WINDTECH

SOLAR LIGHT REFLECTIVITY STUDY

2 FISHBURN CRESCENT, CASTLE HILL (LOT 1 DP 1316896)

WJ274-06F03(REV1)- SR REPORT

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Prepared for:

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EXECUTIVE SUMMARY

This report presents the results of a detailed study for the effect of potential solar glare from the 2 Fishburn Crescent, Castle Hill (Lot 1 DP 1316896). This study identifies any possible adverse reflected solar glare conditions affecting motorists, pedestrians, and to occupants of neighbouring buildings. If necessary, recommendations are made to mitigate any potentially adverse effects. This study assesses compliance with the controls for solar glare from the State Environmental Planning Policy (Housing) 2021 Chapter 4 Design, which contains the Apartment Design Guide (ADG), and the Hills Shire Council Development Control Plan 2012.

The results of the study indicate that, to avoid any adverse glare to motorists and pedestrians on the surrounding streets, occupants of neighbouring buildings, and to comply with the abovementioned planning control requirements, the following limitations to the maximum normal specular reflectance of visible light of the external façade glazing is recommended:

- Building A:
    - The proposed glazing along the western aspect (251°) from Levels 10 to 17, should have either of the following recommendations:
        - Option A:
            - Inclusion of vertical louvers to obstruct/overshadow glazing in this region AND.
            - Glazing in this region should have a maximum normal specular reflectance of visible light of 11%.
        - Option B:
            - The proposed glazed in this region is to have a dark frit covering at least 70% of the glazing AND.
            - Glazing in this region should have a maximum normal specular reflectance of visible light of 11%.
        - Option C:
            - Glazing in this region should have a maximum normal specular reflectance of visible light of 4%.
    - The proposed glazing on the southern end of the external façade along the westerly aspect (251°), as indicated in the architectural drawings, should have a maximum normal specular reflectance of visible light of 11%, from Ground Levels to Level 01.
- Building B:
    - The proposed glazing on the northern end of the external façade along the easterly aspect (056°), as indicated in the architectural drawings, should have a maximum normal specular reflectance of visible light of 16% from Levels 06 - 09.

- Building C:
    - The proposed glazing on the southern end of the external façade along the eastern aspect (071°), as indicated in the architectural drawings, should have a maximum normal specular reflectance of visible light of 11%.
- All other glazing on the external façade should have a maximum normal specular reflectance of visible light of 20%.

It should be noted that the most reflective surface on the façade of a building is the glazing. Reflected solar glare from concrete, brickwork, timber, etc. is negligible (i.e. less than 1% normal specular reflectance) and hence will not cause any adverse solar glare effects. Note also that, for any painted or powder-coated metallic surfaces on the exterior façade of the development, the maximum normal specular reflectance of visible light for those types of surfaces is in the range of 1% to 5%, which is well within the abovementioned limit.

Hence, with the incorporation of the abovementioned recommendations, the results of this study indicate that the subject development will not cause adverse solar glare to motorists or pedestrians in the surrounding area, or to occupants of neighbouring buildings, and will comply with the planning controls regarding reflectivity from the State Environmental Planning Policy (Housing) 2021 Chapter 4 Design, which contains the Apartment Design Guide (ADG), and the Hills Shire Council Development Control Plan 2012

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1 GLARE OBSERVED BY MOTORISTS

1.1 Methodology

The reflectivity analysis of the subject development has been carried out using the technique published by Hassall (1991). The limiting veiling luminance of 500 cd/m^2 for the comfort of motorists, as suggested in Hassall (1991), has been adopted as a basis of assessing the glare impact from the subject development.

The various critical glazed aspects of the development were determined and are shown in Figure 1. Solar charts for each of these critical glazed aspects are presented in Appendix B, and these are used to derive the check zones which are shown in Figure 2. The solar chart of each critical aspect is determined from the standard sun chart of the region, provided in Appendix C (Phillips, 1992), using the method detailed in Hassall (1991). The check zones highlight the areas that are potentially affected by solar reflections from each critical glazed aspect. It should be noted that the check zones shown in Figure 2 do not take into account the effect of overshadowing by neighbouring buildings or the shielding effect of any existing trees or other obstructions. These effects are examined in the detailed analysis described in Section 1.4 of this report.

Study point locations are selected within the check zone areas where motorists are facing the general direction of the subject development (within ±16° of the direct sight-line). These are shown in Figure 2, and summarised in Table 3. Photographs have been taken from the viewpoint of motorists at each study point location using a calibrated camera, and a scaled glare protractor has been superimposed over each viewpoint image (these are presented in Appendix A).

The glare protractor is used to assess the amount of glare likely to be caused and to provide a direct comparison with the criterion of 500 cd/m^2. Alternatively, the glare protractor can be used to determine the maximum acceptable reflectivity index of the façade material of the development for the glare to be within the criterion of 500 cd/m^2, to ensure that solar glare will not cause discomfort or threaten the safety of motorists and hence to enable the subject development to comply with the relevant planning control requirements regarding solar light reflectivity.

The list of the architectural drawings relied on for this assessment are presented in Table 1 below.

Table 1: List of Architectural Drawings Referenced

Drawing Number	Drawing Title	Revision Number	Date
DA-110-007	GA Plans – Lower Ground	ZA	29/08/2025
DA-110-008	GA Plans – Ground Level	Y	29/08/2025
DA-110-009	GA Plans – Upper Ground Level	W	29/08/2025
DA-110-010	GA Plans – Level 01	Q	29/08/2025
DA-110-011	GA Plans – Level 02	P	29/08/2025
DA-110-012	GA Plans – Level 03	P	29/08/2025
DA-110-013	GA Plans – Level 04	P	29/08/2025
DA-110-014	GA Plans – Level 05	P	29/08/2025
DA-110-015	GA Plans – Level 06	P	29/08/2025
DA-110-016	GA Plans – Level 07	S	29/08/2025
DA-110-017	GA Plans – Level 08	P	29/08/2025
DA-110-018	GA Plans – Level 09	P	29/08/2025
DA-110-019	GA Plans – Level 10	S	29/08/2025
DA-110-020	GA Plans – Level 11	Q	29/08/2025
DA-110-021	GA Plans – Level 12	P	29/08/2025
DA-110-022	GA Plans – Level 13	Q	29/08/2025
DA-110-023	GA Plans – Level 14	R	29/08/2025
DA-110-024	GA Plans – Level 15	N	29/08/2025
DA-110-025	GA Plans – Level 16	N	29/08/2025
DA-110-026	GA Plans – Level 17	N	29/08/2025
DA-110-027	GA Plans – Level 18	P	29/08/2025
DA-110-028	GA Plans – Roof Level	N	29/08/2025
DA-210-101	Elevations – North Elevation	B	29/08/2025
DA-210-201	Elevations – East Elevation	B	29/08/2025
DA-210-301	Elevations – South Elevation	B	29/08/2025
DA-210-401	Elevations – West Elevation	B	29/08/2025

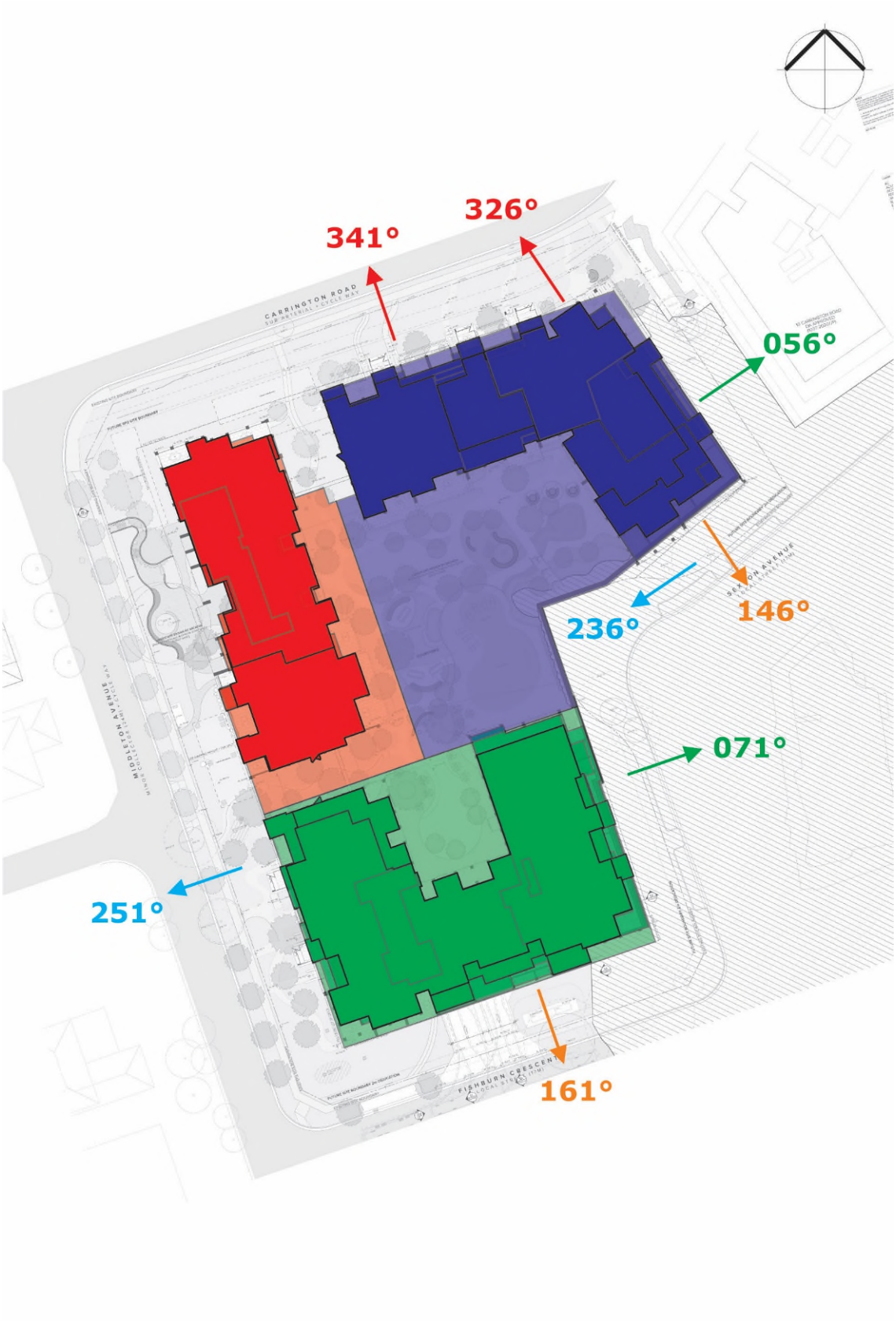


Figure 1: Critical Glazed Aspects of the Development (Ground Floor plan shown)

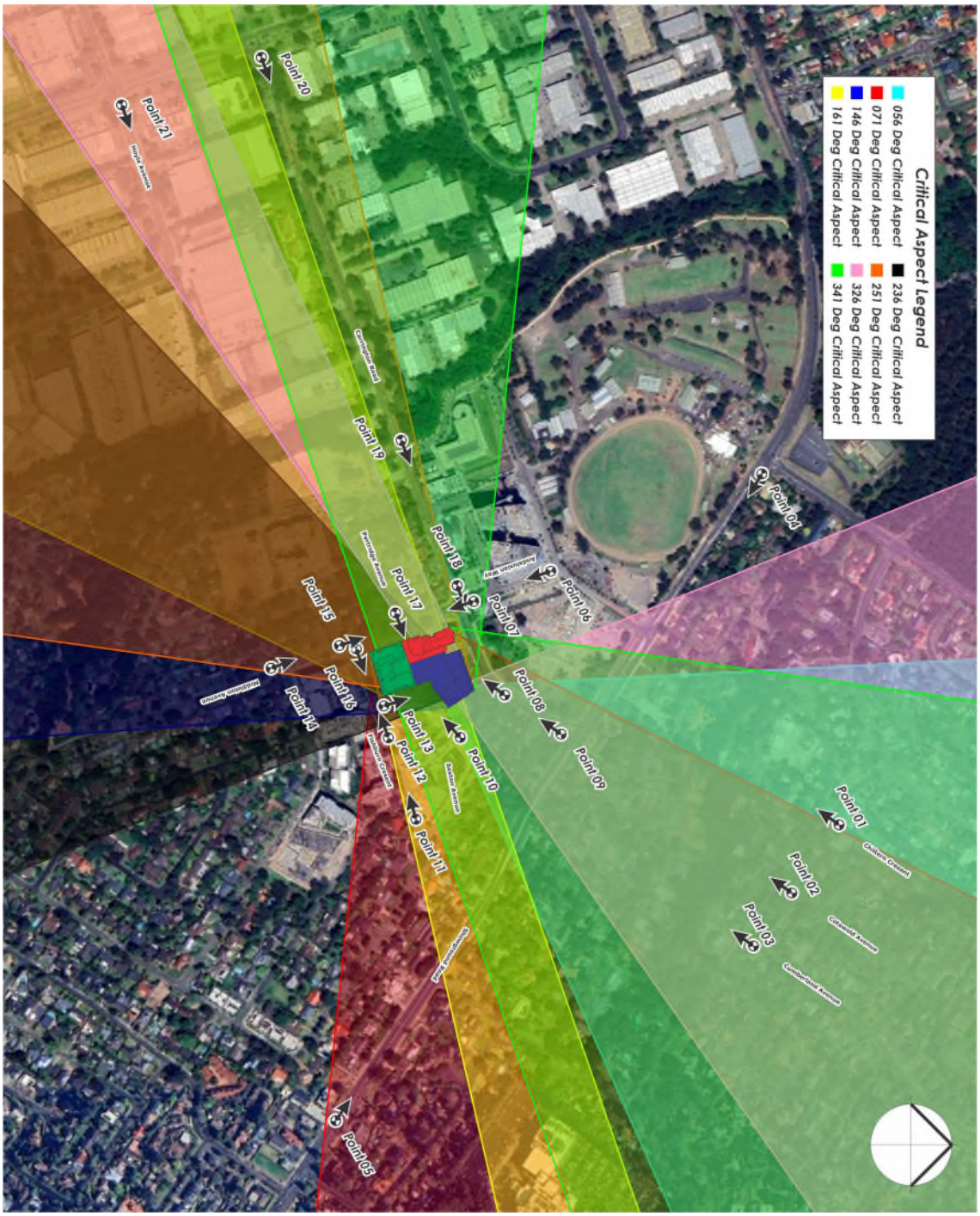


Figure 2: Check Zones and Study Point Locations
(the check zones are the areas where glare could potentially be observed)

1.2 Veiling Luminance

As described in Section 1.1, a limiting veiling luminance of 500 cd/m^2 is utilised in this assessment of glare from the façade of the subject development for the comfort and safety of motorists or train driver. The veiling luminance, measured in units of Candelas per square metre, can be determined using the Holladay Formula as follows:

$$L_v = \frac{10ERcos\theta}{\theta^2} \quad (1.1)$$

Where:

E Is the solar illumination (solar power) of the sun ray on the façade, measured in lux.

θ Is the angle between the line normal to the centre of the glare source and the line of sight of the observer.

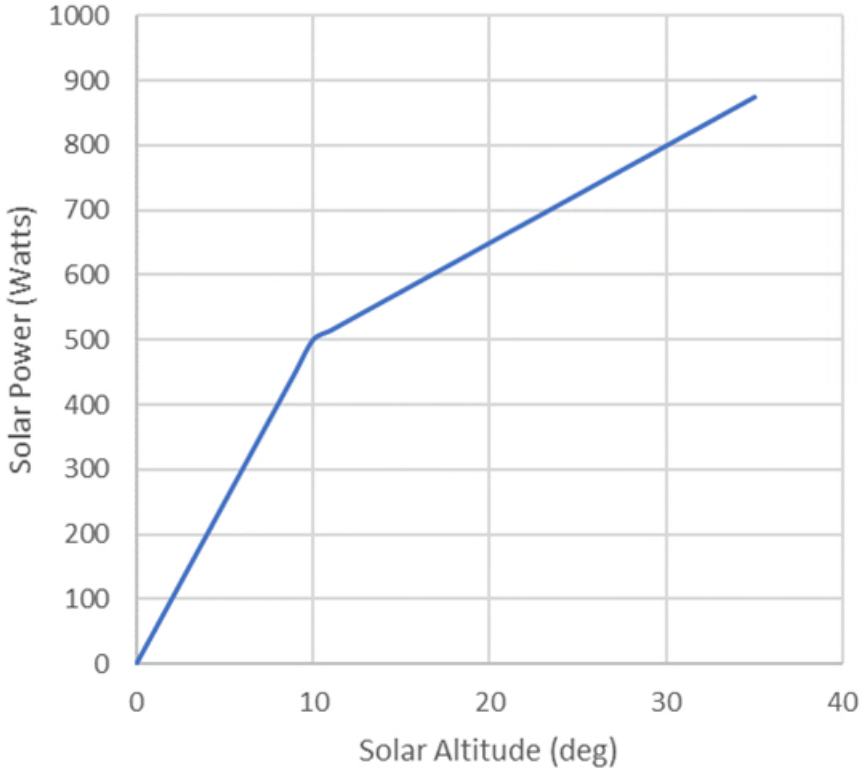
R Is the inherent visual light reflectance value of the glazing as a percentage.

L_v Is the Veiling Luminance in cd/m^2. The limit to which solar glare is assessed is 500 cd/m^2.

The veiling luminance is a function of solar illumination (E), the reflective value of a surface (R) and theta, which is the angle between the glare source and the line of site of the observer. The solar illumination (E) is calculated as a product of the solar power (W/m^2) and luminous efficiency (lumens/W). Solar power and luminous efficiency are both a function of the sun elevation (as shown in Figure 3a, from Hassall, 1991).

The glare protractor, as described in Section 1.1 and shown overlaid onto the viewpoint images in Appendix A, represents the visual acuity of the eye; specifically, the eye's perception to luminance. The centre of the circle on the glare protractor, known as the zone of distinct vision, represents the line of sight of the observer. As the glare source approaches the zone of distinct vision, theta tends to 0 and the veiling luminance increases drastically. Hence, the critical locations on the building façade with regards to glare intensity are (in most cases) locations where the glare source is near the zone of distinct vision (i.e., in the direct sightline of the motorist or train driver). As such, where necessary, the critical locations selected for the calculation of veiling luminance are chosen based on this reasoning.

Further to the above, it should be noted that glass will reflect more than its nominal percentage of reflection if the angle of incidence is greater than approximately 45 degrees. If the angle of incidence is greater than approximately 45 degrees the solar illumination (E) increases exponentially, and hence the intensity of the glare observed also increases exponentially. The relationship between reflected light and angle of incidence is illustrated in Figure 3b. For locations affected by this type of high angle of incidence glare condition, physical obstructions are required to be used to mitigate adverse solar glare, unless the calculated veiling luminance is less than the limiting veiling luminance of 500 cd/m^2.



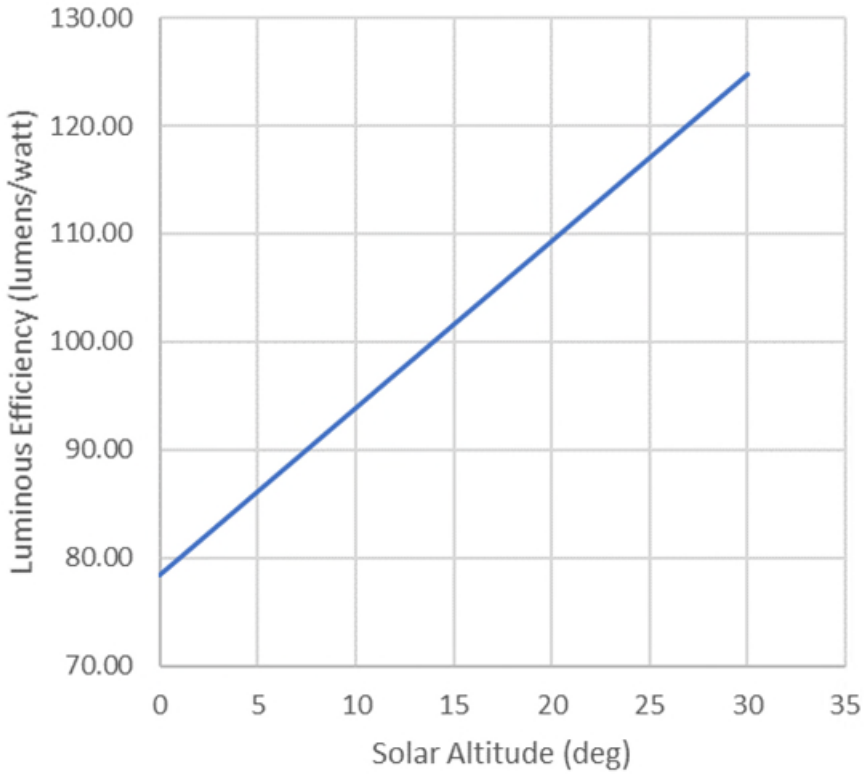
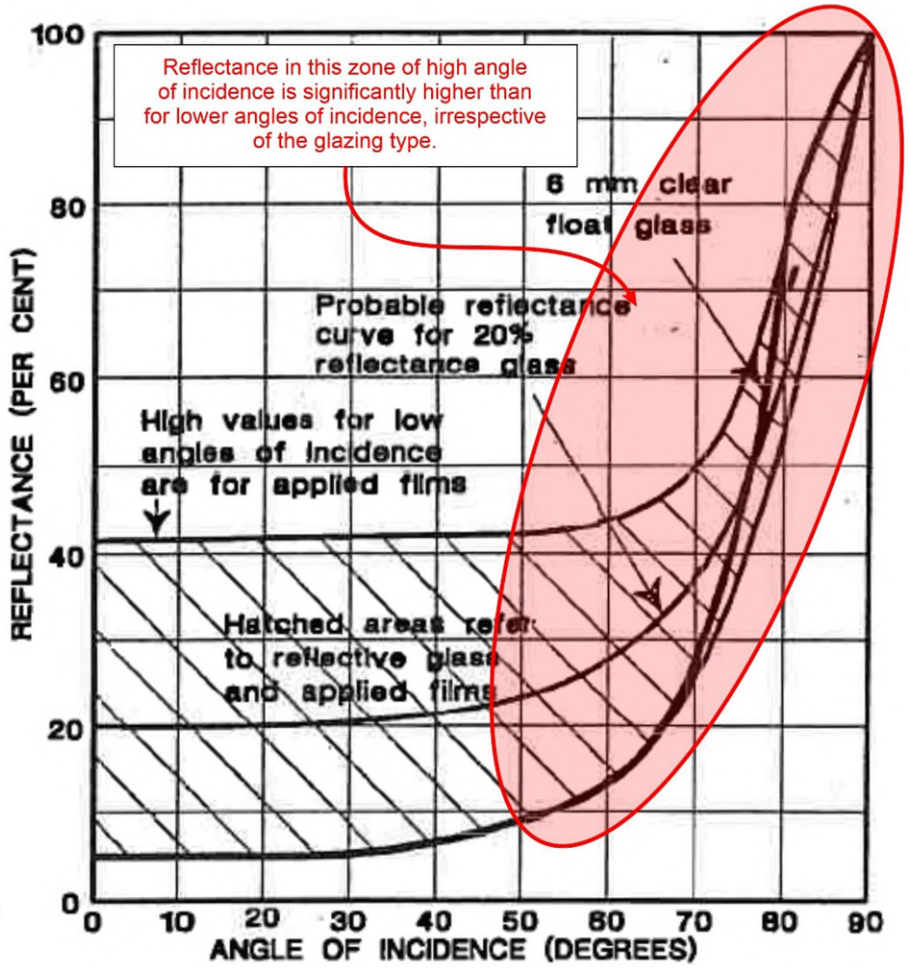
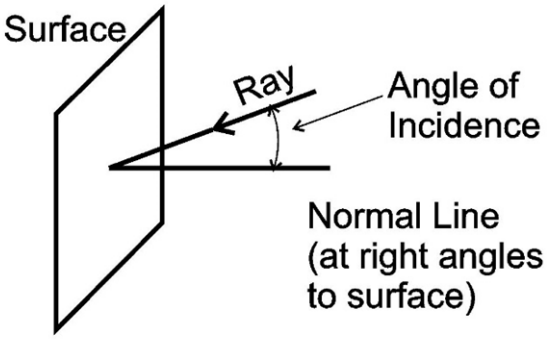


Figure 3a: Relationship between Solar Power, Luminous Efficiency and Solar Altitude (from Hassall, 1991)





Definition of Angle of Incidence

Figure 3b: Reflectance of Different Glazing Types for Varying Angles of Incidence of Light (from Hassall, 1991)

1.3 Analysis and Discussion

The amount of solar glare observed by motorists from the façade of the development at each study point location is presented in this section. Treatment options are provided if excessive solar glare conditions are observed.

Table 2: Viewpoint Assessment from Each Study Point

Study Point	Location and Viewpoint	Development Visibility
Point 01	Chiltern Cresent, heading south-west	Not visible, no further assessment required.
Point 02	Cotswold Avenue, heading south-west	Not visible, no further assessment required.
Point 03	Cumberland Avenue, heading south-west	Not visible, no further assessment required.
Point 04	Showground Road, heading south-east	Not visible, no further assessment required.
Point 05	Showground Road, heading north	Not visible, no further assessment required.
Point 06	Andalusian Way, heading south	Visible, refer to the following sub-section for further analysis.
Point 07	Andalusian Way, heading south	Visible, refer to the following sub-section for further analysis.
Point 08	Carrington Road, heading south-west	Visible, refer to the following sub-section for further analysis.
Point 09	Carrington Road, heading south-west	Visible, refer to the following sub-section for further analysis.
Point 10	Sexton Avenue, heading south-west	Visible, refer to the following sub-section for further analysis.
Point 11	Fishburn Cresent, heading west	Visible, refer to the following sub-section for further analysis.
Point 12	Fishburn Cresent, heading west	Visible, refer to the following sub-section for further analysis.
Point 13	Sexton Avenue, heading north	Visible, refer to the following sub-section for further analysis.
Point 14	Middleton Avenue, heading north	Visible, refer to the following sub-section for further analysis.
Point 15	Middleton Avenue, heading north	Visible, refer to the following sub-section for further analysis.
Point 16	Fishburn Cresent, heading east	Visible, refer to the following sub-section for further analysis.
Point 17	Partridge Avenue, heading east	Visible, refer to the following sub-section for further analysis.
Point 18	Carrington Road, heading east	Visible, refer to the following sub-section for further analysis.
Point 19	Carrington Road, heading east	Visible, refer to the following sub-section for further analysis.
Point 20	Carrington Road, heading east	Visible, refer to the following sub-section for further analysis.
Point 21	Hoyle Avenue, heading east	Not visible, no further assessment required.

Table 3: Aspects of the Development that could reflect Solar Glare to Each Study Point for Motorists

Study Point	Location and Viewpoint	Aspect(s) of the Development
Point 06	Andalusian Way, heading south	Northern and western aspects of the development.
Point 07	Andalusian Way, heading south	Northern and western aspects of the development.
Point 08	Carrington Road, heading south-west	Northern and eastern aspects of the development.
Point 09	Carrington Road, heading south-west	Northern and eastern aspects of the development.
Point 10	Sexton Avenue, heading south-west	Northern and eastern aspects of the development.
Point 11	Fishburn Cresent, heading west	Southern and eastern aspects of the development.
Point 12	Fishburn Cresent, heading west	Southern and eastern aspects of the development.
Point 13	Sexton Avenue, heading north	Southern and eastern aspects of the development.
Point 14	Middleton Avenue, heading north	Southern and western aspects of the development.
Point 15	Middleton Avenue, heading north	Southern and western aspects of the development.
Point 16	Fishburn Cresent, heading east	Southern and western aspects of the development.
Point 17	Partridge Avenue, heading east	Northern, southern and western aspects of the development.
Point 18	Carrington Road, heading east	Northern and western aspects of the development.
Point 19	Carrington Road, heading east	Northern and western aspects of the development.
Point 20	Carrington Road, heading east	Northern and western aspects of the development.

1.4 Analysis and Discussion

The amount of solar glare observed by motorists from the façade of the development at each study point location is presented in this section. Treatment options are provided if excessive solar glare conditions are observed.

1.4.1 Motorists heading south along Andalusian Way at Point 06

An analysis of the glare meter overlaid onto the viewpoint image at Point 06 indicates that portions of the northern (341°) and western (251°) aspects will be visible and within the zone of sensitive vision. However, further analysis indicates that Point 06 does not lie within the check zone for the portions of the northern (341°) and western (251°) aspects which are visible within the zone of sensitive vision. Hence there will be no adverse solar glare observed by motorists heading south along Andalusian Way at Point 06.

1.4.2 Motorists heading south along Andalusian Way at Point 07

An analysis of the glare meters overlaid onto the viewpoint at Point 07 indicates that portions of the northern (341°) and western (251°) aspects are visible and within the zone of sensitive vision. Point 07 is located outside the check zone of the visible western (251°) aspect, however it is within the check zones for the visible northern aspect (341°). Hence there is potential for solar glare to be observed at this location during the early morning period. A review of the sun chart for the Sydney region indicates that the sun will not operate at the angular position required for sunlight to be reflected off the aspect (with the sun located at an acute azimuth angle from the north). Hence there will be no adverse solar glare observed by motorists heading south along Andalusian Way at Point 07.

1.4.3 Motorists heading south-west along Carrington Road at Point 08

An analysis of the glare meter overlaid onto the viewpoint image at Point 08 indicates that a portion of the eastern aspect (056°) is visible and within the zone of sensitive vision. Point 08 is located within the check zones for the visible eastern aspect (056°) and hence there is potential for solar glare to be observed at this location during the early morning period. A review of the architectural drawings indicate that the visible portion of the façade will be overshadowed by the protruding rendered façade at times when solar glare would have otherwise been observed. Rendered façade typically has a negligible specular reflectance value of less than 1% and as such reflected solar glare from rendered facade is not expected to have an adverse impact on the motorists. Additionally, the glazing elements that will not be fully overshadowed by the protruding rendered façade will only have a very narrow vertical strip capable of causing glare to Point 08 at any single point in time. The angular width of that strip of glare when viewed from Point 08 will be less than 0.5^0 arc. As the sun subtends an angular width of 0.5^0, the possibility of the full intensity of the solar glare from being observed off the visible façade is minimised.

Secondly, an analysis of the glare meter overlaid onto the viewpoint image at Point 08 indicates that a portion of the northern (326°) and (341°) aspects is visible and within the zone of sensitive vision. Point 08 is located within the check zones for the visible northern (326°) and (341°) aspects and hence there is potential for solar glare to be observed at this location during the late afternoon period. A review of the architectural drawings indicate that the visible portion of the façade will be overshadowed by the protruding rendered façade at times when solar glare would have otherwise been observed. Rendered façade typically has a negligible specular reflectance value of less than 1% and as such reflected solar glare from rendered facade is not expected to have an adverse impact on the motorists. Additionally, the glazing elements that will not be fully overshadowed by the protruding rendered façade will only have a very narrow vertical strip capable of causing glare to Point 08 at any single point in time. The angular width of that strip of glare when viewed from Point 08 will be less than 0.5^0 arc. As the sun subtends an angular width of 0.5^0, the possibility of the full intensity of the solar glare from being observed off the visible façade is minimised.

Furthermore, an analysis of the glare meter overlaid onto the viewpoint image at Point 08 indicates that a portion of the eastern aspect (071°) is visible and within the zone of sensitive vision. Point 08 is located within the check zones for the visible eastern aspect (071°) and hence there is potential for solar glare to be observed at this location during the early morning period. A further investigation indicates however this portion of the facade

will be overshadowed by the subject buildings at the times when solar glare could have otherwise been observed. Hence there will be no adverse solar glare observed by motorists heading south-west along Carrington Road at Point 08 from the visible eastern aspect (071°).

1.4.4 Motorists heading south-west along Carrington Road at Point 09

An analysis of the glare meter overlaid onto the viewpoint image at Point 09 indicates that a portion of the eastern aspect (056°) is visible and within the zone of sensitive vision. Point 09 is located within the check zones for the visible eastern aspect (056°) and hence there is potential for solar glare to be observed at this location during the early morning period. To ensure that adverse solar glare does not affect motorists heading south-west along Carrington Road at Point 09, it is recommended the maximum normal specular reflectance of visible light for the glazing/façade element used on Building B from Levels 06 to 09 on this aspect is 16%.

Secondly, an analysis of the glare meter overlaid onto the viewpoint image at Point 09 indicates that a portion of the northern (326°) and (341°) aspects is visible and within the zone of sensitive vision. Point 09 is located within the check zones for the visible northern (326°) and (341°) aspects and hence there is potential for solar glare to be observed at this location during the late afternoon period. A review of the architectural drawings indicate that the visible portion of the façade will be overshadowed by the protruding rendered façade at times when solar glare would have otherwise been observed. Rendered façade typically has a negligible specular reflectance value of less than 1% and as such reflected solar glare from rendered facade is not expected to have an adverse impact on the motorists. Additionally, the glazing elements that will not be fully overshadowed by the protruding rendered façade will only have a very narrow vertical strip capable of causing glare to Point 09 at any single point in time. The angular width of that strip of glare when viewed from Point 09 will be less than 0.5^0 arc. As the sun subtends an angular width of 0.5^o, the possibility of the full intensity of the solar glare from being observed off the visible façade is minimised.

An analysis of the glare meter overlaid onto the viewpoint image at Point 09 indicates a portion of the eastern aspect (071°) is visible and within the zone of sensitive vision. Point 09 is located within the check zones for the visible eastern aspect (071°) and hence there is potential for solar glare to be observed at this location during the early morning period. A further investigation indicates however this portion of the facade will be overshadowed by the subject buildings at the times when solar glare could have otherwise been observed. Hence there will be no adverse solar glare observed by motorists heading south-west along Carrington Road at Point 09 from the visible eastern aspect (071°).

1.4.5 Motorists heading south-west along Sexton Avenue at Point 10

An analysis of the glare meter overlaid onto the viewpoint image at Point 10 indicates that a portion of the northern (341°) aspect is visible and within the zone of sensitive vision. Point 10 is located within the check zones for the visible northern aspect (341°) and hence there is potential for solar glare to be observed at this location during the late afternoon period. A further analysis indicates however the incident sun rays would be obstructed by the development before it can reflect off the visible façade and onto the motorists at this location. Hence there will be no adverse solar glare observed by motorists heading south-west along Sexton Avenue at Point 10 from the visible northern aspect (341°).

An analysis of the glare meter overlaid onto the viewpoint image at Point 10 indicates that a portion of the eastern (071°) aspect is visible and within the zone of sensitive vision. Point 10 is located within the check zones for the visible eastern aspect (071°) and hence there is potential for solar glare to be observed at this location during the early morning period. A further analysis indicates however the southern portion of the facade will be obstructed/overshadowed by the neighbouring buildings, 4-6 Sexton Avenue, at the times when solar glare could have otherwise been observed (early morning). Similarly, the lower levels of the northern portion of the facade will be obstructed/overshadowed by existing densely foliating street trees along the Sexton Avenue streetscape, at the times when solar glare could have otherwise been observed (early morning). Note the 4-6 Sexton Avenue development is currently under construction and is expected to be built before the 2 Fishburn Crescent, Castle Hill (Lot 1 DP 1316896) development. Furthermore, the upper levels of the northern portion of the facade will be obstructed/overshadowed by the protruding rendered façade at times when solar glare would have otherwise been observed. Rendered façade typically has a negligible specular reflectance value of less than 1% and as such reflected solar glare from rendered facade is not expected to have an adverse impact on the motorists. Additionally, the glazing elements that will not be fully overshadowed by the protruding rendered façade will only have a very narrow vertical strip capable of causing glare to Point 09 at any single point in time. The angular width of that strip of glare when viewed from Point 09 will be less than 0.5^0 arc. As the sun subtends an angular width of 0.5^0, the possibility of the full intensity of the solar glare from being observed off the visible façade is minimised.

1.4.6 Motorists heading west along Fishburn Cresent at Point 11

An analysis of the glare meter overlaid onto the viewpoint image at Point 11 indicates that a portion of the southern (161°) aspect is visible and within the zone of sensitive vision. Point 11 is located within the check zones for the visible southern aspect (161°) and hence there is potential for solar glare to be observed at this location during the late afternoon period. A review of the architectural drawings indicate that the visible portion of the façade is largely comprised of rendered façade. Rendered façade typically has a negligible specular reflectance value of less than 1% and as such reflected solar glare from rendered facade is not expected to have an adverse impact on the motorists. Similarly, the remaining portions of the southern aspect (161°) that is to be glazed, will be overshadowed by the protruding rendered façade at times when solar glare would have otherwise been observed. Rendered façade typically has a negligible specular reflectance value of less than 1% and as such reflected solar glare from rendered facade is not expected to have an adverse impact on the motorists. Hence there will be no adverse solar glare observed by motorists heading east along Fishburn Cresent at Point 11 from the visible southern aspect (161°).

Additionally, an analysis of the glare meters overlaid onto the viewpoint image at Point 11 indicates that indicates that portions of the eastern (071°) aspect is visible and within the zone of sensitive vision. Point 11 is located within the check zones for the visible eastern aspect (071°) and hence there is potential for solar glare to be observed at this location during the early morning period. A further analysis indicates however the lower levels of the facade will be overshadowed by the neighbouring building, 4-6 Sexton Avenue, and existing densely foliating street trees along the sexton Avenue streetscape, at the times when solar glare could have otherwise been observed. Note the 4-6 Sexton Avenue development is currently under construction and is expected to be built before the 2 Fishburn Crescent, Castle Hill (Lot 1 DP 1316896) development. However, to ensure that adverse solar glare from the upper portion of the facade does not affect motorists heading west along Fishburn Cresent at Point 11, it is recommended the maximum normal specular reflectance of visible light for the glazing/façade element used on the southern portion of the Building C aspect is 11%.

1.4.7 Motorists heading west along Fishburn Cresent at Point 12

An analysis of the glare meter overlaid onto the viewpoint image at Point 12 indicates that a portion of the eastern (071°) aspect is visible and within the zone of sensitive vision. Point 12 is located within the check zones for the visible eastern aspect (071°) and hence there is potential for solar glare to be observed at this location during the early morning period. A further analysis indicates however the incident sun rays would be obstructed by the neighbouring development, 4-6 Sexton Avenue. before it can reflect off the visible façade and onto the motorists at this location. Note the 4-6 Sexton Avenue development is currently under construction and is expected to be built before the 2 Fishburn Crescent, Castle Hill (Lot 1 DP 1316896) development. Hence there will be no adverse solar glare observed by motorists heading west along Fishburn Cresent at Point 12 from the visible eastern aspect (071°).

Additionally, an analysis of the glare meters overlaid onto the viewpoint image at Point 12 indicates that indicates that portions of the southern (161°) aspect is visible and within the zone of sensitive vision. Point 12 is located within the check zones for the visible southern aspect (161°) and hence there is potential for solar glare to be observed at this location during the late afternoon period. A further analysis indicates however the lower levels of the facade will be overshadowed by the neighbouring building, 21 Partridge Avenue, at the times when solar glare could have otherwise been observed. Furthermore, a review of the sun chart for the Sydney region indicates that the sun will not operate at the angular position required for sunlight to be reflected off the upper levels of this facade (with the sun located at an acute azimuth angle from the south). Hence there will be no adverse solar glare observed by motorists heading west along Fishburn Cresent at Point 12 from the visible southern aspect (161°).

1.4.8 Motorists heading north along Sexton Avenue at Point 13

An analysis of the glare meter overlaid onto the viewpoint image at Point 13 indicates that that portions of the western (251°) aspect are visible and within the zone of sensitive vision. However, further analysis indicates that Point 13 does not lie within the check zone for the portions of the western (251°) aspect. Hence there will be no adverse solar glare observed by motorists heading north along Sexton Avenue at Point 13 from the visible western aspect (251°).

Additionally, an analysis of the glare meters overlaid onto the viewpoint image at Point 13 indicates that indicates that portions of the western (236°) aspect is visible and within the zone of sensitive vision. Point 13 is located within the check zones for the visible western (236°) aspect and hence there is potential for solar glare to be observed at this location during the late afternoon period. A further analysis indicates however the incident sun rays would be obstructed by the site development before it can reflect off the visible façade and onto the motorists at this location. Hence there will be no adverse solar glare observed by motorists heading north along Sexton Avenue at Point 13 from the visible western aspect (236°).

An analysis of the glare meters overlaid onto the viewpoint at Point 13 indicates that portions of the southern (146°) and (161°) aspects are visible and within the zone of sensitive vision. Point 13 is located within the check zones for the visible southern (146°) and (161°) aspects. Hence there is potential for solar glare to be observed at this location during the early morning period. A review of the sun chart for the Sydney region indicates that the sun will not operate at the angular position required for sunlight to be reflected off the aspect (with the sun located at an acute azimuth angle from the south). Hence there will be no adverse solar glare observed by motorists heading north along Sexton Avenue at Point 13 from the visible southern (146°) and (161°) aspects.

1.4.9 Motorists heading north along Middleton Avenue at Point 14

An analysis of the glare meter overlaid onto the viewpoint image at Point 14 indicates that that portions of the southern (161°) aspect is visible and within the zone of sensitive vision. However, further analysis indicates that Point 14 does not lie within the check zone for the portions of the southern (161°) aspects which are visible within the zone of sensitive vision. Hence there will be no adverse solar glare observed by motorists heading north along Middleton Avenue at Point 14 from the southern (161°) aspect.

An analysis of the glare meters overlaid onto the viewpoint at Point 14 indicates that portions of the western (251°) aspect are visible and within the zone of sensitive vision. Point 14 is located within the check zones for the visible western (251°) aspect. Hence there is potential for solar glare to be observed at this location during the early morning period. A review of the sun chart for the Sydney region indicates that the sun will not operate at the angular position required for sunlight to be reflected off the aspect (with the sun located at an acute azimuth angle from the south). Hence there will be no adverse solar glare observed by motorists heading north along Middleton Avenue at Point 14 from the western (251°) aspect.

1.4.10 Motorists heading north along Middleton Avenue at Point 15

An analysis of the glare meters overlaid onto the viewpoint at Point 15 indicates that portions of the southern (161°) and western (251°) aspects is visible and within the zone of sensitive vision. Point 15 is located within the check zones for the visible southern (161°) and western (251°) aspects. Hence there is potential for solar glare to be observed at this location during the early morning and late afternoon period. A review of the sun chart for the Sydney region indicates that the sun will not operate at the angular position required for sunlight to be reflected off the aspect (with the sun located at an acute azimuth angle from the south for the southern aspect and with the sun located at an acute azimuth angle from the north for the western aspect). Hence there will be no adverse solar glare observed by motorists heading north along Middleton Avenue at Point 15.

1.4.11 Motorists heading east along Fishburn Cresent at Point 16

An analysis of the glare meters overlaid onto the viewpoint at Point 16 indicates that portions of the western (251°) aspect are visible and within the zone of sensitive vision. Point 16 is located within the check zones for the visible western aspect (251°). Hence there is potential for solar glare to be observed at this location during the late afternoon period. A further examination indicates that when the development is viewed from Point 16, the amount of visible glazing on the visible western (251°) aspect of the development will be minimal. Provided that the maximum normal specular reflectance of visible light of the glazing used on the western (251°) aspect of the existing dwelling is 20%, the intensity of visible glare will be less than 500 cd/m^2, which is suitable for motorists. Hence there will be no adverse solar glare observed by motorists heading east along Fishburn Cresent at Point 16 from the visible western aspect (251°).

An analysis of the glare meters overlaid onto the viewpoint at Point 16 indicates that portions of the southern (161°) aspect are visible and within the zone of sensitive vision. Point 16 is located within the check zones for the visible southern aspect (161°). Hence there is potential for solar glare to be observed at this location during the early morning period. A further analysis indicates however the incident sun rays would be obstructed by the neighbouring buildings, 11 and 15 Fishburn Cresent before it can reflect off the visible façade and onto the motorists at this location. Hence there will be no adverse solar glare observed by motorists heading east along Fishburn Cresent at Point 16 from the visible southern aspect (161°).

1.4.12 Motorists heading east along Partridge Avenue at Point 17

An analysis of the glare meters overlaid onto the viewpoint image at Point 17 indicates that indicates that portions of the northern (341°) and southern (161°) aspects is visible and within the zone of sensitive vision. Point 17 is located within the check zones for the visible northern (341°) and southern (161°) aspects and hence there is potential for solar glare to be observed at this location during the early morning period. A further analysis indicates however the incident sun rays would be obstructed by the neighbouring building, 4-6 Sexton Avenue before it can reflect off the visible façade and onto the motorists at this location. Note the 4-6 Sexton Avenue development is currently under construction and is expected to be built before the 2 Fishburn Crescent, Castle Hill (Lot 1 DP 1316896) development.

Additionally, an analysis of the glare meters overlaid onto the viewpoint image at Point 17 indicates that indicates that portions of the western aspect (251°) from Building A and C is visible and within the zone of sensitive vision. Point 17 is located within the check zones for the visible western aspect (251°) and hence there is potential for solar glare to be observed at this location during the late afternoon period. A further analysis indicates however the incident sun rays would be obstructed by the neighbouring building, 21 Partridge Avenue and 40 Ashford Avenue, before it can reflect off the Building C visible façade and onto the motorists at this location. Note the 21 Partridge Avenue and 40 Ashford Avenue development is currently under construction and is expected to be built before the 2 Fishburn Crescent, Castle Hill (Lot 1 DP 1316896) development. Furthermore, to ensure that adverse solar glare does not affect motorists heading east along Partridge Avenue at Point 17 from the Building A visible façade, it is recommended the maximum normal specular reflectance of visible light for the glazing/façade element used on this aspect is 11% along the southern portion of Ground Level to Level 01.

1.4.13 Motorists heading east along Carrington Road at Point 18

An analysis of the glare meter overlaid onto the viewpoint image at Point 18 indicates that portions of the northern (326°) and western (236°) aspects are visible and within the zone of sensitive vision. However, further analysis indicates that Point 18 does not lie within the check zone for the portions of the northern (326°) and western (236°) aspects which are visible within the zone of sensitive vision. Hence there will be no adverse solar glare observed by motorists heading east along Carrington Road at Point 18 from the visible northern (326°) and eastern (236°) aspects.

An analysis of the glare meters overlaid onto the viewpoint at Point 18 indicates that portions of the western (251°) aspect are visible and within the zone of sensitive vision. Point 18 is located within the check zones for the visible southern (251°) aspects. Hence there is potential for solar glare to be observed at this location during the late afternoon period. A review of the sun chart for the Sydney region indicates that the sun will not operate at the angular position required for sunlight to be reflected off the aspect (with the sun located at an acute azimuth angle from the south). Hence there will be no adverse solar glare observed by motorists heading east along Carrington Road at Point 18 from the visible western (251°) aspect.

Furthermore, an analysis of the glare meters overlaid onto the viewpoint at Point 18 indicates that portions of the northern (341°) aspect are visible and within the zone of sensitive vision. Point 18 is located within the check zones for the visible northern (341°) aspect. Hence there is potential for solar glare to be observed at this location during the early morning and late afternoon period. A review of the architectural drawings indicate that the visible portion of the façade is comprised of protruding rendered façade which will overshadow the proposed glazed at times when solar glare would have otherwise been observed. Rendered façade typically has a negligible specular reflectance value of less than 1% and as such reflected solar glare from rendered facade is not expected to have an adverse impact on the motorists. Additionally, the glazing elements that will not be fully overshadowed by the protruding rendered façade will only have a very narrow vertical strip capable of causing glare to Point 18 at any single point in time. The angular width of that strip of glare when viewed from Point 18 will be less than 0.5^0 arc. As the sun subtends an angular width of 0.5^o, the possibility of the full intensity of the solar glare from being observed off the visible façade is minimised.

1.4.14 Motorists heading east along Carrington Road at Point 19

An analysis of the glare meter overlaid onto the viewpoint image at Point 19 indicates the portions of the northern (341°) aspect is visible and within the zone of sensitive vision. Point 19 is located within the check zones for the visible northern aspect (341°) and hence there is potential for solar glare to be observed at this location during the early morning period. A further analysis indicates however during the early morning period the direct sun will also be visible and within the zone of sensitive vision of motorists at this location. The intensity of the direct view of the sun will be far more severe than any glare reflected from the visible northern (341°) aspect. Thus, the reflective northern (341°) aspect of the development does not constitute a major reflection hazard in comparison to the intensity of the direct sun. Hence there will be no adverse solar glare observed by motorists heading east along Carrington Road at Point 19 from the visible northern aspect (341°).

An analysis of the glare meter overlaid onto the viewpoint image at Point 19 indicates that a portion of the western (251°) aspect is visible and within the zone of sensitive vision. Point 19 is located within the check zones for the visible western aspect (251°) and hence there is potential for solar glare to be observed at this location during the late afternoon period. A review of the architectural drawings indicates that a portion of the visible façade is comprised of rendered façade. Rendered façade typically has a negligible specular reflectance value of less than 1% and as such reflected solar glare from rendered facade is not expected to have an adverse impact on the motorists. However, the northern end of the western aspect (251°) aspect along the Building B will appear within the zone of sensitive vision for motorists at Point 19 and will not benefit from the rendered façade effects. Instead, the remaining glazing elements that will not be fully obstructed by Building façade will only have a very narrow vertical strip capable of causing glare to Point 19 at any single point in time. The angular width of that strip of glare when viewed from Point 19 will be less than 0.5^0 arc. As the sun subtends an angular width of 0.5^0, the possibility of the full intensity of the solar glare from being observed off the visible façade is minimised.

1.4.15 Motorists heading east along Carrington Road at Point 20

An analysis of the glare meter overlaid onto the viewpoint image at Point 20 indicates that that portions of the northern (326°) aspect are visible and within the zone of sensitive vision. However, further analysis indicates that Point 20 does not lie within the check zone for the portions of the northern (326°) aspect. Hence there will be no adverse solar glare observed by motorists heading east along Carrington Road at Point 20 from the visible northern aspect (326°).

Furthermore, an analysis of the glare meter overlaid onto the viewpoint image at Point 20 indicates a portion of the western aspect (251°) is visible and within the zone of sensitive vision. Point 20 is located within the check zones for the visible western aspect (251°) and hence there is potential for solar glare to be observed at this location during the late afternoon period. To ensure that adverse solar glare does not affect motorists east along Carrington Road at Point 20, it is recommended to include one of the following treatment options:

- Option A:
    - Inclusion of vertical louvers to obstruct/overshadow glazing in this region AND.
    - Glazing in this region should have a maximum normal specular reflectance of visible light of 11%.
- Option B:
    - The proposed glazed in this region is to have a dark frit covering at least 70% of the glazing AND.
    - Glazing in this region should have a maximum normal specular reflectance of visible light of 11%.
- Option C:
    - Glazing in this region should have a maximum normal specular reflectance of visible light of 4%.

2 GLARE OBSERVED BY PEDESTRIANS AND OCCUPANTS OF NEIGHBOURING BUILDINGS

Our past experience involving more than 250 projects, and also research by Rofail and Dowdle (2004), tends to indicate that buildings which cause a nuisance to pedestrians and occupants of neighbouring buildings are those that have a normal specular reflectivity of visible light greater than 20%. This seems to justify the suggested limit of 20% reflectivity by many local government authorities and state planning bodies. Hence a general recommendation is made that all glazing and other reflective materials used on the façade of the subject development have a maximum normal specular reflectivity of visible light of 20% to avoid adverse solar glare to pedestrians and occupants of neighbouring buildings.

3 TYPICAL REFLECTANCES OF FAÇADE MATERIALS

It should be noted that the most reflective surface on the façade of a building is the glazing. Reflected solar glare from concrete, brickwork, timber, etc, is negligible (ie: less than 1% normal specular reflectance) and hence will not cause any adverse solar glare effects. The following sub-sections provide some general reflectance values of more reflective materials used on building facades.

3.1 Glazed Surfaces

A glazing supplier will be able to provide information on the maximum normal specular reflectance of visible light of different types of glazing. Some typical reflectivity values of different types of glazing are listed as follows:

- Low reflectance glazing, such as Guardian Clarity – less than 5%
- Clear float glass – typically 5% to 8%
- Low-e solar control glazing – typically 8% to 12%
- Other types of compliant performance glazing – up to 20%

3.2 Painted and/or Powder-Coated Metallic Surfaces

In the event that some portions of the external façade of the development feature powder-coated or painted metallic surfaces, it is not expected that adverse glare will be observed from those surfaces since the maximum normal specular reflectance of visible light of these types of façade materials range from 1% to 5%. This is well within the maximum limits specified in previous sections of this report.

4 SUGGESTED TREATMENTS

The suggested treatments described in this report for ensuring the development does not cause adverse glare conditions are summarised as follows:

- Building A:
    - The proposed glazing along the western aspect (251°) from Levels 10 to 17, should have either of the following recommendations:
        - Option A:
            - Inclusion of vertical louvers to obstruct/overshadow glazing in this region AND.
            - Glazing in this region should have a maximum normal specular reflectance of visible light of 11%.
        - Option B:
            - The proposed glazed in this region is to have a dark frit covering at least 70% of the glazing AND.
            - Glazing in this region should have a maximum normal specular reflectance of visible light of 11%.
        - Option C:
            - Glazing in this region should have a maximum normal specular reflectance of visible light of 4%.
    - The proposed glazing on the southern end of the external façade along the westerly aspect (251°), as indicated in the architectural drawings, should have a maximum normal specular reflectance of visible light of 11%, from Ground Levels to Level 01.
- Building B:
    - The proposed glazing on the northern end of the external façade along the easterly aspect (056°), as indicated in the architectural drawings, should have a maximum normal specular reflectance of visible light of 16% from Levels 06 - 09.
- Building C:
    - The proposed glazing on the southern end of the external façade along the eastern aspect (071°), as indicated in the architectural drawings, should have a maximum normal specular reflectance of visible light of 11%.
- All other glazing on the external façade should have a maximum normal specular reflectance of visible light of 20%.

Treatments Legend

The proposed glazing on the northern end of the external facade along Building A's westerly aspect (251), as indicated in the architectural drawings, should have a maximum normal reflectance of visible light of 11%.

Option A: Inclusion of vertical louvres to obstruct/overshadow glazing along the western aspect (251), on Building A from Levels 10 to 17, AND the proposed glazing in this region should have a maximum normal reflectance of visible light of 11%.

Option B: The proposed glazing along the western aspect (251), on Building A from Levels 10 to 17, is to have a dark frit covering at least 70% of the glazing AND the proposed glazing in this region should have a maximum normal reflectance of visible light of 11%.

Option C: The proposed glazing along the western aspect (251), on Building A from Levels 10 to 17, as indicated in the architectural drawings, should have a maximum normal reflectance of visible light of 4%.

Figure 4a: Suggested Treatments – Building A, Western Elevation

Figure 4b: Suggested Treatments – Building B, Eastern Elevation

Treatments Legend

The proposed glazing on the northern end of the external facade along Building C's easterly aspect (071), as indicated in the architectural drawings, should have a maximum normal reflectance of visible light of 11%.

Figure 4c: Suggested Treatments – Building C, Eastern Elevation

5 CONCLUSION

A detailed study has been undertaken for the effect of potential solar glare from the 2 Fishburn Crescent, Castle Hill (Lot 1 DP 1316896) development. This study identifies any possible adverse reflected solar glare conditions affecting motorists, pedestrians, and to occupants of neighbouring buildings. If necessary, recommendations are made to mitigate any potentially adverse effects. This study assesses compliance with the controls for solar glare from the State Environmental Planning Policy (Housing) 2021 Chapter 4 Design, which contains the Apartment Design Guide (ADG), and the Hills Shire Council Development Control Plan 2012

The results of the study indicate that, to avoid any adverse glare to motorists and pedestrians on the surrounding streets, occupants of neighbouring buildings, and to comply with the abovementioned planning control requirements, the following limitations to the maximum normal specular reflectance of visible light of the external façade glazing is recommended:

- Building A:
    - The proposed glazing along the western aspect (251°) from Levels 10 to 17, should have either of the following recommendations:
        - Option A:
            - Inclusion of vertical louvers to obstruct/overshadow glazing in this region AND.
            - Glazing in this region should have a maximum normal specular reflectance of visible light of 11%.
        - Option B:
            - The proposed glazed in this region is to have a dark frit covering at least 70% of the glazing AND.
            - Glazing in this region should have a maximum normal specular reflectance of visible light of 11%.
        - Option C:
            - Glazing in this region should have a maximum normal specular reflectance of visible light of 4%.
    - The proposed glazing on the southern end of the external façade along the westerly aspect (251°), as indicated in the architectural drawings, should have a maximum normal specular reflectance of visible light of 11%, from Ground Levels to Level 01.
- Building B:
    - The proposed glazing on the northern end of the external façade along the easterly aspect (056°), as indicated in the architectural drawings, should have a maximum normal specular reflectance of visible light of 16% from Levels 06 - 09.

- Building C:
    - The proposed glazing on the southern end of the external façade along the eastern aspect (071°), as indicated in the architectural drawings, should have a maximum normal specular reflectance of visible light of 11%.
- All other glazing on the external façade should have a maximum normal specular reflectance of visible light of 20%.

It should be noted that the most reflective surface on the façade of a building is the glazing. Reflected solar glare from concrete, brickwork, timber, etc. is negligible (i.e. less than 1% normal specular reflectance) and hence will not cause any adverse solar glare effects. Note also that, for any painted or powder-coated metallic surfaces on the exterior façade of the development, the maximum normal specular reflectance of visible light for those types of surfaces is in the range of 1% to 5%, which is well within the abovementioned limit.

Hence, with the incorporation of the abovementioned recommendations, the results of this study indicate that the subject development will not cause adverse solar glare to motorists or pedestrians in the surrounding area, or to occupants of neighbouring buildings, and will comply with the planning controls regarding reflectivity from the State Environmental Planning Policy (Housing) 2021 Chapter 4 Design, which contains the Apartment Design Guide (ADG), and the Hills Shire Council Development Control Plan 2012

6 REFERENCES

The Hills Shire Council, 2012 "The Hills Development Control Plan (DCP) 2012".

Hassall, D.N., 1991, "Reflectivity, Dealing with Rogue Solar Reflections", (published by author).

Phillips, R.O., 1992, "Sunshine and Shade in Australasia", Sixth Edition, CSIRO Publishing.

Rofail, A.W., and Dowdle, B., 2004, "Reflectivity Impact on Occupants of Neighbouring Properties", International Conf. on Building Envelope Systems & Technologies, Sydney.

State Environmental Planning Policy (Housing) 2021 Chapter 4 Design, "Apartment Design Guide", NSW Department of Planning and Environment.

APPENDIX A SIGHT-LINES WITH GLARE OVERLAYS

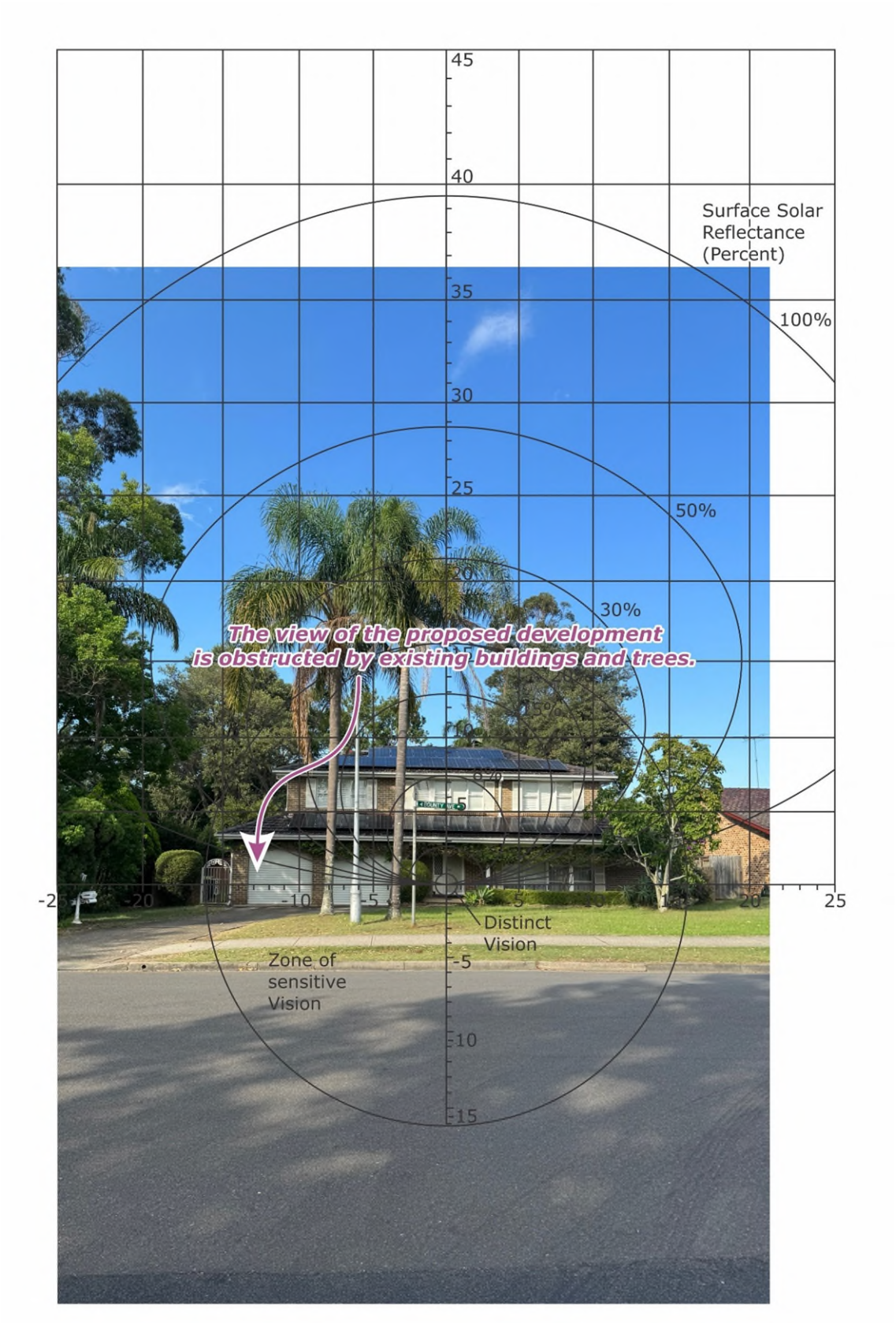


Figure A.1: Glare Overlay of the Viewpoint at Point 01

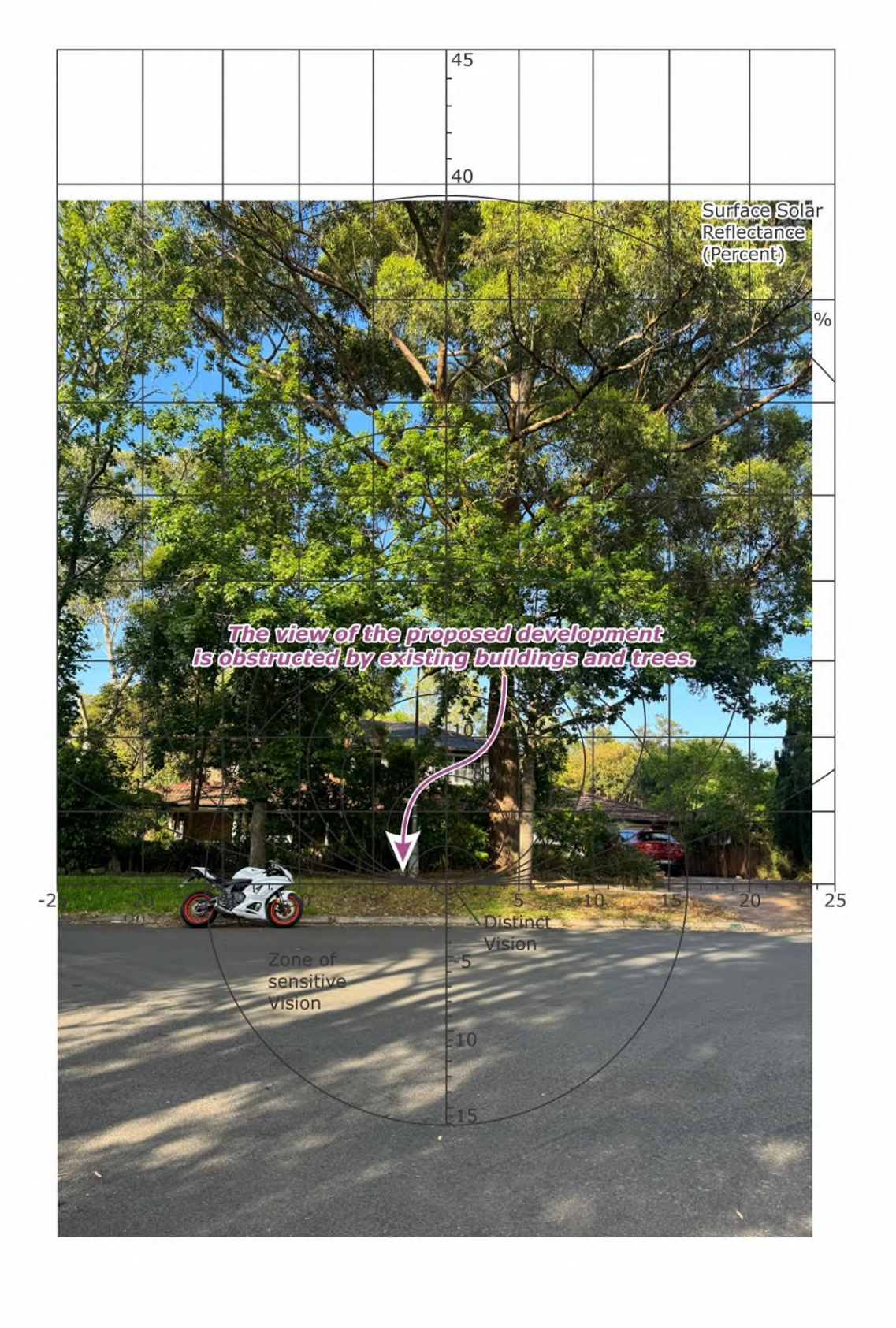


Figure A.2: Glare Overlay of the Viewpoint at Point 02

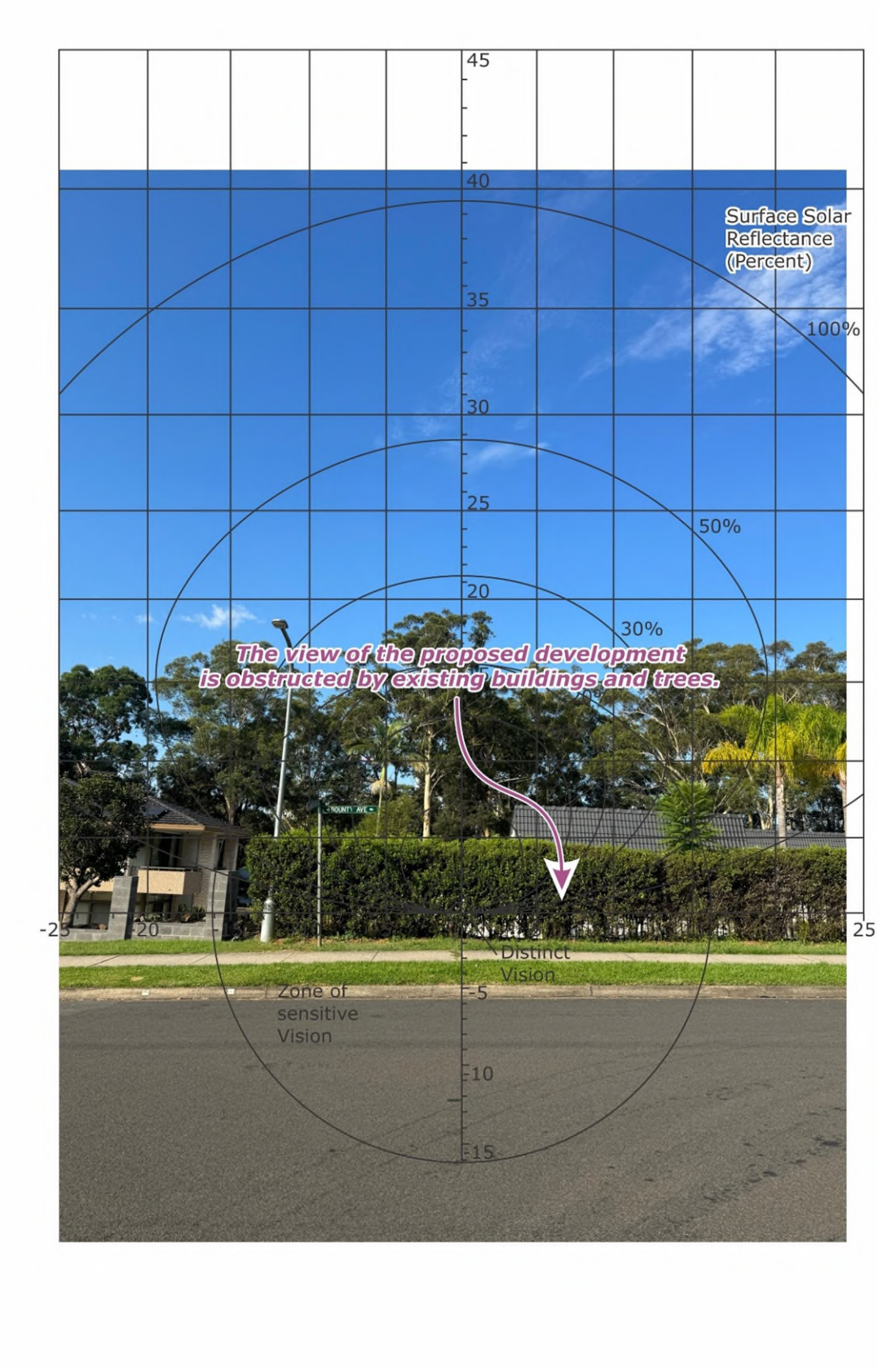


Figure A.3: Glare Overlay of the Viewpoint at Point 03

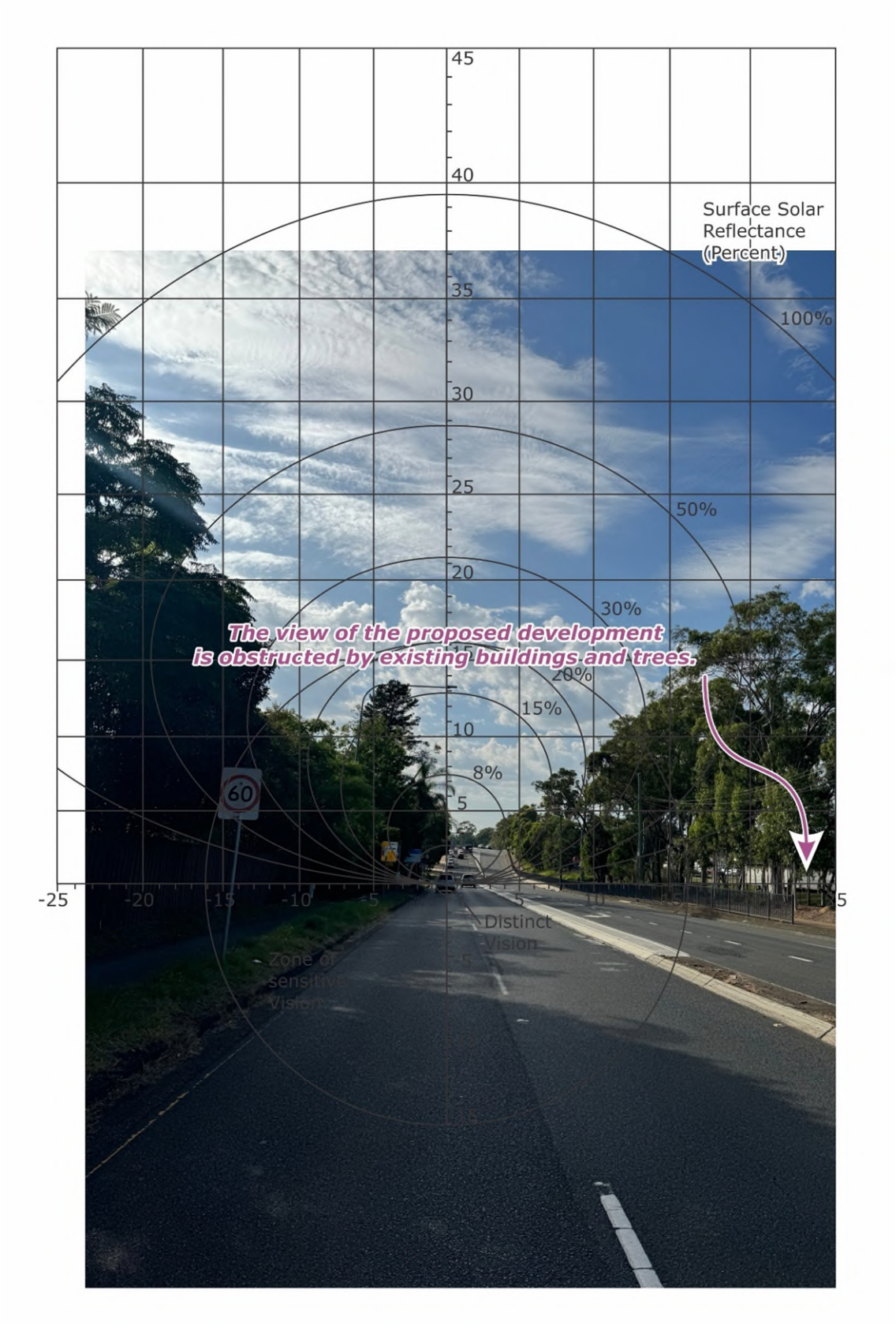


Figure A.4: Glare Overlay of the Viewpoint at Point 04

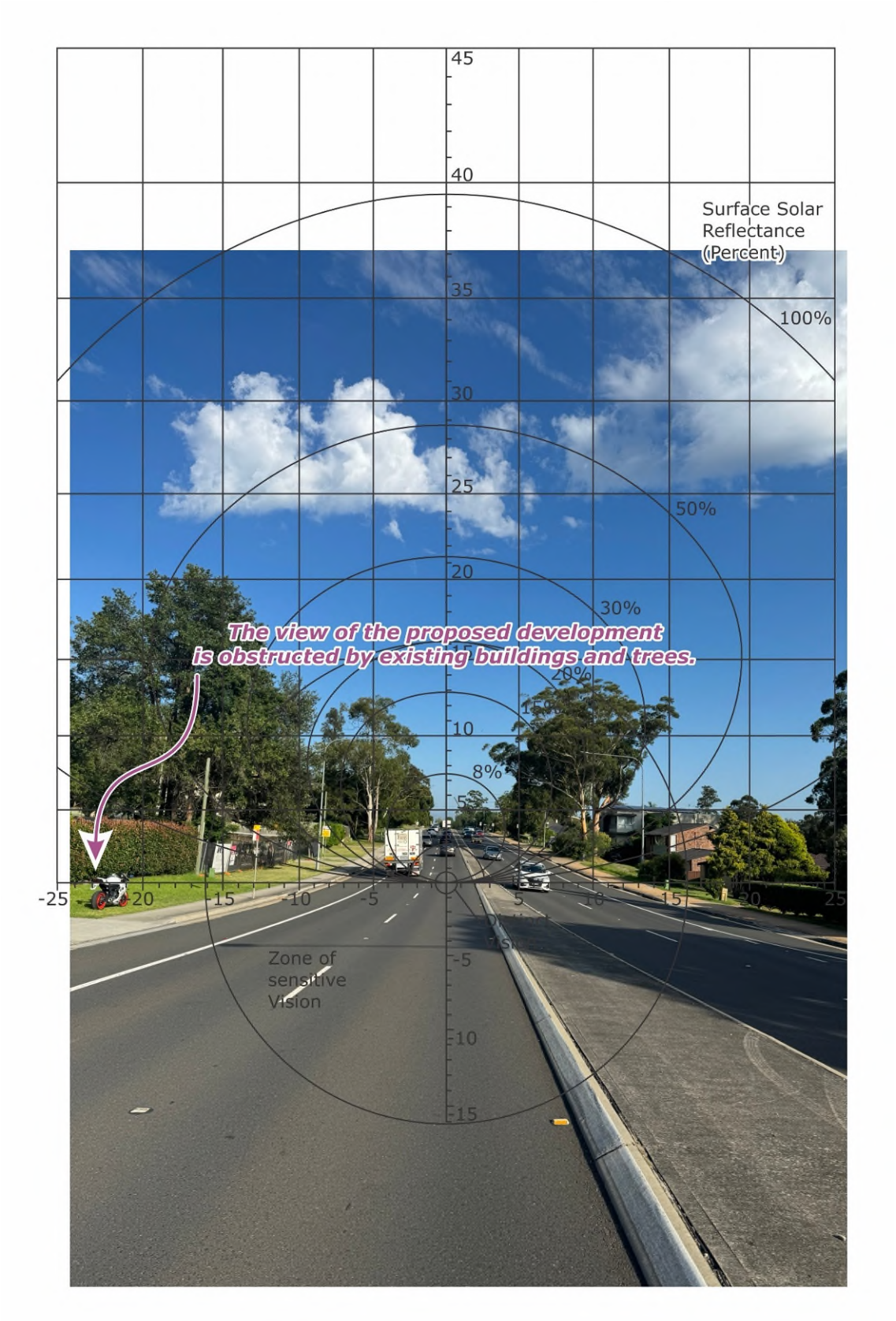


Figure A.5: Glare Overlay of the Viewpoint at Point 05

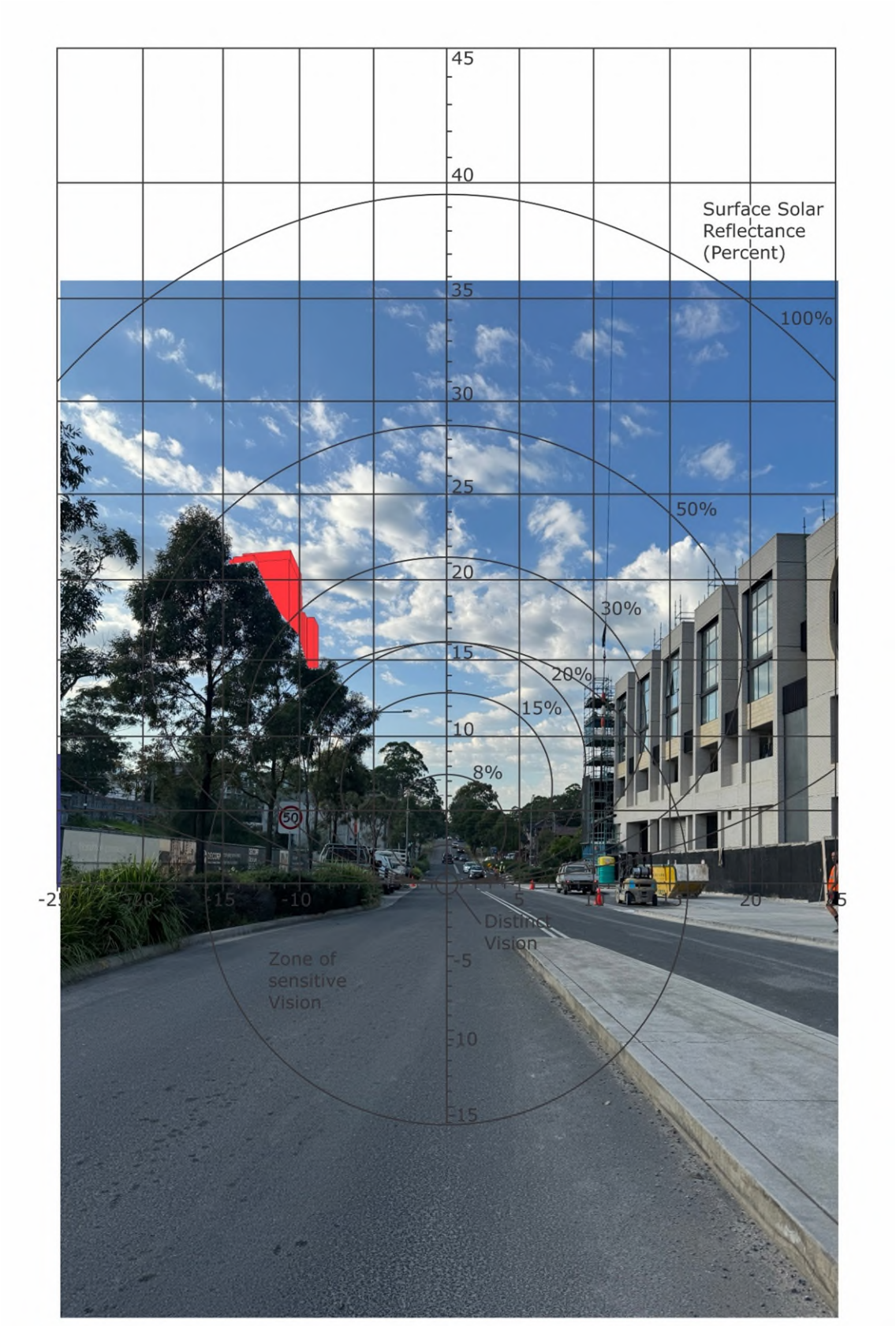


Figure A.6: Glare Overlay of the Viewpoint at Point 06

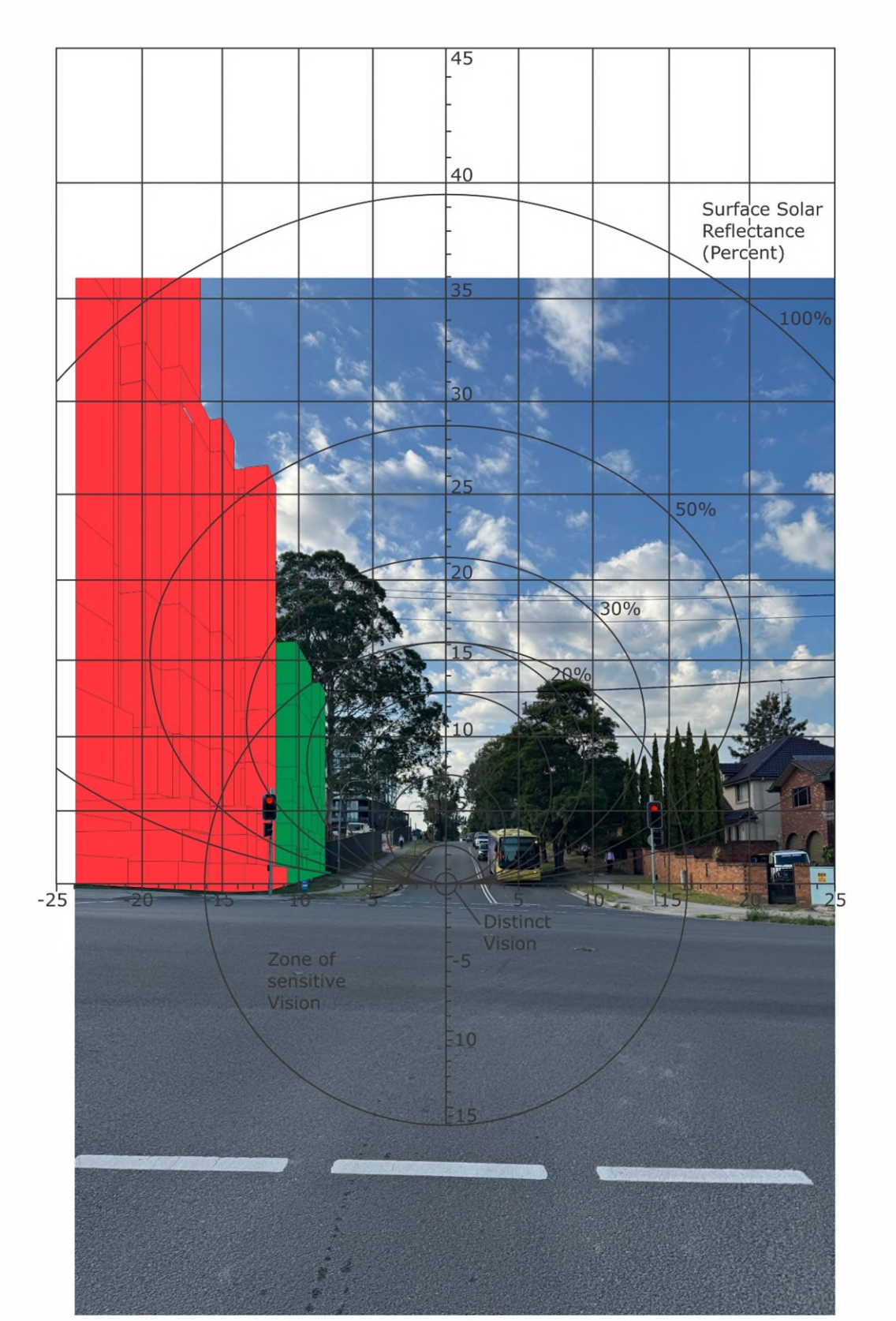


Figure A.7: Glare Overlay of the Viewpoint at Point 07

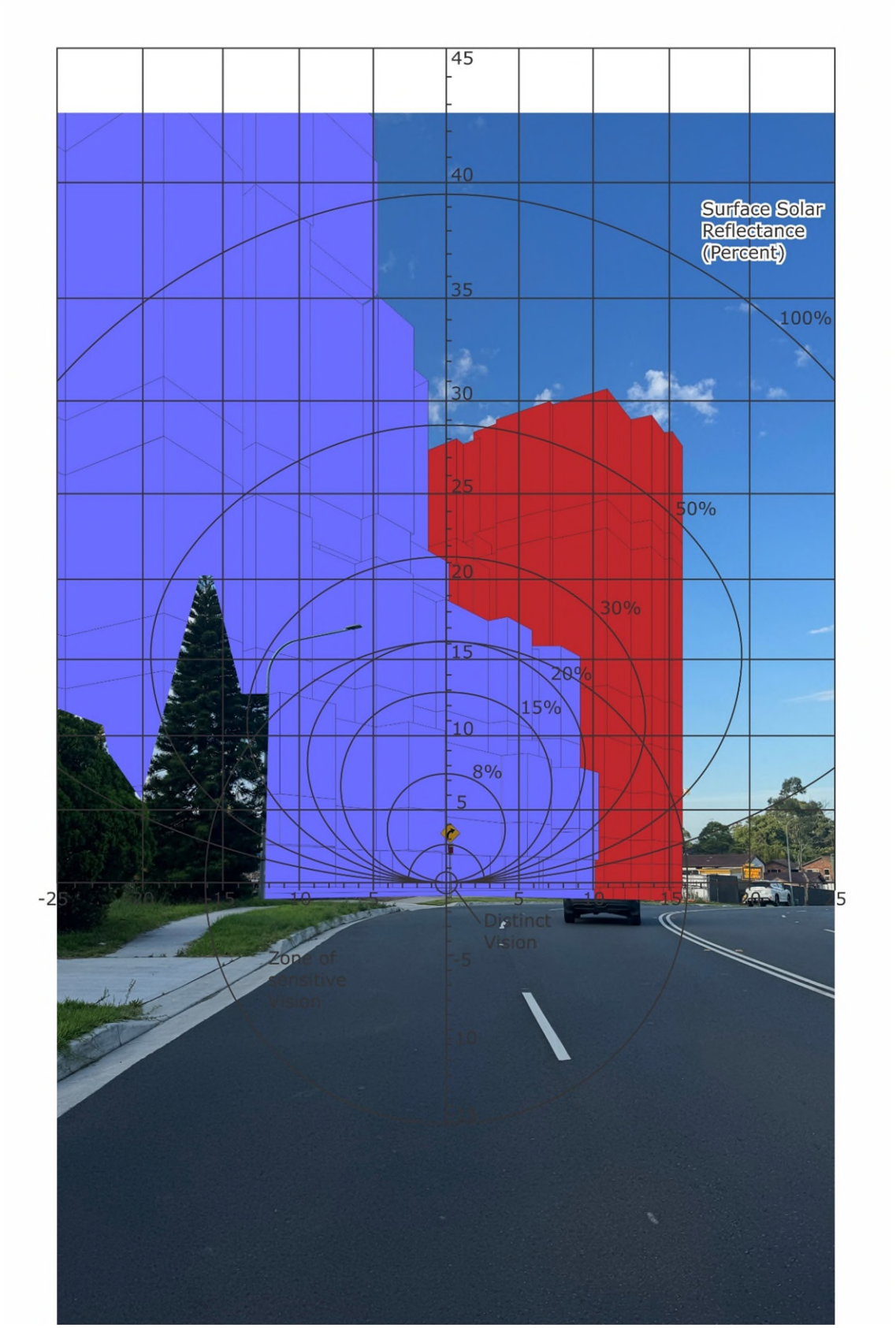


Figure A.8: Glare Overlay of the Viewpoint at Point 08

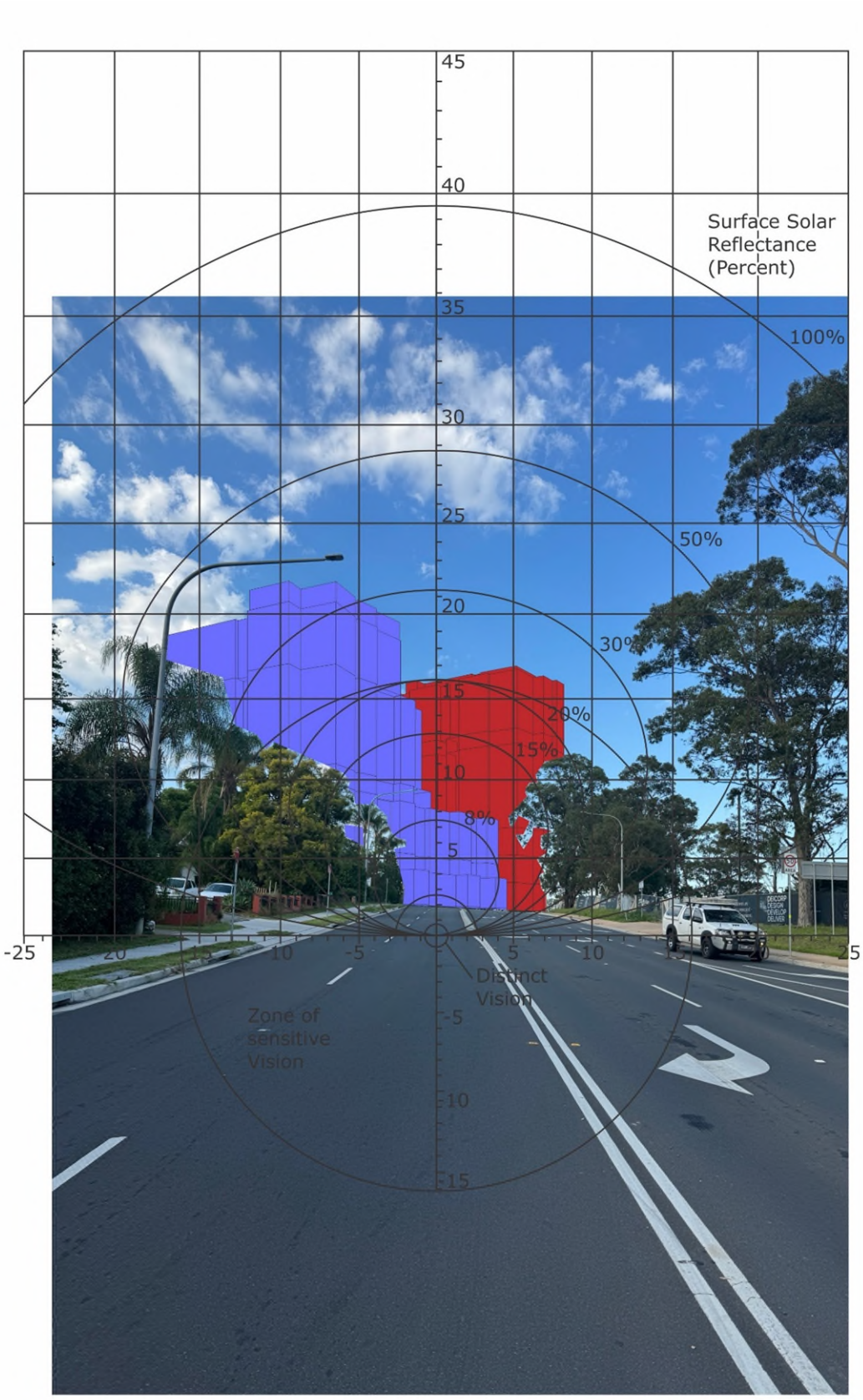


Figure A.9: Glare Overlay of the Viewpoint at Point 09

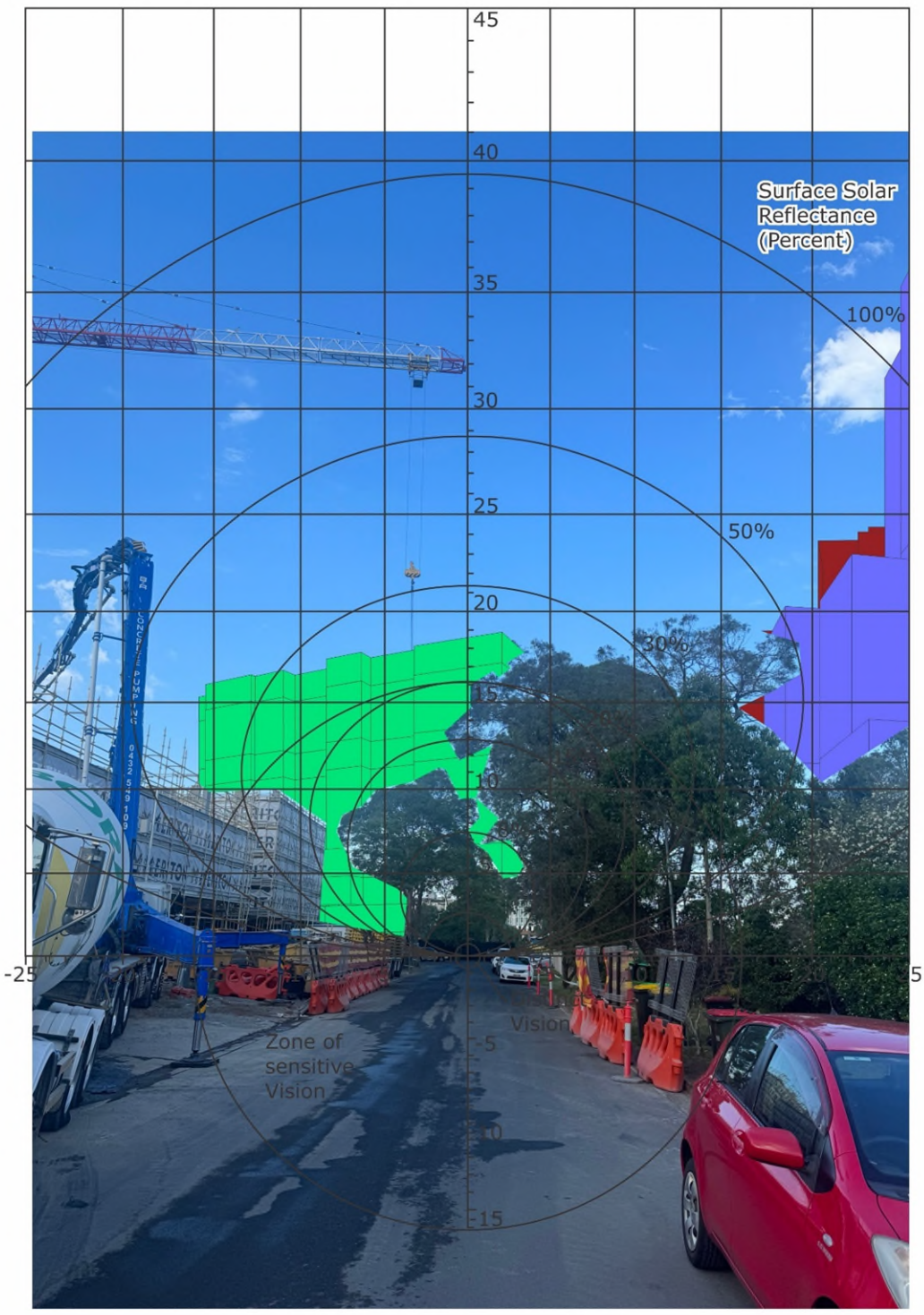


Figure A.10: Glare Overlay of the Viewpoint at Point 10

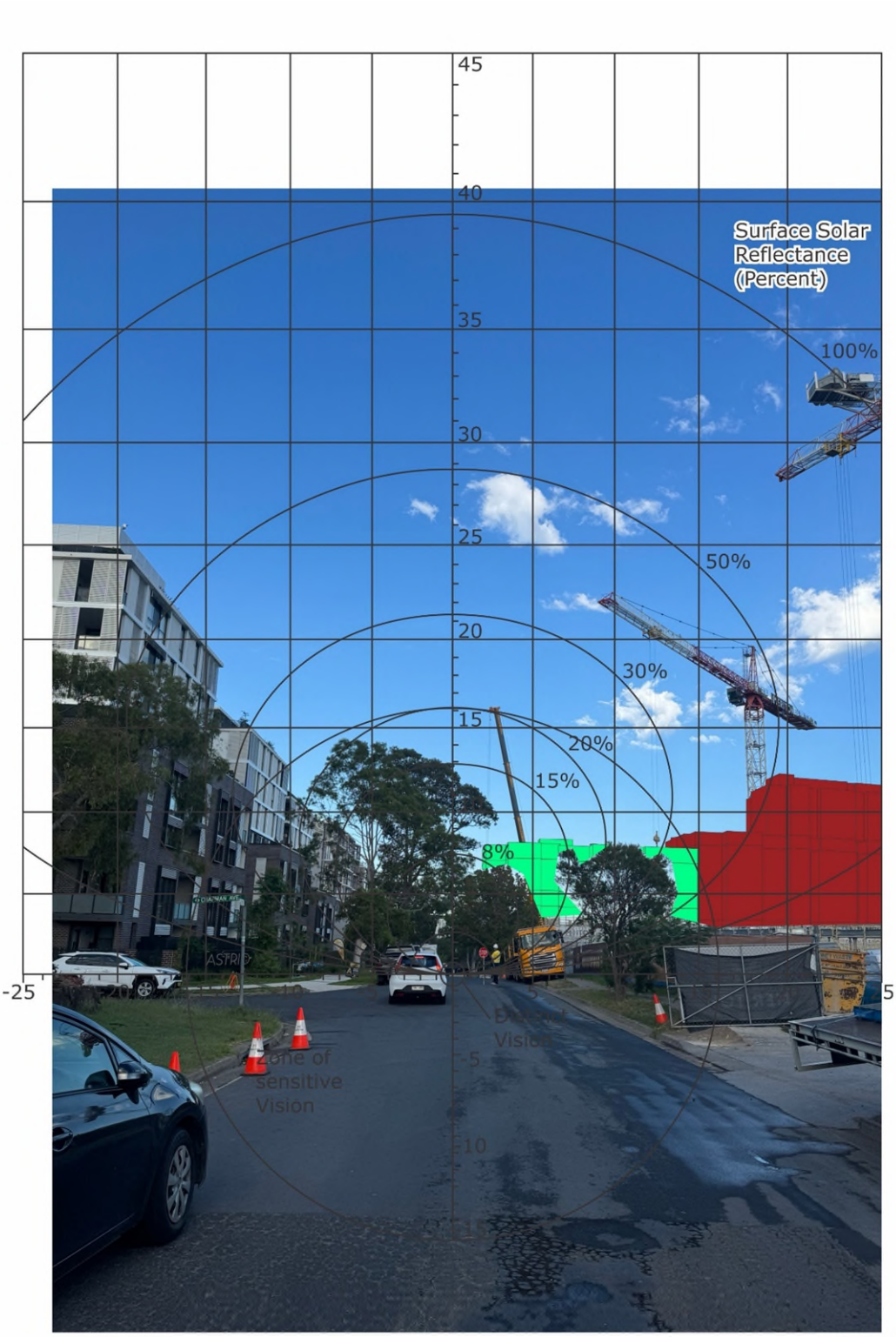


Figure A.11: Glare Overlay of the Viewpoint at Point 11

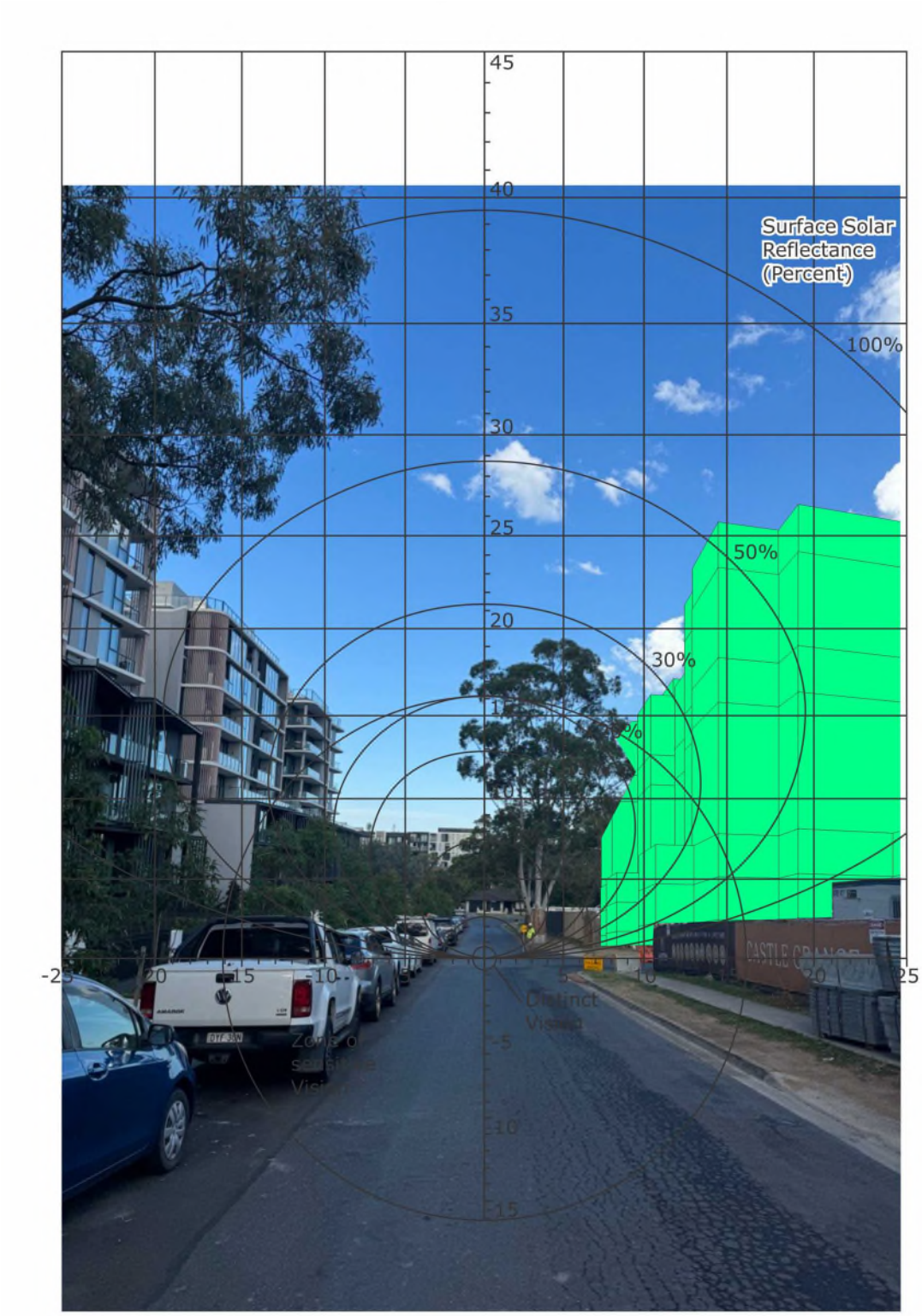


Figure A.12: Glare Overlay of the Viewpoint at Point 12

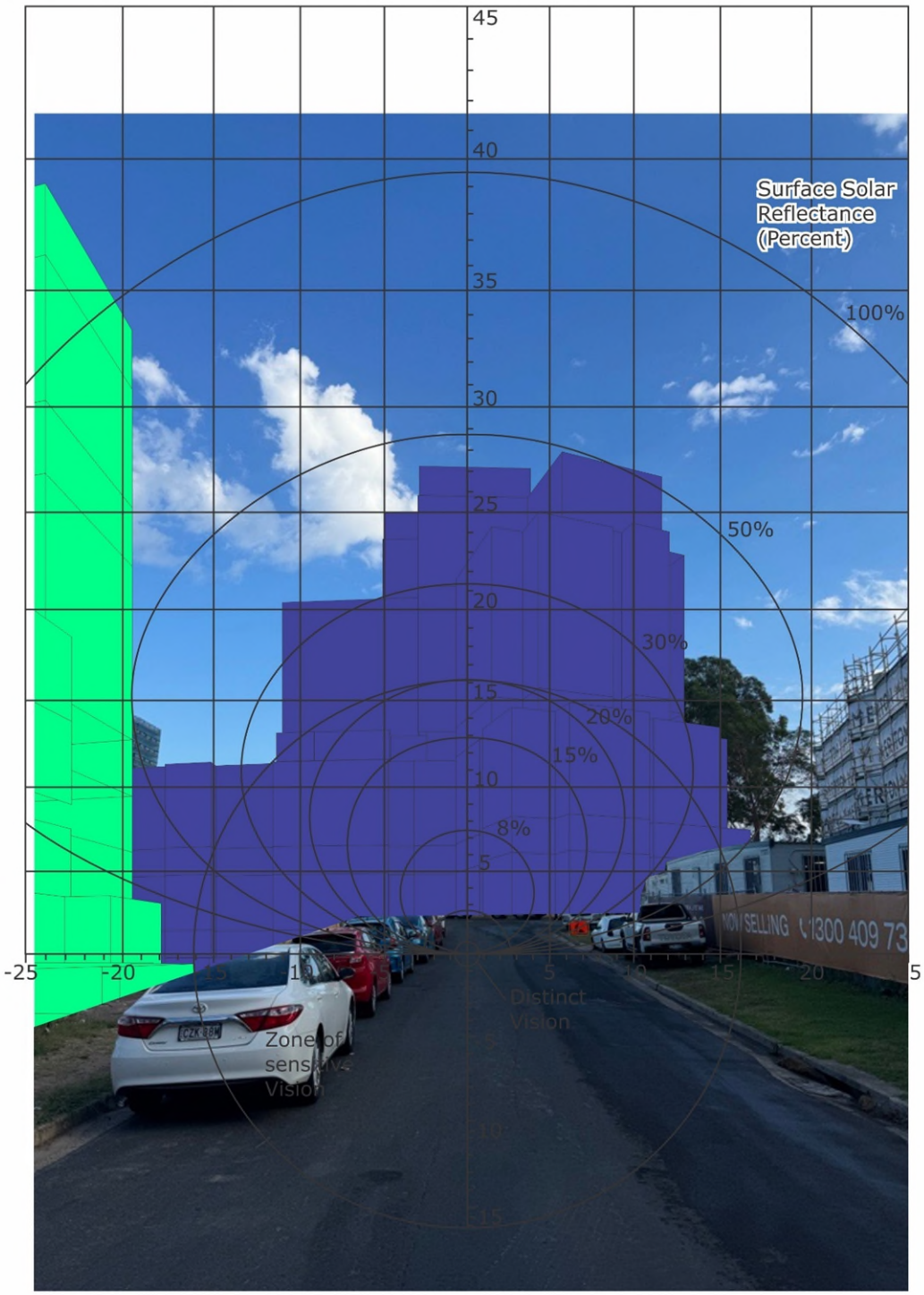


Figure A.13: Glare Overlay of the Viewpoint at Point 13

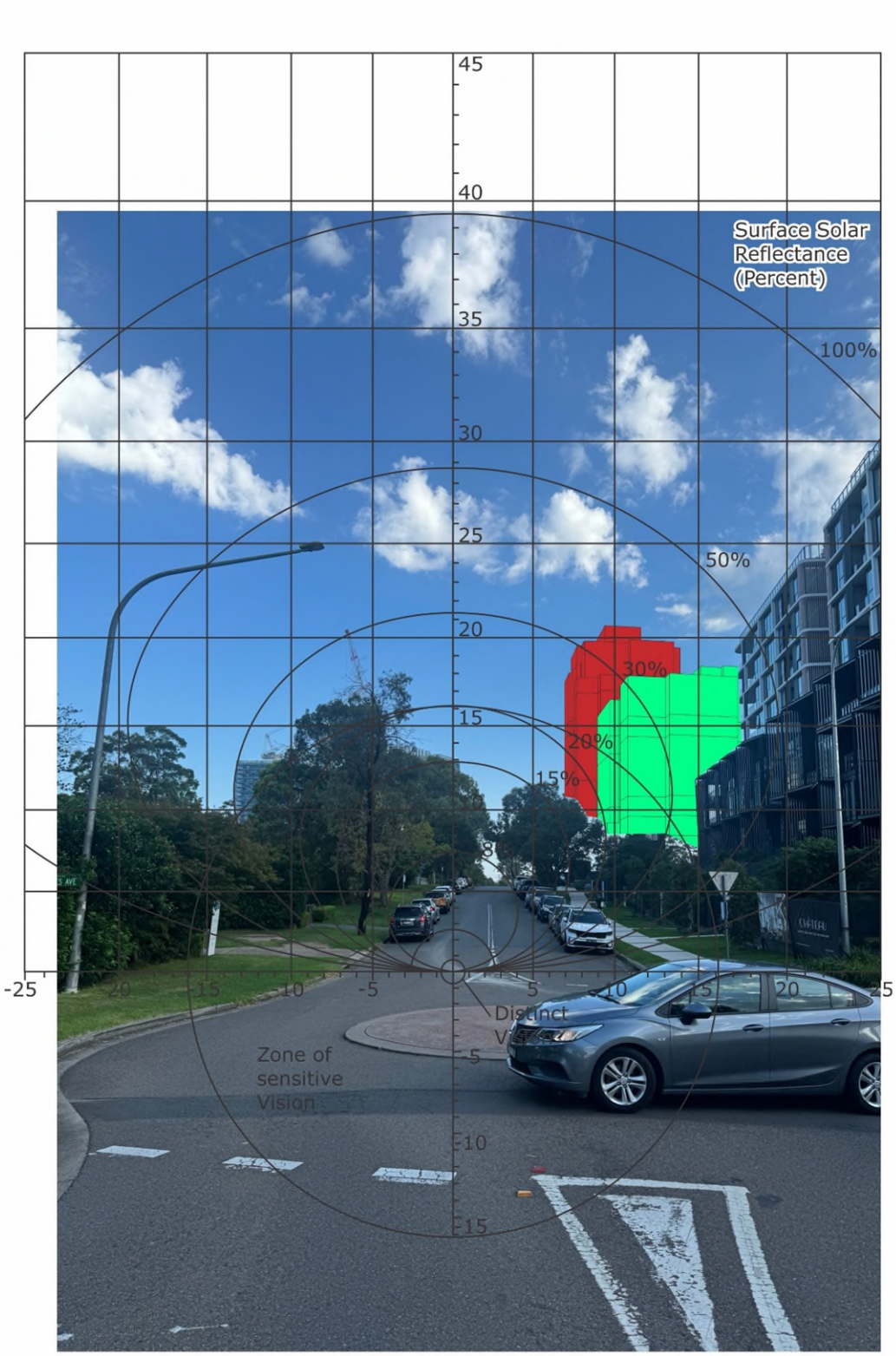


Figure A.14: Glare Overlay of the Viewpoint at Point 14

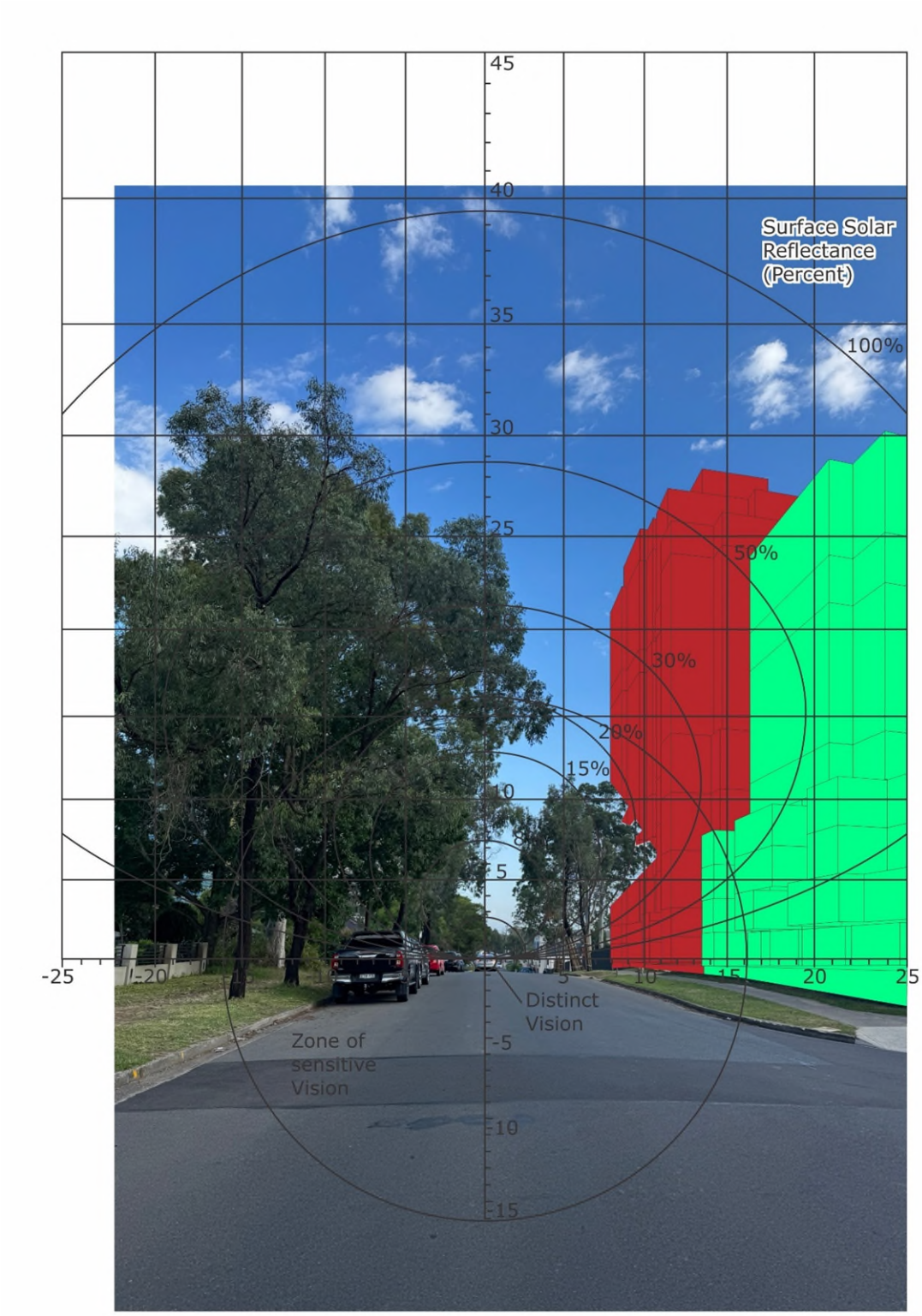


Figure A.15: Glare Overlay of the Viewpoint at Point 15

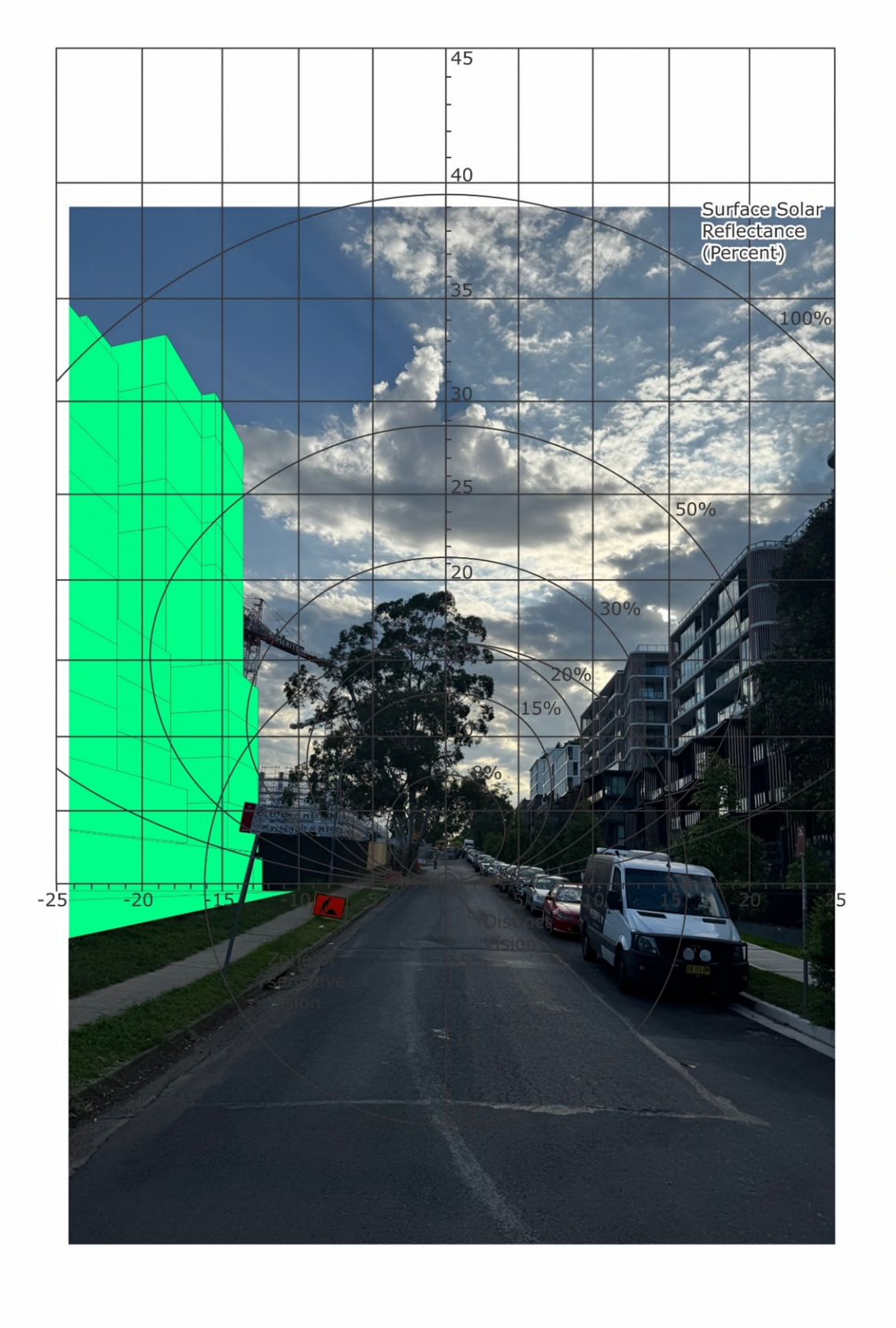


Figure A.16: Glare Overlay of the Viewpoint at Point 16

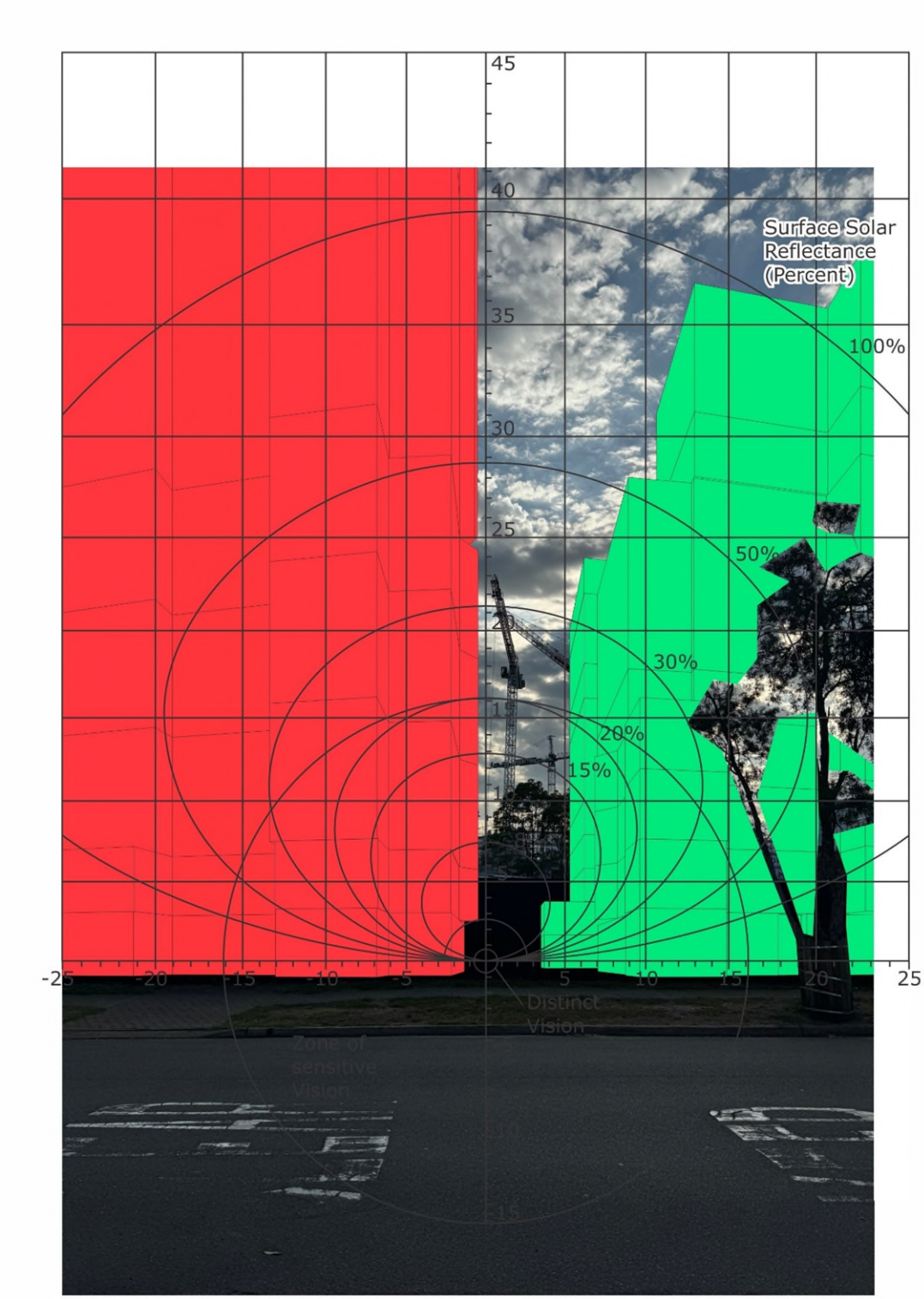


Figure A.17: Glare Overlay of the Viewpoint at Point 17

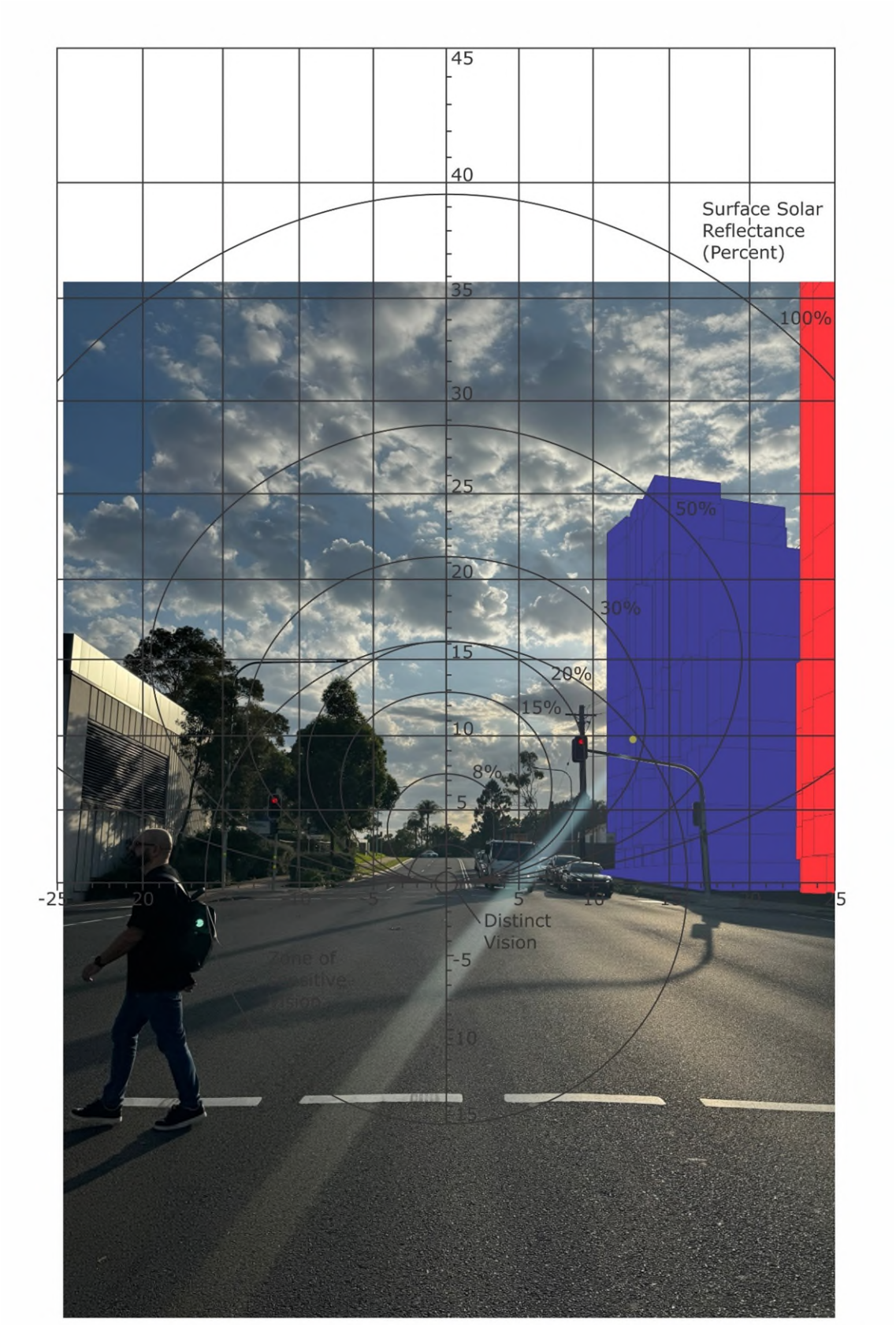


Figure A.18: Glare Overlay of the Viewpoint at Point 18

Figure A.19: Glare Overlay of the Viewpoint at Point 19

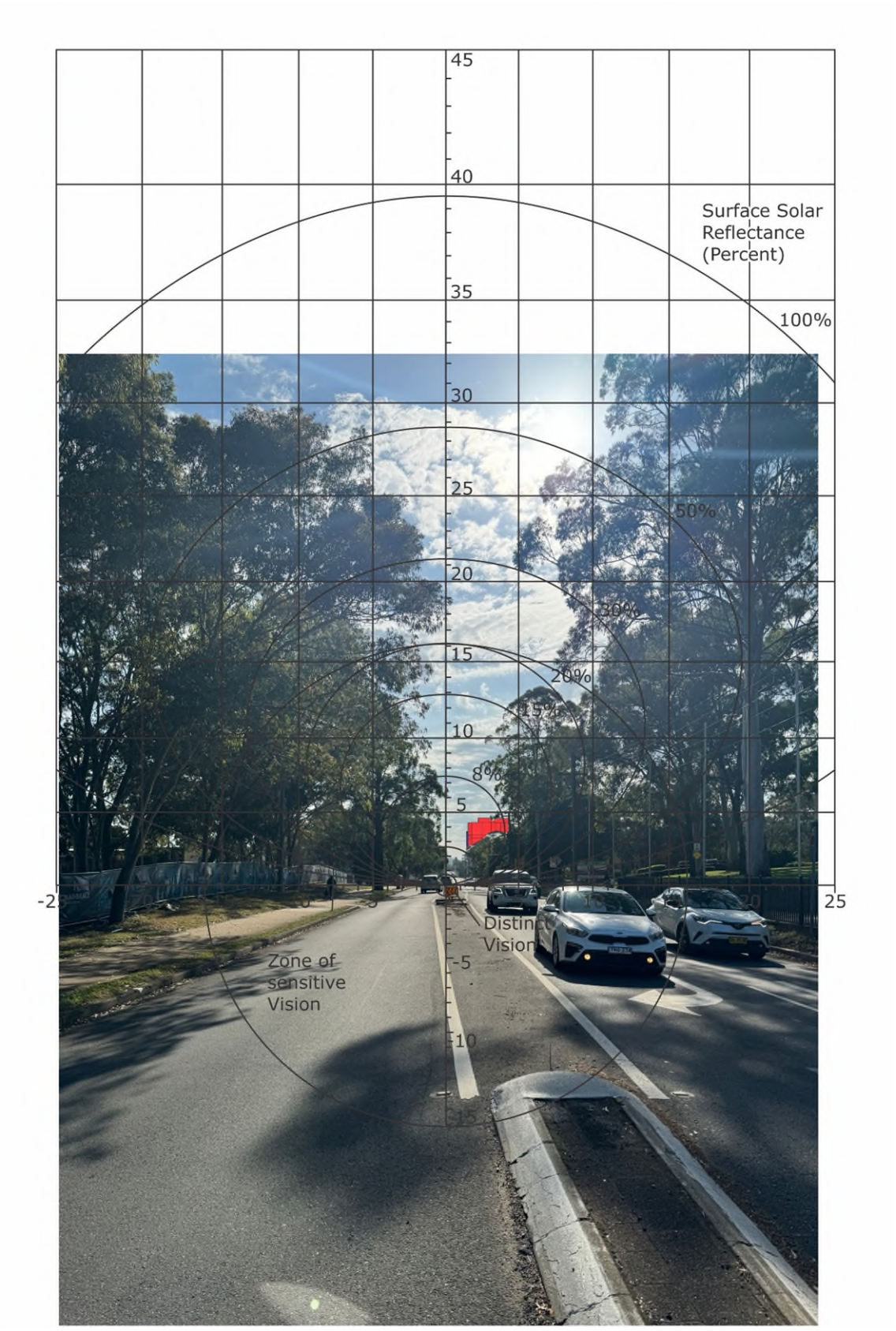


Figure A.20: Glare Overlay of the Viewpoint at Point 20

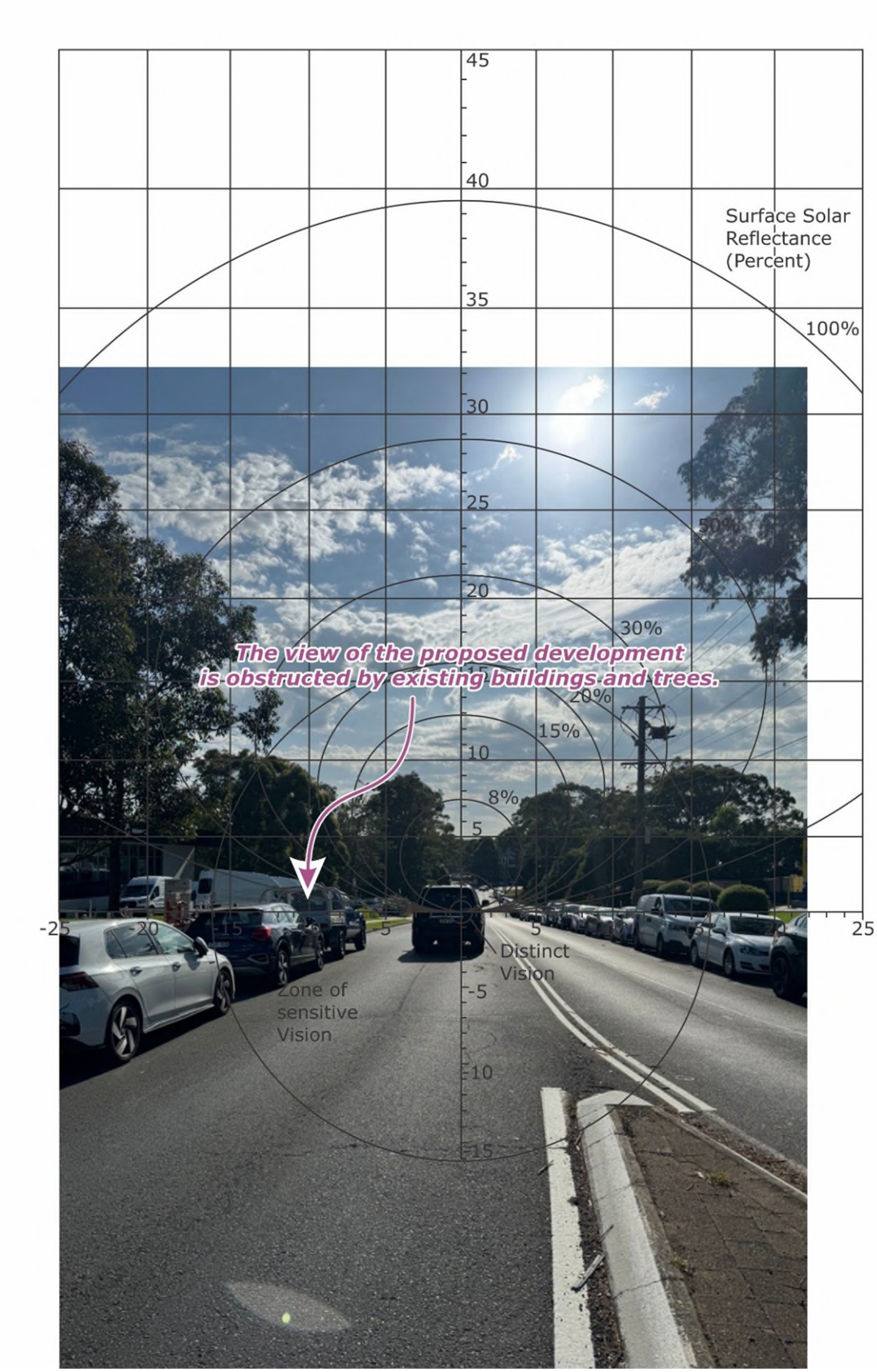


Figure A.21: Glare Overlay of the Viewpoint at Point 21

APPENDIX B CRITICAL ASPECT SOLAR CHARTS

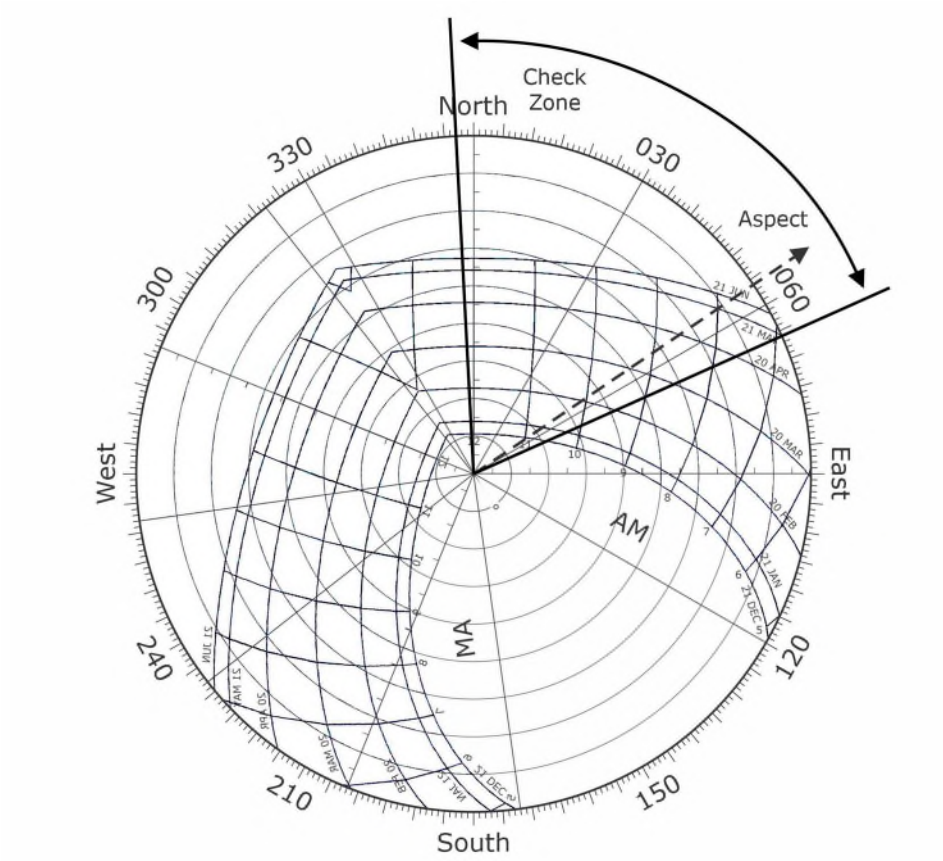


Figure B.1: Sun Chart for the 056° Aspect

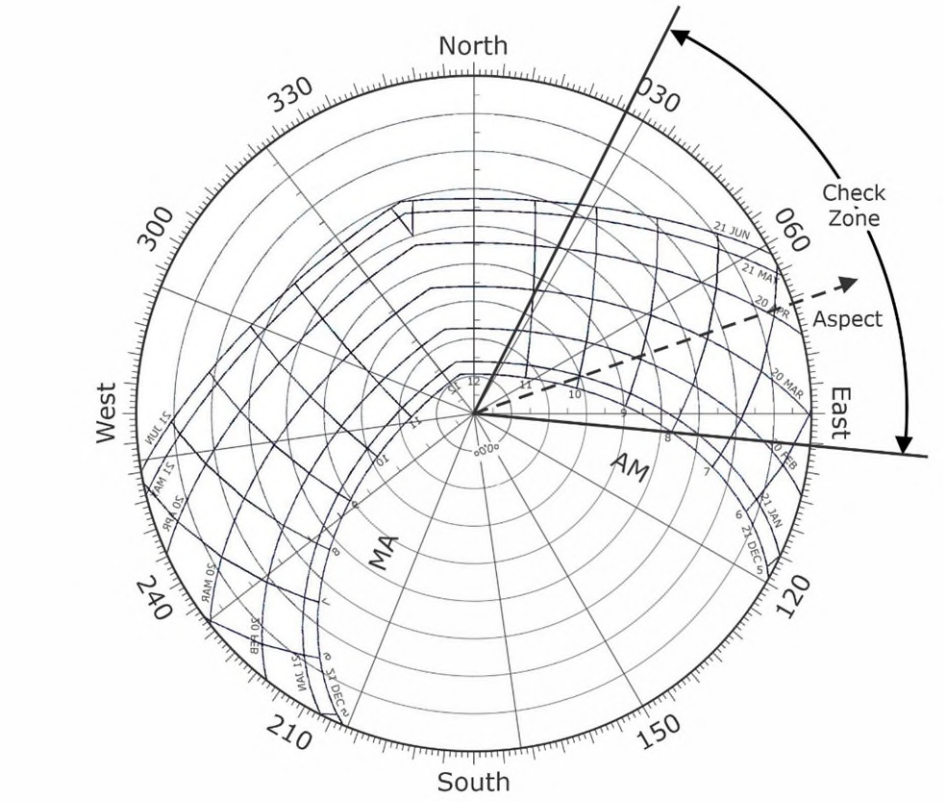


Figure B.2: Sun Chart for the 071° Aspect

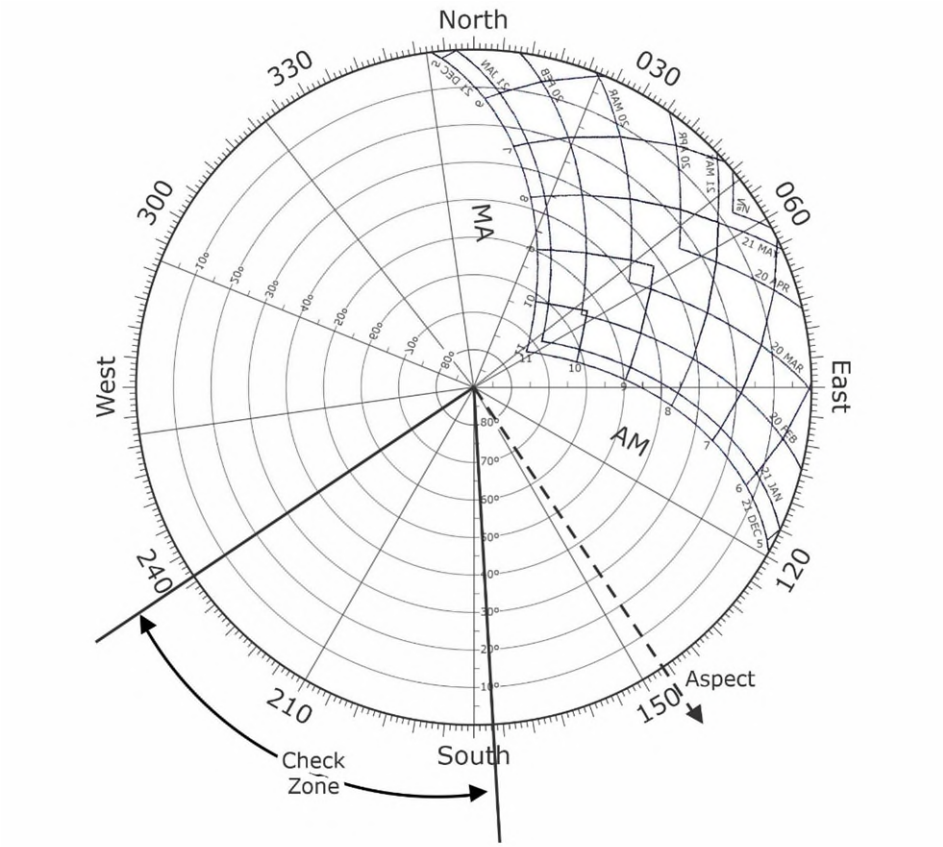


Figure B.3: Sun Chart for the 146° Aspect

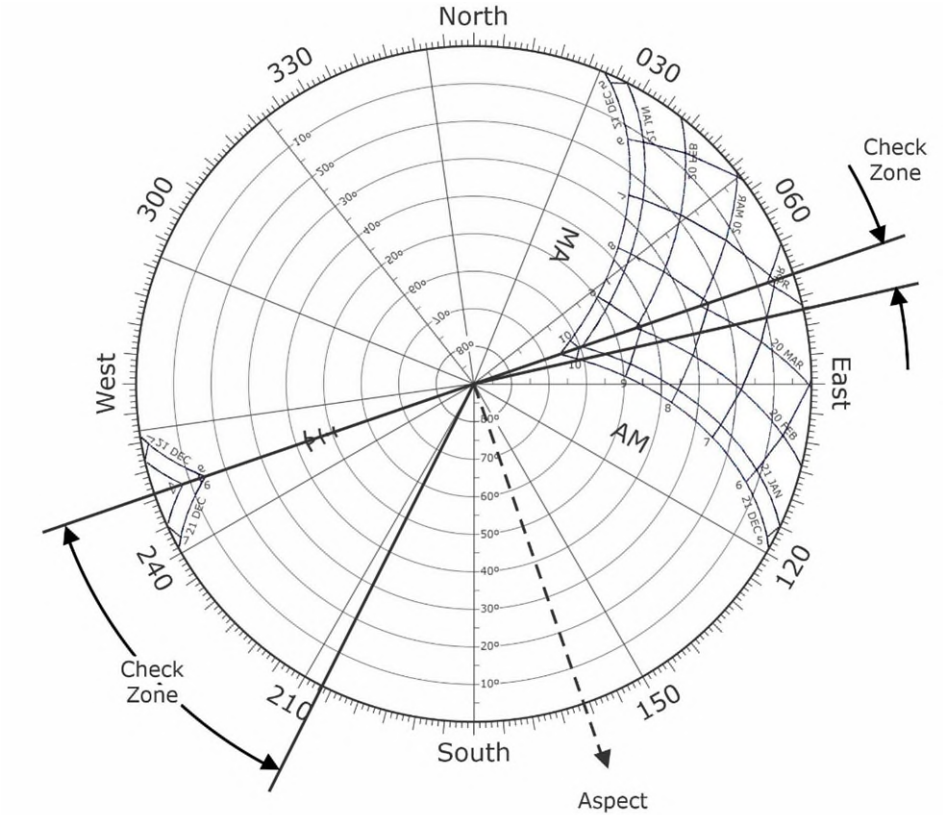


Figure B.4: Sun Chart for the 161° Aspect

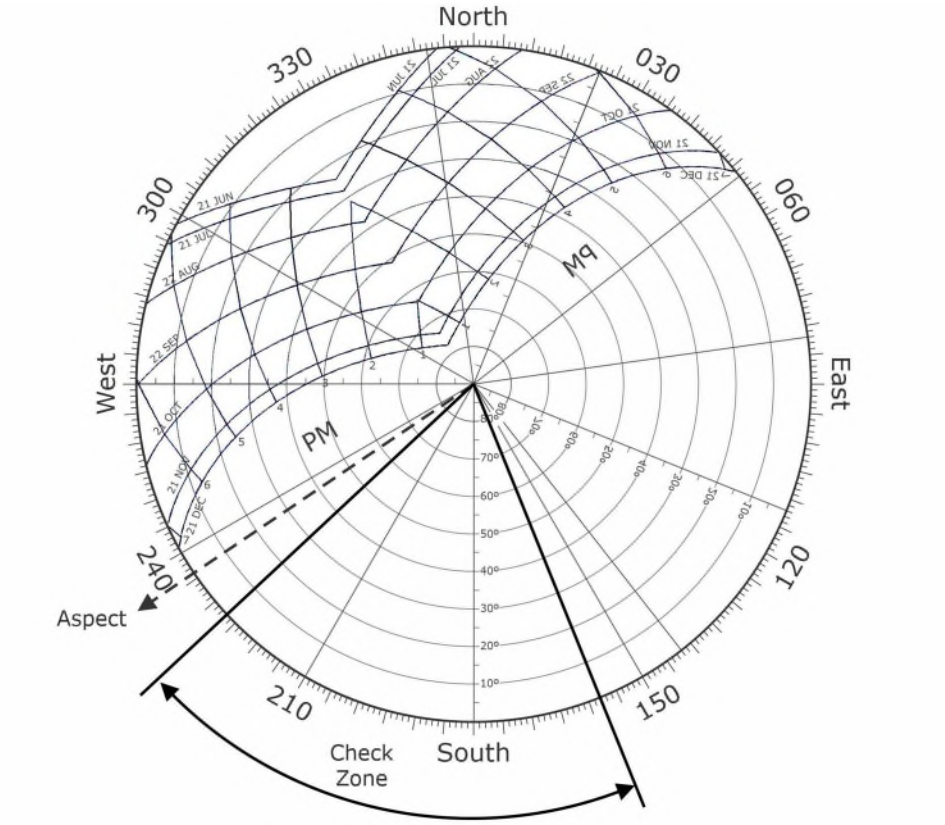


Figure B.5: Sun Chart for the 236° Aspect

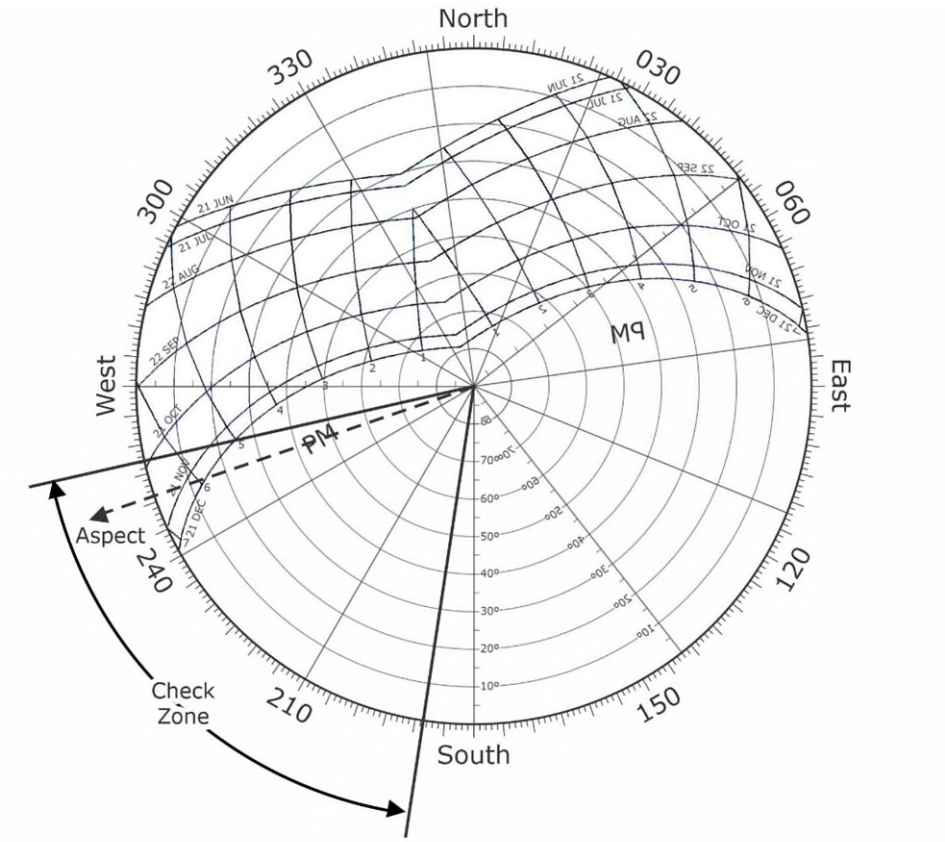


Figure B.6: Sun Chart for the 251° Aspect

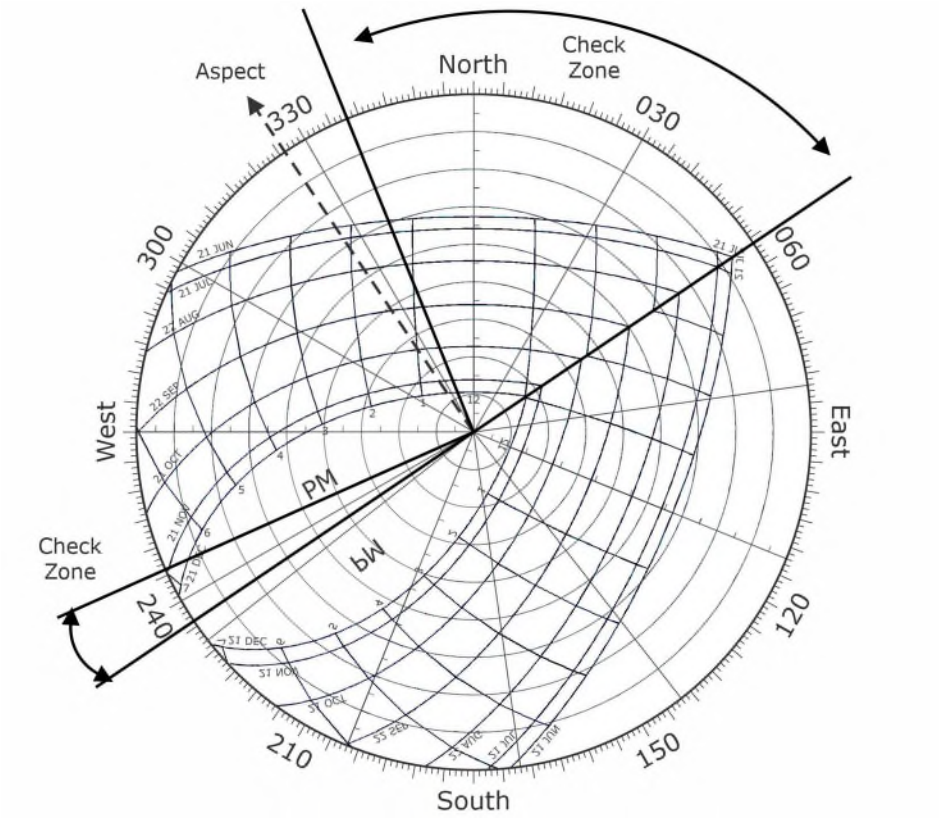


Figure B.7: Sun Chart for the 326° Aspect

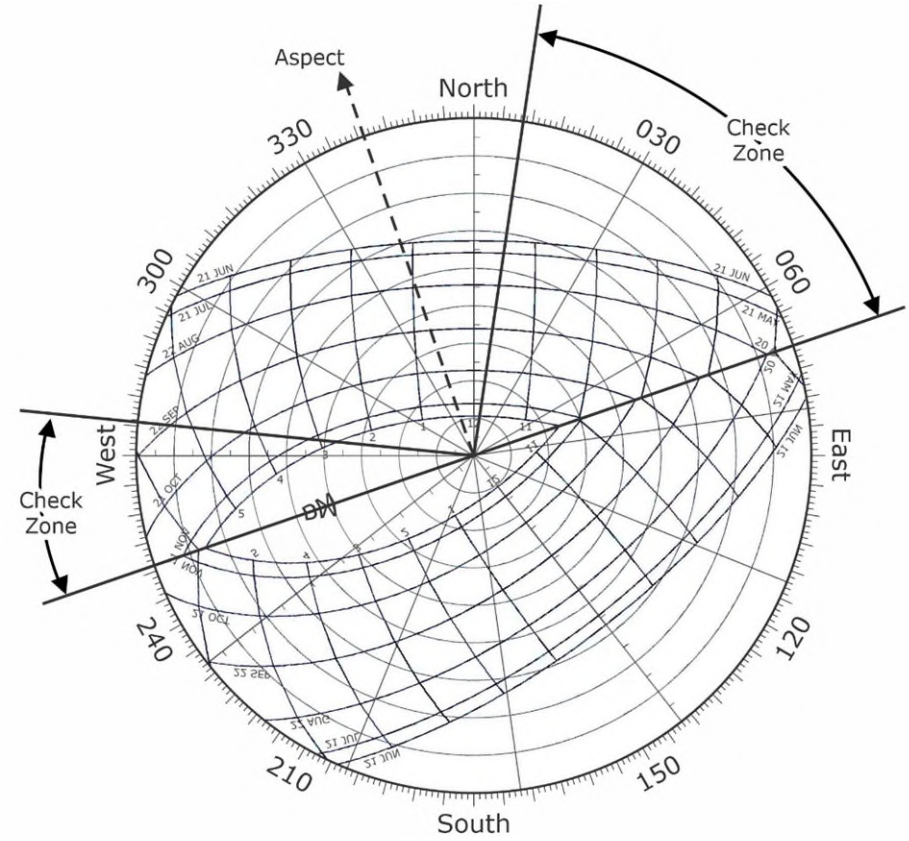


Figure B.8: Sun Chart for the 341° Aspect

APPENDIX C STANDARD SUN CHART FOR THE REGION

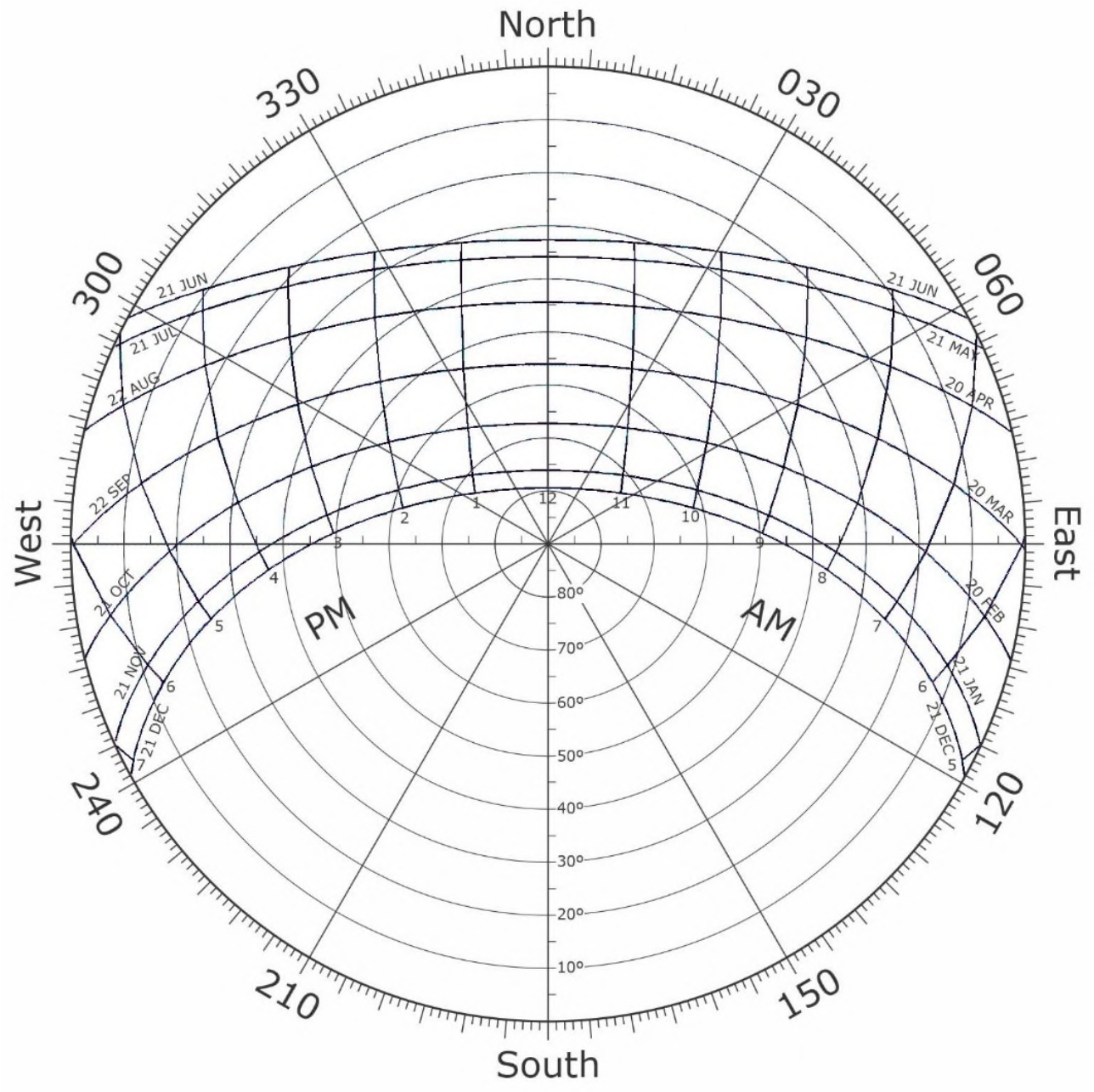


Figure C.1: Standard Sun Chart for the Sydney Region