SOLAR LIGHT REFLECTIVITY STUDY

GRAN CENTRAL, 134-142 PARRAMATTA ROAD, 26-38 GOOD STREET AND 59-61 COWPER STREET, GRANVILLE

WE905-02F03(REV1)- SR REPORT

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Prepared for:

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DOCUMENT CONTROL

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EXECUTIVE SUMMARY

This report presents the results of a detailed study for the effect of potential solar glare from the proposed development located at Gran Central, 134-142 Parramatta Road, 26-38 Good Street and 59-61 Cowper Street, Granville. 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 No. 65 (SEPP65, Part 04 (Designing the Building) for Amenity), which contains the Apartment Design Guide (ADG), and the Parramatta Development Control Plan 2011.

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:

- Main building façade (glazing and building material finishes):
    - Common Podium (Ground Level to Level 3) - Eastern aspect of the main building façade: 11%
    - Tower A (Levels 4 to 24) – Southern and Eastern aspects of the main building façade: 11%.
    - Tower B (Levels 4 to 24) – Southern, Eastern and Western aspects of the main building façade: 11%.
- Balustrade glazing:
    - Common Podium (Ground Level to Level 3) - Eastern aspect balustrades: 8%
    - Tower A (Levels 4 to 24) – Southern and Eastern aspects balustrades: 8%.
    - Tower B (Levels 4 to 24) – Southern, Eastern and Western aspect balustrades: 8%.
- All other building material finishes/glazing (windows and balustrades) 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 SEPP65 and the Parramatta Development Control Plan 2011.

CONTENTS

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 1.2 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 ±10° of the direct sight-line). These are shown in Figure 2, and summarised in Table 1. Photographs have been taken from the viewpoint of motorists at each study point location using a calibrated camera. A scaled glare protractor has been superimposed over each viewpoint image.

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.

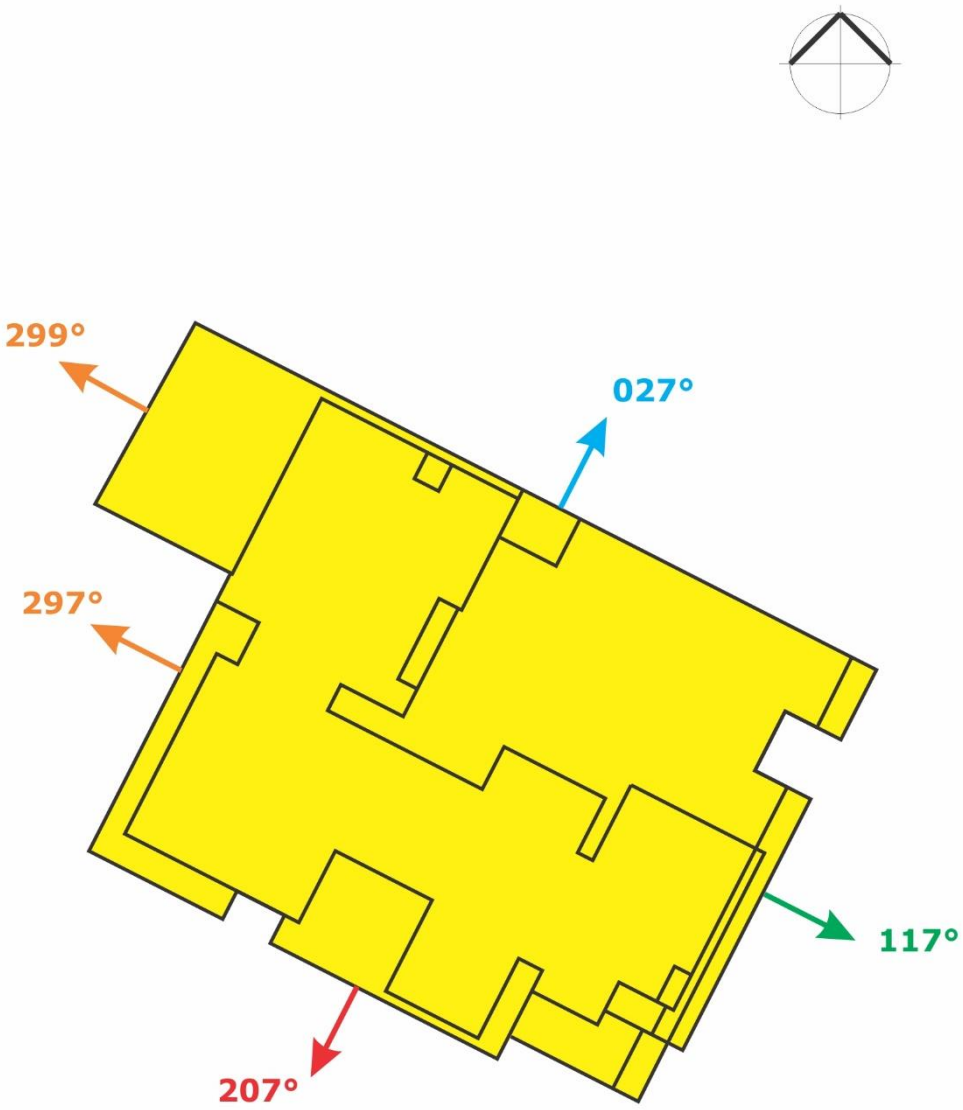

Figure 1: Critical Glazed Aspects of the Development (typical plan shown)

Figure 2: Check Zones and Study Point Locations

(the check zones are the areas where glare could potentially be observed)

Table 1: 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
01	Enid Avenue, heading north.	Eastern aspect.
02	Memorial Drive, heading north-west.	Eastern and southern aspects.
03	Cowper Street, heading north-west.	Eastern and southern aspects.
04	Cowper Street, heading north-west.	Eastern and southern aspects.
05	South Street, heading north.	Eastern aspect.
06	Good Street, heading north-east.	Eastern and southern aspects.
07	Parramatta Road, heading north-west.	Northern aspect.
08	Parramatta Road, heading north-west.	Northern aspect.
09	Parramatta Road, heading south-east.	Northern and western aspects.
10	Parramatta Road, heading south-east.	Northern and western aspects.
11	Cowper Street, heading south-east.	Western aspect.
12	Cowper Street, heading south-east.	Western aspect.

1.2 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.

1.2.1 Motorists heading north along Enid Avenue

Points 01 is located along Enid Avenue, to the south of the development site. This point represents the critical sightline of motorists heading north along Enid Avenue at this location. Calibrated image of the viewpoint of motorists at this location has been overlaid with a scaled glare meter, as shown in Appendix A.

An analysis of the viewpoint at Point 01 indicates that the view of the proposed development will not be visible from this location due to the obstruction from the existing building along Enid Avenue. Hence there will be no adverse solar glare observed by motorists heading north along Enid Avenue at this location.

1.2.2 Motorists heading south-east along Memorial Drive

Points 02 is located along Memorial Drive, to the south-east of the development site. This point represent the critical sightline of motorists heading north-west along Memorial Drive at this location. Calibrated image of the viewpoint of motorists at this location has been overlaid with a scaled glare meter, as shown in Appendix A.

An analysis of the glare meters overlaid onto the viewpoint at Point 02 indicates that portions of the upper levels of the southern and eastern aspects of the Tower A and Tower B will be visible and within the zone of sensitive vision. This study point is located within the check zones of these aspects, and hence solar glare can potentially be observed from the southern and eastern aspects of the Tower A and Tower B at Point 02.

To ensure that no adverse solar glare is observed from Point 02, it is recommended to limit the reflectance of the glazing used on the southern and eastern aspects of the Tower A and Tower B (from Level 4 to Level 24) as follows:

- Maximum normal specular reflectance of visible light of 11% for the glazing on the main building facade.
- Maximum normal specular reflectance of visible light of 8% for the glazed balustrades.

1.2.3 Motorists heading north-west along Cowper Street

Points 03 and 04 are located along Cowper Street, to the east of the development site. These points represent the critical sightline of motorists heading north-west along Cowper Street at these locations. Calibrated images of the viewpoint of motorists at these locations have been overlaid with a scaled glare meter, as shown in Appendix A.

An analysis of the glare meters overlaid onto the viewpoint at Point 03 indicates that portions of the southern and eastern aspects of the Tower A and Tower B will be visible and within the zone of sensitive vision. This study point is located within the check zones of these aspects, and hence solar glare can potentially be observed from the southern and eastern aspects of the development at Point 03.

For solar glare to be reflected off the southern aspect of the Tower A and Tower B, this would occur at certain times of the year in the late afternoon. However, during late afternoon period when the reflected solar glare can be observed, the direct sun will also be visible and within the zone of sensitive vision of motorists at this location. Hence the intensity of the reflected solar glare off the southern aspect will be insignificant in comparison to the intensity of direct sunlight. For solar glare to be reflected off the eastern aspects of the Tower A and Tower B, this would occur at certain times of the year in the early morning

To ensure that no adverse solar glare is observed from Point 03, it is recommended to limit the reflectance of the glazing used on the southern and eastern aspects of the Tower A and Tower B as follows:

Southern Aspect

- Common Podium (Ground Level to Level 3): Maximum normal specular reflectance of visible light of 20% for the glazing on the main building façade and glazed balustrades.
- Towers A and B (Levels 4 to 24): Maximum normal specular reflectance of visible light of 11% for the glazing on the main building façade.
- Towers A and B (Levels 4 to 24):: Maximum normal specular reflectance of visible light of 8% for the glazed balustrades.

Eastern Aspect

- Common Podium & Towers A and B (Ground Level to Level 24): Maximum normal specular reflectance of visible light of 11% for the glazing on the main building façade.
- Common Podium & Towers A and B (Ground Level to Level 24): Maximum normal specular reflectance of visible light of 8% for the glazed balustrades.

An analysis of the glare meters overlaid onto the viewpoint at Point 04 indicates that a portion of the southern aspect of the common podium of the development will be visible and within the zone of sensitive vision. This study point is located within the check zone of this aspect, and hence solar glare can potentially be observed.

For solar glare to be reflected off the southern aspect of the common podium, this would occur at certain times of the year in the late afternoon. However, during late afternoon period when the reflected solar glare can be observed, the direct sun will also be visible and within the zone of sensitive vision of motorists at this location. Hence the intensity of the reflected solar glare off the southern aspect will be insignificant in comparison to the intensity of direct sunlight and

a maximum normal specular reflectance of visible light of 20% is recommended to be used on the glazing along the southern aspect of the common podium.

1.2.4 Motorists heading north along South Street

Point 05 is located along South Street, to the south of the development site. This point represents the critical sightline of motorists heading north along South Street at this location. A calibrated image of the viewpoint of motorists at this location has been overlaid with a scaled glare meter, as shown in Appendix A.

An analysis of the glare meter overlaid onto the viewpoint at Point 05 indicates that portions of the southern and eastern aspects of the Tower A will be visible and within the zone of sensitive vision. Point 05 is not located within the check zone of the southern aspect, however it is located within the check zone of the eastern aspect and hence solar glare can potentially be observed from the eastern aspect. For adverse glare to be reflected off the eastern aspect within the zone of sensitive vision onto motorists at Point 05, the sun's angular position would need to be within 0° to 10° inclination and 224° to 226° azimuth. According to the standard sun chart for Sydney, as shown in Appendix C, the sun does not operate at this angular position. Hence no adverse solar glare will be reflected from the development to motorists heading north along South Street at Point 05.

1.2.5 Motorists heading north-east along Good Street

Point 06 is located along Good Street, to the south of the development site. This point represents the critical sightline of motorists heading north-east along Good Street at this location. Calibrated image of the viewpoint of motorists at this location has been overlaid with a scaled glare meter, as shown in Appendix A.

An analysis of the glare meter overlaid onto the viewpoint at Point 06 indicates that portions of the eastern aspect of the common podium of the development will be visible and within the zone of sensitive vision. Point 06 is located within the check zone for this aspect and hence solar glare can potentially be observed from that aspect at Point 06. For adverse glare to be reflected off the eastern aspect within the zone of sensitive vision onto motorists at Point 06, the sun's angular position would need to be within 0° to 10° inclination and 234° and 236° azimuth. According to the standard sun chart for Sydney, as shown in Appendix C, the sun does not operate at this angular position. Hence no adverse solar glare will be reflected from the development to motorists heading north-east along Good Street at Point 06.

1.2.6 Motorists heading north-west along Parramatta Road

Points 07 and 08 are located along Parramatta Road, to the east of the development site. These points represent the critical sightline of motorists heading north-west along Parramatta Road at these locations. Calibrated images of the viewpoint of motorists at these locations have been overlaid with a scaled glare meter, as shown in Appendix A.

An analysis of the glare meter overlaid onto the viewpoint at Point 07 indicates that portions of the eastern and northern aspects of the Tower A and Tower B will be visible and within the zone of sensitive vision.

Point 07 is not located within the check zone of the eastern aspect, however it is located within the check zone of the northern aspect and hence solar glare can potentially be observed from the northern aspect of Towers A and B.

Further analysis of the visible portion of the northern aspect of Tower A indicates that it will be overshadowed by Tower B at the times when solar glare could have otherwise been observed (shoulder season afternoons).

The visible portion of the northern aspect of Tower B from Point 07 indicates that they appear to be very narrow (when viewed from Point 07) and will have an angular width of less than 0.5deg arc. Hence the intensity of glare observed from that aspect of the development will be less than 500cd/m^2 (providing that the maximum normal specular reflectance of visible light of the glazing is 20%).

An analysis of the glare meter overlaid onto the viewpoint at Point 08 indicates that portions of the northern aspect of the common podium and Tower B will be visible and within the zone of sensitive vision. This study point is located within the check zone of this aspect, and hence solar glare can potentially be observed from the northern aspect of the development at Point 08.

For solar glare to be reflected off the northern aspect of the common podium and Tower B, this would occur at certain times of the year in the late afternoon, however during late afternoon period when the reflected solar glare can be observed, the direct sun will also be visible and within the zone of sensitive vision of motorists at this location. Hence the intensity of the reflected solar glare off the northern aspect will be insignificant in comparison to the intensity of direct sunlight and a maximum normal specular reflectance of visible light of 20% is recommended to be used on the glazing along the northern aspect of the common podium and Tower B.

1.2.7 Motorists heading south-east along Parramatta Road

Points 09 and 10 are located along Parramatta Road, to the west of the development site. These points represent the critical sightline of motorists heading south-east along Parramatta Road at these locations. Calibrated images of the viewpoint of motorists at these locations have been overlaid with a scaled glare meter, as shown in Appendix A.

An analysis of the glare meter overlaid onto the viewpoint at Point 09 indicates that portions of the northern and western aspects of the common podium and Tower B will be visible and within the zone of sensitive vision. This study point is located within the check zones of these aspects, and hence solar glare can potentially be observed from the northern and western aspects of the development at Point 09.

For solar glare to be reflected off the northern aspect of the common podium and Tower B, this would occur at certain times of the year in the early morning, however during early morning period when the reflected solar glare can be observed, the direct sun will also be visible and within the zone of sensitive vision of motorists at this location. Hence the intensity of the reflected solar glare off the northern aspect will be insignificant in comparison to the intensity of direct sunlight and a maximum normal specular reflectance of visible light of 20% is recommended to be used on the glazing along the northern aspect of the common podium and Tower B.

Further analysis indicates that there is no glazing on the western aspect of the common podium which is visible within the zone of sensitive vision at Point 09, and hence will not cause adverse solar glare. However, there is glazing on the western aspect of Tower B.

To ensure that no adverse solar glare is observed from Point 09, it is recommended to limit the reflectance of the glazing used on the western aspect of the Tower B of the development as follows:

- Maximum normal specular reflectance of visible light of 11% for the glazing on the main building façade.
- Maximum normal specular reflectance of visible light of 8% for the glazed balustrades.

An analysis of the glare meter overlaid onto the viewpoint at Point 10 indicates that the eastern end of the northern aspect of the common podium of the development will be visible and within the zone of sensitive vision. A further examination indicates that Point 10 is within the check zone of the northern aspect, hence there is potential for solar glare to be observed (ie: early morning period). However, during the early morning period when the reflected solar glare can be observed off the northern aspect, the direct sun will also be visible and within the zone of sensitive vision of motorists at this location. Hence the intensity of the reflected solar glare off the northern aspect will be insignificant in comparison to the intensity of direct sunlight and a maximum normal specular reflectance of visible light of 20% is recommended to be used on the glazing along the northern aspect of the common podium of the development.

1.2.8 Motorists heading south-east along Cowper Street

Points 11 and 12 are located along Cowper Street, to the west of the development site. These points represent the critical sightline of motorists heading south-east along Cowper Street at these locations. Calibrated images of the viewpoint of motorists at these locations have been overlaid with a scaled glare meter, as shown in Appendix A.

An analysis of the glare meter overlaid onto the viewpoint at Point 11 indicates that portions of the southern and western aspects of the common podium of the development will be visible and within the zone of sensitive vision. Point 11 is not located within the check zone of the southern aspect, however it is located within the check zone of the western aspect (297°) and hence solar glare can potentially be observed from the western aspect of the common podium.

However, this portion of the western aspect will be overshadowed by the adjacent neighbouring building to the west of the development at the times when solar glare could have otherwise been observed (ie: late winter afternoon period), hence there will be no adverse solar glare observed by motorists heading south-east along Cowper Street at this location.

An analysis of the glare meter overlaid onto the viewpoint at Point 12 indicates that a portion of the southern aspect of the common podium of the development will be visible and within the zone of sensitive vision. However, further analysis indicates that Point 12 does not lie within the check zone for the southern aspect of the development. Hence here will be no adverse solar glare observed by motorists heading south-east along Cowper Street at this location.

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 NORMAL SPECULAR REFLECTANCE OF BUILDING SURFACES

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:

- 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 CONCLUSION

A detailed study has been undertaken for the effect of potential solar glare from the proposed development located at Gran Central, 134-142 Parramatta Road, 26-38 Good Street and 59-61 Cowper Street, Granville. 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 No. 65 (SEPP65, Part 04 (Designing the Building) for Amenity), which contains the Apartment Design Guide (ADG), and the Parramatta Development Control Plan 2011.

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:

- Main building façade (glazing and building material finishes):
    - Common Podium (Ground Level to Level 3) - Eastern aspect of the main building façade: 11%
    - Tower A (Levels 4 to 24) – Southern and Eastern aspects of the main building façade: 11%.
    - Tower B (Levels 4 to 24) – Southern, Eastern and Western aspects of the main building façade: 11%.
- Balustrade glazing:
    - Common Podium (Ground Level to Level 3) - Eastern aspect balustrades: 8%
    - Tower A (Levels 4 to 24) – Southern and Eastern aspects balustrades: 8%.
    - Tower B (Levels 4 to 24) – Southern, Eastern and Western aspect balustrades: 8%.
- All other building material finishes/glazing (windows and balustrades) 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 SEPP65 and the Parramatta Development Control Plan 2011.

5 REFERENCES

City of Parramatta, 2011 "Parramatta Development Control Plan 2011".

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 No. 65 (SEPP65), 2015, "Apartment Design Guide", NSW Department of Planning and Environment.

APPENDIX A GLARE OVERLAYS FOR THE CRITICAL SIGHT-LINES

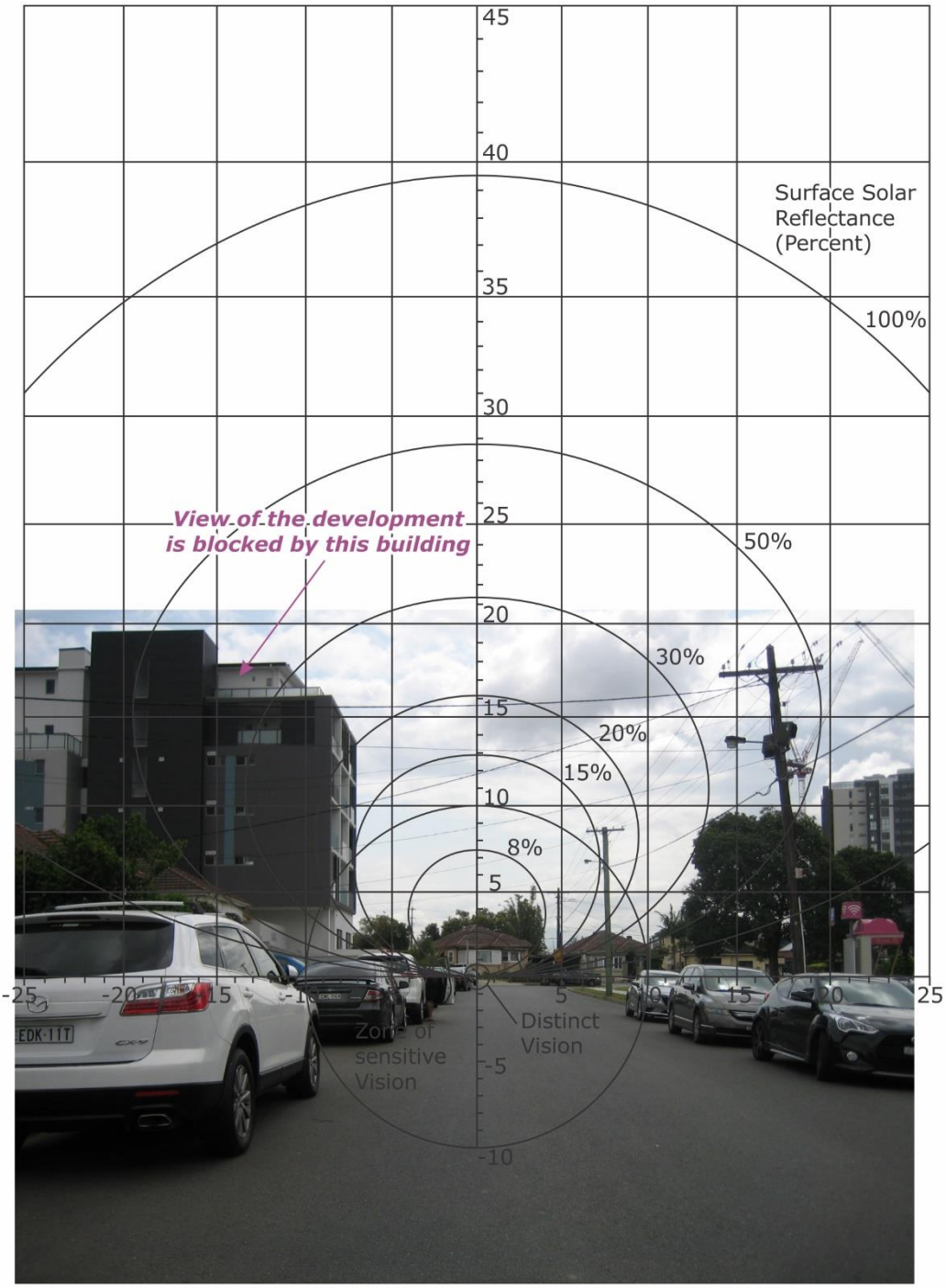

Figure A.1: Glare Overlay of the Viewpoint at Point 01

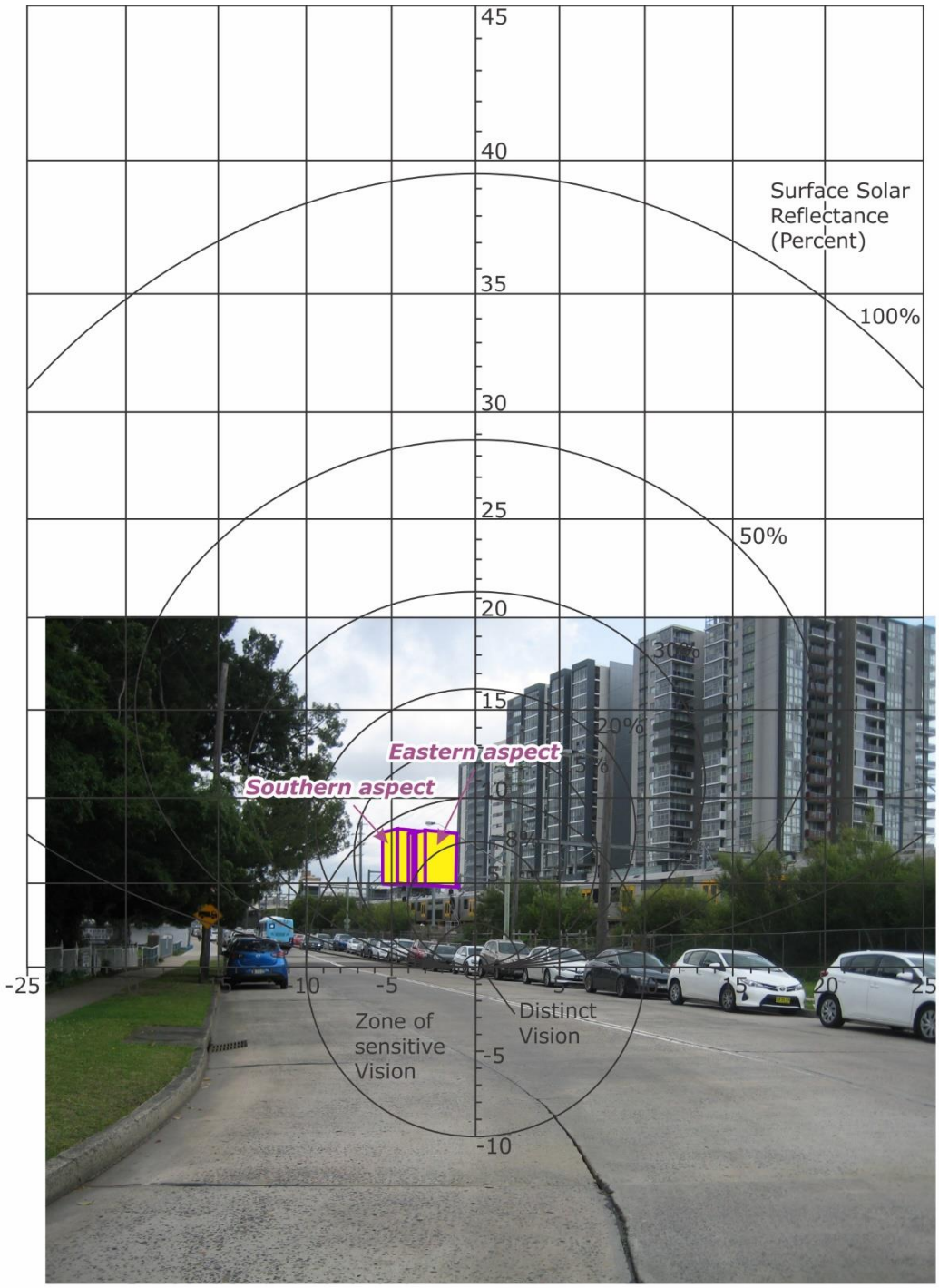

Figure A.2: Glare Overlay of the Viewpoint at Point 02

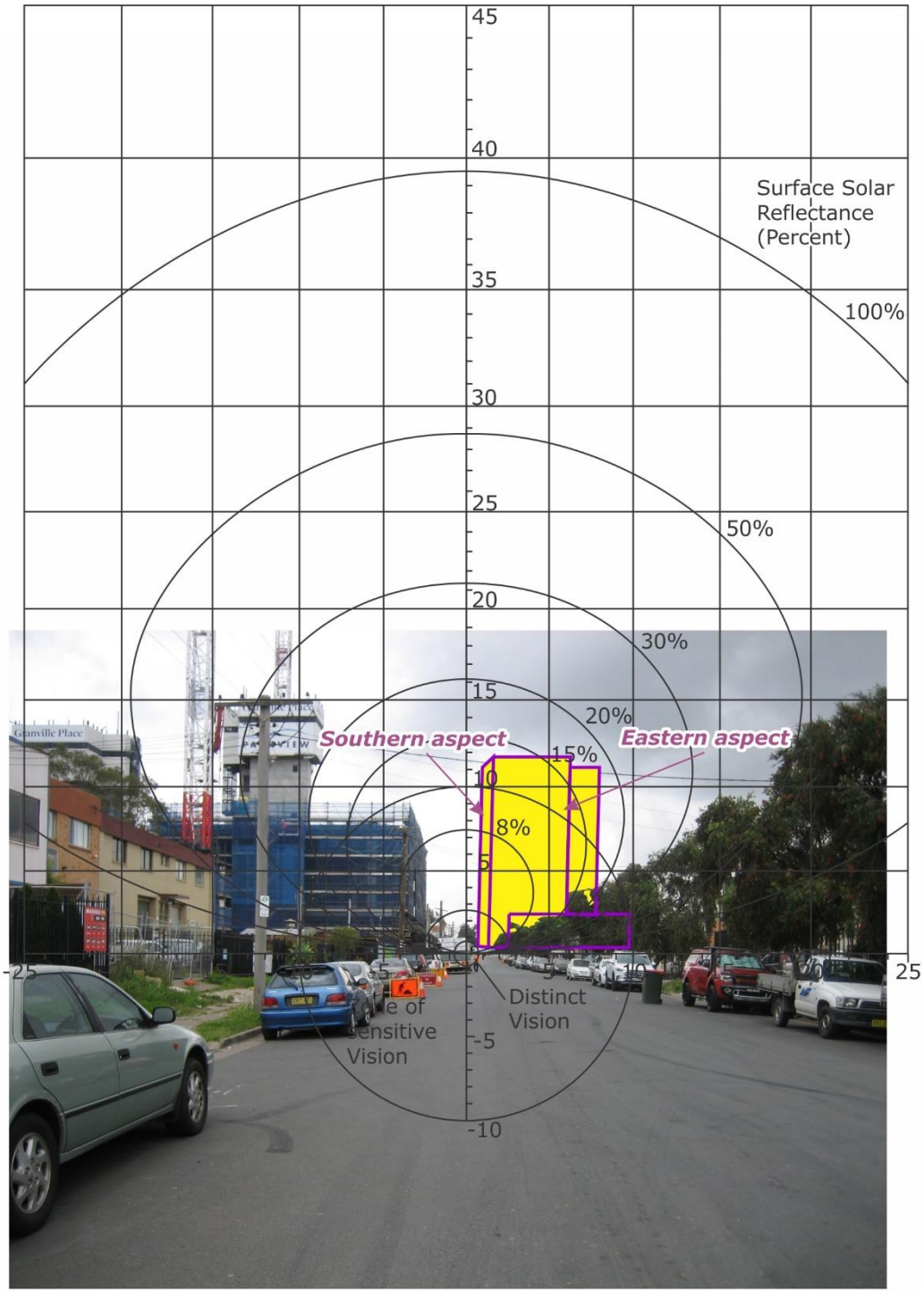

Figure A.3: Glare Overlay of the Viewpoint at Point 03

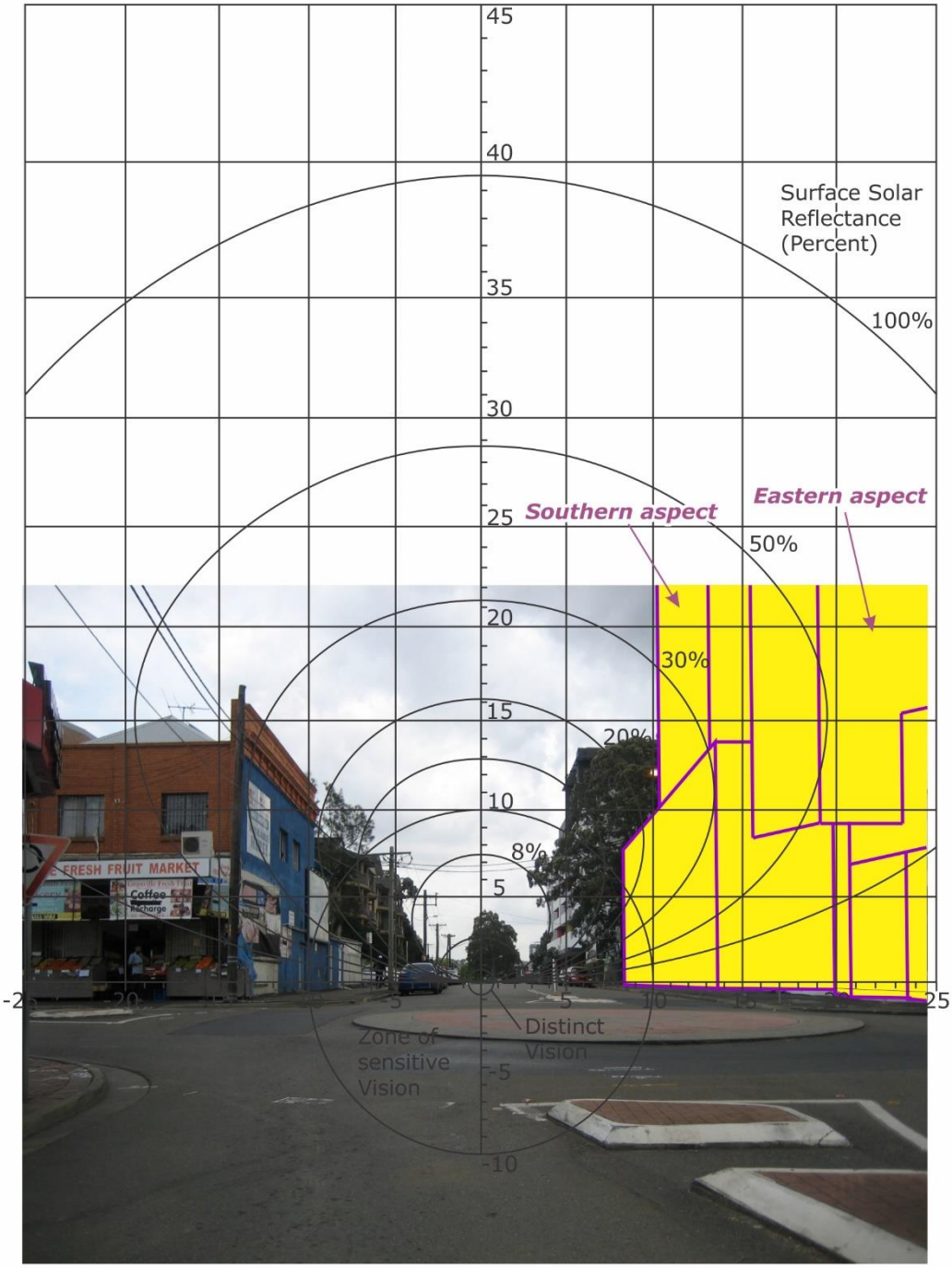

Figure A.4: Glare Overlay of the Viewpoint at Point 04

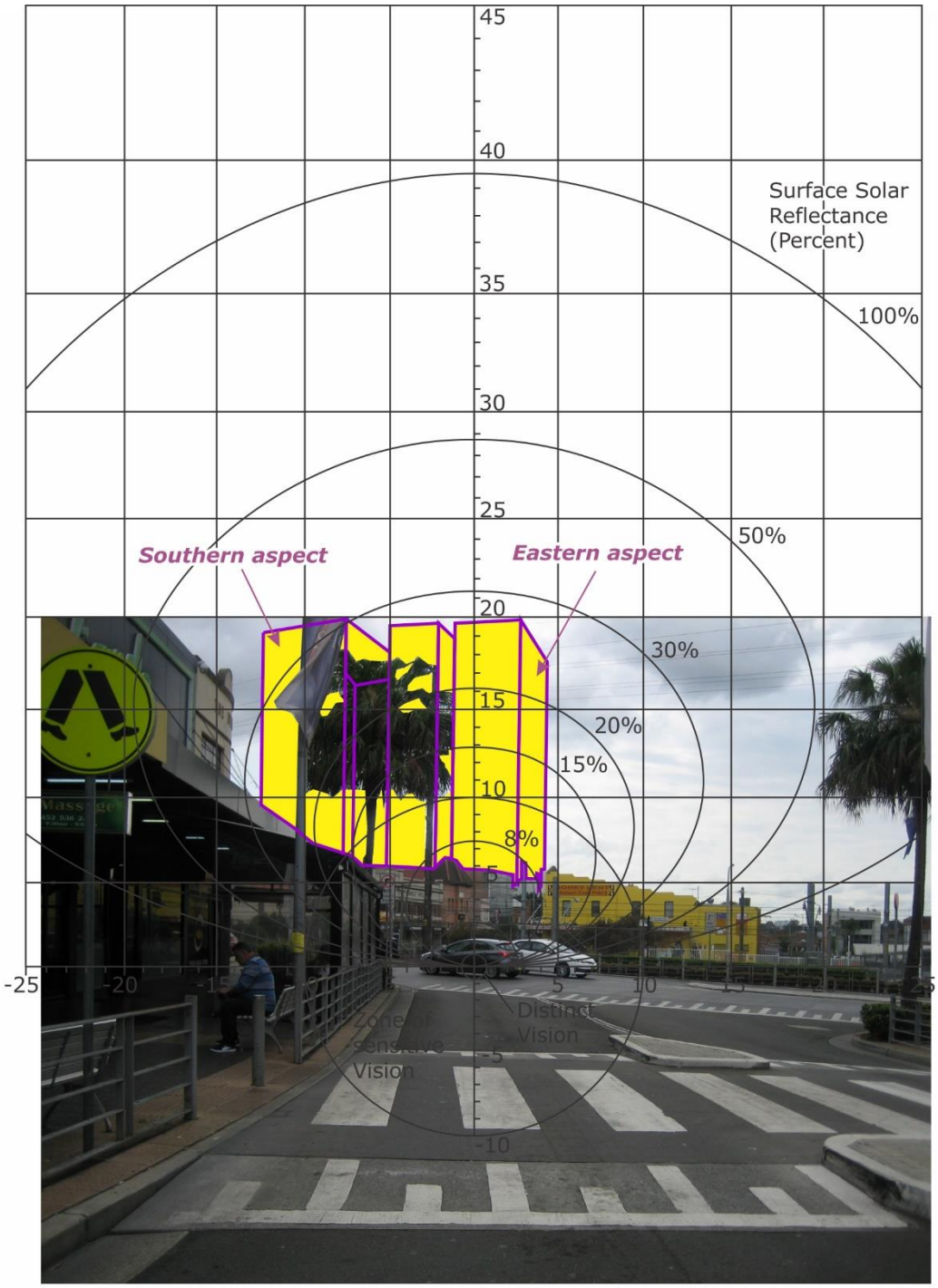

Figure A.5: Glare Overlay of the Viewpoint at Point 05

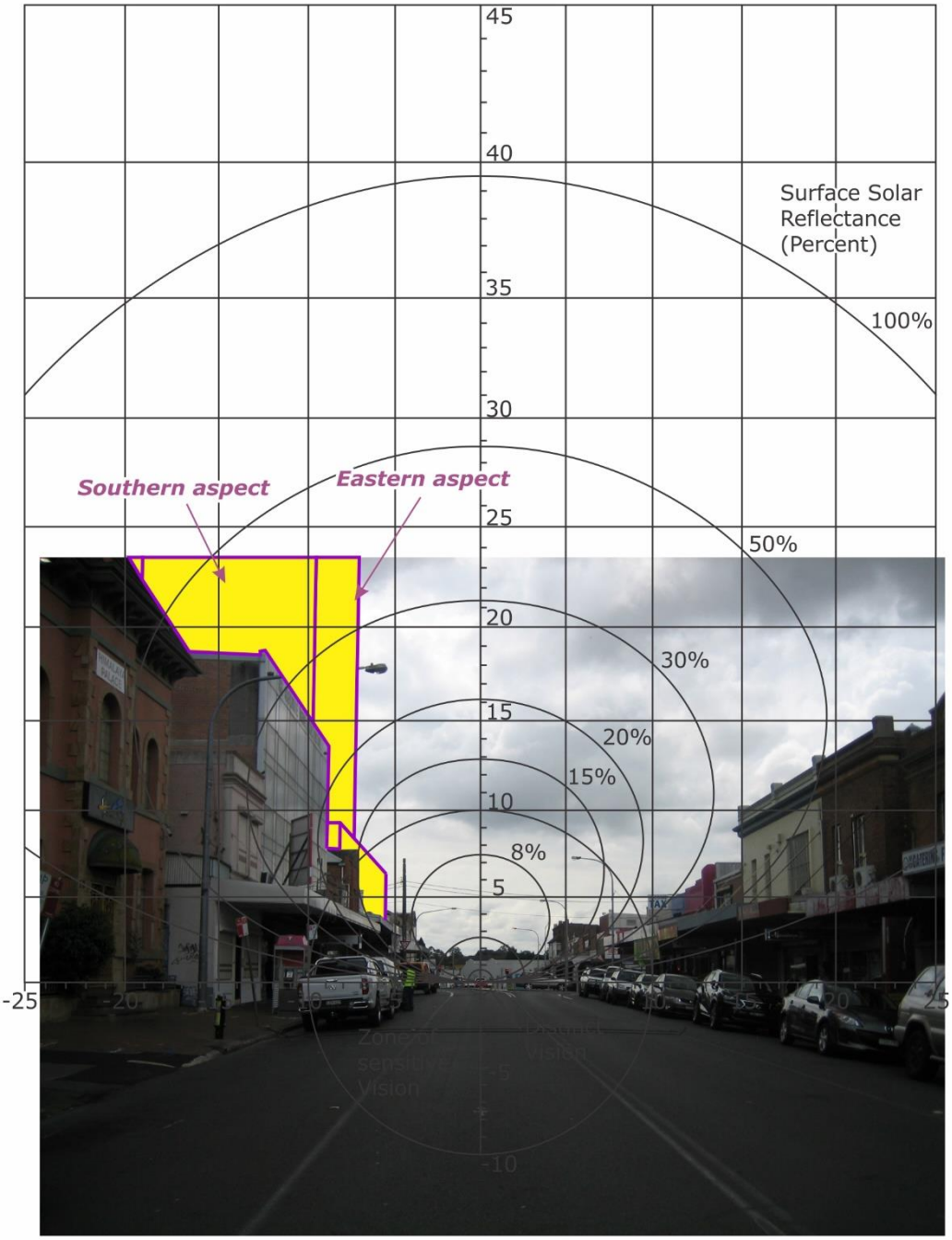

Figure A.6: Glare Overlay of the Viewpoint at Point 06

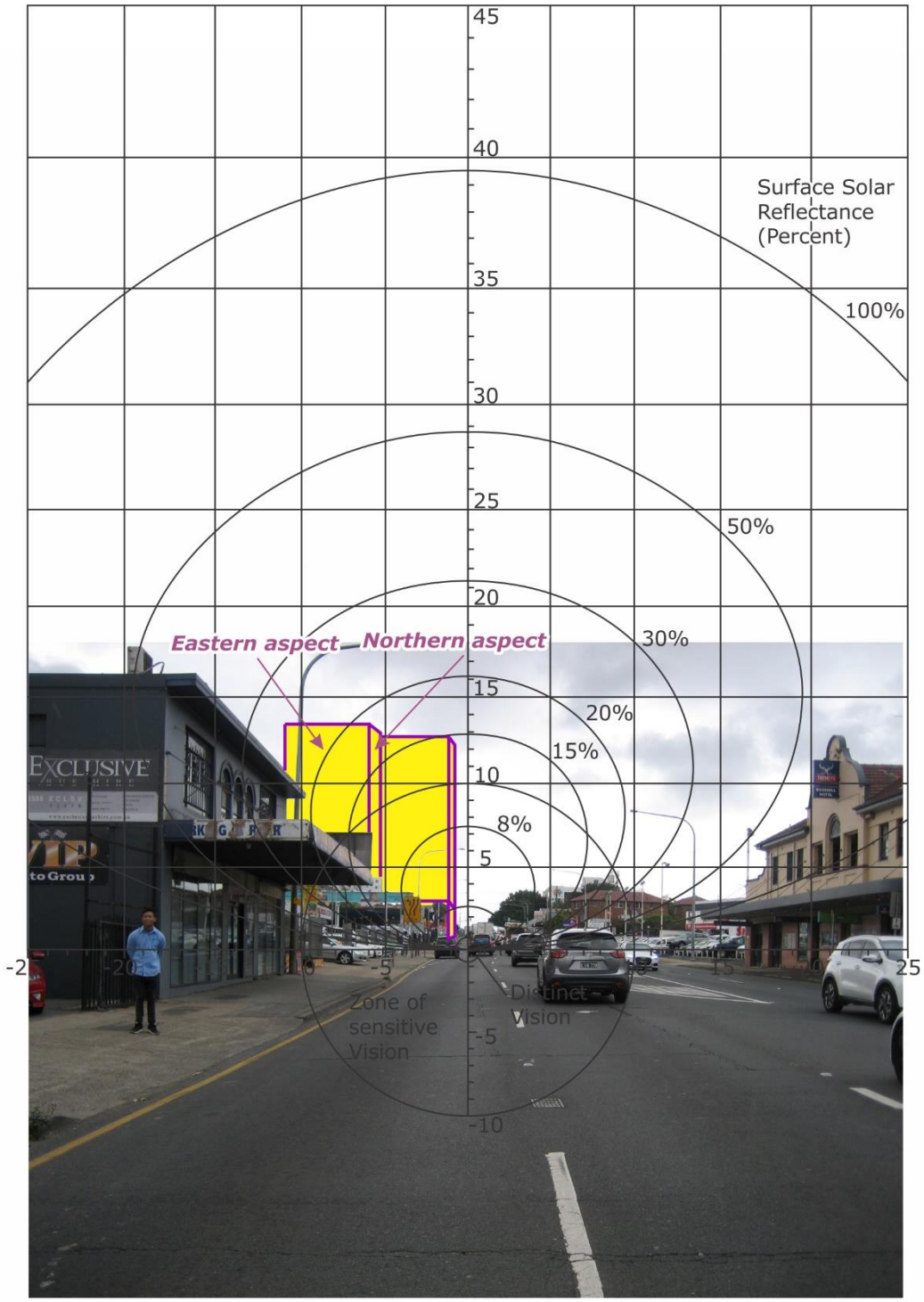

Figure A.7: Glare Overlay of the Viewpoint at Point 07

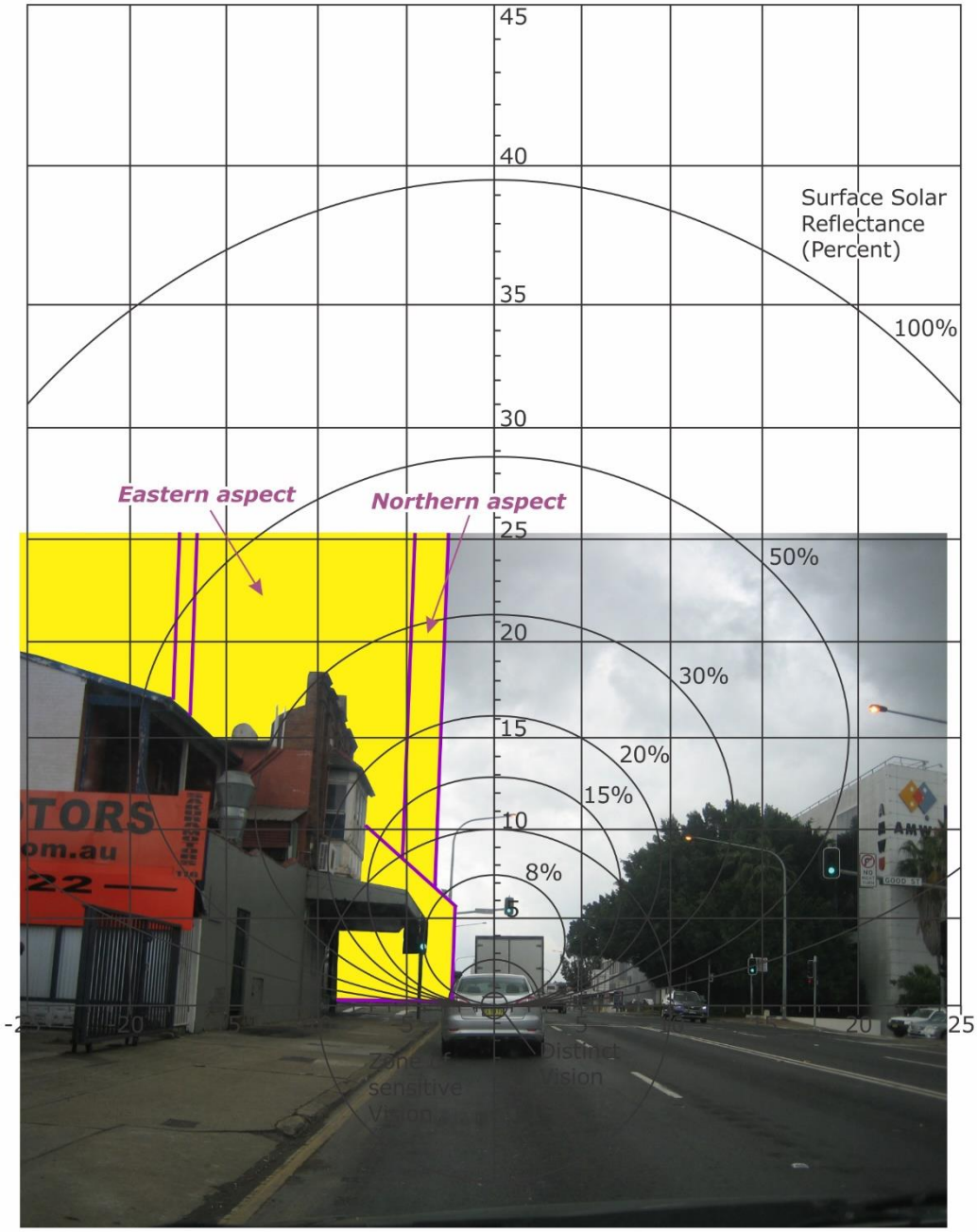

Figure A.8: Glare Overlay of the Viewpoint at Point 08

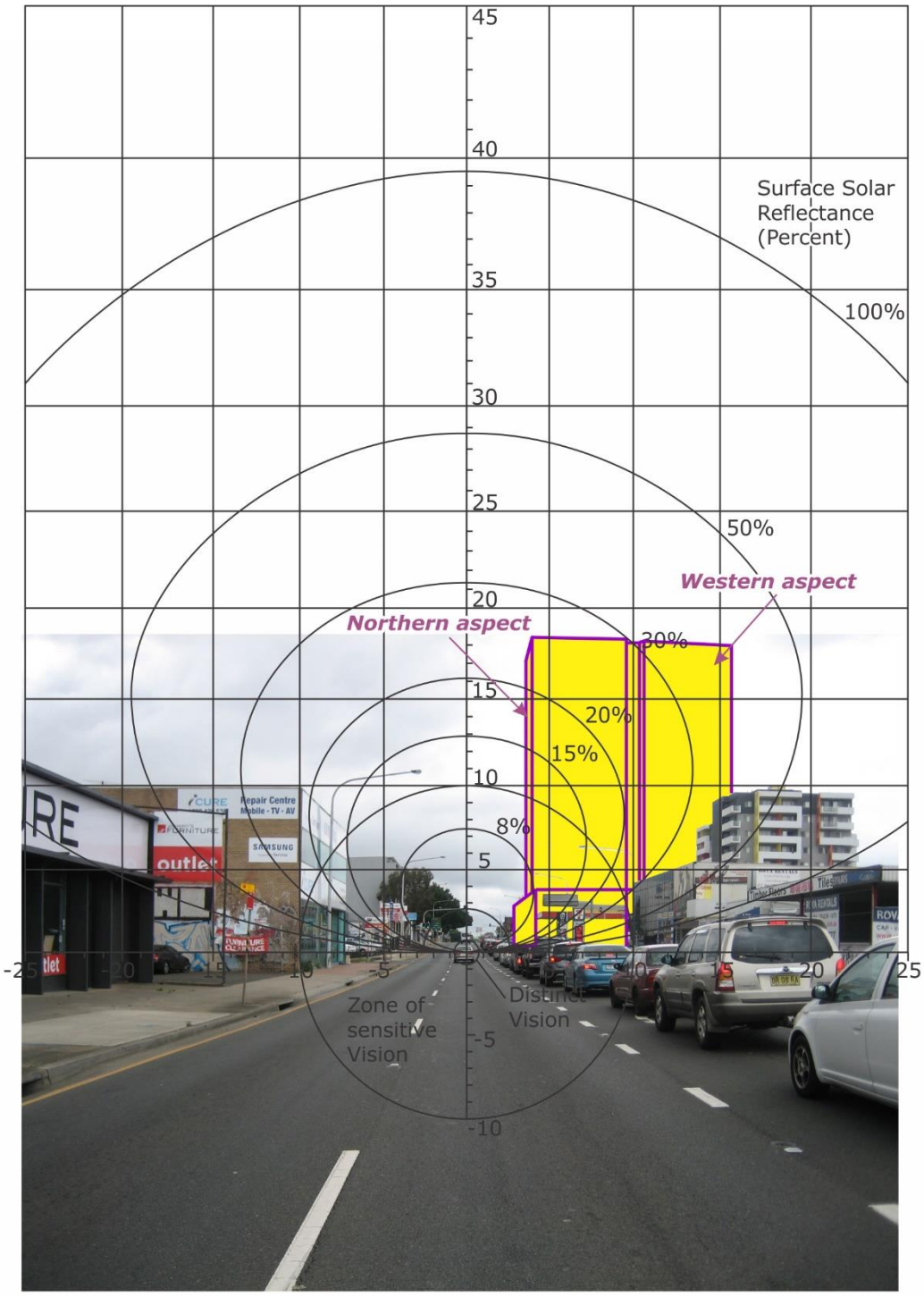

Figure A.9: Glare Overlay of the Viewpoint at Point 09

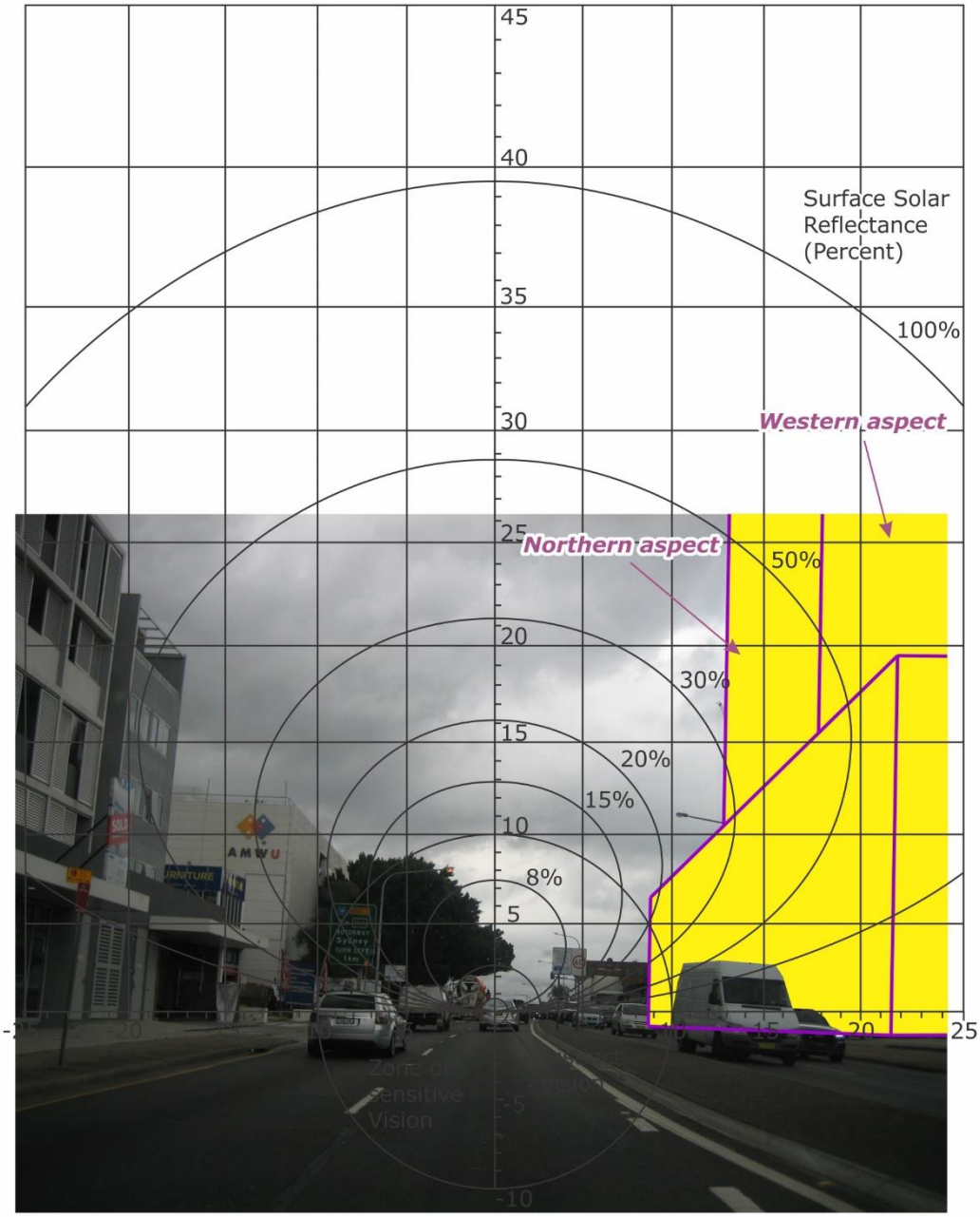

Figure A.10: Glare Overlay of the Viewpoint at Point 10

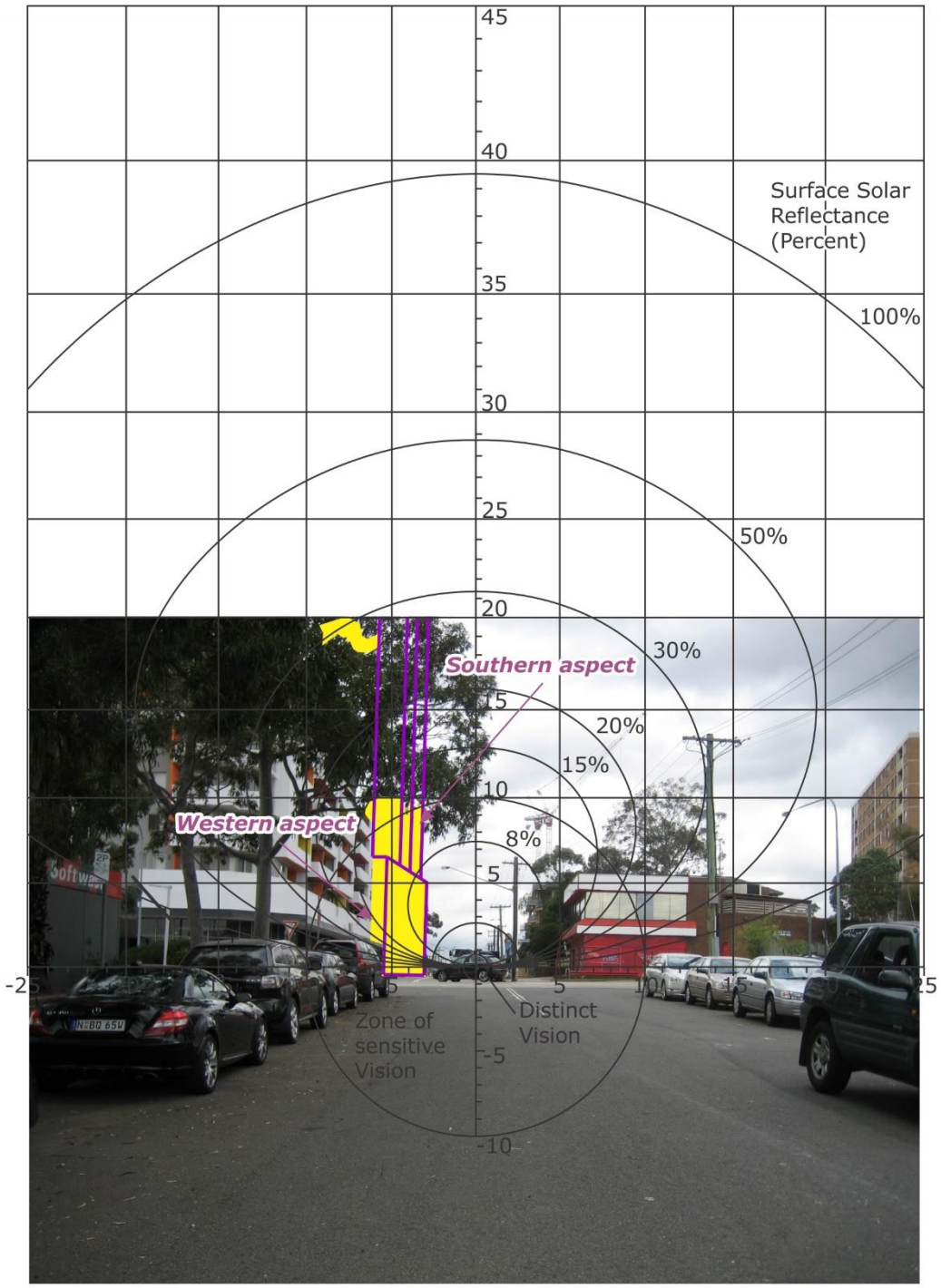

Figure A.11: Glare Overlay of the Viewpoint at Point 11

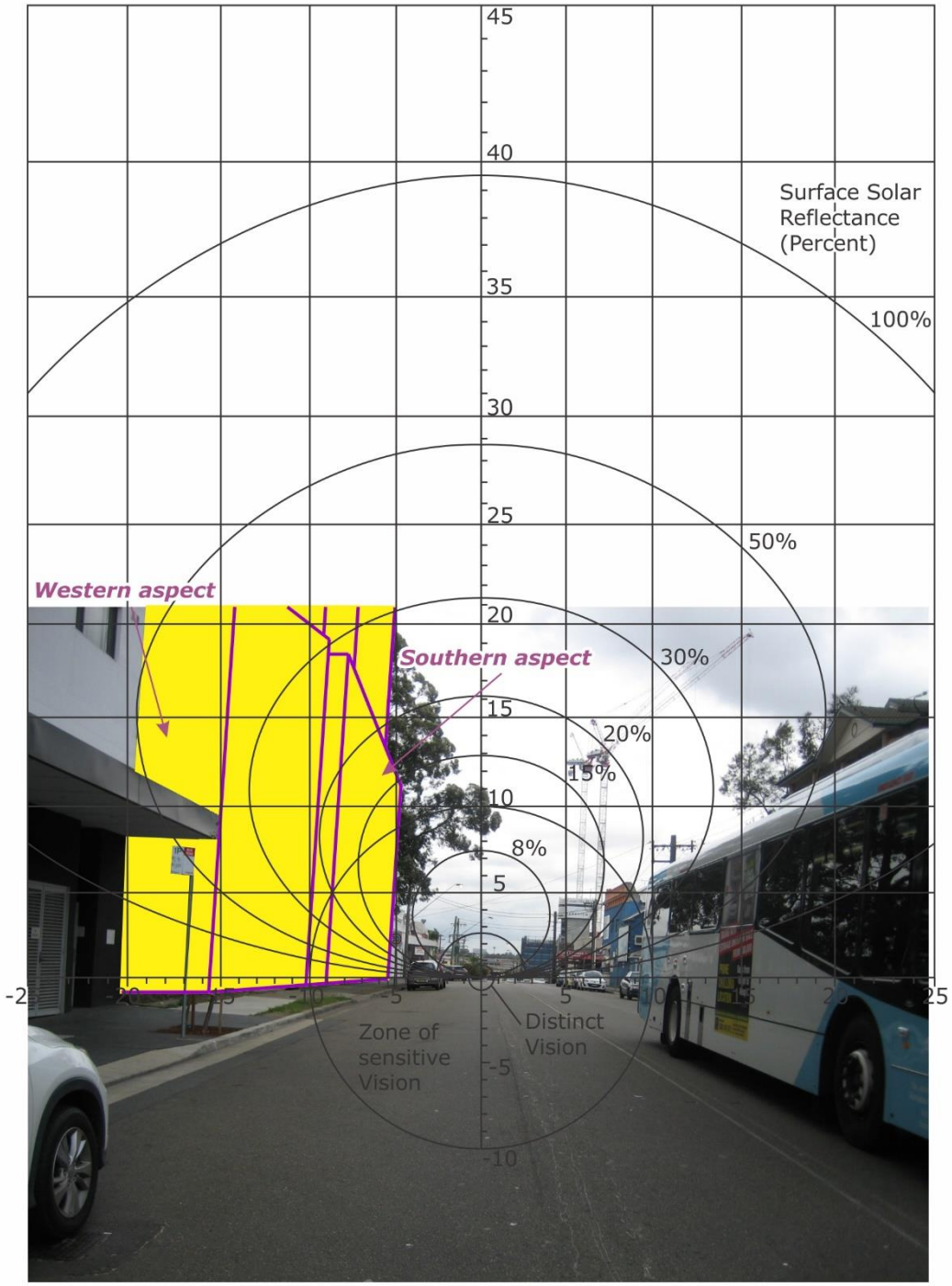

Figure A.12: Glare Overlay of the Viewpoint at Point 12

APPENDIX B SOLAR CHARTS FOR THE VARIOUS CRITICAL ASPECTS

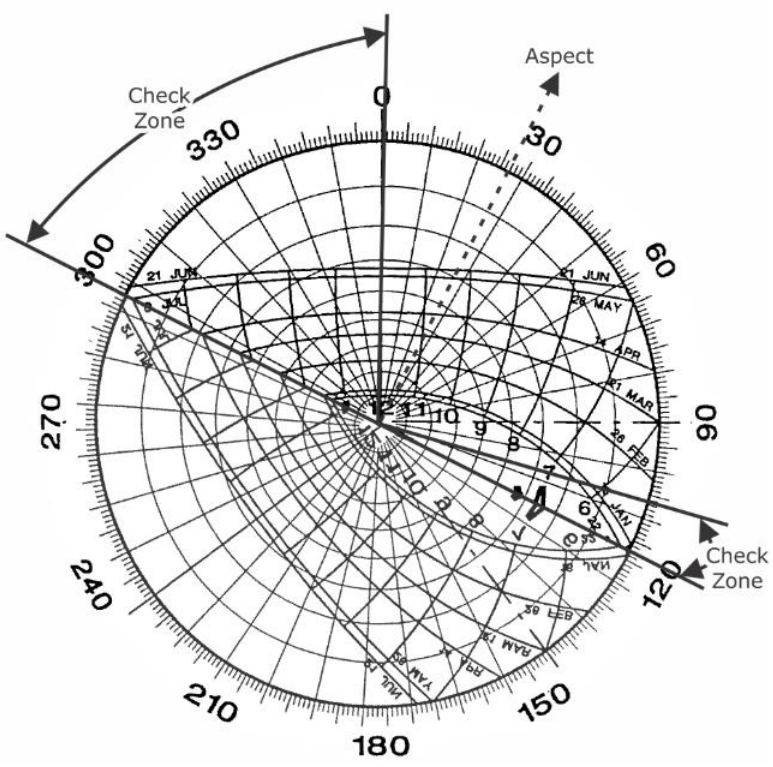

Figure B.1: Sun Chart for the 027° Aspect

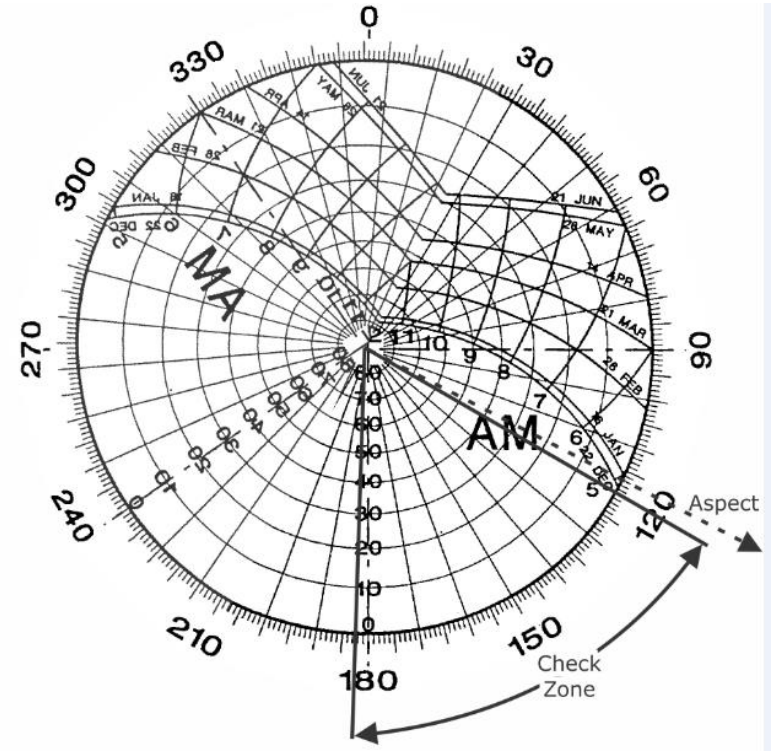

Figure B.2: Sun Chart for the 117° Aspect

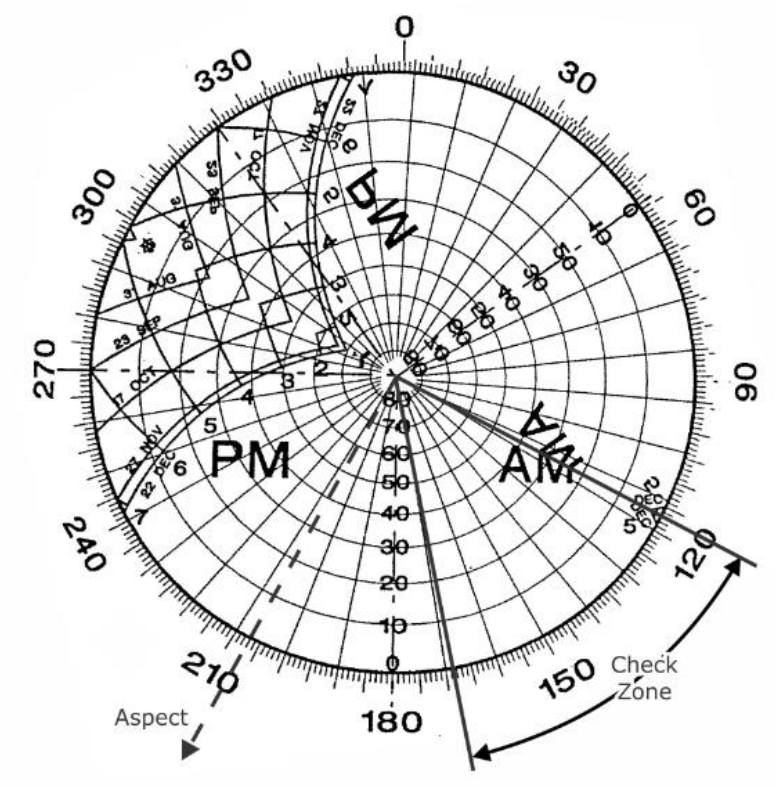

Figure B.3: Sun Chart for the 207° Aspect

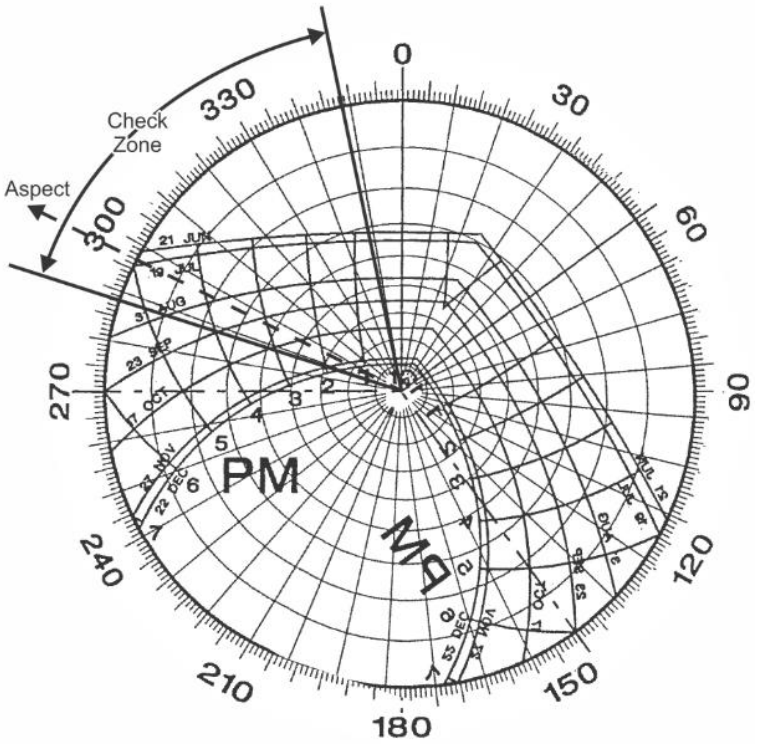

Figure B.4: Sun Chart for the 297° Aspect

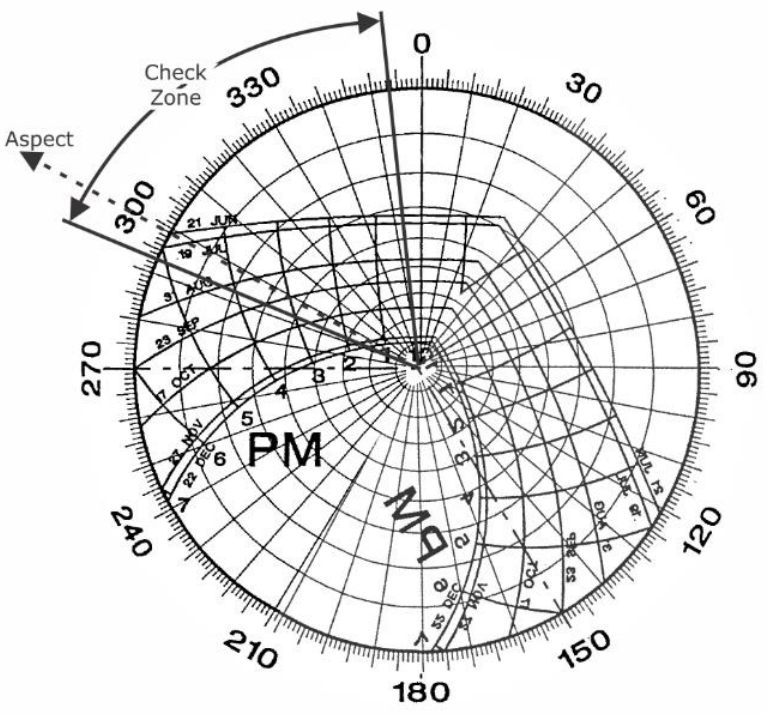

Figure B.5: Sun Chart for the 299° Aspect

APPENDIX C STANDARD SUN CHART FOR THE REGION

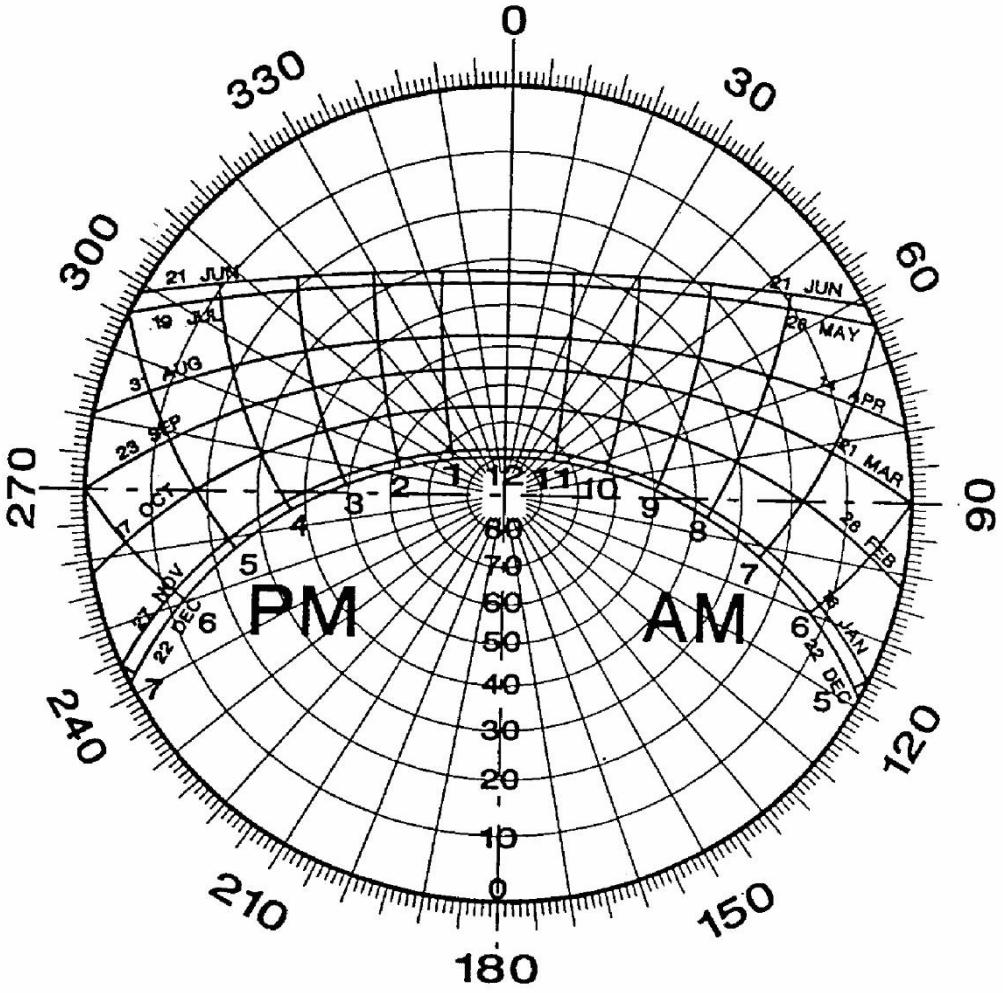

Figure C.1: Standard Sun Chart for the Sydney Region