture and a glazed structure covers the walkway leading into Railway Square. This area forms part of the busy pedestrian connection from Central Station to Railway Square and on to George and Pitt Streets, and pedestrian subways.

The site is listed as an item of local significance under Schedule 5 of the Sydney Local Environmental Plan 2012 'Former Parcels Post Office including retaining wall, early lamp post and building interior', Item 855.

The site is also included within the Central Railway Station State heritage listing. This is listed on the State Heritage Register 'Sydney Terminal and Central Railway Station Group', Item SHR 01255, and in Schedule 5 of the Sydney Local Environmental Plan 2012 'Central Railway Station group including buildings, station yard, viaducts and building interiors' Item 824.

The site is not however listed independently on the State Heritage Register. There is an array of built forms that constitute Central Station, however the Main Terminal Building (particularly the western frontage) and associated clocktower constitute key components in the visual setting of the Parcel Post building.

Urban Reflections

While a common occurrence, solar reflections from buildings can lead to numerous visual and thermal issues.

Visual glare can:

- 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 can:

- 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 (Figure 2) 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 development.

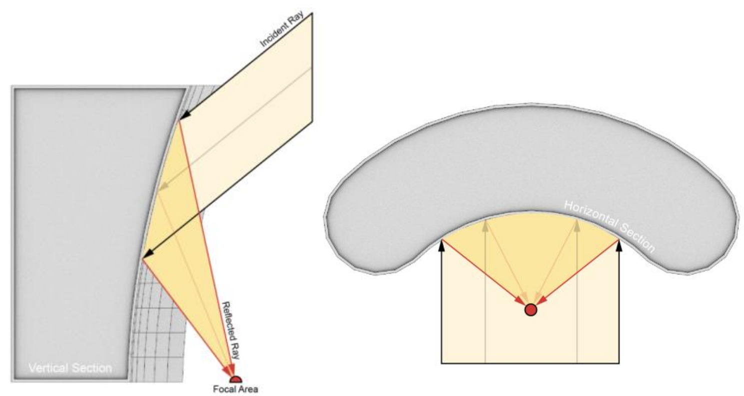

Figure 2: Illustration of Reflection Focusing Due to a Concave Facade

Methodology

The analysis was conducted using RWDI's in-house proprietary *Eclipse* software, as per the steps outlined below:

- The assessment begins with the development of a 3D model of the area of interest (as shown in Figure 3). This is then subdivided into many smaller triangular patches (see Figure 4).
- For each hour in a year, the expected solar position is determined, and "virtual rays" drawn from the sun to each triangular patch of the 3D model. Each ray that is considered to be "unobstructed" was reflected from the building surface and tracked through the surrounding area. The study domain included the entire urban realm within 350 m of the proposed buildings.
- The total reflected energy at that hour from all of the patches is computed and the potential for visual and thermal impacts assessed.
- Finally, a statistical analysis is performed to assess the frequency, and intensity of the glare events occurring throughout the year within the nearby airspace. The criteria used to assess the level of impact can be found in Appendix A of this report.

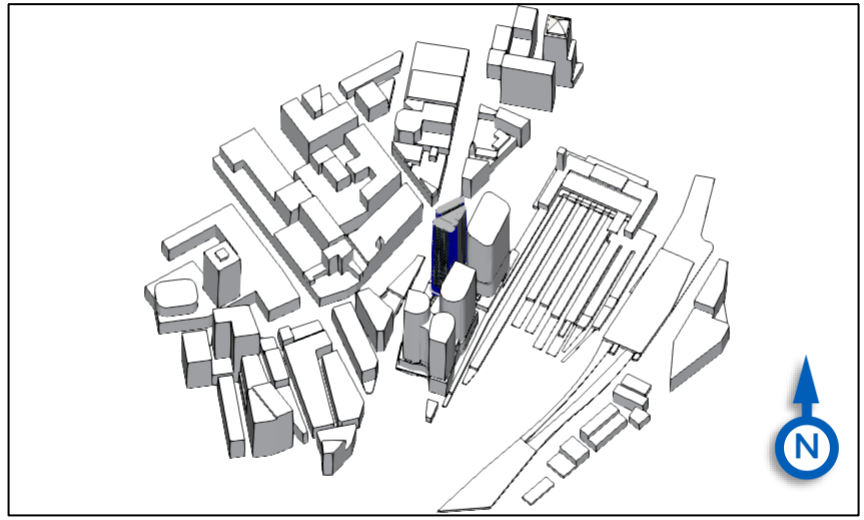

Figure 3: 3D Computer Model of the Proposed Building and Surrounding Context

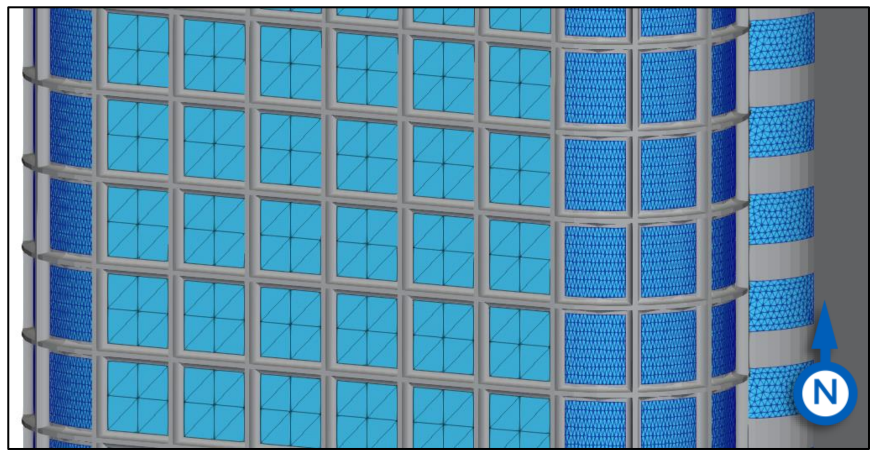

Figure 4: Close-up View of the Model, Showing Surface Subdivisions

Methodology (cont'd)

- In the event that the potential for glare exists on roadways or other sensitive spaces, the detailed analysis phase is triggered. Analysis from receptor locations which are not found to experience potential glare do not require further analysis as it is known that glare intensity will not be of a level which will cause any exceedance, hence is a worse-case scenario.
- This analysis works similarly to the screening simulation, except glare is tested at one-minute increments and a direction of view is explicitly prescribed.
- The detailed study also provides the locations on a building where the glare emanates from and the level of reflectivity reduction required to comply with local criteria.
- The analysis has assumed a maximum specular reflectance of 20% for the glazed surfaces. Other façade surfaces on the building, such as the glazed terracotta elements, typically have a low specular reflectance. Should the selected materials of building surfaces (other than the glazed areas) have a notable specular reflectance, further assessment should be undertaken to verify the potential impact to the surrounding areas.

Assumptions and Limitations

Meteorological Data

This analysis used 'clear sky' solar data computed at the location of Sydney International Airport. This approach uses mathematical algorithms to derive solar intensity values for a given location, ignoring local effects such as cloud cover. This provides a 'worst case' scenario showing the full extent of when and where glare could ever occur.

Radiation Model

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

Potential reductions of solar reflections due to the presence of vegetation or other non-architectural obstructions were not included, nor are reflections from other buildings. Light that has reflected off several surfaces is assumed to have a negligible impact. As such, only a single reflection from the development was included in the analysis.

Study Building and Surrounds Models

The analysis was conducted based on a 3D model of the proposed development provided by TOGA to RWDI on April 14, 2022, with consideration for updated drawings received June 21, 2022.

The surrounding model was based on publicly available data and previous RWDI projects in the area, which includes the approved Atlassian Central tower and the currently proposed Central Place Sydney development.. 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).

All glazing has been assumed to have a nominal 20% reflectivity for both visible light and solar energy. All other materials on the facades (such as the terracotta fins), are assumed to have negligible specular reflectivity, including the glazed terracotta.

Applicability of Results

The results presented in this report are highly dependent on both the form and materiality of the facade. 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.

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 heat, or otherwise intentionally try to cause discomfort/harm to themselves or others and/or damage to property.

Presentation of Results

This section presents the screening results pertaining to the solar impacts of the development on the surrounding urban area. The following plots are presented:

- **Peak Annual Reflected Irradiance:** Figure 5 displays 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.

- **Percentage of Time Above the Veiling Luminance Threshold:** Figure 6 identifies the percentage of day-time hours where the veiling luminance was predicted to exceed the 500 cd/m^2 limit proposed by Hassall. *Note that as a conservative assumption, at each location it is assumed a viewer is facing horizontally in the direction of the building.*

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.

The intention of the following plots is to illustrate the general characteristics of reflections from the development. In order to attain a complete understanding of the impact that reflections may have on people, other factors must be considered, including where the viewer is looking, which is explored in the detailed study if needed.

Peak Annual Reflected Irradiance

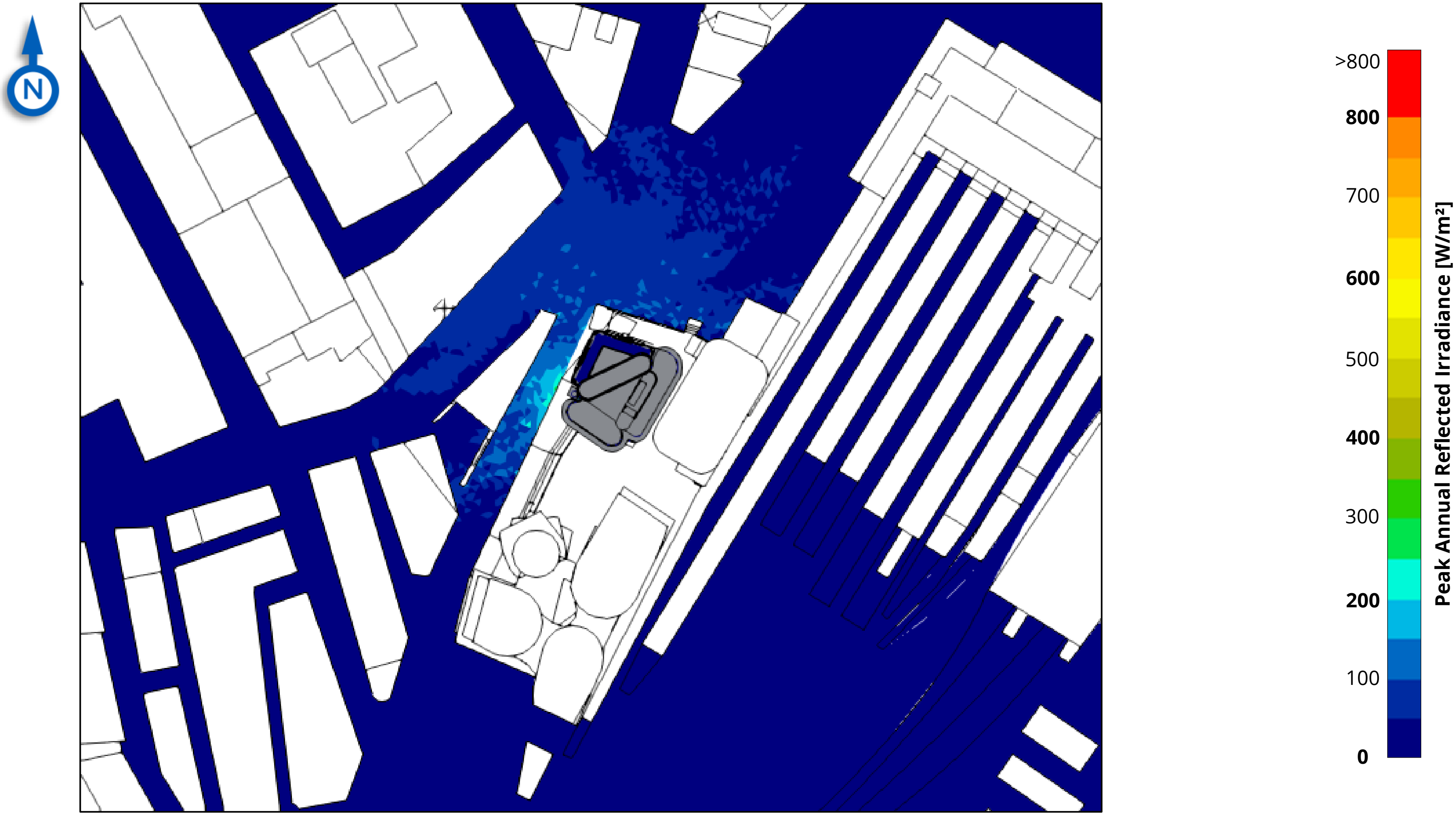

Figure 5: Maximum Annual Intensity of Reflections at Ground Level (eye height)

Percentage of Time Above the Veiling Luminance Threshold

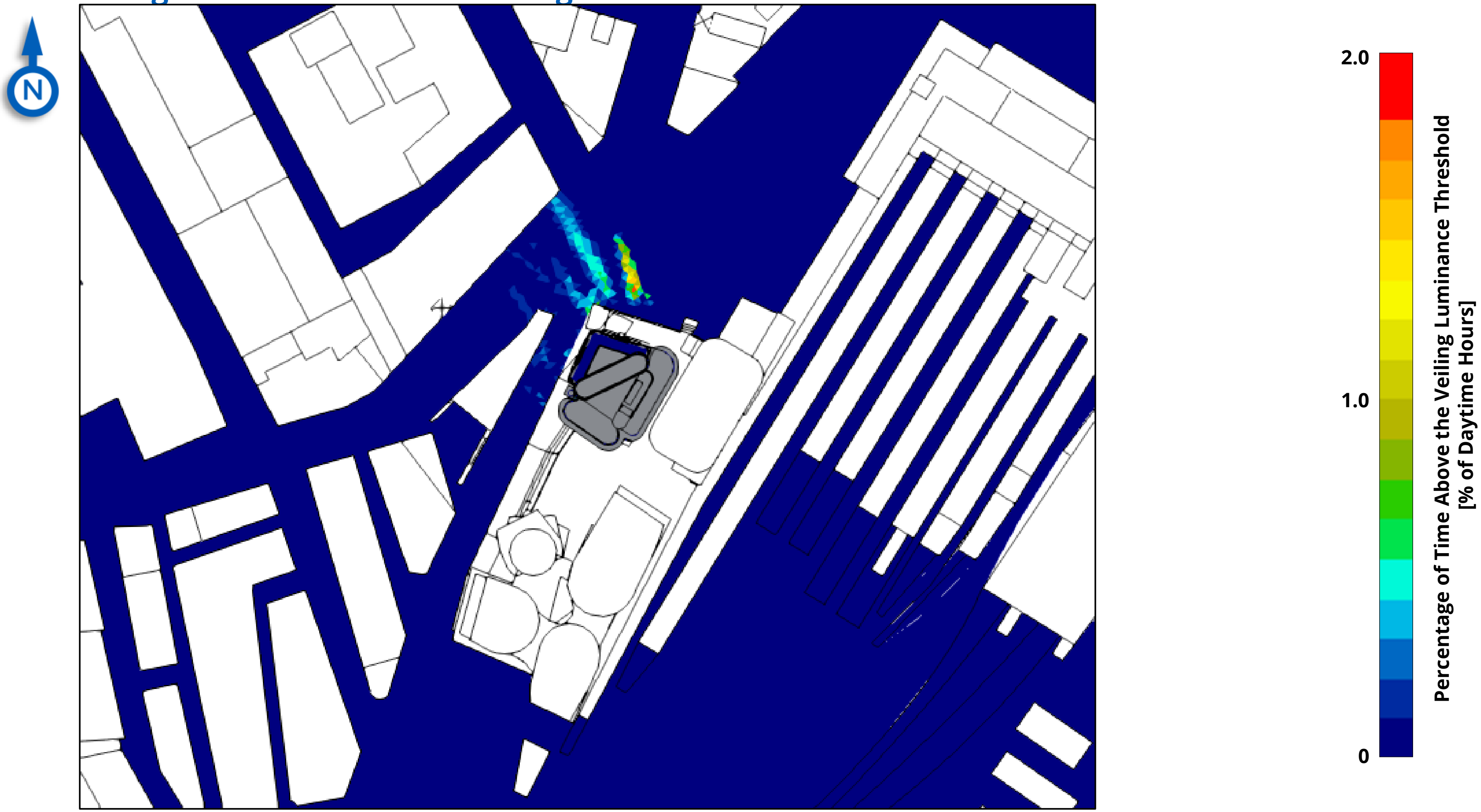

Figure 6: Frequency (% of Daylit Hours) Where Veiling Luminance Above Threshold at Ground Level (eye height) for an 80th Percentile Resident (Age 60)

Based on the findings of the Screening Analysis and the risk levels associated with reflections effecting specific areas, 7 representative points were selected for the Detailed Analysis. These points are described in Table 1 and illustrated in Figure 7. These locations cover a worse case scenario of areas which may be exposed to glare from the development based on the initial analysis, as well as key rail infrastructure.

The direction of view is indicated by the arrows in Figure 7.

Table 1: Receptor Descriptions

Receptor Number	Receptor Description
D1	Northbound drivers on Lee St
D2	Eastbound drivers at Broadway-George St and Harris St-Regent St intersection
D3	Southbound drivers at George St and Pitt St intersection
D4	Southbound drivers on Pitt St
D5	Southbound light rail drivers on George St (Randwick line)
D6	Southbound train drivers on Intercity Train line
D7	Southbound train drivers on Sydney Trains line

Figure 7: Receptor Locations (Map Underlay Credit: Nearmap)

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 8.

Please note that the referenced times are in local standard time. When Daylight Savings 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). Hatching (i.e., dark green areas) indicates when the sun would be within 30° of a motorist's direction of view.

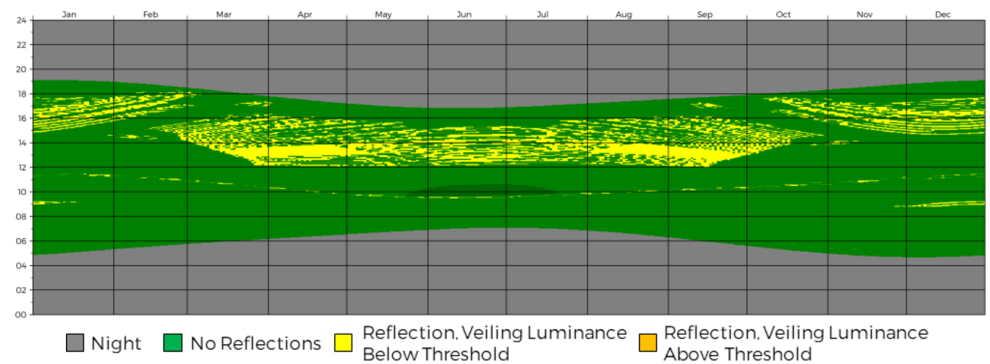

Figure 8: Annual Reflection Impact Diagram for Driver Receptor D1

Receptor D1

Receptor D1 was chosen to assess the visual impact associated with solar reflections affecting drivers travelling north along Lee Street.

The simulations predicted that reflections can primarily fall on this point between 12:00 pm and 6:45 pm AEST throughout the year. Very brief reflections were also predicted to be possible between 8:45 am and 11:45 am AEST.

None of the reflections were predicted to result in a veiling luminance above 500 cd/m².

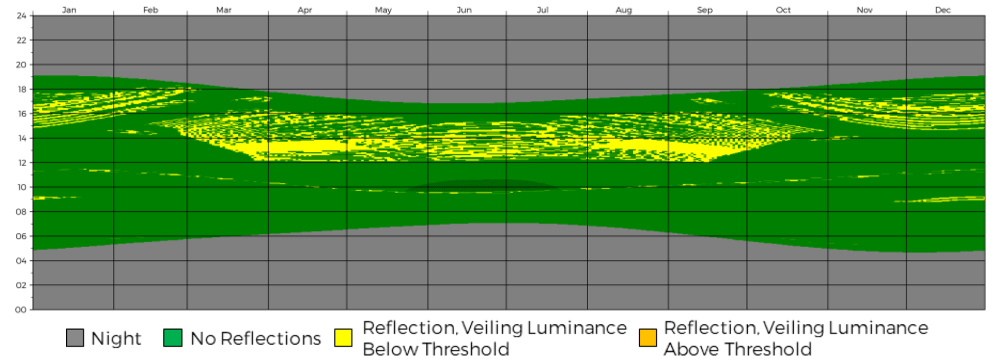

Figure 9: Annual Reflection Impact Diagram for Driver Receptor D1

Receptor D2

Receptor D2 was chosen to assess the visual impact associated with solar reflections affecting drivers travelling east at the Broadway-George Street and Harris Street-Regent Street intersection.

The simulations predicted that reflections can primarily fall on this point between 10:15 am and 5:15 pm AEST from April to August. During March to early April and September to early October, potential reflections were predicted between 7:00 am to 12:15 pm AEST and again from 1:00 pm to 6:30 pm AEST. From October to February, potential reflections were predicted during afternoon hours between 1:45 pm and 6:30 pm AEST.

None of the reflections were predicted to result in a veiling luminance above 500 cd/m².

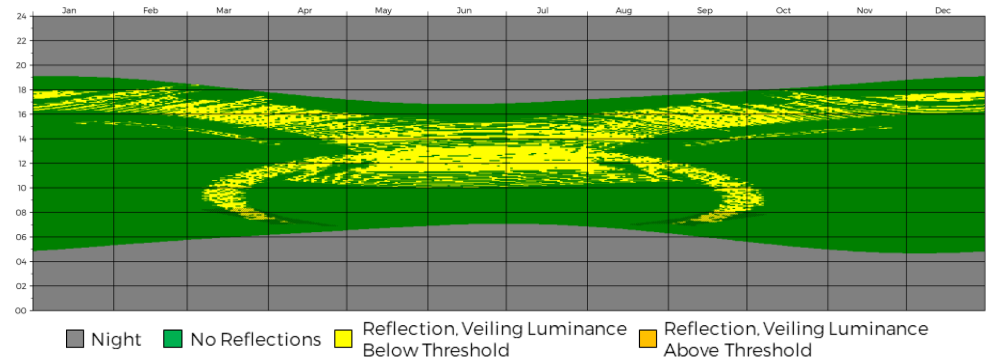

Figure 10: Annual Reflection Impact Diagram for Driver Receptor D2

Receptor D3

Receptor D3 was chosen to assess the visual impact associated with solar reflections affecting drivers travelling south at the George Street and Pitt Street intersection.

The simulations indicated that reflections can primarily fall on this point between 5:45 am and 5:30 pm AEST from mid-February to October.

None of the reflections were predicted to result in a veiling luminance above 500 cd/m².

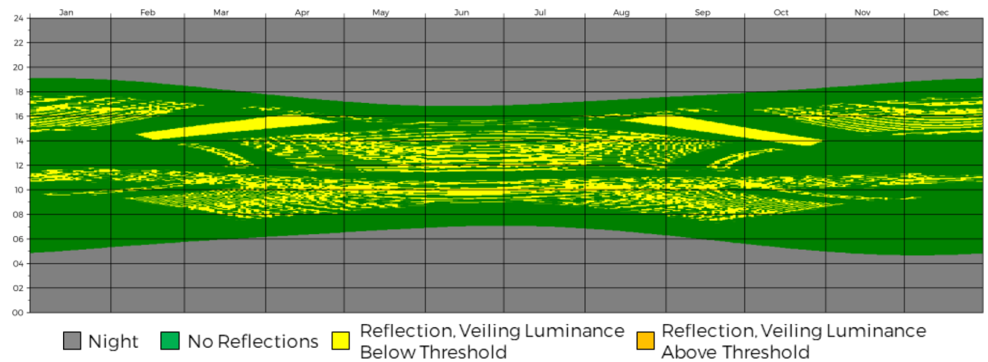

Figure 11: Annual Reflection Impact Diagram for Driver Receptor D3

Receptor D4

Receptor D4 was chosen to assess the visual impact associated with solar reflections affecting drivers travelling south on Pitt Street.

The simulations predicted that reflections can primarily fall on this point between 5:45 am and 5:30 pm AEST from March to September. In the months of October through February, reflections were predicted to be possible between 5:45 am and 9:15 am AEST and again between 11:45 am and 5:00 pm AEST.

None of the reflections were predicted to result in a veiling luminance above 500 cd/m².

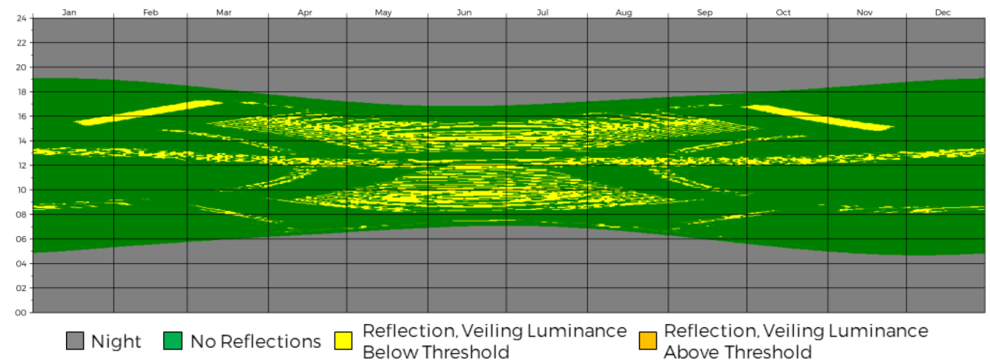

Figure 12: Annual Reflection Impact Diagram for Driver Receptor D4

Receptor D5

Receptor D5 was chosen to assess the visual impact associated with solar reflections affecting train drivers travelling south on Randwick line at George Street.

The simulations predicted that reflections primarily fall on this point between 3:15 pm and 6:30 pm AEST from mid-August through April. Brief reflections were also predicted to be possible throughout the year between 10:00 am and 12:00 pm AEST.

None of the reflections were predicted to result in a veiling luminance above 500 cd/m².

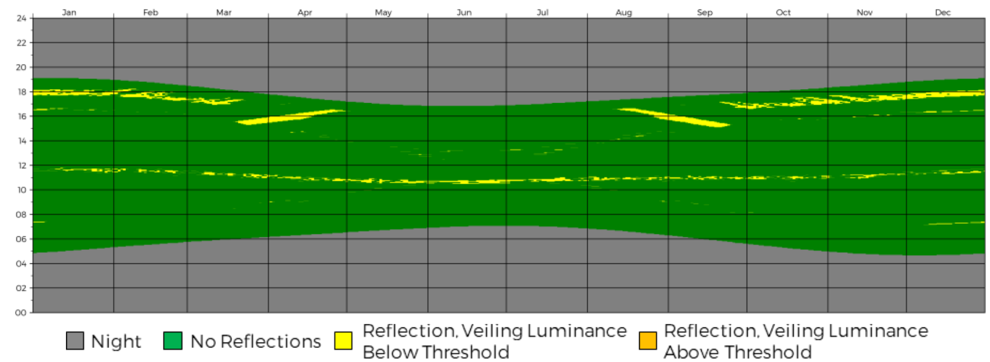

Figure 13: Annual Reflection Impact Diagram for Driver Receptor D5

Receptor D6

Receptor D6 was chosen to assess the visual impact associated with solar reflections affecting train drivers travelling south on the Intercity Train line.

The simulations predicted that reflections can primarily fall on this point between 6:00 am and 2:30 pm AEST from March to mid-October. In the other months, intermittent reflections were predicted to be possible between 8:45 am and 11:00 am AEST and again between 2:00 pm and 5:00 pm AEST though the summer as well.

None of the reflections were predicted to result in a veiling luminance above 500 cd/m².

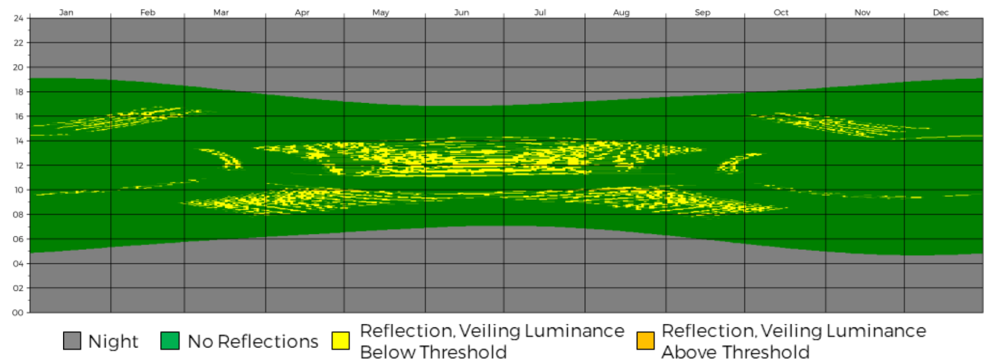

Figure 14: Annual Reflection Impact Diagram for Driver Receptor D6

Receptor D7

Receptor D7 was chosen to assess the visual impact associated with solar reflections affecting train drivers travelling south on the Sydney Trains line.

The simulations indicated that very brief reflections can fall on this point from between 3:15 pm and 5:30 pm AEST late-February to mid-October.

None of the reflections were predicted to result in a veiling luminance above 500 cd/m².

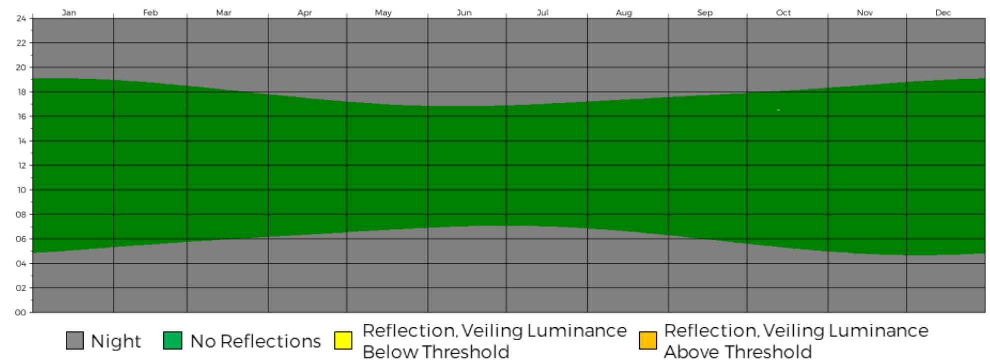

Figure 15: Annual Reflection Impact Diagram for Driver Receptor D7

OBSERVATIONS AND CONCLUSIONS

1. Like any contemporary building, the reflective surfaces of the proposed development are naturally causing solar reflections in the surrounding area.

2. The maximum intensities of the reflected solar energy at the ground level were predicted to be low, with **the majority of the reflections having maximum intensity below 280 W/m²**. This means that **there is no evidence of focusing or concentration of reflections**. 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. Based on the analysis, which included 7 receptor locations which presented some potential risk, **none of the reflections were predicted to result in a veiling luminance above 500 cd/m², based on the glazing having a specular reflectance of 20% or less**. As such, no mitigation measures have been recommended that this time.

4. The screening analysis generally predicted low potential for glare, even with its highly conservative assumption that the viewer would always be looking horizontally towards the source of the reflection. The most frequent reflections were confined within the areas at the Lee Street and Ambulance Avenue junction, and at the Lee Street and Railway Colonnade Drive junction. This was predicted to be possible in less than 2% of daytime hours annually. That said, this can only occur if the driver was looking towards the source of the reflection.

5. The screening analysis also predicted extremely low potential for reflections on a small area of the intercity train line (up to 0.05% of the daytime hours annually). None of these reflections were predicted to exceed the veiling luminance threshold of 500 cd/m².

6. The detailed analysis, which accounted for more realistic view directions and operated at one-minute increments, predicted that drivers approaching the proposed development on George Street, Lee Street and Pitt Street (D1 – D4) have the potential to be exposed to reflections emanating from the proposed development. However, none of these reflections were predicted to exceed the veiling luminance threshold of 500 cd/m².

7. For train drivers on the Sydney Light Rail (Randwick line) and Sydney Trains (receptors D5 – D7), none of the reflections were predicted to exceed the veiling luminance threshold of 500 cd/m².

8. Given the safety risks associated with glare impacts to 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.

GENERAL STATEMENT OF LIMITATIONS

This report entitled *"TOGA Central– Solar Reflection Screening Analysis"*, dated July 21, 2022, was prepared by RWDI Australia Pty Ltd ("RWDI") for TOGA ("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 utilize 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

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].

In the work described herein, we have adopted the typical Australian criteria put forth by Hassall[2], which defines glare as occurring when the veiling luminance of a reflection exceeds 500 cd/m^2.

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/m^2 limit assumes an adaptation luminance corresponding to a dawn or dusk time frame and may be overly conservative during brighter parts of the day.

Thermal Impact (Heat Gain) on People

The primary sources for exposure limits to thermal radiation come from fire protection literature. However, there is currently inconsistency between different bodies regarding what level of exposure can be reasonably tolerated by people.

The U.S. National Fire Protection Association (NFPA) defines 1,700 W/m² as an upper limit for a tenable egress environment[4]; i.e. an individual could escape through such an environment successfully, though they would not necessarily emerge unscathed. The British Standards Institution[5] sets their limit at 2,000 W/m², which "*…is tolerable for ~ 5 min[utes]…*". Other researchers[6] have found that higher irradiance levels (3,500 – 5,000 W/m²) can be tolerated in outdoor environments for several minutes without issue.

The only current quantitative guideline specific to reflections comes from the City of London's Planning Note on 'Solar Convergence'[7]. Produced in conjunction with the UK Building Research Establishment (BRE), this document indicates that no areas should receive 10,000 W/m² or more for any duration, exposures above 2,500 W/m² should be limited to less than 30 seconds; and that "*…areas with reflected irradiances above 1,500 W/m², and preferably those above 1000 W/m², should be minimized.*"

It should be noted that all these thresholds are guideline values only, and that in reality many factors (skin colour, age, clothing choice, etc.) influence how a person reacts to thermal radiation.

Clearly, there are currently no definitive guidelines or criteria with respect to the issue of thresholds for exposure to thermal irradiance in an urban setting. We know this criterion should be lower than the thresholds set in the context of an individual escaping from a fire and greater than typical peak solar noon levels of 1,000 W/m² which people commonly experience.

Therefore, RWDI's opinion at this time, is that reasonable criteria is to establish 2,500 W/m² as a ceiling exposure limit, which reflection intensity should not exceed for any length of time; and 1,500 W/m² as a short term (10 minutes or less) exposure limit.

Thermal Impact (Heat Gain) on Property

The impact of solar irradiance on different materials is primarily based on the temperature gains to the material which can cause softening, deformation, melting, or in extreme cases, combustion. These temperature gains are difficult to predict as they are highly dependent on the convective heat transfer from air movement around the object and long-wave radiative heat transfer to the surroundings.

Generally, irradiance levels at or above 10,000 W/m² for more than 10 minutes are required to ignite common building and automotive materials in the presence of a pilot flame. That value increases to 25,000 W/m² when no pilot flame is present[8,9,10]. However, some materials like plastics and even some asphalts may begin to soften and deform at lower temperatures. For example, some plastics can deform at a temperature of 140°F (60°C), or lower if force is applied. The applied force typically comes from the thermal expansion of the material, the force of gravity acting on the material or an external mechanical force (i.e. someone or something pushing or pulling on it).

Aside from the risk of damage to the material itself, a hot surface poses a safety risk to any person who may come into contact with it. This is particularly important in an urban context as the individual may not expect the object to be heated. NASA[11] defines an upper limit of 111°F (44°C) for surfaces that require extended contact time with bare skin. Surface temperatures below this limit can be handled for any length of time without causing pain.

That said, surfaces within the urban realm are routinely exposed to reflections from windows, metal panels and bodies of water without causing material damage or excessive heating.

Therefore, as this time, RWDI takes a conservative approach and **uses a value of 1,000 W/m², consistent with a single (i.e. non-focused) reflection of the sun's peak intensity, as a baseline threshold for reflected irradiance on stationary objects.**

However, this is simply a starting point. As noted, depending on the environmental conditions and material properties of the object/assembly other values may be used instead.

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