# All Welcome Cultural Centre
# Gordon Street

## Coffs Harbour, NSW

**Prepared for**
Coffs Harbour City Council

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# Contents

## Executive Summary

All Welcome is a cultural precinct project in the centre of Coffs Harbour, NSW. The proposed building comprises public cultural spaces and council facilities. The façade of the building is primarily glass with vertical sunshades.

This reflectivity study has been carried out to verify that the façade of the proposed building will not cause unacceptable risk of solar reflections producing disability glare to car drivers and pedestrians only. It does not consider occupants of adjacent or neighbouring properties.

Eight (8) viewpoints from drivers and pedestrians were assessed to determine areas where there is a risk of a reflected image of the sun being formed. The methodology proposed by David Hassall has been used to assess where there is a risk of disability glare as calculated by the Holladay formula.

The analysis has been carried out based on the architectural drawings provided by BVN.

All viewpoints considered have been analysed and it has been determined that the risk of rogue reflections causing disability glare are limited and acceptable providing that limitations on façade reflectivity are adopted as per the recommendations of this report. This includes a 15% limit on Specular reflectivity to facades on the East and South Elevations of the building.

# 1. Introduction

## 1.1 Purpose of the Report

All Welcome cultural precinct is a proposed development in Coffs Harbour CBD.

This report details the results of a reflectivity study that aims to identify the potential for adverse reflected solar glare that may affect train drivers that pass along the railway corridor to the North and South of Epping station. It does not consider pedestrians, vehicle operators or occupants of adjacent or neighbouring properties.

This report should be read in conjunction with the Architectural documents prepared by BVN.

## 1.2 Project Description

All Welcome is a cultural and civic precinct project in Coffs Harbour, NSW. The proposed building will comprise council facilities and public cultural spaces, including a library, a gallery and a museum.

The project is a 6-storey building that decreases in height, with the North-east elevation having five levels.

The façade to the buildings includes large areas of glazing protected by large vertical sunshades made of green terracotta tile. All materials have been specified to have a specular reflectivity of less than 20%.

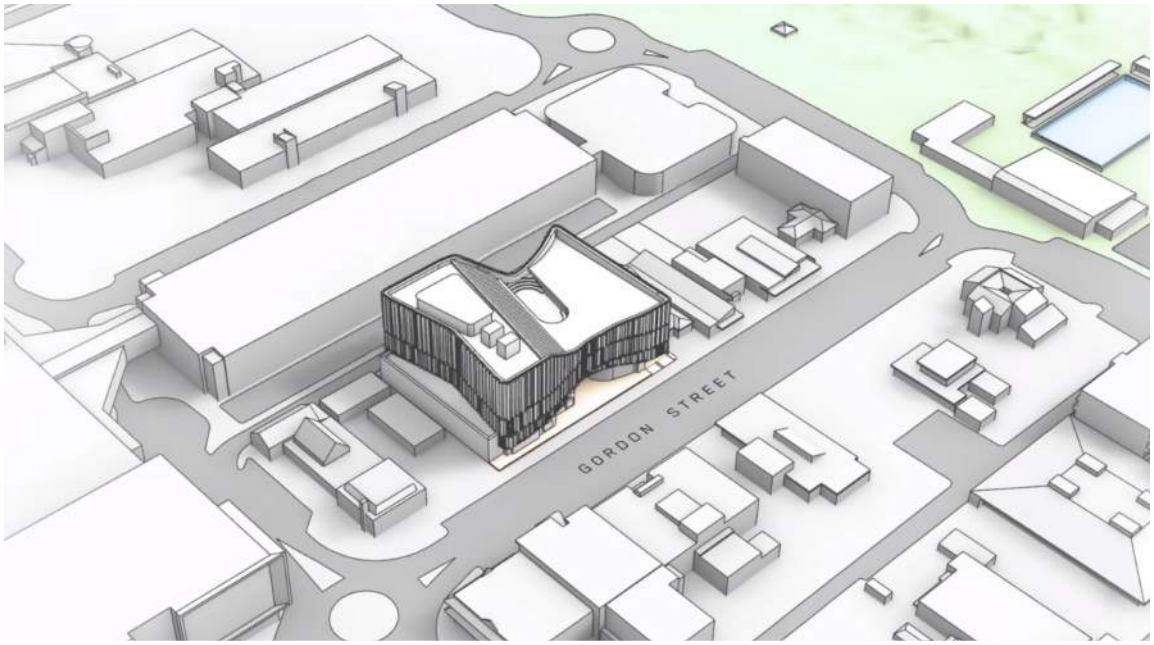


**Figure 1. Architectural 3D model of All Welcome Cultural Centre. Sourced from video available at Coffs Harbour Council website.**

## 1.3 Site Location

The building is located at 23-31 Gordon Street in Coffs Harbour, NWS. This site has been assessed to determine appropriate viewpoints where pedestrians and car drivers would be able to see the building façade in their direct line of vision.

The assessment considers that the building would be visible to pedestrians from the following locations (figure 2):

- Viewpoint P1: Pedestrian looking North-west before taking the crossing in Gordon St.
- Viewpoint P2: Pedestrian looking South-east at the crossing in Riding Ln parallel to Vernon St.
- Viewpoint C1: Car driver travelling South-east along Vernon St. at the level of the roundabout between Castle St. and Riding Ln.

- Viewpoint C2: Car driver travelling North in Gordon St, when turning left at the roundabout in Vernon St.
- Viewpoint C3: Car driver travelling North along Gordon St. after Vernon St. roundabout.
- Viewpoint C4: Car driver travelling South-west along Riding Ln between Coff St. and Vernon St
- Viewpoint C5: Car driver travelling South-west along Gordon St. between Coff St. and Vernon St.
- Viewpoint C6: Car driver travelling South-west at the intersection between Coff St and Gordon St.


**Figure 2. Map of site area showing location of building and assessed viewpoints (Google Maps)**

### 1.3.1 Site Orientation

The building has façade aspects calculated relative to map North (true North). The façade aspects for the All Welcome building are shown in Figure 4 below.


**Figure 3. Site map overlaid with Building plan, showing Façade Aspects (Google earth)**

## 1.4 Stereographic Sun Chart

The position of the sun in the sky throughout the year varies depending on the latitude of the location of the building. A stereographic sun chart is a two-dimensional representation of this path of the sun for a particular line of latitude.

This chart is used in order to determine the location of a virtual reflected sun in accordance with the Hassall methodology in order to assess the potential for glare. Refer to Section 2 of this report for more detailed information on the assessment methodology

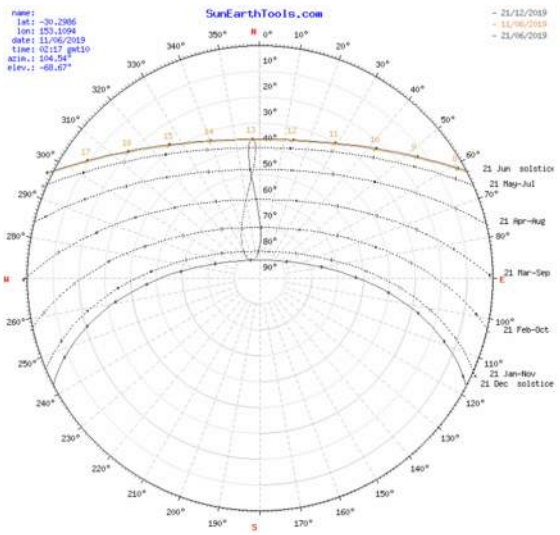


**Figure 4. Stereographic Sun Chart for Coffs Harbour (30-degree latitude)**

# 2. Assessment Methodology

## 2.1 Analysis Philosophy

The glare assessment has been carried out as per the methodology outlined in the technical bulletin "Reflectivity: Dealing with Rogue Solar Reflections" written by David Hassall from the Faculty of Architecture at the University of New South Wales.

This methodology defines a glare ($I_v$) limit of 500 candelas/m$^2$, calculated to the Holladay formula, to which a driver can be exposed without causing disability.

Viewpoints have been defined from which it is expected that either are able to see the building. A stereographic sun path diagram and the building geometry are then used to determine whether a viewpoint will be subject to the reflected sun during the year.

A glare protractor, oriented in the direction of drivers as appropriate, is used to determine the glare based on the reflectivity of the surface and the apparent angle of viewing.

## 2.2 Virtual Sun Location

The virtual suns location is determined with the stereographic sun chart for the project location.

This is completed by plotting the virtual sun on the stereographic sun chart based on the orientation of the façade. The apparent reflective surface of the façade is plotted based on the bounding horizontal and vertical angles from the viewpoint.

## 2.3 Glare Assessment

In order to allow assessment of buildings for glare David Hassall has developed a glare protractor that provides a diagrammatic limit of 500 candelas/m$^2$ based on viewing angle and inclination and reflectivity of the viewing surface. This glare protractor is shown in Figure  and is used where the stereographic sun path indicates that there is glare to a particular viewpoint.

A brief description of the calculation of the glare (equivalent veiling luminance) is provided below for reference. The glare protractor has thereafter been used in this assessment.

The equivalent veiling luminance ($I_v$) is calculated based on the Holladay formula (1), which defines the illumination of a viewer's eye based on a calculated illuminance perpendicular to the surface (EG) and a factor based on the angle of viewing (θ).

$$I_v = 10 \times EG \div \theta^2 \quad (1)$$

The angle of viewing (θ) is based on the angle between the direct line of sight and the glare source (α) and the inclination between a viewing normal and the glare source (β). This is calculated with trigonometry based on Equation 2 below and is shown diagrammatically in Figure 6.

$$\theta = ATAN \times [\sqrt{\{\tan^2(\beta) + \sin^2(\alpha)\}} \div \cos(\alpha)] \quad (2)$$

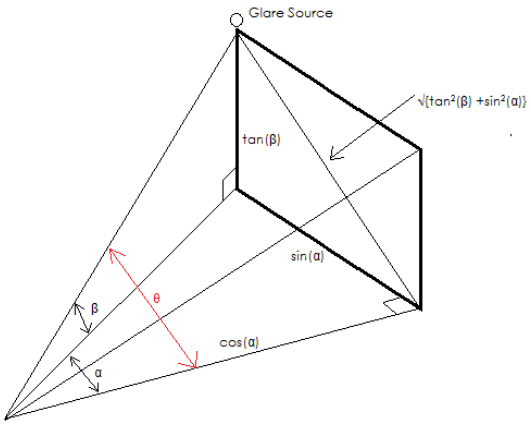


**Figure 5. Diagrammatic Angle of Viewing Calculation**

The illumination of the viewer's eye normal to the light source (EG) is calculated based on the solar illumination (E), the reflectivity of the surface (R) and the angle of viewing (θ) calculated in Equation 2. The solar illumination is calculated in Equation 4 based on the solar power (W), which is dependent on the inclination of the virtual sun (β) and the luminance efficacy ($l_e$).

$$EG = E \times R \times \cos(\theta) \quad (3)$$

$$E = W \times l_e \quad (4)$$

The solar power is determined as 50 watts per degree up to 10 degrees and 15 watts per degree thereafter.

The luminance efficacy is 90 lumens/watt at 7.5° and 117 lumens/watt at 25° and is interpolated for other angles.

The glare protractor by Hassall joins points at incremental reflectivity (iso-glare loops) with varying a and β values in order to set a limit where the equivalent veiling luminance is limited to 500 candelas/m$^2$.

By overlaying the glare protractor on a photo or computer-generated image in the direction of viewing and aligning the verticals with the building it is possible to graphically determine the maximum reflectivity to not cause disability glare.

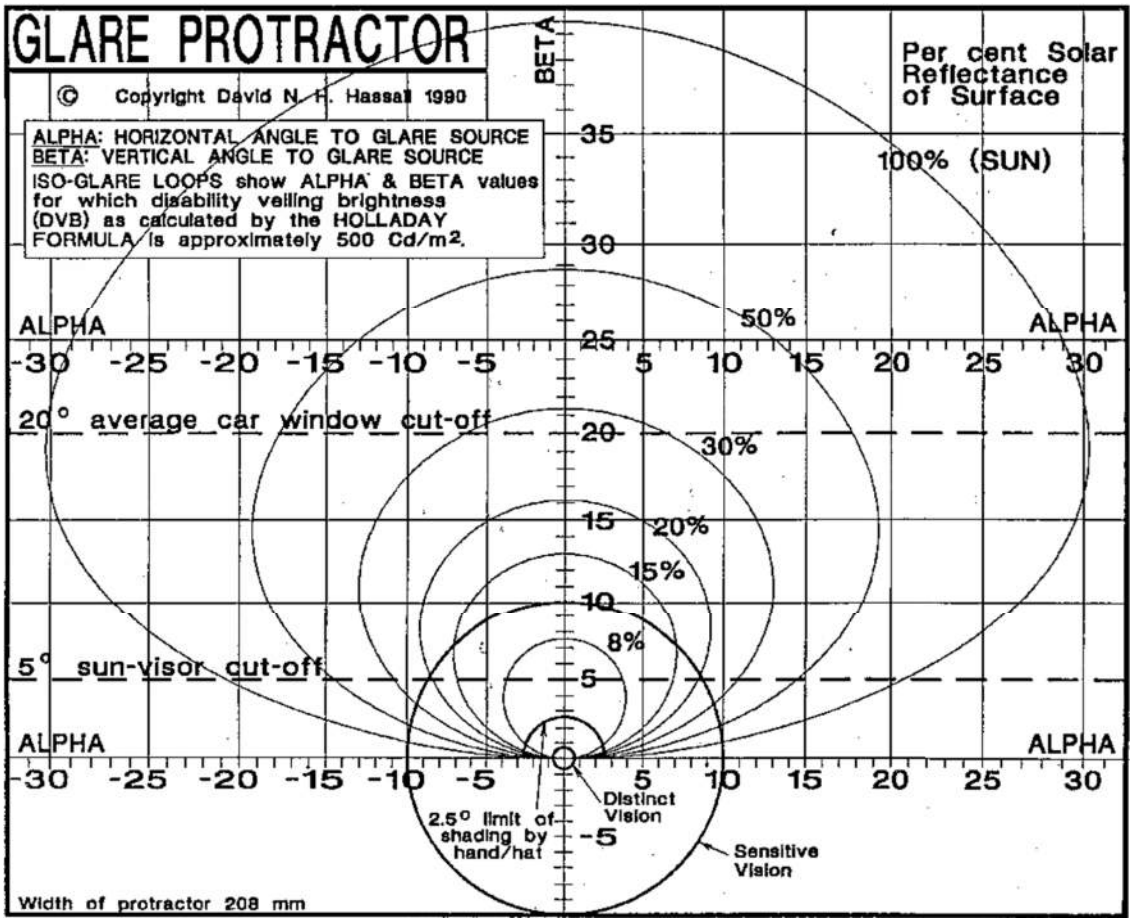


**Figure 6. Glare Protractor**[1]

[1] "Reflectivity: Dealing with Rogue Solar Reflections" – David Hassall

# 3. Results

The façade of the All Welcome cultural precinct development has been assessed from each viewpoint identified in Section 1 of the report.

For determining the vertical bearing angle, the two heights of the building are 25.5 meters for the North-east elevation and 31.26 meters for the South-west elevation.

Where a reflected image of the sun has been identified through the stereographic sun path, the boundary for a 20% solar reflectance was used according to the glare protractor. This determined the maximum reflectivity allowable on the façade surface to achieve a maximum equivalent veiling luminance of 500 candela/$m^2$.

Detailed results have been included in Appendix A. A summary of these results is provided below.

## 3.1 Viewpoint P1

Viewpoint P1 is taken from the viewpoint of a pedestrian that is about to cross the road on Gordon St. The viewing angle of the person is 307° and the distance from Viewpoint P1 to the centre of the building is 67.7 meters.

The path of the reflected sun has been plotted for Façade Aspects 148°, 111°, 129° and 201°, which are visible from viewpoint P1.

There is a period where the sun is reflected from all façade aspects, except for 111°. However, of all Façade Aspects showing a reflection in the sun path analysis, only the reflection from Façade Aspect 201° is located within the pedestrian's direct area of vision. Further analysis using the glare protractor indicates that the reflectivity of the façade elements in this location fall just below required limits for reflectivity (<20%) and do not represent a concern. Refer to Appendix A for details.

## 3.2 Viewpoint P2

Viewpoint P2 is taken from the viewpoint of a pedestrian looking South-east at the crossing in Riding Ln. and parallel to Vernon St. The viewing angle of the person is 130°. and the distance from viewpoint 2 to the centre of the building is 81.5.

The path of the reflected sun has been plotted for Façade Aspects 238°, 201°, 309°, 297°, which are visible from viewpoint P2.

There is no reflected image of the sun that reaches Viewpoint P2 from any of the façade aspects above. Refer to Appendix A.

## 3.3 Viewpoint C1

Viewpoint C1 is taken from the viewpoint of a driver travelling South-east along Vernon St. at the level of the roundabout between Castle St. and Riding Ln. The viewing angle of the driver is 125°. and the distance from viewpoint C1 to the centre of the building is 96.8m.

The path of the reflected sun has been plotted for Façade Aspects 238°, 201°, 309° and 297°, which are visible from viewpoint C1, but are all located outside of the diver's direct vision. As a result, there is no reflected image of the sun that reaches Viewpoint C1 from any of the Façade Aspects and there are not anticipated reflectivity issues from the assessed facades at this location. Refer to Appendix A.

## 3.4 Viewpoint C2

Viewpoint C2 is taken from the viewpoint of a car driver travelling North along Gordon St. at the roundabout in Vernon St. The viewing angle of the driver is 3° and the distance from viewpoint C2 to the centre of the building is 115.2m.

The path of the reflected sun has been plotted for Façade Aspects 201°, 238°, 129° and 148°, which are visible from viewpoint C2.

There is a period where the sun is reflected from Façade Aspects 148° and 238°. However, only a small portion of the reflection from Façade Aspect 238° is located within the driver's direct area of vision. Further analysis overlaying the glare protractor in a photograph from viewpoint C2, indicates that the required reflectivity of the façade elements falls just below the 20% limit for reflectivity. It is recommended that the glass in this façade aspect should have a reflectivity value below 15%. Refer to Appendix A.

## 3.5 Viewpoint C3

Viewpoint C3 is taken from the viewpoint of a car driver travelling North along Gordon St. after the Vernon St roundabout. The viewpoint is located just before the pedestrian crossing in Gordon St. The viewing angle of the driver is 36° and the distance from Viewpoint C3 to the centre of the building is 78.4 meters.

The path of the reflected sun has been plotted for Façade Aspects 201°, 238°, 129° and 148°, which are visible from viewpoint C3.

There is a period where the sun is reflected from all Façade Aspects, except from 201°. However, from all the Façade Aspects showing a reflection in the sun path analysis, only the reflection from Façade Aspect 148° and a small portion of 129° is located within the driver's direct area of vision. Further analysis using the glare protractor indicates that the reflectivity of the façade elements in this location fall just below the 20% limit for reflectivity. It is recommended that the glass in these façade aspects (148° and 129°) should have a reflectivity value below 15%. Refer to Appendix A for details.

## 3.6 Viewpoint C4

Viewpoint C4 is taken from the viewpoint of a person driving a car South-west along Riding Ln between Coff St. and Vernon St. The viewing angle of the driver is 218° and the distance from Viewpoint C4 to the centre of the building is 80.5 meters.

The path of the reflected sun has been plotted for Façade Aspects 39° and 326°, which are visible from viewpoint C4. These Façade Aspects cause a reflection of the sun according to the stereographic sun path analysis. An assessment of the direct area of vision of the driver indicates that most of the reflection from Façade Aspect 39° is located outside of the driver's direct area of vision. Further analysis of photographs of the site indicates that a large tree located in Riding Ln will block any possible reflection from Façade Aspect 326°. Refer to Appendix A for details.

## 3.7 Viewpoint C5

Viewpoint C5 is taken from the viewpoint of a person driving a car South-west along Gordon St. between Coff St. and Vernon St. The viewing angle of the driver is 218° and the distance from Viewpoint C5 to the centre of the building is 88.5 meters.

The path of the reflected sun has been plotted for Façade Aspects 39°, 111° and 129°, which are visible from viewpoint C5. There is no reflected image of the sun that reaches Viewpoint C5 from any of the analysed façade aspects. Refer to Appendix A.

## 3.8 Viewpoint C6

Viewpoint C6 is taken from the viewpoint of a car driver travelling South-west at the intersection between Coff St. and Gordon St. The viewing angle of the driver is 245° and the distance from Viewpoint C6 to the centre of the building is 134.7 meters

The path of the reflected sun has been plotted for Façade Aspects 39°, 111° and 129°, which are visible from viewpoint C5. There is no reflected image of the sun that reaches Viewpoint C6 from any of the analysed façade aspects. Refer to Appendix A.

## Conclusion

This reflectivity study has been carried out in order to address the potential for disability glare that may be caused by the proposed All Welcome Cultural Centre in Gordon St. to car drivers and pedestrians.

The analysis has been completed based on the architectural drawings provided by BVN and satellite images of the project site obtained from Google Earth.

The glare assessment has been carried out as per the methodology outlined in the technical bulletin "Reflectivity: Dealing with Rogue Solar Reflections" written by David Hassall.

A total of 8 viewpoints have been selected for this study to represent possible views from car drivers and pedestrians of the proposed project.

All viewpoints considered have been analysed and it has been determined that the risk of rogue reflections causing disability glare are limited and acceptable providing that limitations on façade reflectivity are adopted as per the recommendations of this report. This includes a 15% limit on Specular reflectivity to facades on the East and South Elevations of the building.

# Appendix A

# Appendix A – Detailed Results

### Viewpoint P1

Viewpoint P1 is taken from the viewpoint of a pedestrian that is about to take the crossing road in Gordon St. The viewing angle of the person is 307°. The following façade aspects are visible from the Viewpoint (in a 180° segment oriented to the direction of viewing):

- 148°
- 111°
- 129°
- 201°

The distance from Viewpoint P1 to the centre of the building is 67.7 meters and the heights of the building relevant to the façade aspects are 31.26 meters and 25.5.

The vertical bearing angles have been calculated for each façade aspect that is visible from Viewpoint P1 according to the formula below.

$\beta_{Higher\ facade} = \tan^{-1}(31.26m \div 67.7m) = 24.78°$ $\beta_{Lower\ facade} = \tan^{-1}(25.5m \div 67.7m) = 20.63°$

**Table 1. Summary table of angles for viewpoint P1**

| Façade Aspect | Vertical Bearing Angles | | Horizontal Bearing Angles (0° at North) | |
|---|---|---|---|---|
| | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| 148° | 0° | 20.63° | 5° | 17.47° |
| 111° | 0° | 24.78° | 5° | 356° |
| 129° | 0° | 24.78° | 325° | 356° |
| 201° | 0° | 24.78° | 315° | 321° |

These bearing angles have been plotted on the reflected sun path diagrams in Figures 8 to 11 below. Further assessment of reflectivity issues is shown in figures12 and 13.

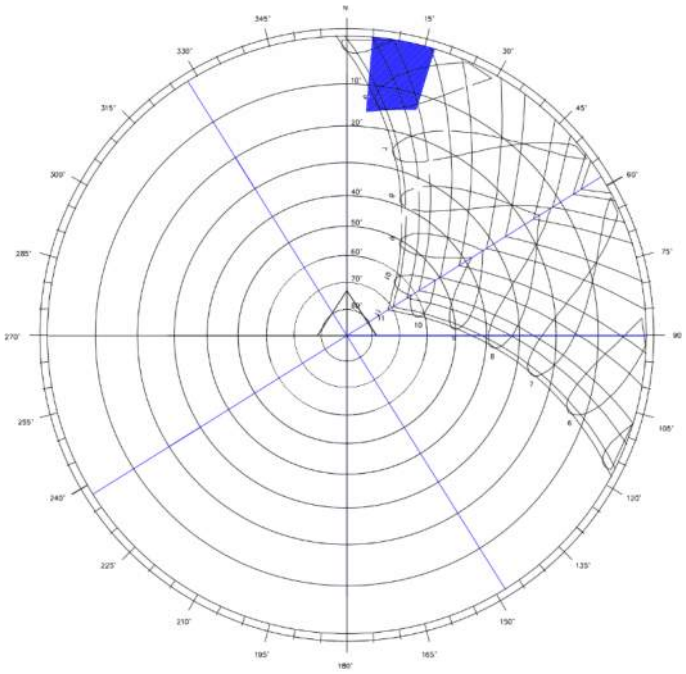

**Figure 7. Façade Aspect 148° Reflected Virtual Sun from Viewpoint P1**

There is a reflected image of the sun that reaches Viewpoint P1 from Façade Aspect 148°. Rerefer to viewpoint analysis in Figure 11 for further assessment.

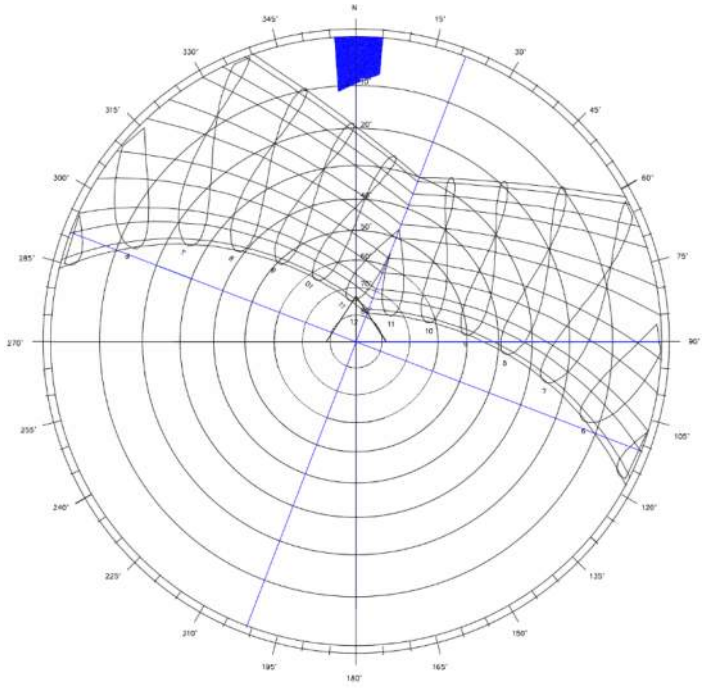

**Figure 8. Façade Aspect 111° Reflected Virtual Sun from Viewpoint P1**

There is no reflected image of the sun that reaches Viewpoint P1 from Façade Aspect 111°.

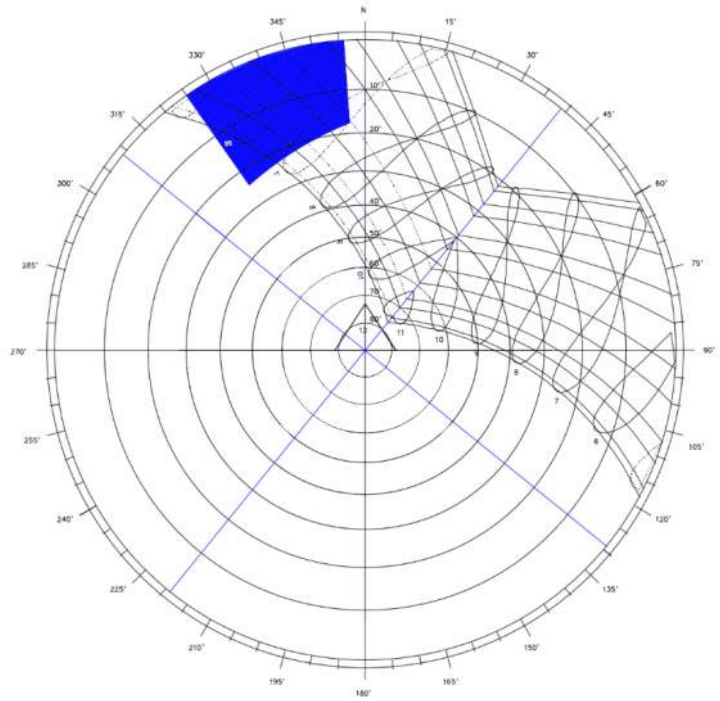

**Figure 9. Façade Aspect 129° Reflected Virtual Sun from Viewpoint P1**

There is a reflected image of the sun that reaches Viewpoint P1 from Façade Aspect 129°. Rerefer to viewpoint analysis in Figure 11 for further assessment.

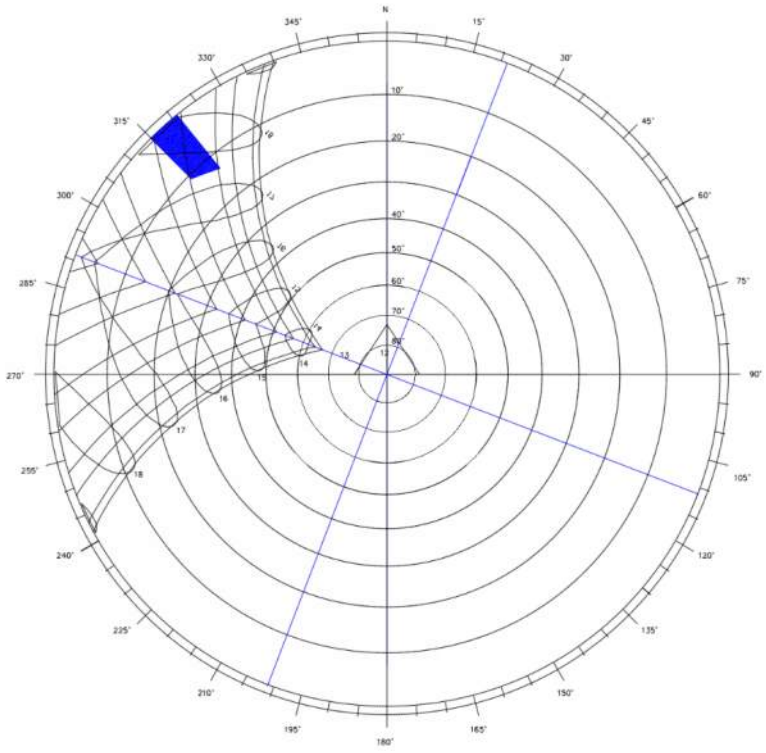

**Figure 10. Façade Aspect 201° Reflected Virtual Sun from Viewpoint P1**

There is a reflected image of the sun that reaches Viewpoint 1 from Façade Aspect 201°.

The façade aspects that produce a reflected image of the sun according to the analysis above are 148°, 129°, and 201°. From these façade aspects, only 201° lies within the sensitive angle of vision of viewpoint P1 (figure 12).


**Figure 11. Schematic of the sensitive vision area of the driver according to the glare protractor values.**

Further assessment was undertaken based on the angles for sensitive vision as drawn in the glare protractor. An image from viewpoint P1 was used to analyse the potential for glare. In figure 13 it

can be seen that the building façade lies outside of the sensitive vision area of the pedestrian. The reflectivity of the façade elements in this location fall just below required limits for reflectivity. There is not envisaged to be an issue in this location.

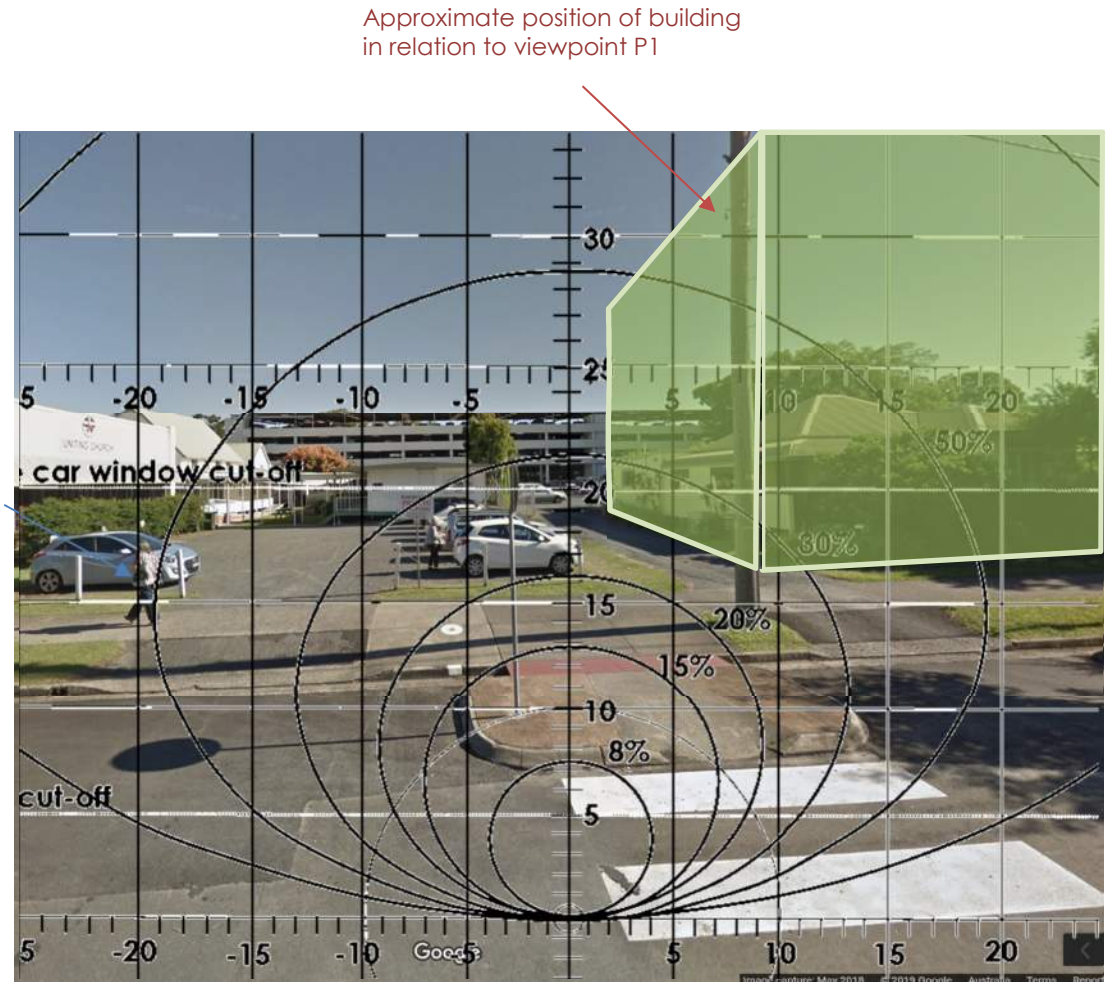


**Figure 12. Glare protractor analysis from viewpoint P1.**

### Viewpoint P2

Viewpoint P2 is taken from the viewpoint of a pedestrian walking South-east that is about to cross Riding Ln. in the intersection with Vernon St. The viewing angle of the person is 130°. The following façade aspects are visible from the Viewpoint (in a 180° segment oriented to the direction of viewing):

- 238°
- 201°
- 309°
- 297°

The distance from Viewpoint P2 to the centre of the building is 81.5 meters and the heights of the building relevant to the façade aspects are 31.26 meters and 25.5.

The vertical bearing angles have been calculated for each façade aspect that is visible from Viewpoint P2.

$\beta_{High\ facade} = \tan^{-1}(31.26m \div 81.5m) = 20.9°$ $\beta_{Lower\ facade} = \tan^{-1}(25.5m \div 81.5m) = 17.3°$

**Table 2. Summary table of angles for viewpoint P2**

| Façade Aspect | Vertical Bearing Angles | | Horizontal Bearing Angles (0° at North) | |
|---|---|---|---|---|
| | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| 238° | 0° | 20.9° | 74° | 90° |
| 201° | 0° | 20.9° | 55° | 74° |
| 309° | 0° | 20.9° | 50° | 55° |
| 297° | 0° | 17.3° | 48° | 50° |

These bearing angles have been plotted on the reflected sun path diagrams in Figures 13 to 16 below.

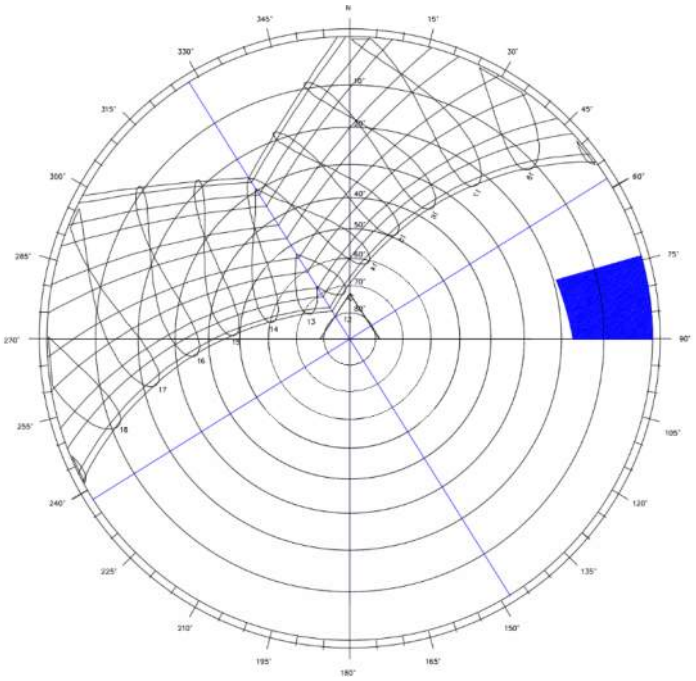

**Figure 13. Façade Aspect 238° Reflected Virtual Sun from Viewpoint P2**

There is no reflected image of the sun that reaches Viewpoint P2 from Façade Aspect 238°.

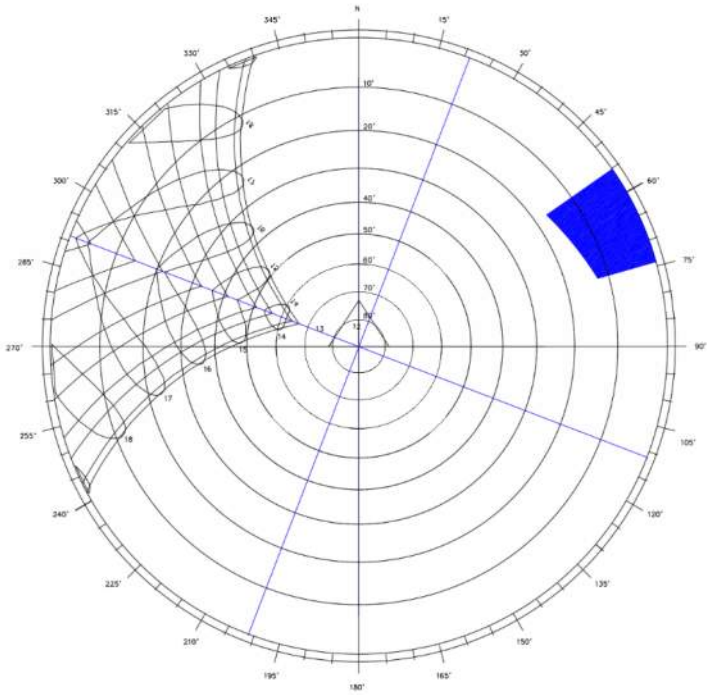

**Figure 14. Façade Aspect 201° Reflected Virtual Sun from Viewpoint P2**

There is no reflected image of the sun that reaches Viewpoint P2 from Façade Aspect 201°.

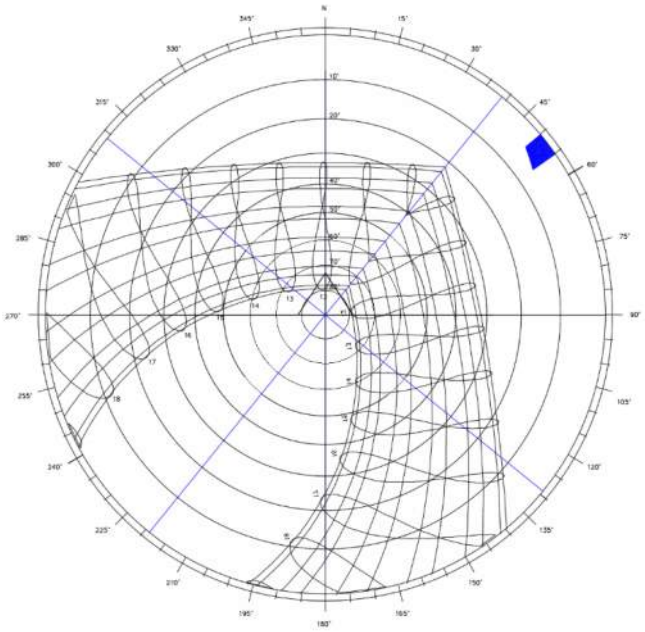

**Figure 15. Façade Aspect 309° Reflected Virtual Sun from Viewpoint P2**

There is no reflected image of the sun that reaches Viewpoint P2 from Façade Aspect 309°.

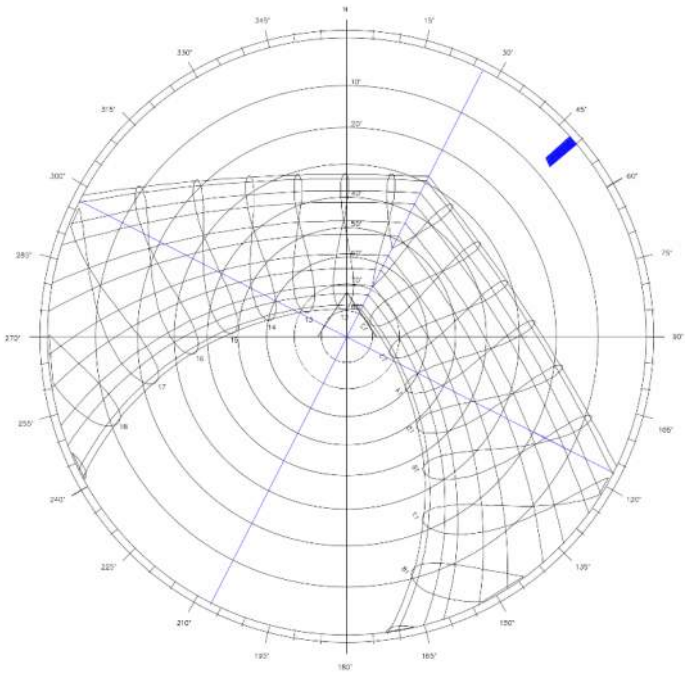

**Figure 16. Façade Aspect 297° Reflected Virtual Sun from Viewpoint P2**

There is no reflected image of the sun that reaches Viewpoint P2 from Façade Aspect 297°.

### Viewpoint C1

Viewpoint C1 is taken from the viewpoint of a person driving a car South-east along Vernon St. at the level of the roundabout between Castle St. and Riding Ln. The viewing angle of the driver is 125°. The following façade aspects are visible from the Viewpoint (in a 180° segment oriented to the direction of viewing):

- 238°
- 201°
- 309°
- 297°

The distance from Viewpoint C1 to the centre of the building is 96.8 meters and the heights of the building relevant to the façade aspects are 31.26 meters and 25.5.

The vertical bearing angles have been calculated for each façade aspect that is visible from Viewpoint C1 according the formula below.

$\beta_{High\ facade} = \tan^{-1}(31.26m \div 96.8m) = 17.8°$ $\beta_{Lower\ facade} = \tan^{-1}(25.5m \div 96.8m) = 14.7°$

**Table 3. Summary table of angles for viewpoint C1**

| Façade Aspect | Vertical Bearing Angles | | Horizontal Bearing Angles (0° at North) | |
|---|---|---|---|---|
| | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| 238° | 0° | 17.8 | 74° | 88° |
| 201° | 0° | 17.8 | 61° | 74° |
| 309° | 0° | 17.8° | 55° | 61° |
| 297° | 0° | 14.7° | 53° | 55° |

These bearing angles have been plotted on the reflected sun path diagrams in Figures 17 to 20 below.

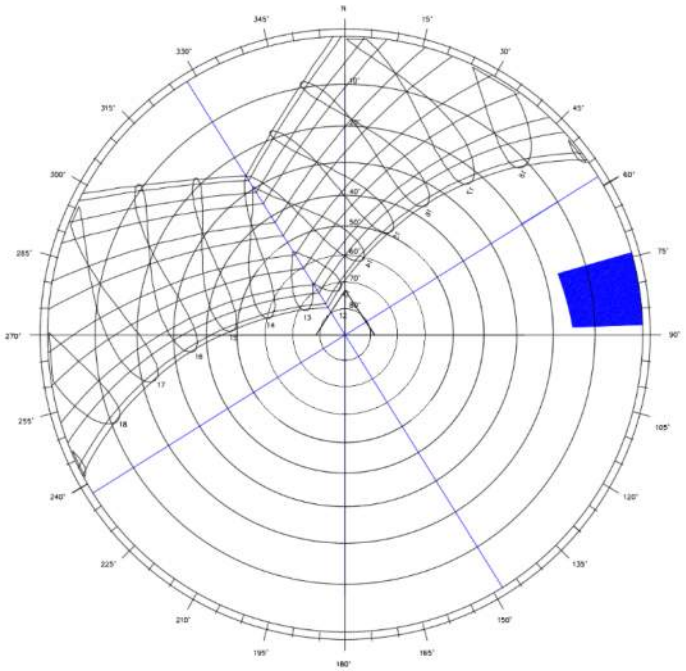

**Figure 17. Façade Aspect 238° Reflected Virtual Sun from Viewpoint C1**

There is no reflected image of the sun that reaches Viewpoint C1 from Façade Aspect 238°.

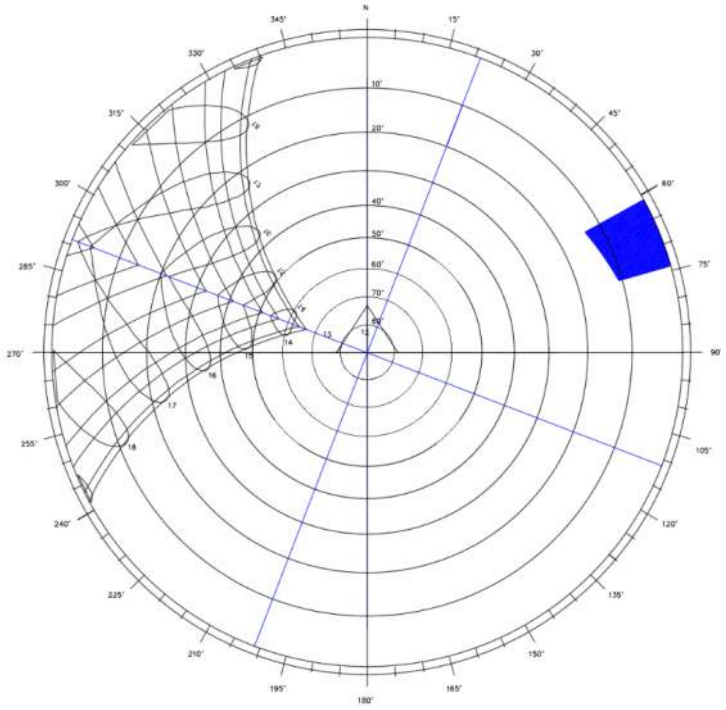

**Figure 18. Façade Aspect 201° Reflected Virtual Sun from Viewpoint C1**

There is no reflected image of the sun that reaches Viewpoint C1 from Façade Aspect 201°.

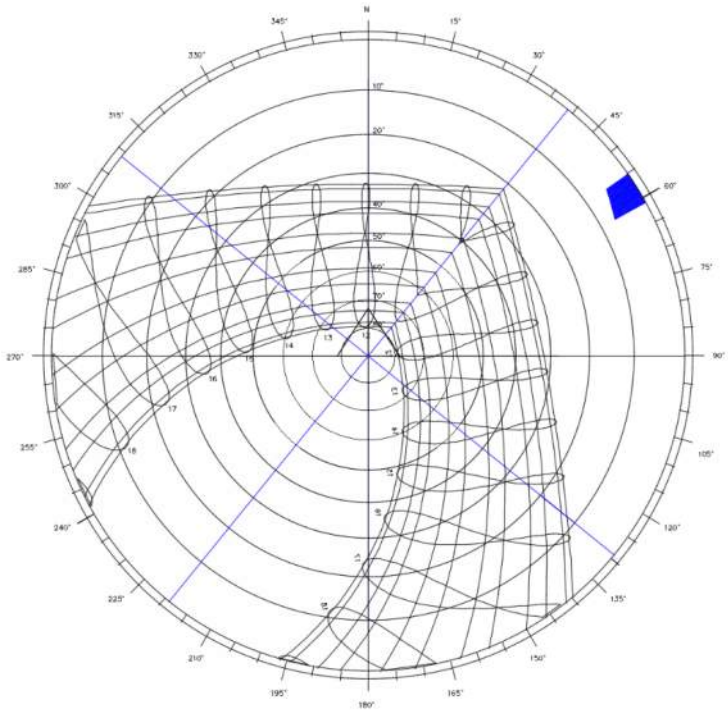

**Figure 19. Façade Aspect 309° Reflected Virtual Sun from Viewpoint C1**

There is no reflected image of the sun that reaches Viewpoint C1 from Façade Aspect 309°.

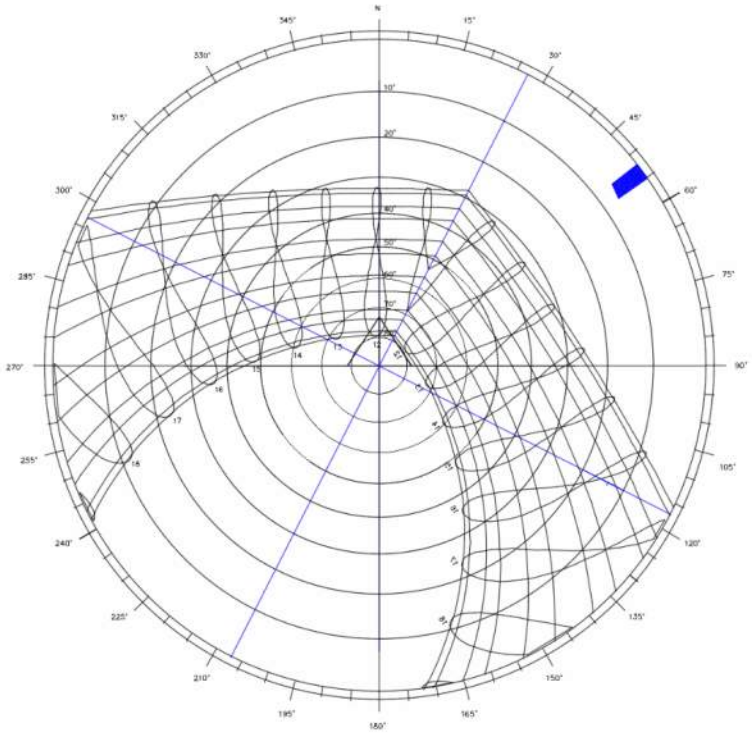

**Figure 20. Façade Aspect 297° Reflected Virtual Sun from Viewpoint C1**

There is no reflected image of the sun that reaches Viewpoint C1 from Façade Aspect 297°.

### Viewpoint C2

Viewpoint C2 is taken from the viewpoint of a person driving a car North along Gordon St. at the roundabout in Vernon St. The viewing angle of the driver is 3°. The following façade aspects are visible from the Viewpoint (in a 180° segment oriented to the direction of viewing):

- 201°
- 238°
- 129°
- 148°

The distance from Viewpoint C2 to the centre of the building is 115.2 meters and the heights of the building relevant to the façade aspects are 31.26 meters and 25.5.

The vertical bearing angles have been calculated for each façade aspect that is visible from Viewpoint C2.

$\beta_{Higher\ facade} = \tan^{-1}(31.26m \div 115.2m) = 15.18°$ $\beta_{Lower\ facade} = \tan^{-1}(25.5m \div 115.2m) = 12.48°$

**Table 4. Summary table of angles for viewpoint C2**

| Façade Aspect | Vertical Bearing Angles | | Horizontal Bearing Angles (0° at North) | |
|---|---|---|---|---|
| | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| 148° | 0° | 12.48° | 29° | 32° |
| 129° | 0° | 15.18° | 26° | 29° |
| 238° | 0° | 15.18° | 11° | 26° |
| 201° | 0° | 15.18° | 0° | 11° |

These bearing angles have been plotted on the reflected sun path diagrams in Figures 21 to 24 below. Further assessment of façade aspects that present reflectivity issues is shown in figures 25-26.

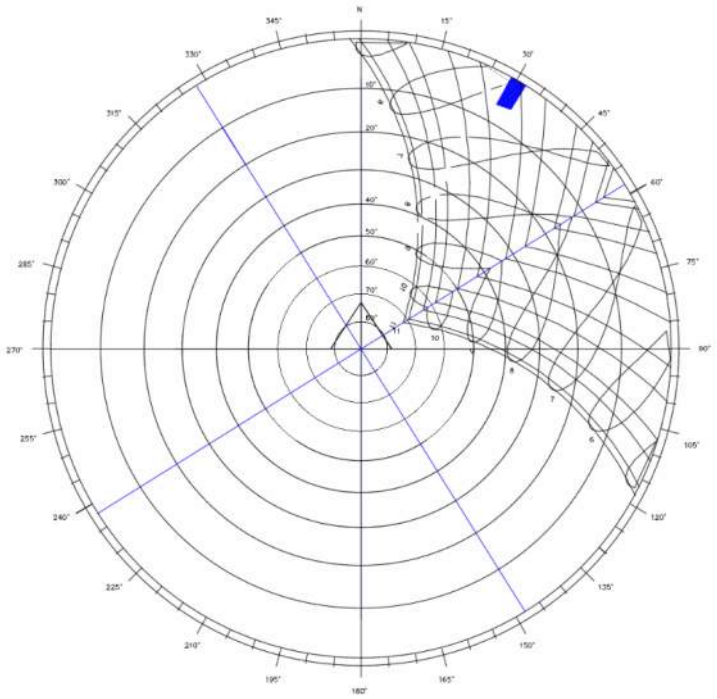

**Figure 21. Façade Aspect 148° Reflected Virtual Sun from Viewpoint C2**

There is a reflected image of the sun that reaches Viewpoint C2 from Façade Aspect 148°. Rerefer to viewpoint analysis in Figure 25 for further assessment.

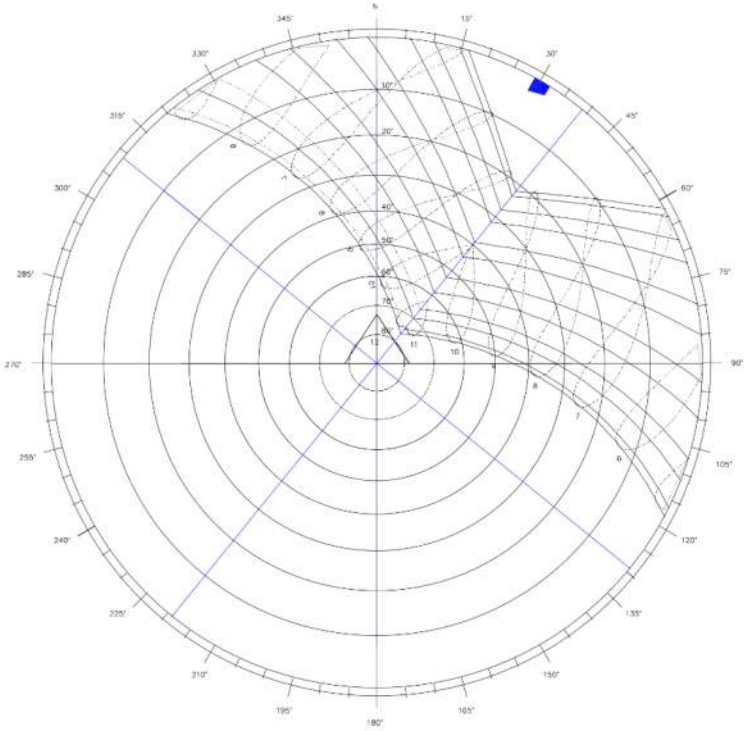

**Figure 22. Façade Aspect 129° Reflected Virtual Sun from Viewpoint C2**

There is no reflected image of the sun that reaches Viewpoint C2 from Façade Aspect 129°.

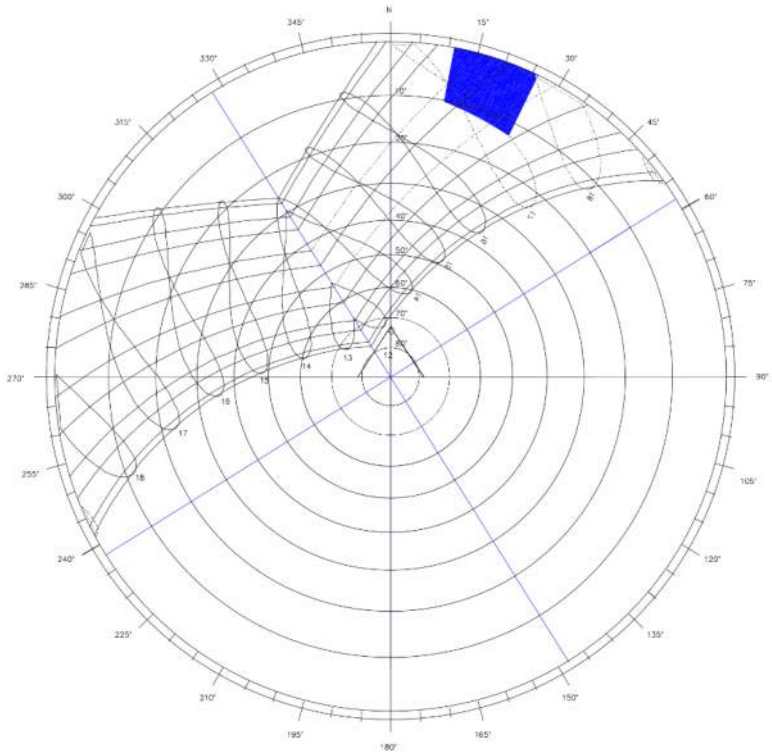

**Figure 23. Façade Aspect 238° Reflected Virtual Sun from Viewpoint C2**

There is no reflected image of the sun that reaches Viewpoint C2 from Façade Aspect 238°. Rerefer to viewpoint analysis in Figure 25 for further assessment.

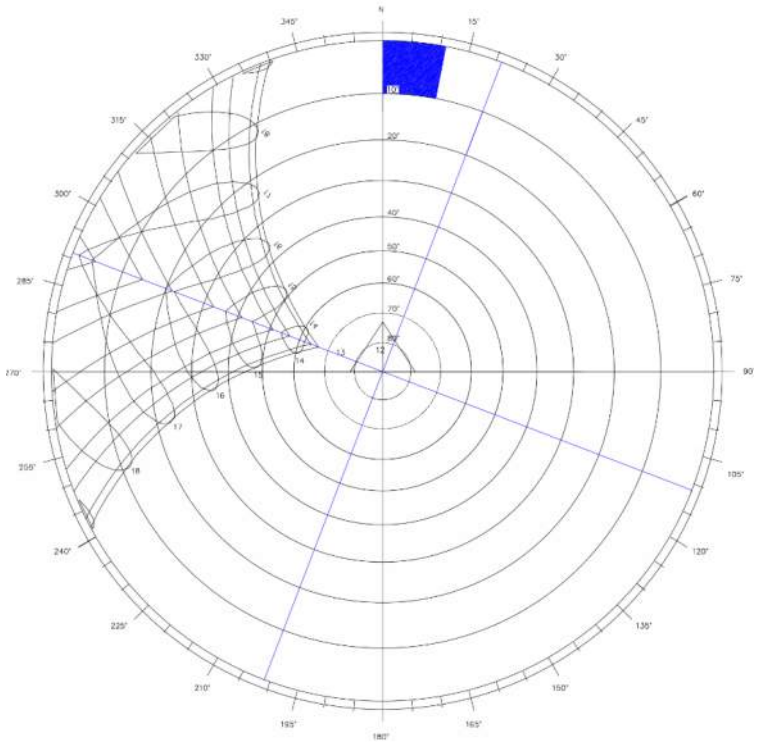

**Figure 24. Façade Aspect 201° Reflected Virtual Sun from Viewpoint C2**

There is no reflected image of the sun that reaches Viewpoint C2 from Façade Aspect 201°.

The façade aspects that produce a reflected image of the sun according to the analysis above are 148° and 238°. From these façade aspects, only a small portion a façade aspect 238° lies within the sensitive angle of vision of viewpoint C2 (figure 25).

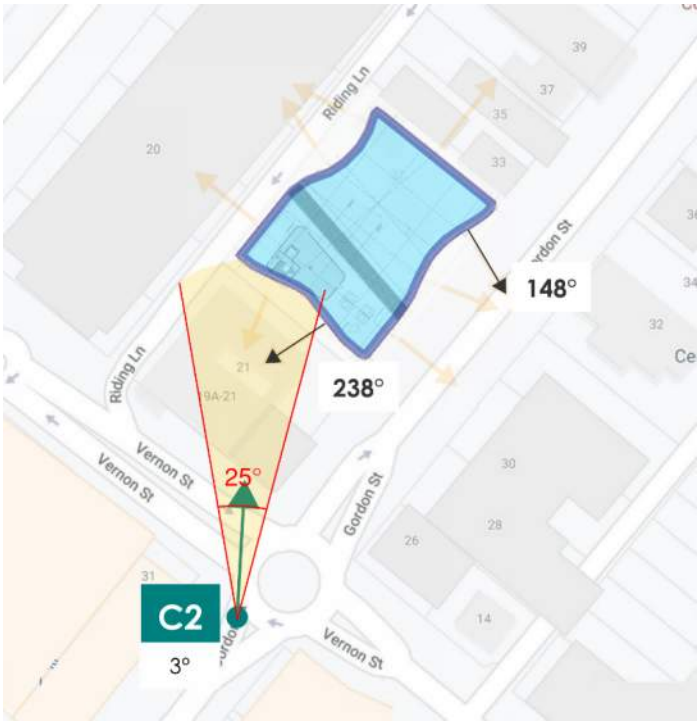


**Figure 25. Schematic of the sensitive vision area of the driver according to the glare protractor values.**

Further assessment was undertaken based on the angles for sensitive vision as drawn in the glare protractor. An image from viewpoint C2 was used to analyse the potential for glare. Figure 26 shows how the visible building façade lies outside of the sensitive vision area of the driver. The reflectivity of the façade elements in this location fall just below the required limits for reflectivity. There is not envisaged to be an issue in this location, but It is recommended that the glass in this façade aspect should have a reflectivity value below 15%.

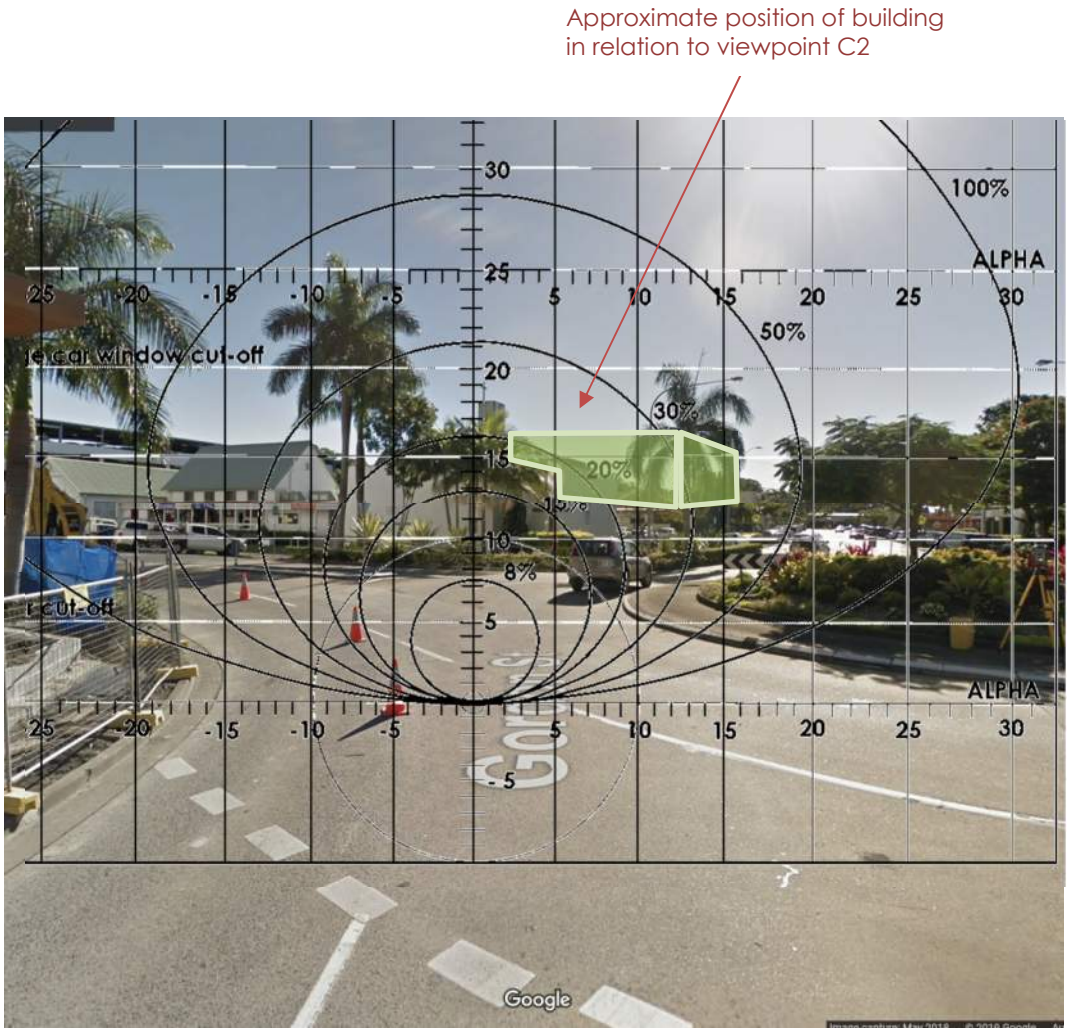


**Figure 26. Glare protractor analysis from viewpoint C2.**

### Viewpoint C3

Viewpoint C3 is taken from the viewpoint of a person driving a car North along Gordon St. after the Vernon St roundabout. The viewpoint is located just before the pedestrian crossing in Gordon St. The viewing angle of the driver is 36°. The following façade aspects are visible from the Viewpoint (in a 180° segment oriented to the direction of viewing):

- 201°
- 238°
- 129°
- 148°

The distance from Viewpoint C3 to the centre of the building is 78.4 meters and the heights of the building relevant to the façade aspects are 31.26 meters and 25.5.

The vertical bearing angles have been calculated for each façade aspect that is visible from Viewpoint C3.

$\beta_{High\ facade} = \tan^{-1}(31.26m \div 78.4m) = 21.73°$ $\beta_{Lower\ facade} = \tan^{-1}(25.5m \div 78.4m) = 18.01°$

**Table 5. Summary table of angles for viewpoint C3**

| Façade Aspect | Vertical Bearing Angles | | Horizontal Bearing Angles (0° at North) | |
|---|---|---|---|---|
| | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| 148° | 0° | 18.01° | 24° | 30° |
| 129° | 0° | 21.73° | 16° | 23° |
| 238° | 0° | 21.73° | 16° | 352° |
| 201° | 0° | 21.73° | 343° | 352° |

These bearing angles have been plotted on the reflected sun path diagrams in Figures 27 to 30 below. Further assessment of façade aspects that present reflectivity issues is shown in figures 30-31.

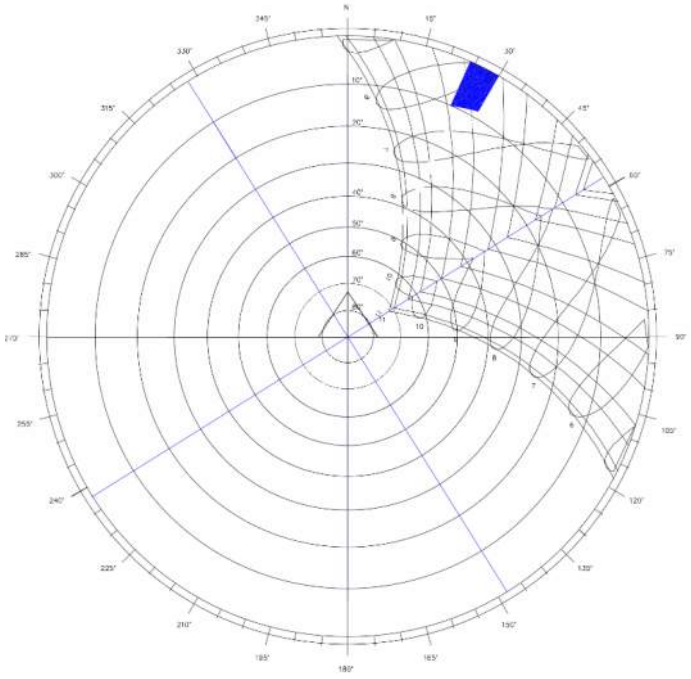

**Figure 27. Façade Aspect 148° Reflected Virtual Sun from Viewpoint C3**

There is a reflected image of the sun that reaches Viewpoint C3 from Façade Aspect 148°. Rerefer to viewpoint analysis in Figure 32 for further assessment.

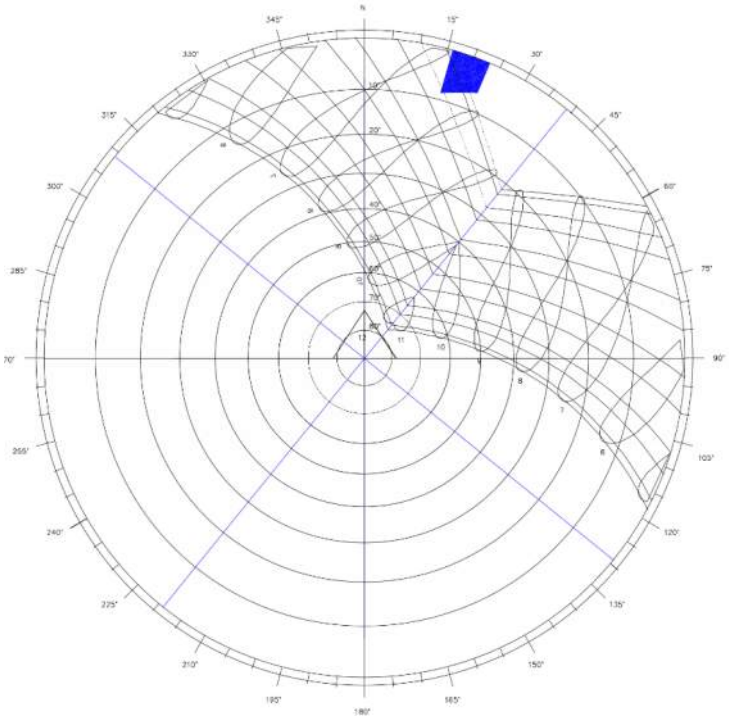

**Figure 28. Façade Aspect 129° Reflected Virtual Sun from Viewpoint C3**

There is a reflected image of the sun that reaches Viewpoint C3 from Façade Aspect 129°. Refer to viewpoint analysis in Figure 32 for further assessment.

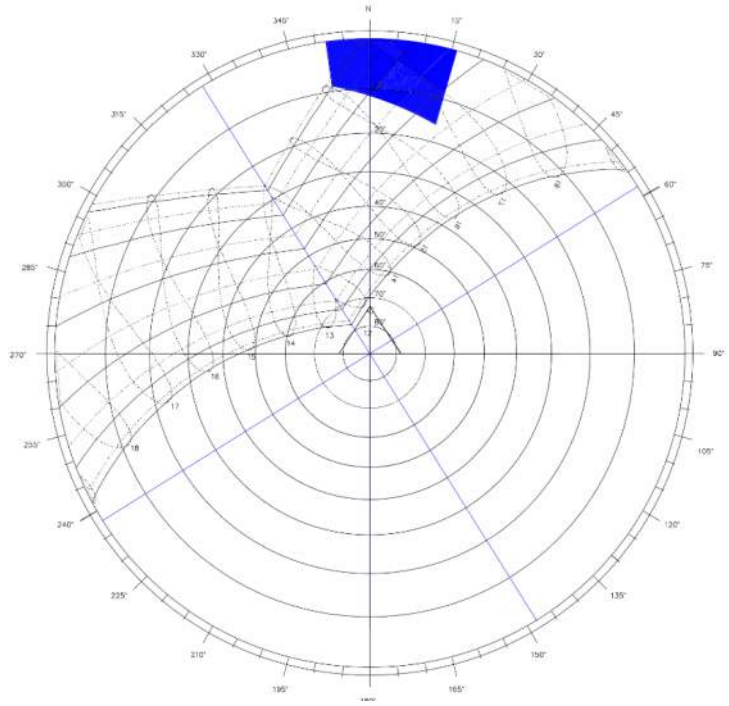

**Figure 29. Façade Aspect 238° Reflected Virtual Sun from Viewpoint C3**

There is a reflected image of the sun that reaches Viewpoint C3 from Façade Aspect 238°. Rerefer to viewpoint analysis in Figure x for further assessment.

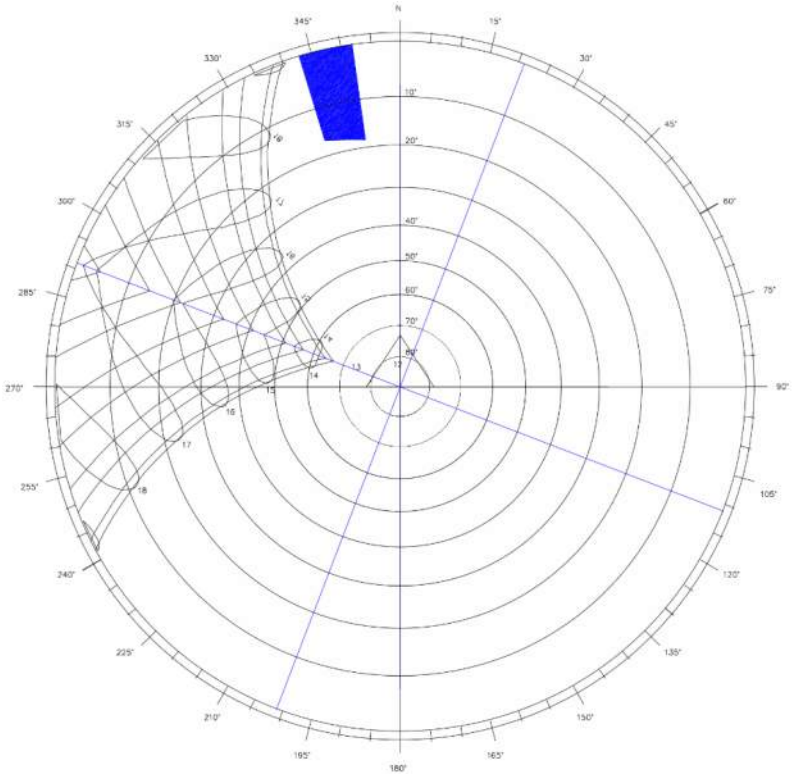

**Figure 30. Façade Aspect 201° Reflected Virtual Sun from Viewpoint C3**

There is no reflected image of the sun that reaches Viewpoint C3 from Façade Aspect 201°.

The façade aspects that produce a reflected image of the sun according to the analysis above are 148°, 129° and 238°. From these façade aspects, only 148° and a small portion a façade aspect 129° lie within the sensitive angle of vision of viewpoint C2 (figure 31).


**Figure 31. Schematic of the sensitive vision area of C3 driver according to the glare protractor values.**

Further assessment was undertaken based on the angles for sensitive vision as drawn in the glare protractor. An image from viewpoint C3 was used to analyse the potential for glare. Figure 32 shows how the visible building façade lies outside of the sensitive vision area of the driver. The reflectivity of the façade elements in this location fall just below required for reflectivity. There is not envisaged to be an issue in this location, but It is recommended that the glass in this façade aspects should have a reflectivity value below 15%.

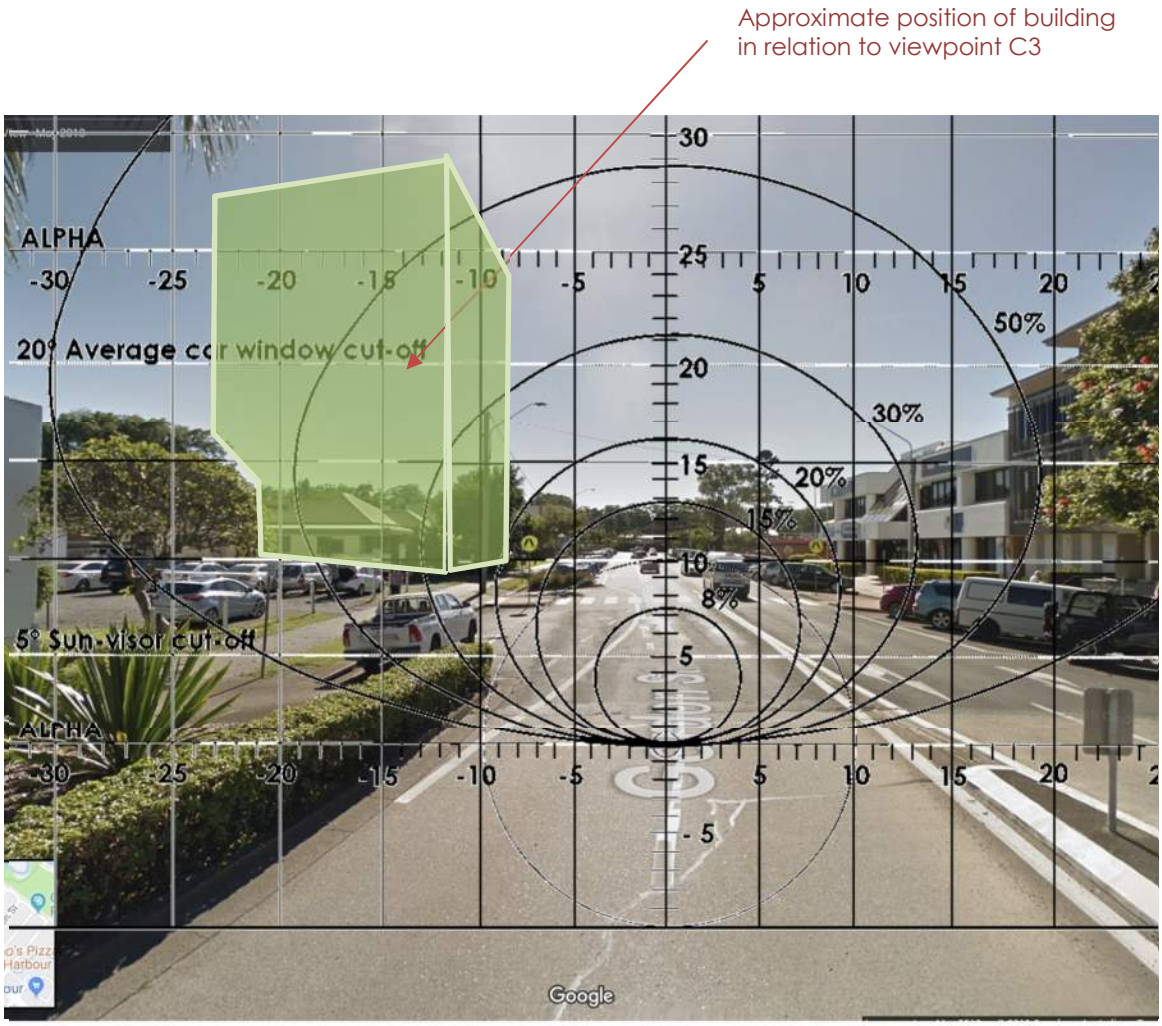


**Figure 32. Glare protractor analysis from viewpoint C3.**

### Viewpoint C4

Viewpoint C4 is taken from the viewpoint of a person driving a car South-west along Riding Ln between Coff St. and Vernon St. The viewing angle of the driver is 218°. The following façade aspects are visible from the Viewpoint (in a 180° segment oriented to the direction of viewing):

- 39°
- 326°

The distance from Viewpoint C4 to the centre of the building is 80.5 meters and the heights of the building relevant to the façade aspects are 31.26 meters and 25.5.

The vertical bearing angles have been calculated for each façade aspect that is visible from Viewpoint C4.

$\beta_{High\ facade} = \tan^{-1}(31.26m \div 80.5m) = 21.22°$ $\beta_{Lower\ facade} = \tan^{-1}(25.5m \div 80.5mm) = 17.57°$

**Table 6. Summary table of angles for viewpoint C4**

| Façade Aspect | Vertical Bearing Angles | | Horizontal Bearing Angles (0° at North) | |
|---|---|---|---|---|
| | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| 39° | 0° | 17.57° | 210° | 180° |
| 326° | 0° | 21.22° | 210° | 216° |

These bearing angles have been plotted on the reflected sun path diagrams in Figures 33 and 34 below. Further assessment of façade aspects that present reflectivity issues is shown in figures 35.

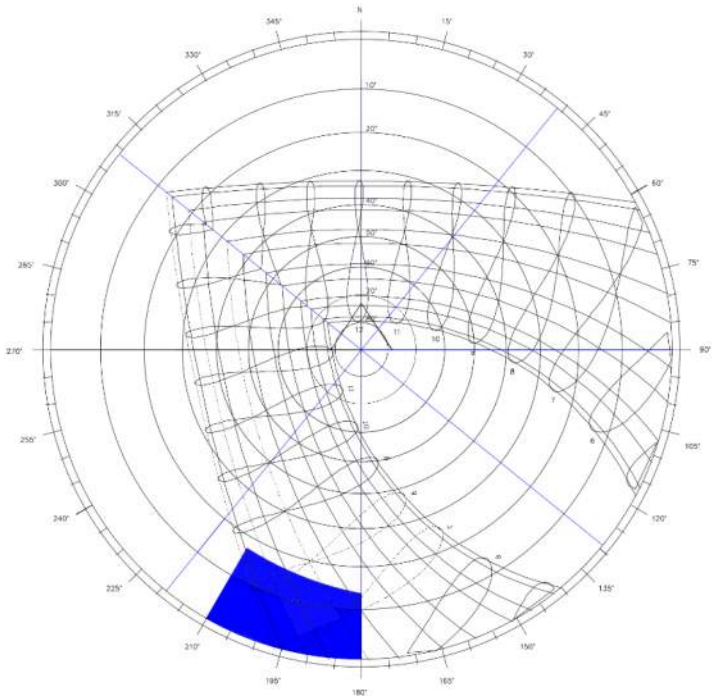

**Figure 33. Façade Aspect 39° Reflected Virtual Sun from Viewpoint C4**

There is a reflected image of the sun that reaches Viewpoint C4 from Façade Aspect 39°. Rerefer to viewpoint analysis in Figure 35 for further assessment.

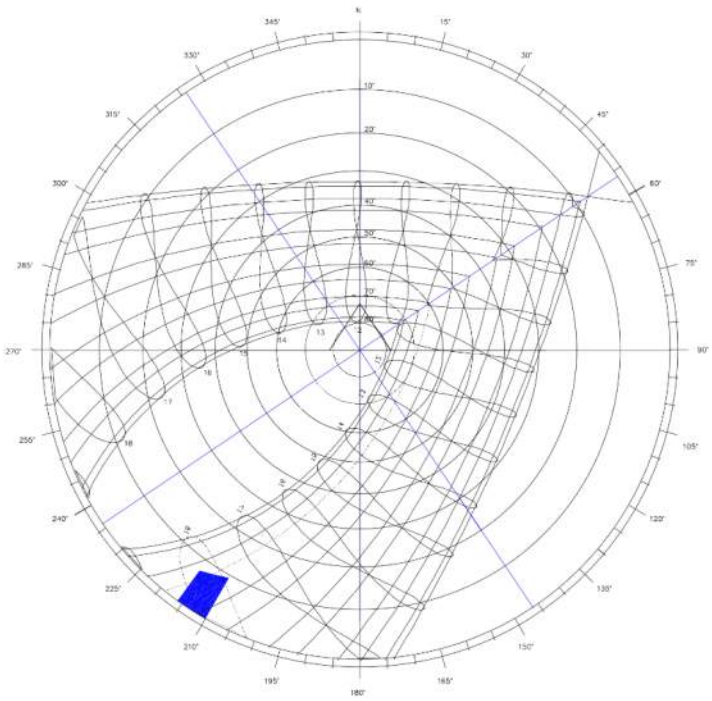

**Figure 34. Façade Aspect 326° Reflected Virtual Sun from Viewpoint C4**

There is a reflected image of the sun that reaches Viewpoint C4 from Façade Aspect 326°.

Both façade aspects analysed produce a reflected image of the sun. From these façade aspects, only 326° and a very small portion of 39° lie within the sensitive angle of vision of viewpoint C4. However, existing vegetation block any possible reflection from façade aspect 326° as depicted in figure 31. There is not envisaged to be an issue in this location.


**Figure 35. Schematic of the sensitive vision area of C4 driver according to the glare protractor values.**

### Viewpoint C5

Viewpoint C5 is taken from the viewpoint of a person driving a car South-west along Gordon St. between Coff St. and Vernon St. The viewing angle of the driver is 218°. The following façade aspects are visible from the Viewpoint (in a 180° segment oriented to the direction of viewing):

- 39°
- 111°
- 129°

The distance from Viewpoint C5 to the centre of the building is 88.5 meters and the heights of the building relevant to the façade aspects are 31.26 meters and 25.5.

The vertical bearing angles have been calculated for each façade aspect that is visible from Viewpoint C5.

$\beta_{High\ facade} = \tan^{-1}(31.26m \div 88.5m) = 19.45°$

$\beta_{Lower\ facade} = \tan^{-1}(25.5m \div 88.5mm) = 16.07°$

**Table 7. Summary table of angles for viewpoint C5**

| Façade Aspect | Vertical Bearing Angles | | Horizontal Bearing Angles (0° at North) | |
|---|---|---|---|---|
| | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| 39° | 0° | 16.07° | 236° | 266° |
| 111° | 0° | 19.45° | 230° | 235° |
| 129° | 0° | 19.45° | 228° | 230° |

These bearing angles have been plotted on the reflected sun path diagrams in Figures x to x below.

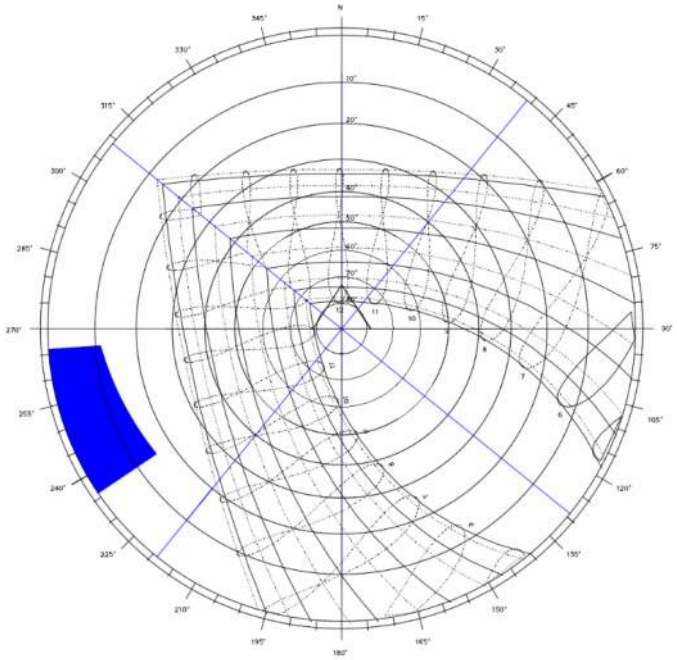

**Figure 36. Façade Aspect 39° Reflected Virtual Sun from Viewpoint C5**

There is no reflected image of the sun that reaches Viewpoint C5 from Façade Aspect 39°.

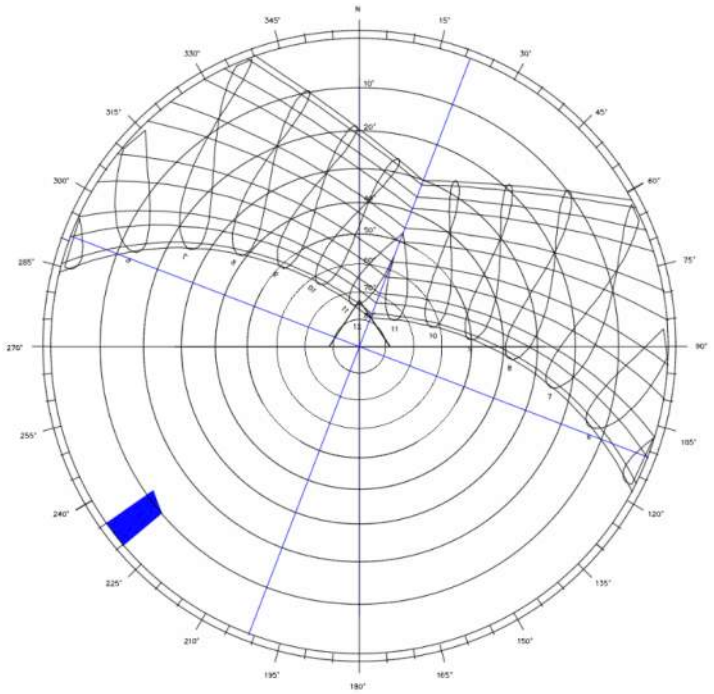

**Figure 37. Façade Aspect 111° Reflected Virtual Sun from Viewpoint C5**

There is no reflected image of the sun that reaches Viewpoint C5 from Façade Aspect 111°.

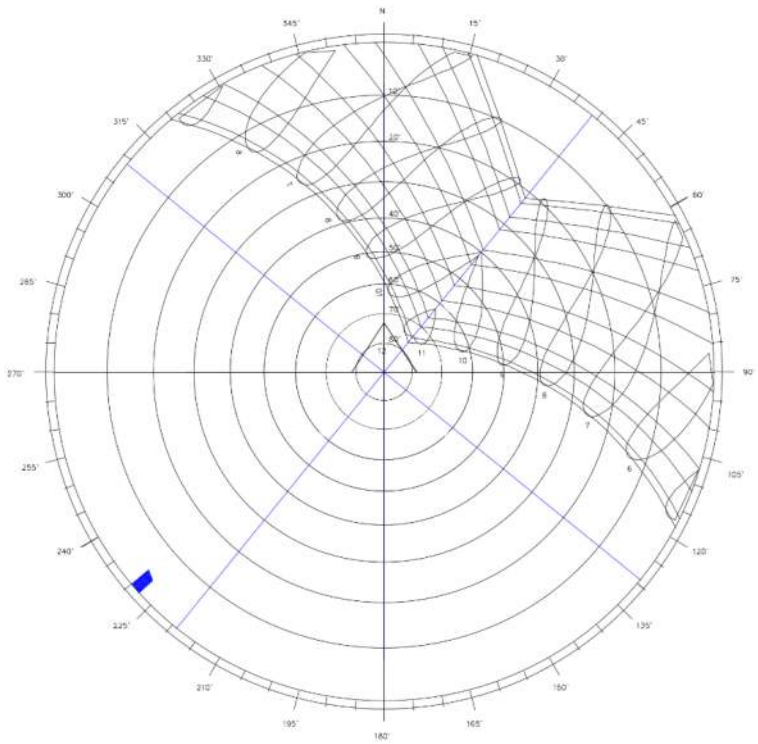

**Figure 38. Façade Aspect 129° Reflected Virtual Sun from Viewpoint C5**

There is no reflected image of the sun that reaches Viewpoint C5 from Façade Aspect 129°.

### Viewpoint C6

Viewpoint C6 is taken from the viewpoint of a person driving a car South-west at the intersection between Coff St and Gordon St. The viewing angle of the driver is 245°. The following façade aspects are visible from the Viewpoint (in a 180° segment oriented to the direction of viewing):

- 39°
- 111°
- 129°

The distance from Viewpoint C6 to the centre of the building is 134.7 meters and the heights of the building relevant to the façade aspects are 31.26 meters and 25.5.

The vertical bearing angles have been calculated for each façade aspect that is visible from Viewpoint C6.

$\beta_{High\ facade} = \tan^{-1}(31.26m \div 134.7m) = 13.06°$

$\beta_{Lower\ facade} = \tan^{-1}(25.5m \div 134.7mm) = 10.71°$

**Table 8. Summary table of angles for viewpoint C5**

| Façade Aspect | Vertical Bearing Angles | | Horizontal Bearing Angles (0° at North) | |
|---|---|---|---|---|
| | Lower Bound | Upper Bound | Lower Bound | Upper Bound |
| 39° | 0° | 10.71° | 237° | 248° |
| 111° | 0° | 13.06° | 226.4° | 237° |
| 129° | 0° | 13.06° | 225° | 226° |

These bearing angles have been plotted on the reflected sun path diagrams in Figures x to x below.

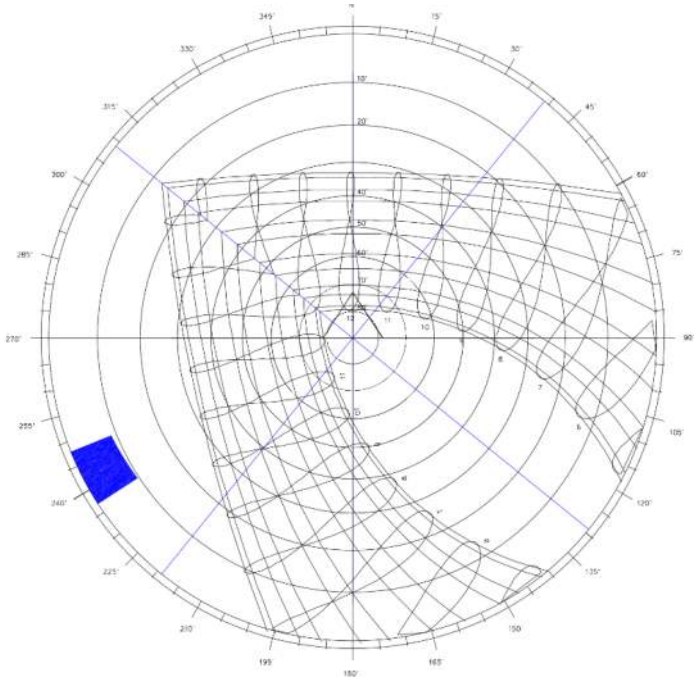

**Figure 39. Façade Aspect 39° Reflected Virtual Sun from Viewpoint C6**

There is no reflected image of the sun that reaches Viewpoint C6 from Façade Aspect 39°.

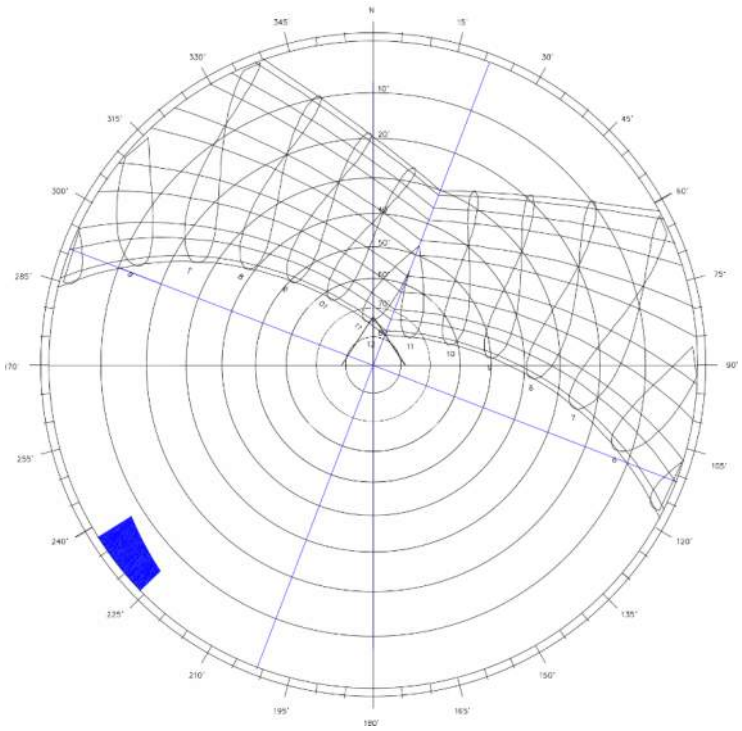

**Figure 40. Façade Aspect 111° Reflected Virtual Sun from Viewpoint C6**

There is no reflected image of the sun that reaches Viewpoint C6 from Façade Aspect 111°.

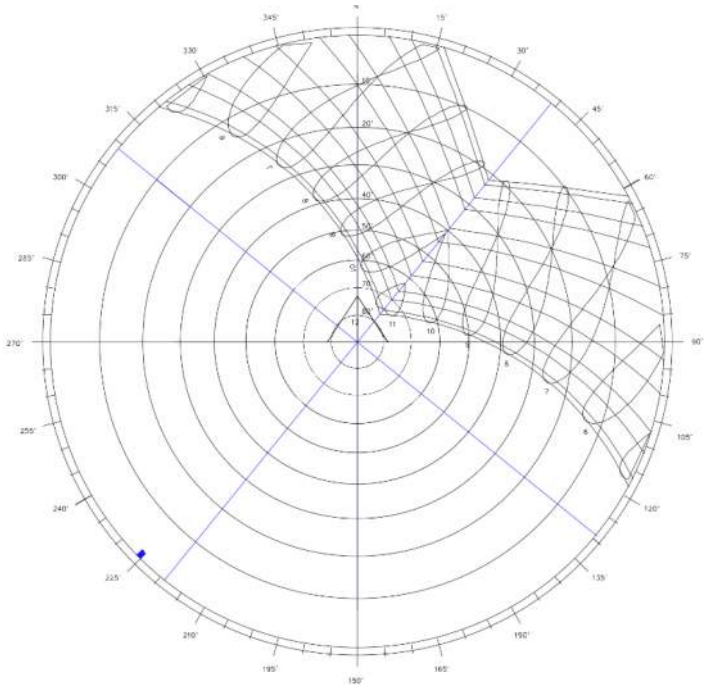

**Figure 41. Façade Aspect 129° Reflected Virtual Sun from Viewpoint C6**

There is no reflected image of the sun that reaches Viewpoint C6 from Façade Aspect 129°.