Report:

# Reflectivity Analysis

Project:

## Western Sydney University - Bankstown

For:

## Archerfield Partners

By:

## Inhabit Australasia Pty Ltd.

Doc. No: 7830-RPT-ES0001
Date: 2019-07-12
Revision: 01

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| 00 | 2019-04-12 | **Description** | Reflectivity Glare Study | | |
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| 01 | 2019-07-12 | **Description** | Update to Façade | | |
| | | | **Prepared by** | **Checked by** | **Approved by** |
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## Limitations

Inhabit Australasia Plc will not be held liable for predicted glass transmission light colour estimates, nor for the reliance by any party on those results, for any purpose. Simulations of façade performance are idealised representations of the actual façade that cannot fully represent all of the intricacies of the building once built. As a result, simulation results only represent an interpretation of the façade performance. No guarantee or warrantee for the occurrence of glare in practice can be based on simulation results alone.

## Executive Summary

An external glare study has been undertaken to determine the impact of façade solar reflections onto roads and existing buildings surrounding the proposed Western Sydney University (WSU) Bankstown campus development.

The proposed WSU campus has been modelled, along with the surrounding building on the site. A computational glare assessment has been undertaken at 7 critical view locations around the proposed development, located on roads where motorists vision may be impacted and at nearby surrounding buildings.

Since delivering the report 7830-RPT-ES0001(00): Reflectivity Analysis, issued 12th April 2019, the design of the facade has undergone further development, which alters the external building envelope. The east façade has an increased amount of solid clad areas & green wall, the sunshade form is different on north and west facades, with shading removed on the south. These design changes have significantly improved the external reflectivity outcome since the previous assessment.

As façade materials are to be confirmed, conservative material properties have been assigned. The glazing on the façade has been modelled to represent an external reflectivity of 16%.

The results indicate that intolerable glare - with a Daylight Glare Index (DGI) result greater than 28 - is seen in all locations. However, most of this intolerable glare is due to direct exposure to the sun, and not due to reflected glare from the proposed WSU façade. A summary of reflected glare issues and comments for each location is presented in Table 1.

At locations 2 and 6 - looking west on Rickard Road - there is no intolerable glare due to the building façade. At location 1, facing east on Rickard Road, there is intolerable reflected glare due to the proposed building's western façade at 6pm in December, January and February. This glare issue is present for approximately 1.8% of annual daylight hours throughout the year. Additionally, the intolerable DGI result is comparable to the glare that motorists experience in mornings during summer, from direct exposure to the sun. Modelling has shown that an external glazing reflectivity of 7% or less is required to alleviate this issue.

At location 5, facing north on Chapel Road, there is intolerable reflected glare due to the proposed building's south-east façade at 5pm in October. This location has been deemed low-risk as the modelling did not account for trees that appear to block the line-of-sight between the viewpoint and proposed building, expected to reduce the glare intensity.

The reflected glare impact to surrounding buildings (Locations 3 and 4) is significant, as seen in Figure 1. It is expected that architectural details not accounted for in the model, such as balconies and shading devices, will greatly reduce the impact of this glare. Additionally, occupants may utilise blinds if the glare issue is present.

The results have been generated with certain material properties specified. These values are intended to be conservative. However, for the glare assessment to remain applicable, material finishes on the building façade must have reflectivity values equal to or lesser than those specified in Section 4.5. Increased material reflectivity or variation in surface finish may contribute to additional glare and unforeseen issues.

**Table 1:** Summary of Reflected Glare Issues and Comments for Each Location Assessed

| Location | % of Annual Daylight Hours with Intolerable Glare Due to WSU Façade | Problem times | Comment |
|---|---|---|---|
| 1: Motorist heading east on Rickard Road | 2% | 18:00 December, January and February | o Reflected glare is equivalent to glare from direct view of the sun in the morning<br>o Glazing on the western façade must have a reflectivity of 7% or less to remove the glare issue |
| 2: Motorist heading west on Rickard Road | 0% | - | o No glare issue detected |
| 3: Residents at 63 Rickard Road | 4% | 13:00-15:00, April to August | o Reflected glare is equivalent to glare from direct view of the sun in the late afternoon<br>o It is expected that balconies will act as vertical shading and reduce the impact of reflected glare<br>o Residents may utilise blinds in the event of glare issues |
| 4: Occupants of Bankstown Library and Knowledge Centre | 2% | 15:00 March and October, 16:00 October and November | o It is expected that the significant sun-shades on the library façade will reduce the impact of the reflected glare<br>o The exterior glazing on the library will only transmit a portion of the reflected light |
| 5: Motorist heading north on Chapel Road | 1% | 17:00 October | o The simplified glare model does not include surrounding trees and greenery. Trees appear to block the line-of-sight between the assessed viewpoint and proposed development |
| 6: Motorist heading west on Rickard Road - before Jacobs Street | 0% | - | o No glare issue detected |
| 7: Occupants of Bankstown Community Services Centre | 2% | 7:00-9:00 January, November and December | o Reflected glare is equivalent to glare from direct view of the sun in the late afternoon<br>o Occupants may utilise blinds to for the 2% of annual daylight hours where intolerable glare is present. |

**Table 2:** Percentage of each Daylight Glare Index Result for Annual Daylight Hours*

| Visual Comfort | DGI Score | Location | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Imperceptible - Acceptable | < 22 | 75% | 78% | 83% | 90% | 55% | 75% | 78% |
| Borderline between Comfort and Discomfort | ≥ 22 & < 24 | 0% | 1% | 0% | 1% | 4% | 2% | 0% |
| Uncomfortable | ≥ 24 & < 28 | 11% | 8% | 1% | 6% | 11% | 5% | 6% |
| Intolerable (Direct Sun) | ≥ 28 | 12% | 13% | 12% | 2% | 29% | 18% | 14% |
| Intolerable (Reflected Glare) | ≥ 28 | 2% | 0% | 4% | 1% | 1% | 0% | 2% |

**Daylight hours are 6am to 7pm inclusive*

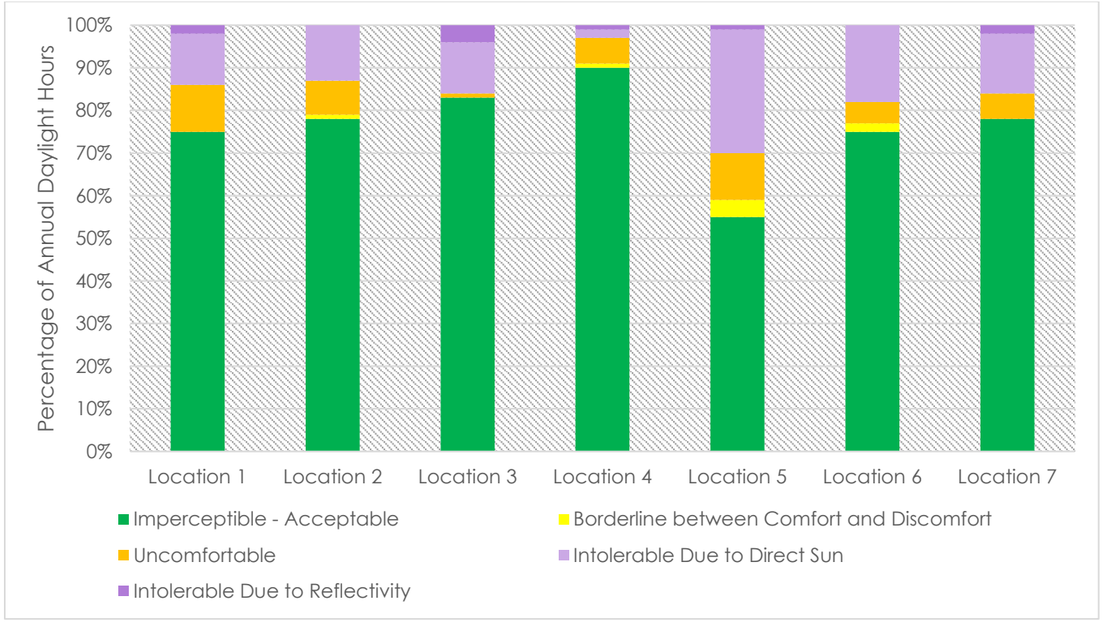



**Figure** 1: Summary of Results - % of Annual Daylight Hour Occurences in Each Comfort Band

The façade development and design changes have improved the external reflectivity outcome since the previous assessment. These improvements are summarised in Table 3 below

**Table 3:** Summary of Intolerable Glare Results - Previous and Current Facade Design

| Location | % of Annual Daylight Hours with Intolerable Glare Due to WSU Façade | | Comment |
|---|---|---|---|
| | Previous Design | Current Design | |
| 1: Motorist heading east on Rickard Road | 1.2% | 1.8% | ○ Increased reflected glare result is due to the updated model detecting glare at a time that was previously overlooked due to the time resolution.<br>○ Reflected glare intensity from the current façade design is approximately 12-20% lower |
| 2: Motorist heading west on Rickard Road | 0% | 0% | ○ No change |
| 3: Residents at 63 Rickard Road | 7.7% | 4.2% | ○ Improvement of 3.5% |
| 4: Occupants of Bankstown Library and Knowledge Centre | 4.8% | 2.4% | ○ Improvement of 2.4% |
| 5: Motorist heading north on Chapel Road | 0.60% | 0.60% | ○ Reflected glare intensity from the current façade design is approximately 6% lower |
| 6: Motorist heading west on Rickard Road - before Jacobs Street | 0% | 0% | ○ No change |
| 7: Occupants of Bankstown Community Services Centre | 3% | 1.8% | ○ Improvement of 1.2% due to additional green wall on the eastern façade |

# 1. Introduction

Western Sydney University is developing a new campus in Bankstown, New South Wales. The proposed building aims to accommodate up to 2,000 students on any one day across am and pm. The new campus building is set to occupy a 2500 square metre site in Bankstown's CBD, located aside the Bankstown Library and Knowledge Centre and Bankstown Community Services centre. Rickard Road borders the north of the site, identified as a location for potential glare issues.

Inhabit has been appointed to determine the risk of direct solar reflections off the façade and onto roads and existing buildings surrounding the proposed development. An architectural render of the proposed design is shown in Figure 2 below.


**Figure 2:** Architectural Render of the Proposed Development (source: Lyons Architects)

The aim of this study has been to identify the possible causes of visual impairment to people in the external environment within the context of the proposed façade. Computational techniques have been used to quantify the degree to which people are likely to be affected.

A method of identifying times and locations that are considered high risk of glare have been established. This study has effectively reviewed the levels of potential risks of glare from the proposed façade to seven critical locations throughout the year.

# 2. Potential Sources of Visual Impairment

## 2.1 Solar Reflections

The human eye can only tolerate a certain level of light luminance. Glare issues occur when too much light strikes the observer's field of vision; this can be caused by direct sunlight or reflected sunlight. The reflective nature of the material, in addition to the specularity and roughness of the surface determine the intensity of reflected light.

## 2.2 Glare

Glare can be categorised in two kinds: discomfort glare and disability glare. Discomfort glare prompts an affected individual user to look away the problem light source, where disability glare weakens vision without necessarily causing discomfort (International Commission on Illumination, Standard of Lighting Vocabulary, CIE S 017/E:2011, 2011). Factors that affect visual comfort include:

- Location of receiver and view direction;
- Position of sun;
- Geometry, reflectivity, specularity & roughness of surfaces in the built environment.

### 2.2.1 Daylight Glare Index

The glare sources and field are analysed using the Daylight Glare Index (DGI) over a field of view 90° in each direction on the horizontal plane. The DGI is a glare index that is adapted to relatively large sources of glare and accounts for the eye's greater tolerance to glare from daylight sources rather than artificial sources (Daylight Glare: A Review of Discomfort Indices, L Bellia et al, 2007). The degree of perceived glare using the DGI is shown in Table 4 below.

**Table 4:** The Degree of Perceived Glare using the DGI Scale

| Glare Response | DGI |
|---|---|
| Imperceptible | < 16 |
| Perceptible | ≥ 16 & < 20 |
| Acceptable | ≥ 20 & < 22 |
| Borderline between Comfort and Discomfort | ≥ 22 & < 24 |
| Uncomfortable | ≥ 24 & < 28 |
| Intolerable | ≥ 28 |

# 3. Methodology

## 3.1 General

The analysis has been conducted iteratively, in order to determine limiting reflective material properties on the buildings façade. A massing model of the site has been developed, based on a model provided the project architect to ensure accurate geometry is considered. The sun path over Bankstown was considered to identify any critical locations where glare issues may arise. Conservative material properties have been assigned to the glazing, shading devices and other external surfaces.

Further details on the methodology are included below.

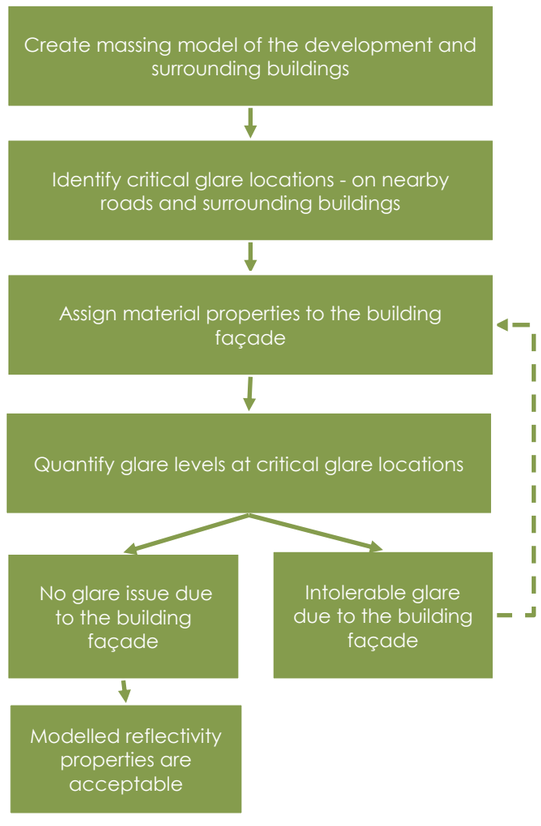



**Figure 3:** Flowchart of the reflected glare evaluation procedure

### 3.2 Quantification of Glare Risk

With the critical locations identified, images have been rendered using the Radiance plug-in for Rhinoceros. Radiance is a high-detail, open source, ray-tracing software. It was developed with primary support from the U.S. Department of Energy and additional support from the Swiss Federal Government; it's widely considered the industry standard tool for lighting simulation and glare calculations.

Radiance has been used to generate high quality fisheye images with a 180° field of view. The wide angle enables the glare calculation to sample areas representing the entire field of view of people in the surrounding environment.

The Radiance programme 'Evalglare' has been used to automatically identify glare sources in the fisheye image at each location; the risk of glare is calculated using the DGI scale. The Evalglare programme outputs an image highlighting glare sources and colour-coding the intensity.

An example fisheye image and Evalglare output is included in Figure 4 below. No direct solar glare is identified in this environment however reflected glare due to the building façade is present, represented as a blue dot in the Evalglare image.

**Figure 4:** Example of fisheye image (left) and output from Evalglare (right)

The glare result above was analysed on the 21st of July at 3pm. The viewpoint has been arbitrarily located on the façade of the council building to the east of the proposed development, facing west. The DGI for this time and location is 39.26, translating to an intolerable level of glare. However, the intolerable glare is due to the sun and not reflected off the building façade.

## 4. Analysis Inputs

### 4.1 Climate & Location

The coordinates of Bankstown, New South Wales, have been used for the solar analysis. The following details have been used to locate the development with respect the sun:

- Latitude: -33.93° South
- Longitude: 150.988° East
- Elevation: 8.8m above sea level

The data used for this assessment of the building is: AUS_NSW_Sydney-Bankstown.AP.947650_TMYx.2003-2017.epw, and has been sourced from the U.S. Department of Energy's (DOE) Energy Plus database.

### 4.2 Sky Conditions

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

The location of the sun in the sky for each time and date throughout the year is based on the actual celestial path for Bankstown in NSW.

### 4.3 Model Geometry

The model geometry used in the glare analysis has been based on an architectural site model provided by Lyons Architects on the 7th of July 2019, as well as the following elevations:

- A40-01, Building Elevations - North (Rickard Rd.), Revision 17 (28th June 2019)
- A40-02, Building Elevations - East (Appian Way), Rev 16 (28th June 2019)
- A40-03, Building Elevations - South, Rev 17 (28th June 2019)
- A40-04, Building Elevations - West, Rev 17 (28th June 2019)

The WSU Bankstown development and surrounding buildings included in the analysis can be seen in Figure 5 below.

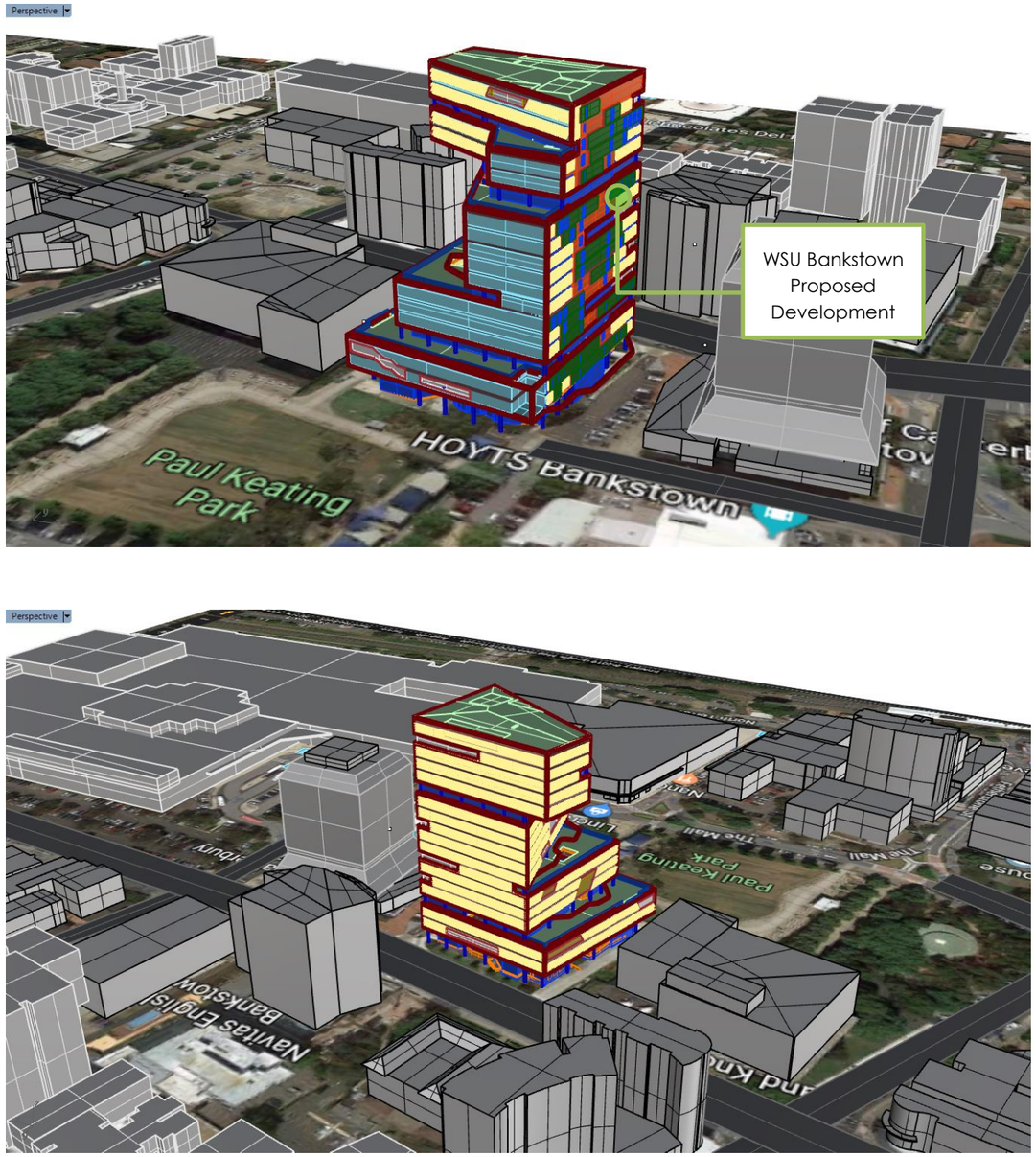



**Figure 5**: Model Geometry (Top: North West Facing View, Bottom: South East Facing View)

## 4.4 Critical Glare Locations

### 4.4.1 Roads

To assess the risk to motorists, critical glare locations on roads nearby the proposed development have been assessed. These locations lie on Rickard Rd and Chapel Rd, as shown in Figure 6 below. Glare is expected to be prevalent in the morning when driving east along Rickard Rd, and in the afternoon when driving west. The view angle has been oriented to align with the road ahead, as this is where motorists will be focusing their gaze.

### 4.4.2 Surrounding Buildings

The indicative glare impact on the following nearby buildings has been assessed:

- Bankstown Library and Knowledge centre
- Bankstown Council Building
- Residential building, 63 Rickard Road

This methodology presents an approximate glare impact from the proposed development; a realistic position of occupants within the building and their direction of view is difficult to consider. The view location is positioned on the building façade and does not consider the building envelope and interior spaces of the assessed buildings. The viewpoint has been arbitrarily located on the façade of each building, with the view directed towards the WSU Bankstown development. All assessed locations are shown in Figure 6 below.


**Figure 6:** WSU proposed development and surrounding assessment locations

Table 5 below summarises the assumed eye level of users at each location.

**Table 5:** Analysed locations

| Location | User | Elevation (above G.L) |
|---|---|---|
| 1 | Motorist heading east on Rickard Road | 2m |
| 2 | Motorist heading west on Rickard Road | 2m |
| 3 | Residents at 63 Rickard Road | 24m |
| 4 | Occupants of Bankstown Library and Knowledge Centre | 8m |
| 5 | Motorist heading north on Chapel Road | 2m |
| 6 | Motorist heading west on Rickard Road - before Jacobs Street | 2m |
| 7 | Occupants of Bankstown Community Services Centre | 25m |

## 4.5 Material Definitions

Materials have been selected by considering the document, '*Façade Schedule, Design Development, Rev 3*', issued by Lyons on the 28th of June 2019. As some façade materials are still to be confirmed, several conservative assumptions have been made.

- The façade design shows a varying colour gradient on the shading fins, changing on each floor. For simplicity, and to generate conservative reflectivity results, a bright colour has been assumed throughout.
- The green wall and Ronstan mesh façade elements have been modelled as a dull, slightly rough material.
- The visual benchmark glass has an external reflectivity of 14%. A glazing reflectivity of 16% has been used in the analysis.

The material values listed in the Table 6 below are based on typical properties.

**Table 6:** Material Properties

| Element | Façade Schedule Reference | Reflectivity | Specularity | Surface Roughness |
|---|---|---|---|---|
| Glazing | FT-CW1, FT-CW2, FT-CW3, FT-CW4, BA-GL1 | 0.16 | 0.9 | 0.0 |
| Sefar Mesh Glazing | FT-CW6 | 0.2 | 0.9 | 0.1 |
| Ronstan Mesh + Green Wall | FT-MS1, FT-MS2, FT-GW1 | 0.1 | 0.0 | 0.1 |
| Cladding | FT-CW3, FT-CW4 | 0.6 | 0.016 | 0.0 |
| Shading Fins | FT-CW2, FT-CW3, FT-CW4, | 0.8 | 0.067 | 0.1 |
| GRC Panels | FT-GRC1 | 0.25 | 0.0 | 0.1 |
| Louvres | FT-CW1, FT-CW2, FT-CW3, FT-CW4 | 0.35 | 0.02 | 0.0 |
| Façade Framing | FT-CW6, FT-MS1,FT-MS2, FT-GW1 | 0.4 | 0.02 | 0.0 |
| Exterior Floor and Ceiling | FT-SF1 | 0.5 | 0.05 | 0.0 |
| Road | - | 0.2 | 0.0 | 0.2 |
| Ground | - | RGB: 0.60/0.34/0.08 | 0.0 | 0.2 |
| Surrounding Buildings | - | 0.2 | 0.1 | 0.0 |

The results have been generated assuming the material properties outlined in Table 6. These values are intended to be conservative. However, for the glare assessment to remain applicable, material finishes on

the building façade must have reflectivity values equal to or lesser than those specified in Table 6. Increased material reflectivity or variation in surface finish may contribute to additional glare and unforeseen issues.

## 4.6 Time of Analysis

Each location has been considered for hours 6:00am to 7:00pm, on the 21st day each month of the year. The 21st is considered to account for the summer and winter solstice. As results can be unpredictable given varied façade orientations, all months have been assessed. The simulation time would be too large to run for each day and subsequent hour of the year, and this time resolution provides adequate information on the impact of glare annually.

## 4.7 Radiance Parameters

Appendix A of this report details the Radiance parameters used in the glare analysis. These values are at the accurate level that Radiance recommends for rendering.

# 5. Results

## 5.1 Location 1

| | 6:00 | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 0.00 | 38.77 | 37.03 | 33.99 | 28.58 | 27.48 | 0.00 | 0.00 | 0.00 | 0.00 | 0.56 | 1.15 | 31.68 | 0.00 |
| February | 0.00 | 38.16 | 19.18 | 7.51 | 29.41 | 27.75 | -15.06 | 0.00 | 0.00 | 0.00 | -3.88 | -3.96 | 31.24 | 0.00 |
| March | 0.00 | 0.00 | 0.00 | 9.65 | 21.01 | 15.52 | -11.96 | 0.00 | 0.00 | 0.00 | 24.77 | 0.00 | 0.00 | 0.00 |
| April | 0.00 | 0.00 | 0.00 | 12.63 | 28.10 | 20.38 | 2.79 | 26.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| May | 0.00 | 0.00 | 24.84 | 32.75 | 27.49 | 26.54 | 0.00 | 0.00 | 0.00 | -10.35 | 0.00 | 0.00 | 0.00 | 0.00 |
| June | 0.00 | 0.00 | 25.28 | 13.76 | 29.35 | 26.36 | -7.88 | -7.44 | -9.28 | -7.68 | 0.00 | 0.00 | 0.00 | 0.00 |
| July | 0.00 | 0.00 | 0.00 | 13.76 | 29.47 | 26.37 | -9.64 | -11.77 | -11.61 | -6.07 | -15.76 | 0.00 | 0.00 | 0.00 |
| August | 0.00 | 0.00 | 0.00 | 13.22 | 29.21 | 26.67 | 0.00 | 0.00 | 0.00 | 0.00 | -15.39 | 0.00 | 0.00 | 0.00 |
| September | 0.00 | 17.59 | 15.13 | 10.24 | 27.71 | 25.99 | 0.00 | 0.00 | 0.00 | -9.03 | -3.57 | -6.29 | 0.00 | 0.00 |
| October | 0.00 | 20.19 | 15.84 | 30.57 | 27.92 | 26.81 | 0.00 | 0.00 | 0.00 | -8.91 | -0.39 | -1.06 | 0.00 | 0.00 |
| November | 37.01 | 37.10 | 34.92 | 31.61 | 27.90 | 27.36 | 0.00 | 0.00 | 0.00 | -9.86 | -1.10 | -1.37 | -1.97 | 0.00 |
| December | 20.15 | 37.48 | 35.38 | 32.07 | 28.16 | 27.63 | 0.00 | 0.00 | 0.00 | -13.36 | -1.57 | -1.64 | 31.22 | 0.00 |

| | DGI | % of Annual Daylight Hours |
|---|---|---|
| Imperceptible - Acceptable | <22 | 75.60% |
| Borderline between Comfort and Discomfort | ≥22 & <24 | 0.00% |
| Uncomfortable | ≥24 & <28 | 10.71% |
| Intolerable (Direct Sun) | ≥ 28 | 11.90% |
| Intolerable (Reflected Glare) | ≥ 28 | 1.79% |

At location 1, facing east on Rickard Road, there is intolerable reflected glare due to the proposed building's western façade at 6pm in Summer months. All other intolerable DGI values at this location are due to direct exposure to the sun.

21st November 6:00

37.01 - Intolerable Glare

21st August 10:00

29.21 - Intolerable Glare

21st December 18:00

31.22 - Intolerable Glare

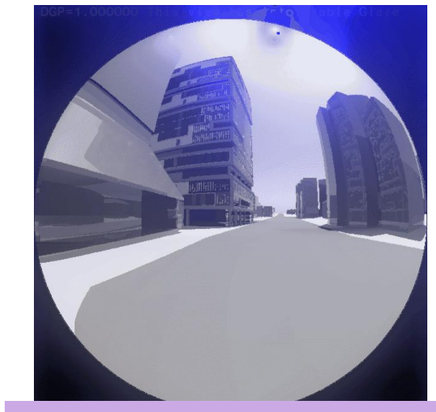
## 5.2 Location 2

| | 6:00 | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 1.89 | 1.89 | 0.73 | -18.15 | 0.00 | 0.00 | 0.00 | 27.21 | 30.01 | 36.76 | 20.46 | 21.75 | 20.25 | 14.66 |
| February | 0.73 | 0.73 | 3.45 | -15.38 | 0.00 | 0.00 | 0.00 | 26.91 | 27.93 | 33.74 | 37.71 | 23.17 | 21.08 | 0.00 |
| March | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.68 | -3.65 | 20.56 | 26.88 | 34.88 | 32.53 | 38.53 | 19.35 | 0.00 |
| April | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.16 | 6.87 | 26.62 | 11.10 | 18.06 | 21.38 | 37.89 | 0.00 | 0.00 |
| May | 0.00 | 0.00 | 11.89 | -11.20 | -4.33 | -8.50 | -0.30 | 26.79 | 10.71 | 17.31 | 19.40 | 0.00 | 0.00 | 0.00 |
| June | 0.00 | 0.00 | 9.18 | -0.77 | -1.60 | -2.65 | 1.37 | 26.92 | 13.68 | 16.70 | 18.38 | 0.00 | 0.00 | 0.00 |
| July | 0.00 | 0.00 | 0.00 | -8.81 | -2.09 | -8.28 | -1.26 | 27.02 | 12.31 | 16.47 | 19.17 | 18.50 | 0.00 | 0.00 |
| August | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -3.94 | 27.19 | 8.16 | 17.70 | 21.08 | 38.84 | 0.00 | 0.00 |
| September | 0.00 | 10.94 | -27.26 | 0.00 | 0.00 | 0.00 | -0.32 | 27.58 | 31.06 | 36.38 | 40.32 | 42.14 | 0.00 | 0.00 |
| October | 0.00 | 2.56 | -5.83 | 0.00 | 0.00 | 0.00 | 21.98 | 27.79 | 30.40 | 35.93 | 40.21 | 22.47 | 18.06 | 0.00 |
| November | 12.15 | -0.07 | -16.35 | 0.00 | 0.00 | 0.00 | 24.86 | 28.13 | 29.08 | 34.65 | 21.53 | 21.28 | 19.35 | 0.00 |
| December | 10.27 | 1.07 | -16.61 | 0.00 | 0.00 | 0.00 | 10.91 | 27.96 | 30.11 | 33.26 | 20.47 | 36.15 | 19.87 | 14.22 |

| | DGI | % of Annual Daylight Hours |
|---|---|---|
| Imperceptible - Acceptable | <22 | 77.98% |
| Borderline between Comfort and Discomfort | ≥22 & <24 | 1.19% |
| Uncomfortable | ≥24 & <28 | 7.74% |
| Intolerable (Direct Sun) | ≥ 28 | 13.10% |
| Intolerable (Reflected Glare) | ≥ 28 | 0.00% |

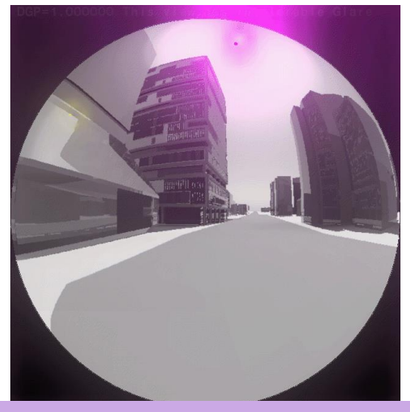
It has been found that at location 2, facing west on Rickard Road, the proposed building does not contribute to any intolerable glare. All intolerable DGI values at this location are due to direct exposure to the sun.

21st November 13:00



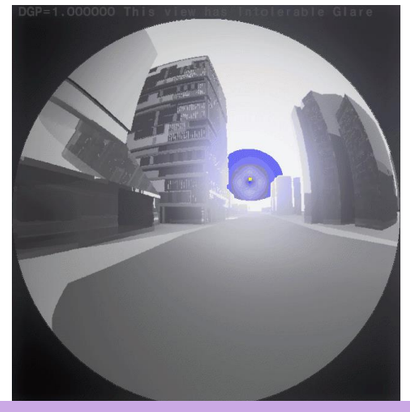
28.13 - Intolerable Glare

21st December 14:00



30.11 - Intolerable Glare

21st September 17:00



42.14 - Intolerable Glare

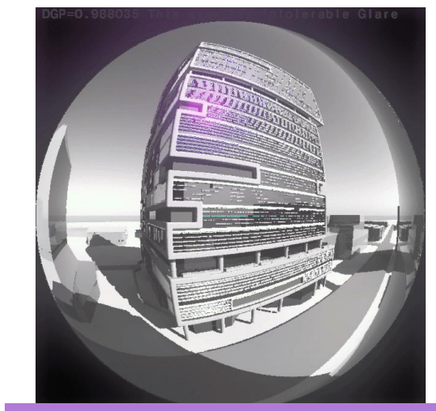
## 5.3 Location 3

| | 6:00 | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 0.00 | -8.64 | 0.00 | 0.00 | -8.60 | 0.00 | 0.00 | 0.00 | -2.27 | 28.36 | 32.76 | 37.40 | 39.57 | 15.28 |
| February | 0.00 | 0.00 | -5.46 | -15.09 | 5.40 | 0.00 | 0.00 | -16.59 | -17.09 | -1.62 | 30.71 | 34.46 | 38.08 | 0.00 |
| March | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -16.92 | -8.47 | 0.14 | 14.71 | 30.89 | 28.73 | 0.00 |
| April | 0.00 | 0.00 | 0.00 | 0.00 | -6.67 | 0.00 | 0.00 | 0.02 | -13.40 | 29.31 | 12.87 | 15.48 | 0.00 | 0.00 |
| May | 0.00 | 0.00 | 0.00 | 6.75 | 12.57 | 14.87 | 14.87 | 6.61 | 10.24 | 36.06 | 10.72 | 0.00 | 0.00 | 0.00 |
| June | 0.00 | 0.00 | 0.00 | 10.70 | 13.16 | 15.38 | 14.68 | 15.44 | 12.29 | 35.50 | 9.38 | 0.00 | 0.00 | 0.00 |
| July | 0.00 | 0.00 | 0.00 | -14.36 | 11.08 | 15.05 | 14.49 | 29.69 | 31.17 | 35.91 | 10.29 | 13.01 | 0.00 | 0.00 |
| August | 0.00 | 0.00 | 0.00 | -5.45 | 11.75 | 12.40 | 2.21 | 5.23 | 4.87 | 30.74 | 12.44 | 16.00 | 0.00 | 0.00 |
| September | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -10.33 | -2.65 | -0.12 | 3.09 | 16.00 | 34.64 | 0.00 | 0.00 |
| October | 0.00 | -1.61 | -15.02 | 0.00 | -0.88 | -13.74 | -8.94 | -13.03 | -6.52 | 8.50 | 33.91 | 37.23 | 33.90 | 0.00 |
| November | -8.13 | -11.56 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -0.65 | 29.37 | 34.12 | 35.27 | 39.11 | 0.00 |
| December | -3.18 | -5.41 | 0.00 | 0.00 | 0.00 | -7.59 | 0.00 | 0.00 | -1.86 | 28.68 | 34.85 | 38.43 | 24.02 | 15.39 |

| | DGI | % of Annual Daylight Hours |
|---|---|---|
| Imperceptible - Acceptable | <22 | 83.33% |
| Borderline between Comfort and Discomfort | ≥22 & <24 | 0.00% |
| Uncomfortable | ≥24 & <28 | 0.60% |
| Intolerable (Direct Sun) | ≥ 28 | 11.90% |
| Intolerable (Reflected Glare) | ≥ 28 | 4.17% |

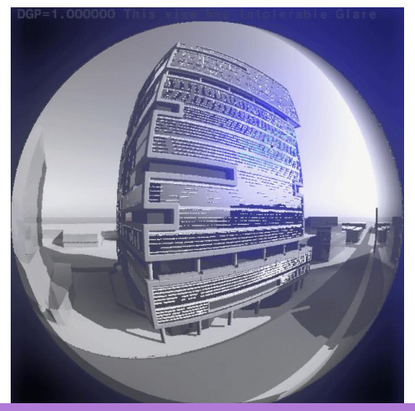
Location 3 is at an arbitrary point on the façade of the residential tower north of the proposed development. At this location, there is a significant amount of intolerable glare caused by the proposed buildings north facing façade. The glare issue is prevalent between the hours of 1pm and 3pm, in autumn and winter when the sun is lower in the sky. All other intolerable DGI values at this location are due to direct exposure to the sun.

21st July 13:00



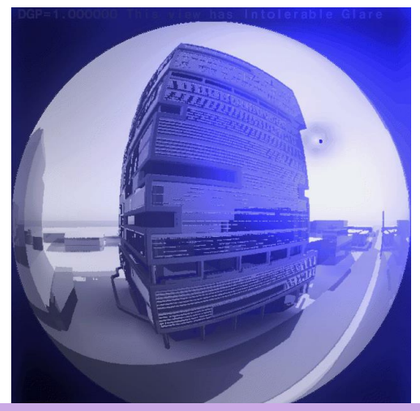
29.69 - Intolerable Glare

21st July 15:00



35.91 - Intolerable Glare

21st December 17:00



38.43 - Intolerable Glare

21st November 18:00


39.11 - Intolerable Glare

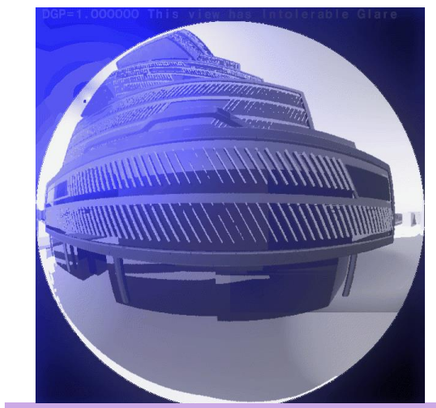
## 5.4 Location 4

| | 6:00 | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 0.00 | 8.76 | 5.07 | 2.25 | 14.84 | 5.95 | 0.00 | 0.00 | 0.00 | 4.16 | 15.92 | 11.69 | 5.25 | 0.00 |
| February | 0.00 | 6.87 | 4.08 | 6.23 | 13.92 | 4.76 | -12.78 | -8.48 | 0.00 | 9.46 | 6.28 | 11.69 | -1.83 | 0.00 |
| March | 0.00 | 0.00 | 0.00 | 8.92 | 10.04 | 17.51 | -15.95 | -7.48 | 0.00 | 29.32 | 0.45 | 0.00 | 0.00 | 0.00 |
| April | 0.00 | 0.00 | 0.00 | 11.18 | 26.73 | 18.62 | 4.74 | 0.00 | -11.91 | 3.19 | 11.42 | 0.00 | 0.00 | 0.00 |
| May | 0.00 | 0.00 | 8.27 | 12.45 | 25.97 | 16.32 | 0.00 | -8.94 | 26.77 | 13.27 | 4.00 | 0.00 | 0.00 | 0.00 |
| June | 0.00 | 0.00 | 6.91 | 12.08 | 27.56 | 18.04 | 0.00 | -5.88 | 12.07 | 12.44 | -1.43 | 0.00 | 0.00 | 0.00 |
| July | 0.00 | 0.00 | 0.00 | 11.90 | 27.80 | 22.36 | 0.00 | -10.61 | 5.21 | 13.97 | 7.60 | 0.00 | 0.00 | 0.00 |
| August | 0.00 | 0.00 | 0.00 | 11.57 | 28.01 | 24.59 | 0.00 | -10.20 | 1.15 | 13.15 | 11.46 | 0.00 | 0.00 | 0.00 |
| September | 0.00 | 4.89 | 8.01 | 9.45 | 9.95 | 23.95 | -9.17 | -16.57 | 6.29 | 15.28 | 11.14 | 4.09 | 0.00 | 0.00 |
| October | 0.00 | 5.02 | 4.85 | 5.02 | 3.81 | 25.81 | -11.38 | -13.49 | -5.86 | 30.28 | 34.26 | 7.45 | 0.00 | 0.00 |
| November | 9.01 | 7.77 | 5.43 | 2.46 | 4.66 | 27.13 | 0.00 | 0.00 | 0.00 | 24.00 | 32.54 | 9.36 | -11.81 | 0.00 |
| December | 9.77 | 9.79 | 7.15 | 3.76 | 3.63 | 27.60 | 0.00 | 0.00 | 0.00 | 9.14 | 14.92 | 13.01 | 1.69 | -19.68 |

| | DGI | % of Annual Daylight Hours |
|---|---|---|
| Imperceptible - Acceptable | <22 | 89.88% |
| Borderline between Comfort and Discomfort | ≥22 & <24 | 1.19% |
| Uncomfortable | ≥24 & <28 | 5.95% |
| Intolerable (Direct Sun) | ≥ 28 | 0.60% |
| Intolerable (Reflected Glare) | ≥ 28 | 2.38% |

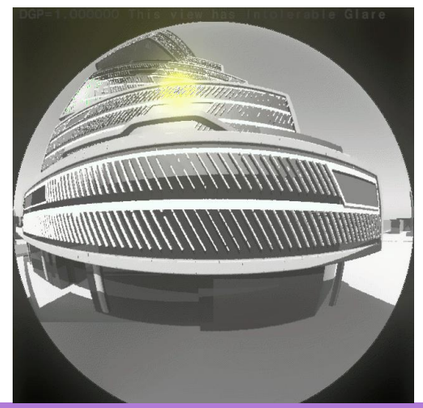
Location 4 is at an arbitrary point on the façade of the Bankstown Library and Knowledge Centre, west of the proposed development. At this location, there is intolerable glare caused by the proposed buildings west façade in the mid to late afternoon, in March, October and November.

21st August 10:00



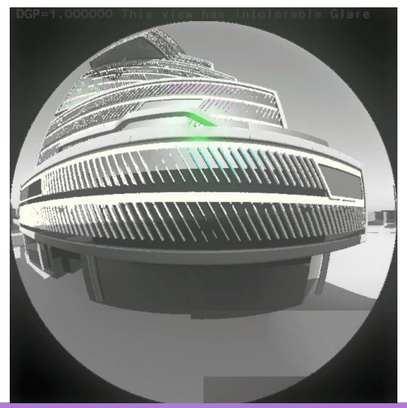
28.01 - Intolerable Glare

21st October 15:00



30.38 - Intolerable Glare

21st October 16:00



34.26 - Intolerable Glare

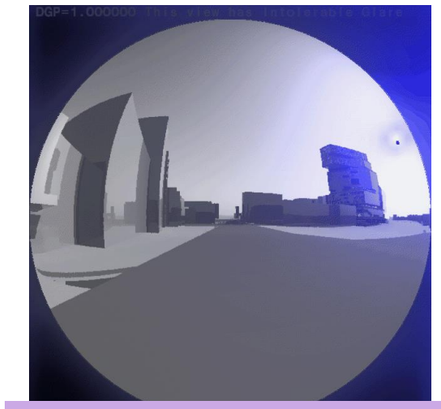
## 5.5 Location 5

| | 6:00 | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 0.00 | 25.55 | 26.80 | 28.07 | 28.42 | 27.75 | 28.21 | 26.69 | -1.67 | -15.98 | 2.13 | 2.72 | -0.24 | 0.00 |
| February | 0.00 | 27.44 | 30.67 | 30.87 | 29.70 | 28.22 | 28.03 | 27.44 | 26.41 | 0.18 | 1.92 | 0.47 | -0.86 | 0.00 |
| March | 0.00 | 0.00 | 0.00 | 33.30 | 23.35 | 17.23 | 29.13 | 22.75 | 23.36 | 25.29 | 3.17 | -5.30 | 14.08 | 0.00 |
| April | 0.00 | 0.00 | 0.00 | 34.63 | 36.30 | 31.09 | 22.59 | 31.33 | 21.12 | 5.32 | 2.16 | -4.21 | 0.00 | 0.00 |
| May | 0.00 | 0.00 | 18.37 | 38.81 | 39.55 | 37.98 | 36.82 | 9.73 | 5.60 | 4.95 | 0.04 | 0.00 | 0.00 | 0.00 |
| June | 0.00 | 0.00 | 34.06 | 40.16 | 41.91 | 39.00 | 38.19 | 12.65 | 10.03 | 4.27 | 0.29 | 0.00 | 0.00 | 0.00 |
| July | 0.00 | 0.00 | 0.00 | 38.34 | 39.37 | 38.11 | 37.28 | 10.04 | 6.96 | 4.70 | 1.83 | -3.81 | 0.00 | 0.00 |
| August | 0.00 | 0.00 | 0.00 | 37.42 | 37.08 | 35.48 | 34.16 | 32.14 | 29.90 | 5.22 | 2.83 | -3.68 | 0.00 | 0.00 |
| September | 0.00 | 29.61 | 30.61 | 32.18 | 32.83 | 30.20 | 28.80 | 28.07 | 27.36 | 20.45 | 3.47 | -0.43 | 0.00 | 0.00 |
| October | 0.00 | 30.14 | 30.59 | 29.96 | 28.43 | 28.23 | 28.05 | 27.47 | 19.60 | 1.51 | 3.76 | 30.61 | 0.00 | 0.00 |
| November | 22.08 | 25.36 | 26.35 | 28.02 | 28.02 | 28.13 | 27.34 | 25.57 | -11.74 | -17.09 | -2.04 | 0.59 | -7.27 | 0.00 |
| December | 21.48 | 23.82 | 26.07 | 27.70 | 27.89 | 27.80 | 27.67 | 19.16 | 0.00 | 0.00 | 1.74 | 2.76 | -7.24 | 0.00 |

| | DGI | % of Annual Daylight Hours |
|---|---|---|
| Imperceptible - Acceptable | <22 | 55.36% |
| Borderline between Comfort and Discomfort | ≥22 & <24 | 3.57% |
| Uncomfortable | ≥24 & <28 | 11.31% |
| Intolerable (Direct Sun) | ≥ 28 | 29.17% |
| Intolerable (Reflected Glare) | ≥ 28 | 0.60% |

It has been found that at location 5, facing north on Chapel Road, there is intolerable reflected glare due to the proposed building's south-east façade at 5pm in October. Although not captured in the results, it's likely there will also be an intolerable glare issue at this time of day sometime between February and March when the sun is at an equivalent position in the sky. All other intolerable DGI values at this location are due to direct exposure to the sun.

21st October 7:00

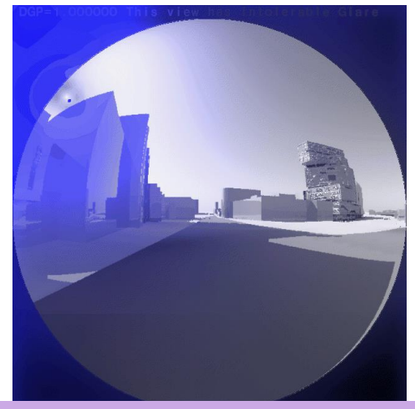


30.14 - Intolerable Glare

21st July 10:00

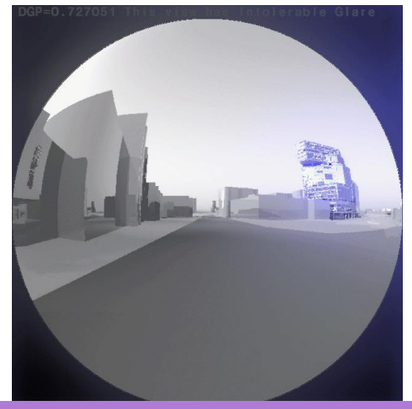
39.37 - Intolerable Glare

21st August 14:00



29.90 - Intolerable Glare

21st October 17:00



30.61 - Intolerable Glare

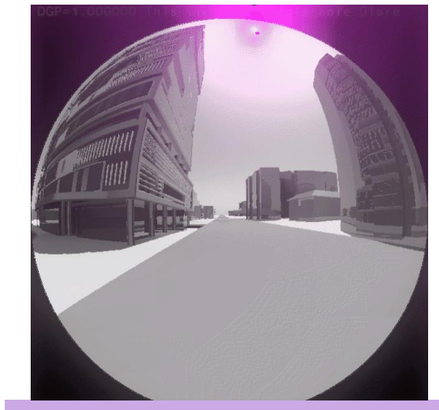
## 5.6 Location 6

| | 6:00 | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 0.00 | -10.43 | -13.62 | 0.00 | -17.68 | 0.00 | 16.11 | 27.57 | 28.49 | 33.26 | 19.19 | 21.32 | 19.78 | 14.08 |
| February | 0.00 | -1.31 | -3.46 | 0.00 | 0.00 | 0.00 | 18.29 | 27.71 | 28.96 | 34.39 | 37.92 | 31.42 | 20.85 | 0.00 |
| March | 0.00 | 0.00 | 0.00 | 0.00 | -7.49 | 3.11 | 26.55 | 16.64 | 26.77 | 36.71 | 33.16 | 38.74 | 19.64 | 0.00 |
| April | 0.00 | 0.00 | 0.00 | 0.00 | 6.85 | 1.75 | 5.41 | 10.96 | 18.39 | 33.49 | 41.67 | 33.04 | 0.00 | 0.00 |
| May | 0.00 | 0.00 | 13.38 | 5.48 | 6.53 | 7.93 | 14.24 | 13.36 | 17.58 | 40.13 | 22.46 | 0.00 | 0.00 | 0.00 |
| June | 0.00 | 0.00 | 10.58 | 7.15 | 5.20 | 7.82 | 13.83 | 14.49 | 17.29 | 20.26 | 21.73 | 0.00 | 0.00 | 0.00 |
| July | 0.00 | 0.00 | 0.00 | -6.78 | 5.67 | 4.67 | 13.37 | 12.45 | 17.04 | 39.49 | 22.38 | 20.32 | 0.00 | 0.00 |
| August | 0.00 | 0.00 | 0.00 | -11.38 | 8.83 | 6.10 | 8.47 | 10.11 | 16.01 | 38.62 | 41.55 | 22.46 | 0.00 | 0.00 |
| September | 0.00 | -2.12 | 0.00 | 0.00 | 0.00 | -0.58 | 26.97 | 3.38 | 33.83 | 38.09 | 40.92 | 42.26 | 0.00 | 0.00 |
| October | 0.00 | -0.10 | -23.32 | 0.00 | 0.00 | -16.53 | 27.27 | 28.27 | 31.49 | 36.07 | 40.39 | 22.38 | 17.98 | 0.00 |
| November | 10.48 | -19.49 | 0.00 | 0.00 | -17.64 | 0.00 | 26.72 | 28.14 | 29.71 | 34.66 | 21.37 | 20.91 | 19.01 | 0.00 |
| December | 8.75 | -15.71 | 0.00 | 0.00 | 0.00 | 0.00 | 26.63 | 28.33 | 28.95 | 33.25 | 20.22 | 20.70 | 19.29 | 13.96 |

| | DGI | % of Annual Daylight Hours |
|---|---|---|
| Imperceptible - Acceptable | <22 | 75.00% |
| Borderline between Comfort and Discomfort | ≥22 & <24 | 2.38% |
| Uncomfortable | ≥24 & <28 | 4.76% |
| Intolerable (Direct Sun) | ≥ 28 | 17.86% |
| Intolerable (Reflected Glare) | ≥ 28 | 0.0% |

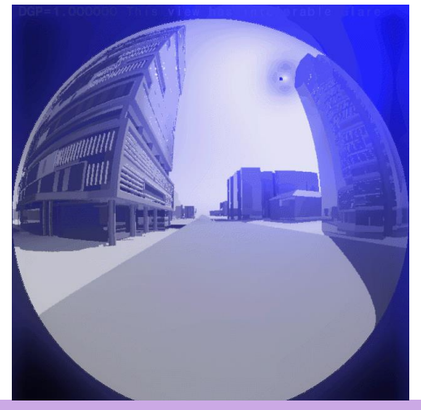
It has been found that at location 6, facing west on Rickard Road, the proposed building does not contribute to any intolerable glare. All other intolerable DGI values at this location are due to direct exposure to the sun.

21st November 13:00



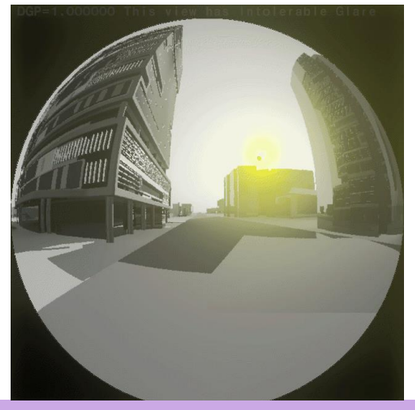
28.14 - Intolerable Glare

21st September 14:00



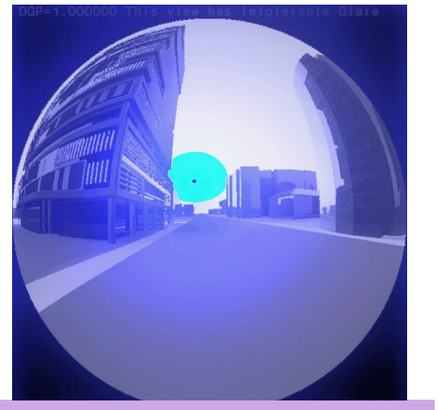
33.83 - Intolerable Glare

21st August 16:00



41.55 - Intolerable Glare

21st September 17:00



42.26 - Intolerable Glare

## 5.7 Location 7

| | 6:00 | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 0.00 | -12.07 | 30.45 | -3.96 | -10.48 | 0.00 | -0.99 | 27.73 | 28.37 | -3.23 | -5.23 | 13.05 | 14.67 | 12.27 |
| February | 0.00 | 0.00 | 2.10 | -0.34 | -10.20 | 0.00 | 1.15 | 27.53 | 28.87 | -0.95 | 0.86 | 8.35 | 0.0 | 0.00 |
| March | 0.00 | 0.00 | 0.00 | -5.80 | 0.00 | 1.33 | 3.77 | 30.54 | 28.36 | 14.35 | 13.99 | 9.59 | 7.06 | 0.00 |
| April | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.72 | 9.22 | 28.61 | 25.67 | 19.19 | 17.40 | 13.54 | 0.00 | 0.00 |
| May | 0.00 | 0.00 | -5.99 | 0.00 | -2.53 | 5.05 | 8.36 | 30.42 | 36.09 | 39.83 | 17.74 | 0.00 | 0.00 | 0.00 |
| June | 0.00 | 0.00 | 0.00 | -5.24 | 1.98 | 7.44 | 9.05 | 30.75 | 35.84 | 39.35 | 17.95 | 0.00 | 0.00 | 0.00 |
| July | 0.00 | 0.00 | 0.00 | 0.00 | 5.21 | 4.68 | 7.89 | 29.86 | 35.09 | 39.26 | 18.35 | 14.72 | 0.00 | 0.00 |
| August | 0.00 | 0.00 | 0.00 | 0.00 | 1.47 | -5.57 | 3.71 | 28.61 | 34.48 | 19.22 | 17.74 | 14.73 | 0.00 | 0.00 |
| September | 0.00 | -0.58 | -11.96 | -20.24 | 0.00 | -2.09 | 28.33 | 28.24 | 33.37 | 15.73 | 15.03 | 12.07 | 0.00 | 0.00 |
| October | 0.00 | 3.78 | 0.60 | 26.70 | 0.00 | 0.00 | 27.11 | 28.26 | 4.96 | -5.68 | 1.41 | 11.58 | 11.50 | 0.00 |
| November | 0.00 | 30.21 | -5.49 | -4.83 | -18.73 | 0.00 | 26.86 | 33.29 | 2.75 | -6.75 | 7.27 | 13.67 | 15.32 | 0.00 |
| December | 0.00 | -20.60 | 30.63 | -7.31 | -15.42 | 0.00 | 25.83 | 28.34 | 28.66 | -3.38 | 4.16 | 14.68 | 16.27 | 14.35 |

| | DGI | % of Annual Daylight Hours |
|---|---|---|
| Imperceptible - Acceptable | <22 | 77.98% |
| Borderline between Comfort and Discomfort | ≥22 & <24 | 0.00% |
| Uncomfortable | ≥24 & <28 | 5.95% |
| Intolerable (Direct Sun) | ≥ 28 | 14.29% |
| Intolerable (Reflected Glare) | ≥ 28 | 1.79% |

Location 7 is at an arbitrary point on the façade of the Bankstown Community Services Centre, east of the proposed development. At this location, there is a reasonable amount of intolerable glare caused by the proposed buildings west façade in the morning, between November and January. All other intolerable DGI values at this location are due to direct exposure to the sun.

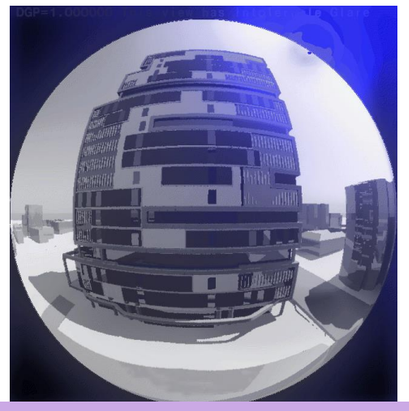
21st November 7:00

30.21 - Intolerable Glare

21st January 8:00

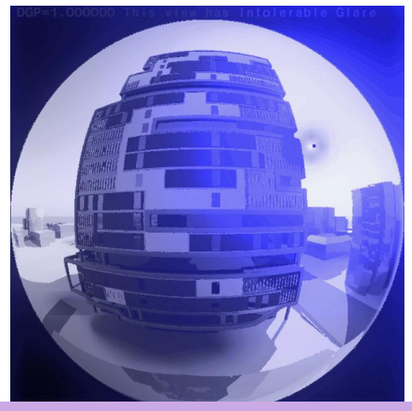
30.45 - Intolerable Glare

21st September 12:00



28.33 - Intolerable Glare

21st July 15:00



39.26 - Intolerable Glare

## 6. Discussion

The results have been generated assuming certain material properties on the building façade. For the results to remain relevant, these surface properties must be maintained for the following façade elements:

- External shading devices and fins: low sheen surface finish
- Glazing: External reflectivity below 16%
- Louvres: low sheen surface finish

The percentage of each DGI result for annual daylight hours and each location is presented in Table 7 and Figure 7 below. There is imperceptible glare for 55%-90% of daylight hours, subject to the viewpoint. Daylight hours have been taken from 6am to 7pm inclusive. Intolerable glare - with a DGI result greater than 28 - is seen in all locations. However, most of this intolerable glare is due to direct exposure to the sun, and not due to reflected glare from the proposed WSU façade. Locations 2 and 6 show no intolerable glare due to the building façade, where locations 3 and 4 present significant issues.

**Table 7**: Percentage of each Daylight Glare Index Result for Annual Daylight Hours

| Visual Comfort | DGI Score | Location | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Imperceptible - Acceptable | < 22 | 75% | 78% | 83% | 90% | 55% | 75% | 78% |
| Borderline between Comfort and Discomfort | ≥ 22 & < 24 | 0% | 1% | 0% | 1% | 4% | 2% | 0% |
| Uncomfortable | ≥ 24 & < 28 | 11% | 8% | 1% | 6% | 11% | 5% | 6% |
| Intolerable (Direct Sun) | ≥ 28 | 12% | 13% | 12% | 2% | 29% | 18% | 14% |
| Intolerable (Reflected Glare) | ≥ 28 | 2% | 0% | 4% | 1% | 1% | 0% | 2% |


**Figure 7:** Summary of Results - % of Annual Daylight Hour Occurences in Each Comfort Band

**Table 8:** Summary of Reflected Glare Issues and Comments for Each Location Assessed

| Location | % of Annual Daylight Hours with Intolerable Glare Due to WSU Façade | Problem times | Comment |
|---|---|---|---|
| 1: Motorist heading east on Rickard Road | 2% | 18:00 December, January and February | ○ Reflected glare is equivalent to glare from direct view of the sun in the morning<br>○ Glazing on the western façade must have a reflectivity of 7% or less to remove the glare issue |
| 2: Motorist heading west on Rickard Road | 0% | - | ○ No glare issue detected |
| 3: Residents at 63 Rickard Road | 4% | 13:00-15:00, April to August | ○ Reflected glare is equivalent to glare from direct view of the sun in the late afternoon<br>○ It is expected that balconies will act as vertical shading and reduce the impact of reflected glare<br>○ Residents may utilise blinds in the event of glare issues |
| 4: Occupants of Bankstown Library and Knowledge Centre | 2% | 15:00 March and October, 16:00 October and November | ○ It is expected that the significant sun-shades on the library façade will reduce the impact of the reflected glare<br>○ The exterior glazing on the library will only transmit a portion of the reflected light |
| 5: Motorist heading north on Chapel Road | 1% | 17:00 October | ○ The simplified glare model does not include surrounding trees and greenery. Trees appear to block the line-of-sight between the assessed viewpoint and proposed development |
| 6: Motorist heading west on Rickard Road - before Jacobs Street | 0% | - | ○ No glare issue detected |
| 7: Occupants of Bankstown Community Services Centre | 2% | 7:00-9:00 January, November and December | ○ Reflected glare is equivalent to glare from direct view of the sun in the late afternoon<br>○ Occupants may utilise blinds to for the 2% of annual daylight hours where intolerable glare is present. |

Since delivering the report 7830-RPT-ES0001(00): Reflectivity Analysis, issued 12th April 2019, the design of the facade has undergone further development, which alters the external building envelope. The east façade has an increased amount of solid clad areas & green wall, the sunshade form is different on north and west facades, with shading removed on the south.

The façade development and design changes have improved the external reflectivity outcome since the previous assessment. These improvements are summarised in Table 3 below

**Table 9:** Summary of Results Differences between Previous and Current Facade Design

| Location | % of Annual Daylight Hours with Intolerable Glare Due to WSU Façade | | Comment |
|---|---|---|---|
| | Previous Design | Current Design | |
| 1: Motorist heading east on Rickard Road | 1.2% | 1.8% | ○ Increased reflected glare result is due to the updated model detecting glare at a time that was previously overlooked due to the time resolution.<br>○ Reflected glare intensity from the current façade design is approximately 12-20% lower |
| 2: Motorist heading west on Rickard Road | 0% | 0% | ○ No change |
| 3: Residents at 63 Rickard Road | 7.7% | 4.2% | ○ Improvement of 3.5% |
| 4: Occupants of Bankstown Library and Knowledge Centre | 4.8% | 2.4% | ○ Improvement of 2.4% |
| 5: Motorist heading north on Chapel Road | 0.60% | 0.60% | ○ Reflected glare intensity from the current façade design is approximately 6% lower |
| 6: Motorist heading west on Rickard Road - before Jacobs Street | 0% | 0% | ○ No change |
| 7: Occupants of Bankstown Community Services Centre | 3% | 1.8% | ○ Improvement of 1.2% due to additional green wall on the eastern façade |

A summary of reflected glare issues and comments for each location assessed is presented in Table 8 below. Further information can be found in sections 6.1 and 6.2.

## 6.1 Glare Impact to Motorists

View locations 1, 2, 5 and 6 are positioned on roads surrounding the proposed development. Locations 2 and 6 - representing a motorist driving west on Rickard Road - show no reflected glare issues from the building façade.

View location 5, representing a motorist driving north on Chapel Road, shows intolerable reflected glare due to the proposed building's south-east façade at 5pm in October. The results show that intolerable glare due to the building façade is present for 0.6% of annual daylight hours. The simplified glare model does not include surrounding trees and greenery, as shown in Figure 8 below. The trees shown in Figure 8 block the line-of-sight between the assessed viewpoint and proposed development. Considering this and the infrequency of intolerable glare, this location is not a high risk to road users.

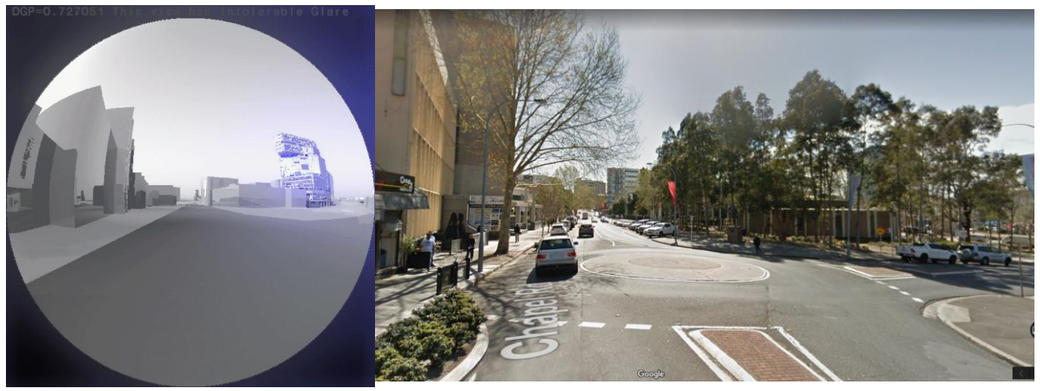


**Figure 8:** Location 5 on Chapel Road, Glare Model (left) and Actual Environment (right)

View location 1, representing a motorist driving east on Rickard Road, shows intolerable reflected glare due to the proposed building's western façade at 6pm in January, February and December. The evalglare output at 6pm in December is shown in the left-hand image of Figure 9. The result shows a reflected glare DGI result of 31.22. This is less severe than the glare from direct view of the sun in the morning, with a DGI value of 38.8 (Figure 9, right). If required, a 7% or less external glazing reflectivity may be applied to this façade to remove the glare impact.

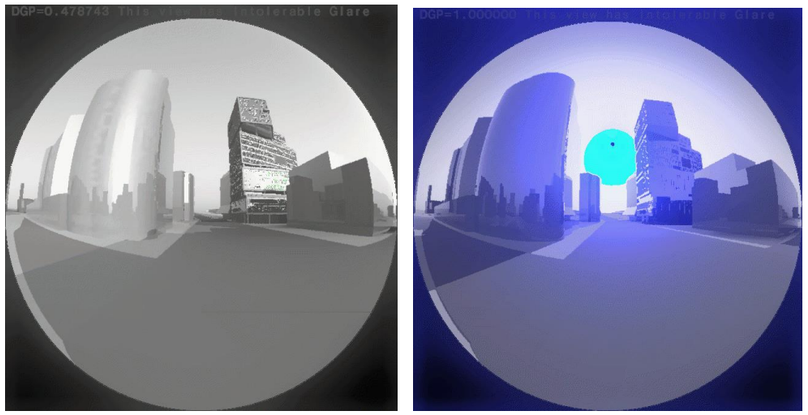


**Figure 9:** Location 1, 21st December 18:00, DGI = 31.22 (left), 21st January, 7:00, DGI = 38.8 (right)

## 6.2 Glare Impact to Surrounding Buildings

Locations 3, 4 and 7 are situated on nearby surrounding buildings. These locations present the largest amount of intolerable glare issues throughout the year. The results present approximate glare impact from the proposed development; a realistic position of occupants within the building and their direction of view is difficult to consider. The assessed direction is towards the proposed development, presenting a worst-case result.

Location 3 is at an arbitrary point on the façade of the residential tower north of the proposed development, as shown in Figure 10 below. At this location, there is intolerable glare due to the WSU building façade for approximately 4% of annual daylight hours. This glare occurs during the hours of 1pm and 3pm in autumn and winter. The DGI result from glare reflecting off the WSU façade is equivalent to the glare from direct sun during the late afternoon. As the occupied interior spaces are set back further than the point assessed, it is expected that the balconies will act as vertical shading and block some of the reflected glare. Residents may also utilise blinds in the event of reflected glare issues in interior spaces.


**Figure 10:** Approximate Location 3 and 7 Viewpoints

Location 7 is at an arbitrary point on the façade of the Bankstown Community Services Centre, east of the proposed development. At this location, there is a reasonable amount of intolerable glare caused by the proposed buildings west façade in the morning, between November and January. The DGI result from glare reflecting off the WSU façade is equivalent to the glare from direct sun during the late afternoon. The occupants may utilise blinds to for the 3% of annual daylight hours where intolerable glare is present.

Location 4 is at a point on the façade of the Bankstown Library and Knowledge Centre, west of the proposed development. At this location, the results show intolerable glare caused by the proposed buildings west façade between 3pm and 4pm in March, October and November. As the occupied interior spaces are set back further than the point assessed, it is expected that the significant sun-shades on the library façade will block some of the reflected glare. Additionally, the exterior glazing on the library will only transmit a portion of the reflected light.

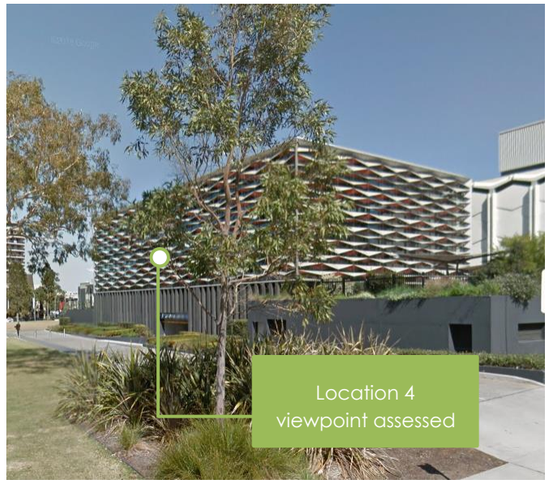



**Figure 11:** Approximate Location 4 Viewpoint

# 7. Conclusion

An external glare study has been undertaken to determine the impact of façade solar reflections onto roads and existing buildings surrounding the proposed Western Sydney University (WSU) Bankstown campus development. This glare assessment has considered 7 view locations around the proposed WSU development: 4 locations on surrounding roads, and 3 locations situated on nearby buildings.

Since delivering the report 7830-RPT-ES0001(00): Reflectivity Analysis, issued 12th April 2019, the design of the facade has undergone further development, which alters the external building envelope. The east façade has an increased amount of solid clad areas & green wall, the sunshade form is different on north and west facades, with shading removed on the south. These design changes have significantly improved the external reflectivity outcome since the previous assessment.

As façade materials are to be confirmed, conservative material properties have been assigned. The glazing on the façade has been modelled to represent an external reflectivity of 16%.

The results indicate that intolerable glare - with a DGI result greater than 28 - is seen in all locations. However, most of this intolerable glare is due to direct exposure to the sun, and not due to reflected glare from the proposed WSU façade. At locations 2 and 6 - looking west on Rickard Road - there is no intolerable glare due to the building façade.

At location 1, facing east on Rickard Road, there is intolerable reflected glare due to the proposed building's western façade at 6pm in January and February. A glazing reflectivity of 7% or less is required to alleviate this issue. This issue is present for approximately 1-2% of annual daylight hours throughout the year. Additionally, the intolerable DGI result is comparable to the glare that motorists experience in mornings during summer, from direct exposure to the sun.

At location 5, facing north on Chapel Road, there is intolerable reflected glare due to the proposed building's south-east façade at 5pm in October. This location has been deemed low-risk as the modelling did not account for trees that appear to block the line-of-sight between the viewpoint and proposed building, expected to reduce the glare intensity.

The reflected glare impact to surrounding buildings is significant, however, it is expected that architectural details not accounted for in the model, such as balconies and shading devices, will block some of the reflected glare. Additionally, occupants may utilise blinds if the glare issue is present.

The results have been generated with certain material properties specified. These values are intended to be conservative. However, for the glare assessment to remain applicable, material finishes on the building façade must have reflectivity values equal to or lesser than those specified in Section 4.5. Increased material reflectivity or variation in surface finish may contribute to additional glare and unforeseen issues.

## 8. Appendix A – Radiance Modelling Parameters

| Parameter | Parameter Description | Value |
|---|---|---|
| -pt | sampling threshold | 0.15 |
| -pj | anti-aliasing jitter | 0.6 |
| -dj | source jitter | 0.0 |
| -ds | source sub-structuring | 0. 5 |
| -dt | direct thresholding | 0.5 |
| -dc | direct certainty | 0.25 |
| -dr | direct relays | 0 |
| -dp | direct pre-test density | 64 |
| -ab | ambient bounces | 2 |
| -aa | ambient accuracy | 0.25 |
| -ar | ambient resolution | 16 |
| -ad | ambient divisions | 512 |
| -as | ambient super-samples | 128 |
| -lr | limit reflection | 4 |
| -lw | limit weight | 0.05 |

## 9. Appendix B - Glossary of Terms

**Reflectivity:** the percentage of light that is not absorbed or transmitted by the material, but is reflected

**Diffuse**: This indicates that a material has a surface roughness or texture, i.e. it scatters the light that it reflects and is non-specular

**Specularity:** the degree to which a surface has a mirror-like reflection of light. An incoming single ray of light onto a highly specular surface is reflected into a single outgoing direction.

**Luminance**: describes the amount of light that is emitted or reflected from a particular area, and falls within a given solid angle. This is measured in candela per square metre.

**Field of Luminance**: the angular extent of the observable world that influences an observer's perception of brightness. In this instance defined as 180° from the centre of view.

**Field of View**: also known as field of vision, the angular extent of the observable world that is visible.

**Glare Threshold**: the limiting luminance that defines a glare source from the field of luminance.

**Daylight Glare Index (DGI)**: the established measurement of discomfort glare due to daylight as a function of glare source luminance, field luminance, and solid angle and location glare source.

**Solid Angle**: the angle in a three-dimensional space that an object subtends at a point. It is a measure of how big that object appears to an observer looking from that point.

**Viewing Angle**: the angular change in viewing direction from the centre of view in the horizontal plane.

## 10. Appendix D - Disability glare

Disability glare impairs the vision of objects without necessarily causing discomfort. The disability glare effect is described as an equivalent uniform luminance resulting from the stray light in the eye which superimposes on the location of the vertical image, thus lowering contrast. This equivalent veiling luminance depends mainly on two parameters:

- The illumination on the observer's eye produced by the glare sources in the plane perpendicular to the line of sight;
- The angle between the centre of the glare source and the line of sight.

## 11. Appendix E - Discomfort Glare

Discomfort glare causes discomfort without necessarily impairing the vision of objects and details. It is the result of high or non-uniform luminance distribution within field or by high contrasts of luminance between the glare source and its surroundings. It is generally agreed that discomfort glare produced by an individual source depends on four main parameters:

- Source luminance in the direction of the observer's eye;
- Solid angle subtended by the source at the observer's eye;
- Angular displacement of the source from the observer's line of sight;
- General field luminance controlling the adaptation level of the observer's eye.

Discomfort glare is often measured in metrics such as Daylight Glare Index.

## 12. Appendix F - Limitations

Although the methodology developed is considered robust in terms of finding and analysing glare sources, due to the complex nature of the study there are inherent limitations.

The geometry used in this model is believed to be accurate but any excluded geometry, errors in measurements or changes to the surrounding area (such as new developments) could alter the way the sun interacts with the façade and the surrounding environment. Material assumptions have been made that are considered a fair representation of the situation; however a building's façade is made from a variety of materials with a large range of reflectances. The computational model of the façade is unlikely to be a truly accurate representation of the as-built façade as manufacturing tolerances could create discrepancies with the modelled geometry.

As discussed, the scenario analysed in this report contains more than one dynamic variable; people in the surrounding environment and the sun are both in motion. The study highlights extremes of sun brightness and altitude by analysing the solstices. It also focuses on glare resulting from the reflections from the façade and not from direct sunlight. Analysis locations were chosen based on a quantitative assessment of the surrounding environment, which highlighted key locations where glare could be problematic. There are infinite variations in the location of people in the surrounding environment and sun positions and so the presence of further, unidentified periods of glare is possible. As it is not practical to analyse all variations, the study aims to locate and examine critical and extreme examples.

The ray-tracing software used is considered to be highly accurate; however limitations must be made to allow reasonable computation power to be employed, variables such as the number of solar reflections and image resolution are set to produce high quality images, but these can never be true to life.

As the effect of glare itself is a subjective sensation, individuals' perception of glare can vary greatly from one person to another, and factors such as age and eye colour can affect the perceived sensation. The Daylight Glare Index used to measure the glare in this analysis is derived from clinical tests employed to measure glare sensitivity, and is an established tool for the measurement of glare. Several immeasurable phenomena exist that could redirect or scatter light, such as scratched surfaces or incorrectly mounted glazing systems, but these effects are unpredictable and are not included in the study. The dynamic effect of glare, or rather the observer's ability to adapt to changes of light levels over time is also not included in this study.