



SOLAR LIGHT REFLECTIVITY ANALYSIS
1 DENISON STREET, NORTH SYDNEY

WA637-07F02(REV1)- SR REPORT

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Prepared for:

Winten Property Group

Level 10, 61 Lavender Street

Milsons Point, NSW 2061

WINDTECH Consultants Pty Ltd ABN 72 050 574 037

Head Office: 607 Forest Road, Bexley, NSW 2207, Australia

P +61 2 9503 0300 **E** reception@windtech.com.au **W** www.windtechconsult.com

Sydney | Abu Dhabi | London | Melbourne | Mumbai | New York | Shanghai | Singapore

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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 1 Denison Street, North Sydney. The analysis has been undertaken based on the architectural drawings prepared by the project architect Bates Smart, received on October 27, 2016. A comparison is also made with the results of the Solar Light Reflectivity Analysis undertaken for the previously approved DA design (Windtech report reference: WA637-01F03(rev2), dated April 6, 2009).

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 North Sydney Development Control Plan (2013).

A site survey has been undertaken to obtain photographs of the critical sightlines of motorists on the surrounding streets. These photographs are calibrated and are able to be overlaid with a glare meter, which allows the extent, if any, of potential solar glare reflections from the subject development to be determined.

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 is recommended:

- A maximum normal specular reflectance of visible light of 11% for the glazing used on the external façade of the inclined northern aspect for Levels 26 to 34.
- A maximum normal specular reflectance of visible light of 11% for the glazing used on the external façade of the eastern aspect for Levels 22 to 26.
- All other glazing used on the external façade of the development should have a maximum normal specular reflectance of visible light of 20%.

In comparison with the previously approved design scheme, the results of this analysis indicates additional treatments are required in order to mitigate the potential for solar glare. This is a due to the use of the glazed curtain wall façade of the latest design scheme, which is minimally shaded, as well as the inclined northern aspect which has a greater potential for causing solar glare to be observed by motorists. However, as demonstrated by this analysis, adverse glare can be avoided to motorists and pedestrians, and to occupants of neighbouring buildings, with the incorporation of the abovementioned treatments.

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. 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.

With the incorporation of these recommendations, the results of this study indicate that the subject development will not cause adverse solar glare to pedestrians and motorists in the surrounding area, or to occupants of neighbouring buildings, and will comply with the planning controls regarding reflectivity from the North Sydney Development Control Plan (2013).

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1 METHODOLOGY

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 North Sydney Development Control Plan (2013).

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/m² 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. In meeting this criterion for vehicle motorists, conditions will also be satisfactory for pedestrians. The glare impact on occupants of neighbouring buildings is also discussed in this assessment.

The various critical glazed aspects were determined for the development 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 Figures 2a and 2b. Figure 2a displays the check zones based on the glazed façade of the main building tower, whereas Figure 2b shows additional check zones for unique façade aspects on the podium levels. 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 Figures 2a and 2b, 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 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. These are also shown in Figures 2a and 2b. For each of the study point locations, photographs have been taken from the viewpoint of motorists using a calibrated camera. Views from the study point locations are presented in Appendix A of this report. A scaled glare protractor has been superimposed over each photograph.

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/m². 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/m².

If it is found that a section of the subject development will be within the zone of sensitive vision of a motorist at a selected study point location (the central area of the glare protractor), the glare protractor is used to determine what the maximum normal specular reflectance of visible light should be for the glazing or any other reflective material used on that section of the façade of the development to ensure that solar glare will not cause discomfort or threaten the safety of motorists or pedestrians, and hence to allow the subject development to comply with the relevant planning control requirements.

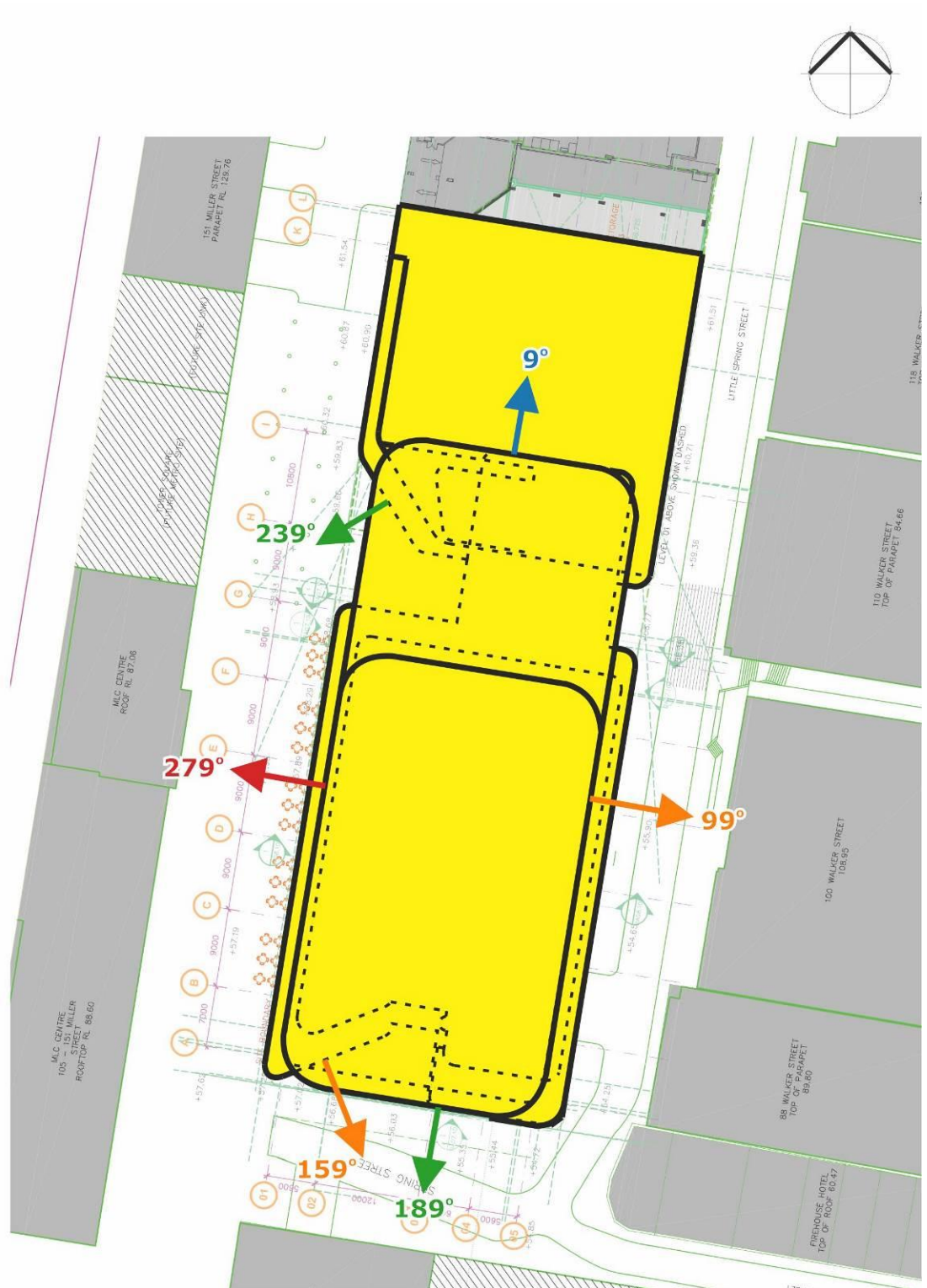
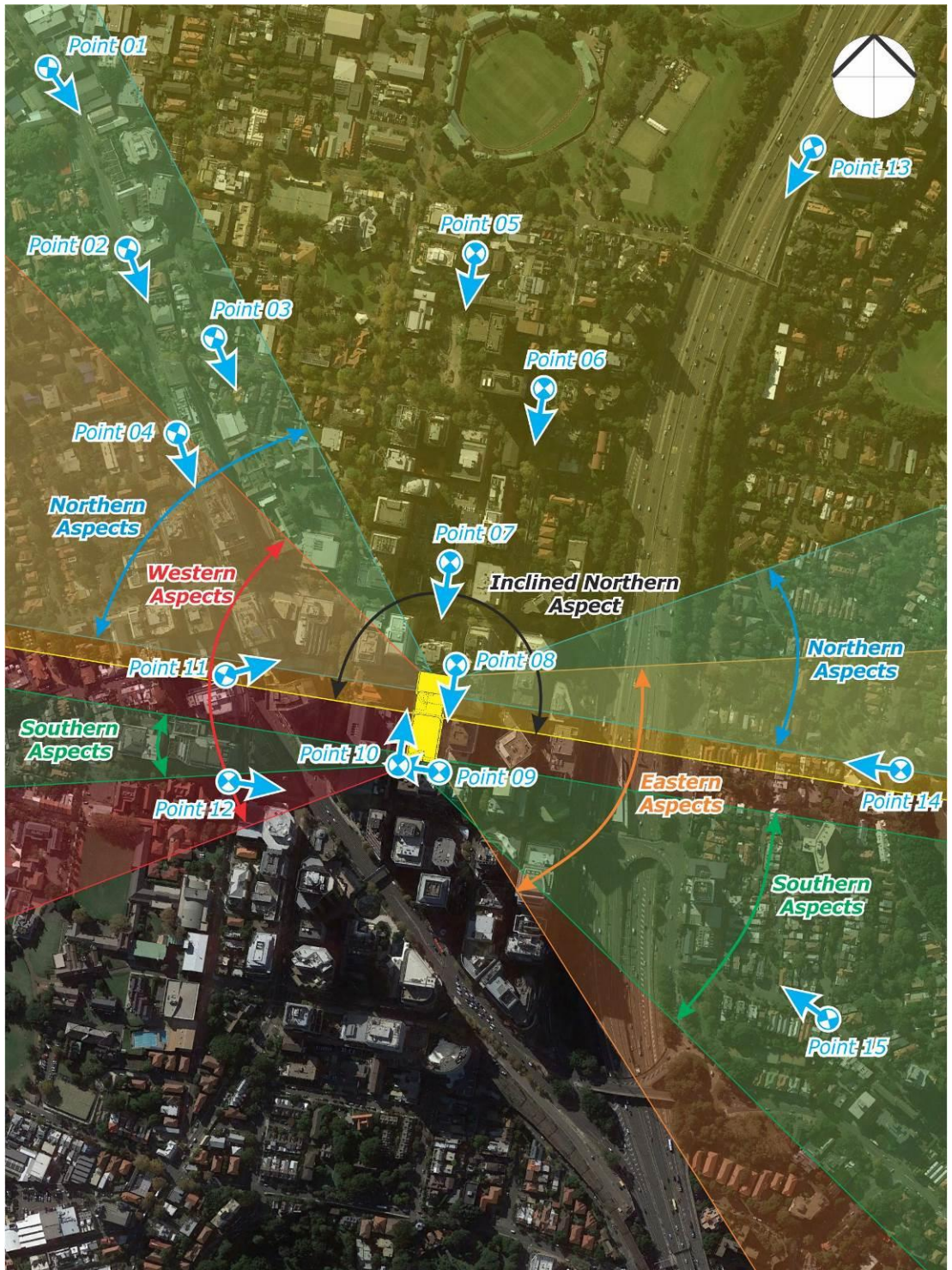


Figure 1: Critical Glazed Aspects of the Development



**Figure 2a: Check Zones and Study Point Locations, for the Tower
Main Building Façade Aspects
(the check zones are the areas where glare could potentially be observed)**



Figure 2b: Check Zones and Study Point Locations
Unique Podium Level Façade Aspects
(the check zones are the areas where glare could potentially be observed)

2 ANALYSIS

2.1 Impact onto Motorists and Pedestrians

From the study of the check zones shown in Figures 2a and 2b, a total of 15 street level locations have been identified for detailed analysis. A summary of the location of each study point, and the aspects of the subject development that could potentially reflect solar glare to each study point location, is shown in Table 1 below. Note that, as mentioned in Section 1, the check zones shown in Figures 2a and 2b, 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 the following sub-sections.

Table 1: Aspects of the Proposed Development potentially reflecting Solar Glare at each Study Point

Study Point	Location	Direction of Travel	Aspect(s) of the Development
1	Pacific Highway near Eden Lane	Southbound	Inclined Northern Aspect and Northern Aspects
2	Pacific Highway near West Street	Southbound	Inclined Northern Aspect and Northern Aspects
3	Church street near McLaren Street	Southbound	Inclined Northern Aspect and Northern Aspects
4	Pacific Highway near Bay Rd	Southbound	Inclined Northern Aspect, Northern Aspects and Western Aspects
5	Elliot Street	Southbound	Inclined Northern Aspect
6	Walker Street near McLaren Street	Southbound	Inclined Northern Aspect
7	Ward Street	Southbound	Inclined Northern Aspect
8	Little Spring Street	Southbound	Inclined Northern Aspect
9	Spring Street	Westbound	Southern Aspects
10	Denison Street	Northbound	Southern Podium Aspects and Western Aspects
11	Charles Street	Eastbound	Inclined Northern Aspect and Western Aspects
12	Mount Street	Eastbound	Western Aspects
13	Warringah Freeway	Southbound	Inclined Northern Aspect
14	Kurraba Road	Westbound	Inclined Northern Aspect and Eastern Aspects
15	Whaling Road	Westbound	Southern Aspects and Eastern Aspects

2.1.1 Drivers heading south along Pacific Highway

Points 1, 2 and 4 are located along Pacific Highway, to the north-west of the development site. These points represent the critical sightlines of drivers heading south along Pacific Highway at these locations. A site survey of these points has been undertaken, and photographs showing the viewpoints of drivers at these locations were obtained using a calibrated camera. Each photograph has been scaled to enable the glare meter to be overlaid onto these images, as shown in Figure A1, A2 and A4 in Appendix A.

An analysis of the glare meter overlaid onto the viewpoints at Points 1 and 2 indicates that the proposed development will not be visible within the zone of sensitive vision of motorists at these locations. An analysis of the viewpoint at Point 4 indicates that the subject development will not be visible at this location. Hence, there will be no adverse solar glare observed by motorists or pedestrians heading south along Pacific Highway.

2.1.2 Drivers heading south along Church Street

Point 3 is located along Church Street, to the north-west of the development site. This point represents the critical sightlines of drivers heading south along Church Street at this location. A site survey of this point has been undertaken, and a photograph showing the viewpoint of drivers at this location was obtained using a calibrated camera. The photograph has been scaled to enable the glare meter to be overlaid onto the image, as shown in Figure A3 of Appendix A.

An analysis of the glare meter overlaid onto the viewpoint at Point 3 indicates that the proposed development will not be visible within the zone of sensitive vision of motorists at this location. Hence, there will be no adverse solar glare observed by motorists or pedestrians heading south along Church Street.

2.1.3 Drivers heading south along Elliot Street

Point 5 is located along Elliot Street, to the north of the development site. This point represents the critical sightlines of drivers heading south along Elliot Street at this location. A site survey of this point has been undertaken, and a photograph showing the viewpoint of drivers at this location was obtained using a calibrated camera. The photograph has been scaled to enable the glare meter to be overlaid onto the image, as shown in Figure A5 of Appendix A.

An analysis of the viewpoint at Point 5 indicates that the subject development will not be visible at this location. Hence, there will be no adverse solar glare observed by motorists or pedestrians heading south along Elliot Street.

2.1.4 Drivers heading south along Walker Street near McLaren Street

Point 6 is located along Walker Street, to the north of the development site. This point represents the critical sightlines of drivers heading south along Walker Street at this location. A site survey of this point has been undertaken, and a photograph showing the viewpoint of drivers at this location was obtained using a calibrated camera. The photograph has been scaled to enable the glare meter to be overlaid onto the image, as shown in Figure A6 of Appendix A.

An analysis of the viewpoint at Point 6 indicates that the subject development will not be visible at this location. Hence, there will be no adverse solar glare observed by motorists or pedestrians heading south along Walker Street.

2.1.5 Drivers heading south along Ward Street

Point 7 is located along Ward Street, to the north of the development site. This point represents the critical sightlines of drivers heading south along Ward Street at this location. A site survey of this point has been undertaken, and a photograph showing the viewpoint of drivers at this location was obtained using a calibrated camera. The photograph has been scaled to enable the glare meter to be overlaid onto the image, as shown in Figure A7 of Appendix A.

An analysis of the viewpoint at Point 7 indicates that the subject development will not be visible at this location. Hence, there will be no adverse solar glare observed by motorists or pedestrians heading south along Ward Street.

2.1.6 Drivers heading south along Little Spring Street

Point 8 is located along Little Spring Street, immediately east of the development site. This point represents the critical sightlines of drivers heading south along Little Spring Street at this location. A site survey of this point has been undertaken, and a photograph showing the viewpoint of drivers at this location was obtained using a calibrated camera. The photograph has been scaled to enable the glare meter to be overlaid onto the image, as shown in Figure A8 of Appendix A.

An analysis of the glare meter overlaid onto the viewpoint at Point 8 indicates that the eastern aspect of the subject development is visible and is partly within the zone of sensitive vision of motorists. However, Point 8 lies outside of the check zone for this portion of the eastern façade. Hence, there will be no adverse solar glare observed by motorists or pedestrians heading south along Ward Street.

2.1.7 Drivers heading west along Spring Street

Point 9 is located along Spring Street, immediately south of the development site. This point represents the critical sightlines of drivers heading west along Spring Street at this location. A site survey of this point has been undertaken, and a photograph showing the viewpoint of drivers at this location was obtained using a calibrated camera. The photograph has been scaled to enable the glare meter to be overlaid onto the image, as shown in Figure A9 of Appendix A.

An analysis of the glare meter overlaid onto the viewpoint at Point 9 indicates that the proposed development will be not be visible within the zone of sensitive vision of motorists at this location. Hence, there will be no adverse solar glare observed by motorists or pedestrians heading west along Spring Street.

2.1.8 Drivers heading north along Denison Street

Point 10 is located along Denison Street, to the immediate west of the development site. This point represents the critical sightlines of drivers heading north along Denison Street at this location. A site survey of this point has been undertaken, and a photograph showing the viewpoint of drivers at this location was obtained using a calibrated camera. The photograph has been scaled to enable the glare meter to be overlaid onto the image, as shown in Figure A10 of Appendix A.

An analysis of the glare meter overlaid onto the viewpoint at Point 10 indicates that the western aspect of the subject development is visible and partly within the zone of sensitive vision of motorists. Similarly, the 239° aspect within the podium may also be partially visible within the zone of sensitive vision of motorists.

However, as the visible portion of the western façade is the northern portion of the western façade, it is expected that Point 10 would be outside of the effective check zone of this visible area. Similarly, while likely only marginally visible from the viewpoint of Point 10, the 239° aspect within the podium is expected to be shaded by neighbouring buildings at the time when the sun's position in the sky has potential to create solar glare off this critical façade aspect. Hence, there will be no adverse solar glare observed by motorists or pedestrians heading north along Denison Street.

2.1.9 Drivers heading east along Charles Street

Point 11 is located along Charles Street, to the west of the development site. This point represents the critical sightlines of drivers heading east along Charles Street at this location. A site survey of this point has been undertaken, and a photograph showing the viewpoint of drivers at this location was obtained using a calibrated camera. The photograph has been

scaled to enable the glare meter to be overlaid onto the image, as shown in Figure A11 of Appendix A.

An analysis of the viewpoint at Point 11 indicates that the subject development will not be visible at this location. Hence, there will be no adverse solar glare observed by motorists or pedestrians heading east along Charles Street.

2.1.10 Drivers heading east along Mount Street

Point 12 is located along Mount Street, to the west of the development site. This point represents the critical sightlines of drivers heading east along Mount Street at this location. A site survey of this point has been undertaken, and a photograph showing the viewpoint of drivers at this location was obtained using a calibrated camera. The photograph has been scaled to enable the glare meter to be overlaid onto the image, as shown in Figure A12 of Appendix A.

An analysis of the viewpoint at Point 12 indicates that the subject development will not be visible at this location. Hence, there will be no adverse solar glare observed by motorists or pedestrians heading east along Mount Street.

2.1.11 Drivers heading south along Warringah Freeway

Point 13 is located along Warringah Freeway, to the north-east of the development site. This point represents the critical sightlines of drivers heading south along Warringah Freeway at this location. A site survey of this point has been undertaken, and a photograph showing the viewpoint of drivers at this location was obtained using a calibrated camera. The photograph has been scaled to enable the glare meter to be overlaid onto the image, as shown in Figure A13 of Appendix A.

An analysis of the glare meter overlaid onto the viewpoint at Point 13 indicates that the inclined northern aspect and eastern aspect of the proposed development are visible and within the zone of sensitive vision of motorists. Point 13 lies outside of the check zone of the eastern aspects, and hence there will be no adverse glare observed reflecting of the eastern façade at this location. However, Point 13 is situated within the check zone for the inclined northern aspect, and Levels 26 to 34 of this aspect of the proposed development are within the zone of sensitive vision for motorists. As such, in order to mitigate adverse solar glare from the inclined northern aspect of the development being observed at Point 13, it is recommended that the normal specular reflectance of visible light for the glazing used on the external façade between Levels 26 to 34 should be a maximum of 11%.

2.1.12 Drivers heading west along Kurraba Road

Point 14 is located along Kurraba Road, to the east of the development site. This point represents the critical sightlines of drivers heading west along Kurraba Road at this location. A site survey of this point has been undertaken, and a photograph showing the viewpoint of drivers at this location was obtained using a calibrated camera. The photograph has been scaled to enable the glare meter to be overlaid onto the image, as shown in Figure A14 of Appendix A.

An analysis of the glare meter overlaid onto the viewpoint at Point 14 indicates that the proposed development will not be visible within the zone of sensitive vision of motorists at this location. Hence, there will be no adverse solar glare observed by motorists or pedestrians heading west along Kurraba Road.

2.1.13 Drivers heading west along Whaling Road

Point 15 is located along Whaling Road, to the east of the development site. This point represents the critical sightlines of drivers heading west along Whaling Road at this location. A site survey of this point has been undertaken, and a photograph showing the viewpoint of drivers at this location was obtained using a calibrated camera. The photograph has been scaled to enable the glare meter to be overlaid onto the image, as shown in Figure A15 of Appendix A.

An analysis of the glare meter overlaid onto the viewpoint at Point 15 indicates that the southern and eastern aspects will be visible, with a portion of the eastern aspect within the zone of sensitive vision of motorists at this location. As the angle that this portion of the façade subtends is greater than 0.5° , solar glare can be observed from Levels 22 to 26 of the eastern aspect of the development at this location. To mitigate adverse solar glare from this portion of the façade, it is recommended that the normal specular reflectance of visible light for the glazing used on the external façade at these levels should be a maximum of 11%.

2.2 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 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 occupants of neighbouring buildings.

2.3 Typical Normal Specular Reflectivity from 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.

2.3.1 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%

2.3.2 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.

3 CONCLUSION

An analysis has been undertaken to assess the potential for solar glare from the proposed development located at 1 Denison Street, North Sydney. The analysis has been undertaken based on the architectural drawings prepared by the project architect Bates Smart, received on October 27, 2016. A comparison is also made with the results of the Solar Light Reflectivity Analysis undertaken for the previously approved DA design (Windtech report reference: WA637-01F03(rev2), dated April 6, 2009).

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 North Sydney Development Control Plan (2013).

A site survey has been undertaken to obtain photographs of the critical sightlines of motorists on the surrounding streets. These photographs are calibrated and are able to be overlaid with a glare meter, which allows the extent, if any, of potential solar glare reflections from the subject development to be determined.

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 is recommended:

- A maximum normal specular reflectance of visible light of 11% for the glazing used on the external façade of the inclined northern aspect for Levels 26 to 34.
- A maximum normal specular reflectance of visible light of 11% for the glazing used on the external façade of the eastern aspect for Levels 22 to 26.
- All other glazing used on the external façade of the development should have a maximum normal specular reflectance of visible light of 20%.

In comparison with the previously approved design scheme, the results of this analysis indicates additional treatments are required in order to mitigate the potential for solar glare. This is a due to the use of the glazed curtain wall façade of the latest design scheme, which is minimally shaded, as well as the inclined northern aspect which has a greater potential for causing solar glare to be observed by motorists. However, as demonstrated by this analysis, adverse glare can be avoided to motorists and pedestrians, and to occupants of neighbouring buildings, with the incorporation of the abovementioned treatments.

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. 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.

With the incorporation of these recommendations, the results of this study indicate that the subject development will not cause adverse solar glare to pedestrians and motorists in the surrounding area, or to occupants of neighbouring buildings, and will comply with the planning controls regarding reflectivity from the North Sydney Development Control Plan (2013).

REFERENCES

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.

North Sydney Council, 2013, "North Sydney Development Control Plan 2013"

APPENDIX A - GLARE OVERLAYS FOR THE CRITICAL SIGHT-LINES

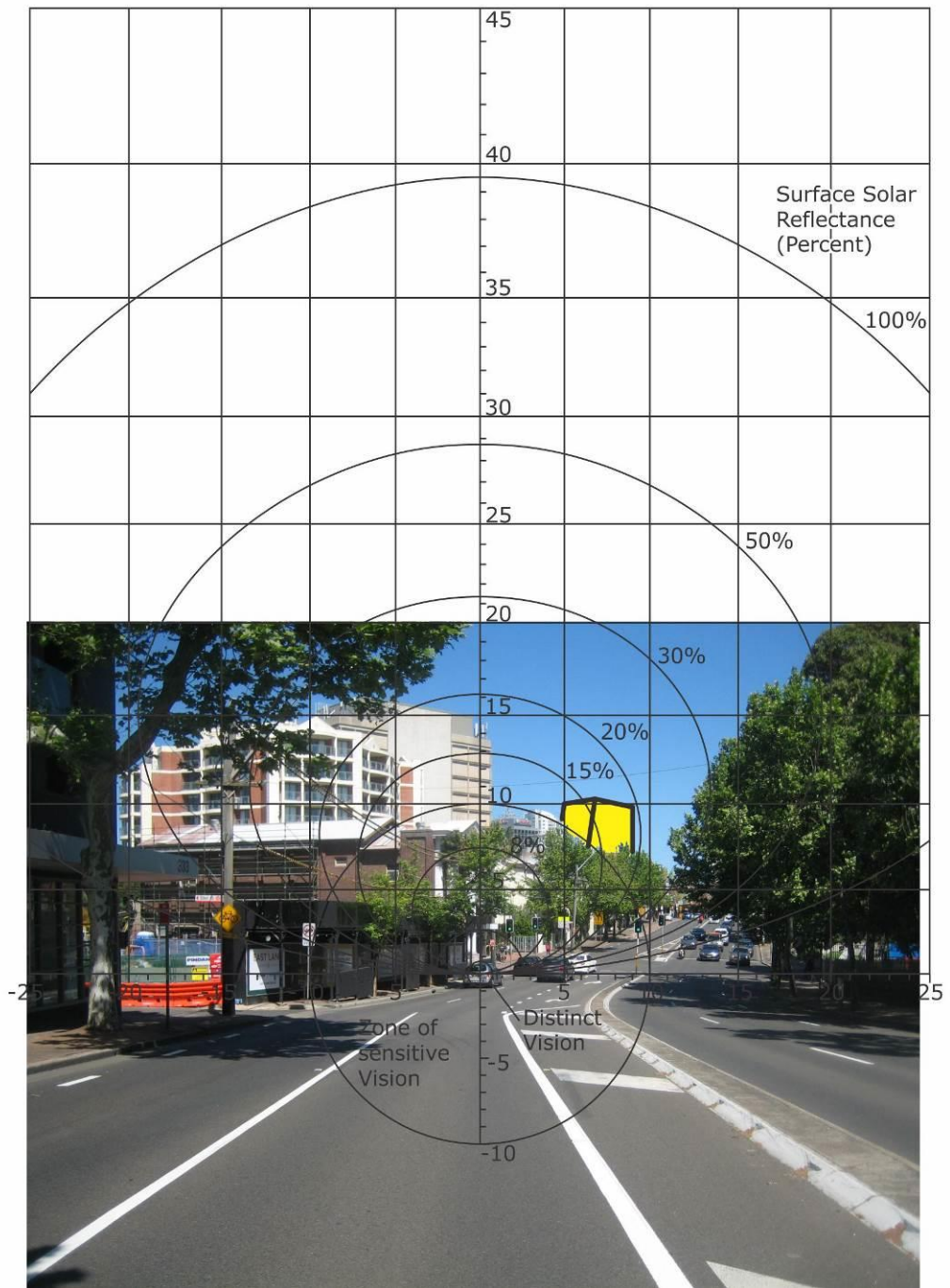


Figure A1: Glare Overlay for Point 1

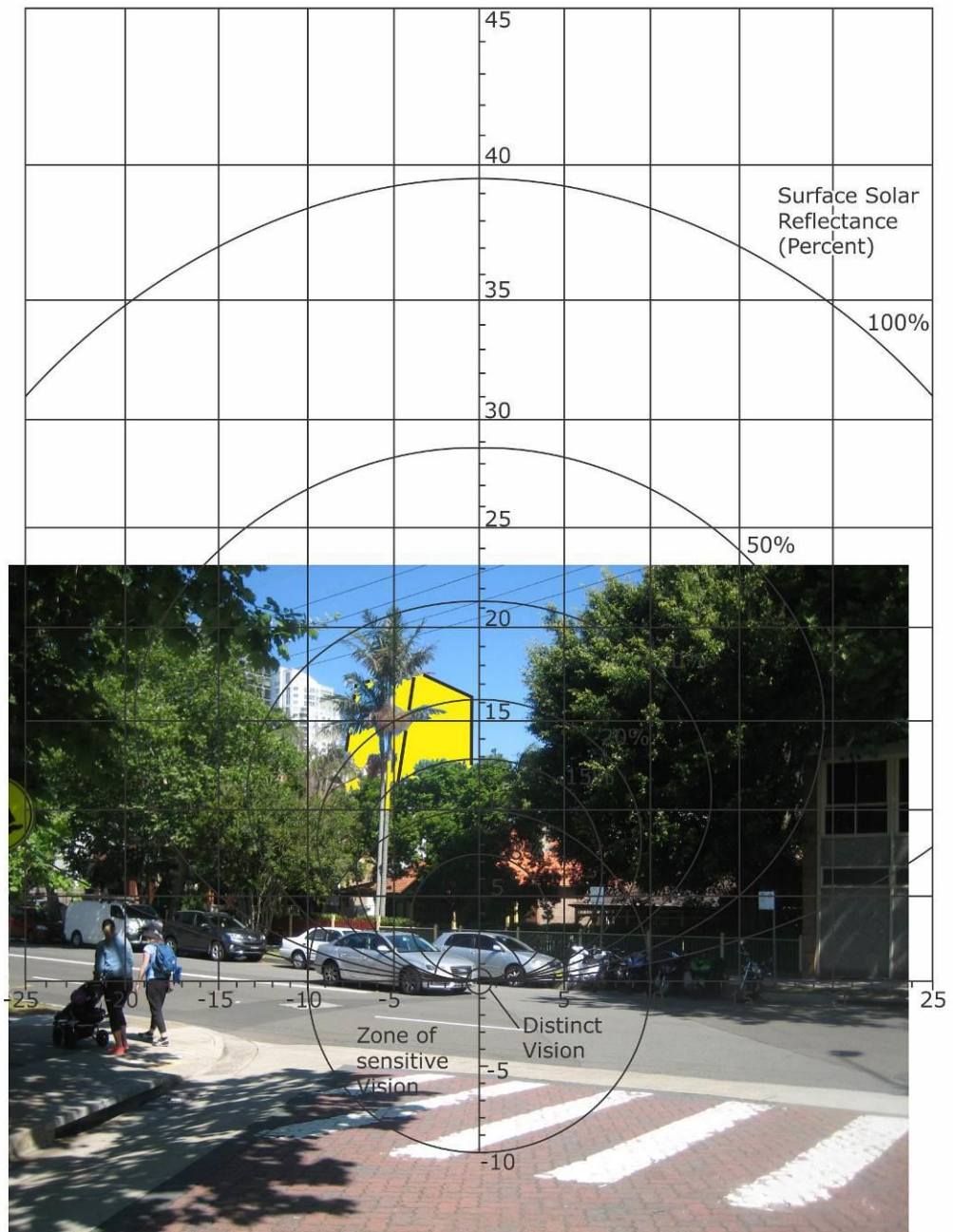


Figure A3: Glare Overlay for Point 3

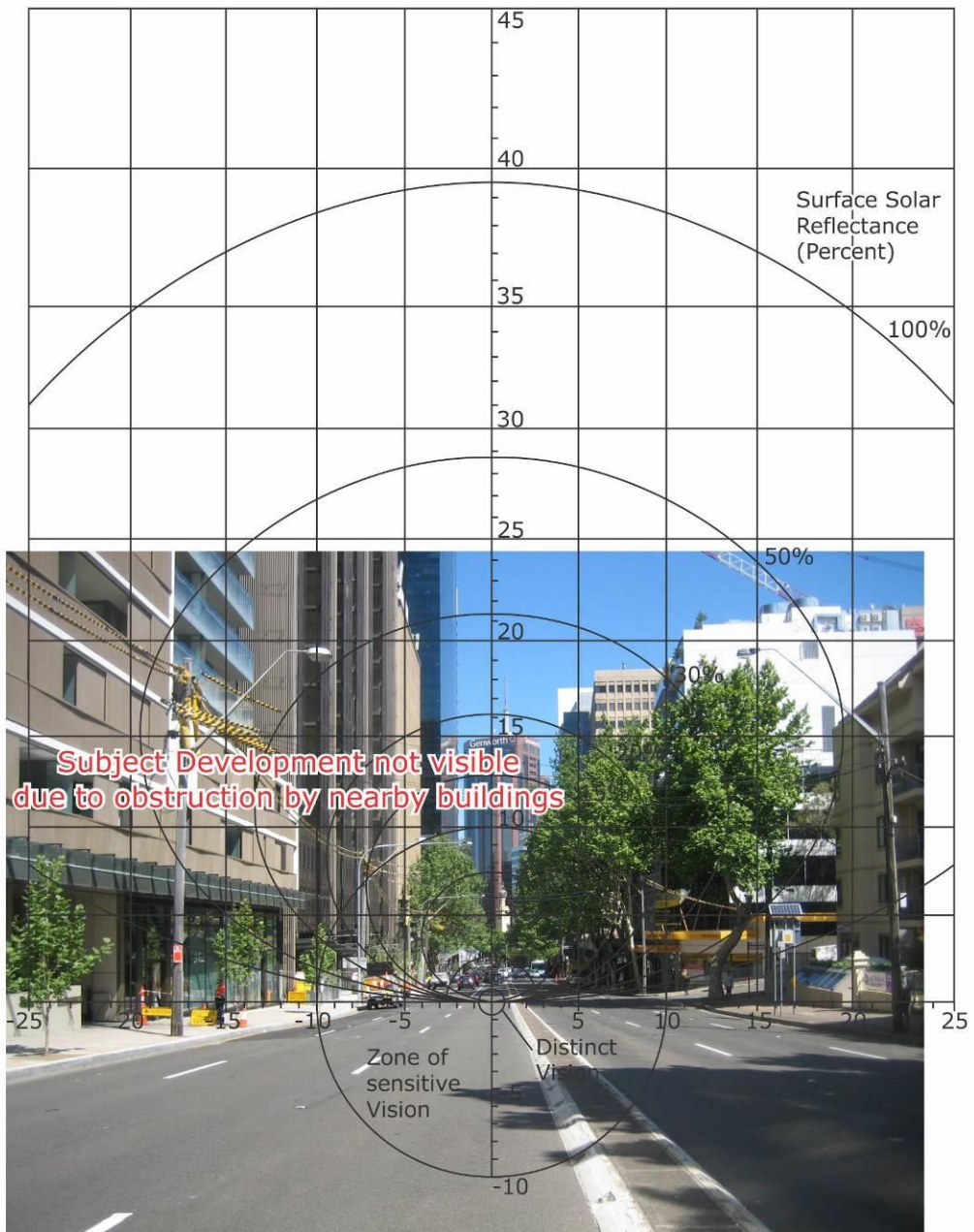


Figure A4: Glare Overlay for Point 4

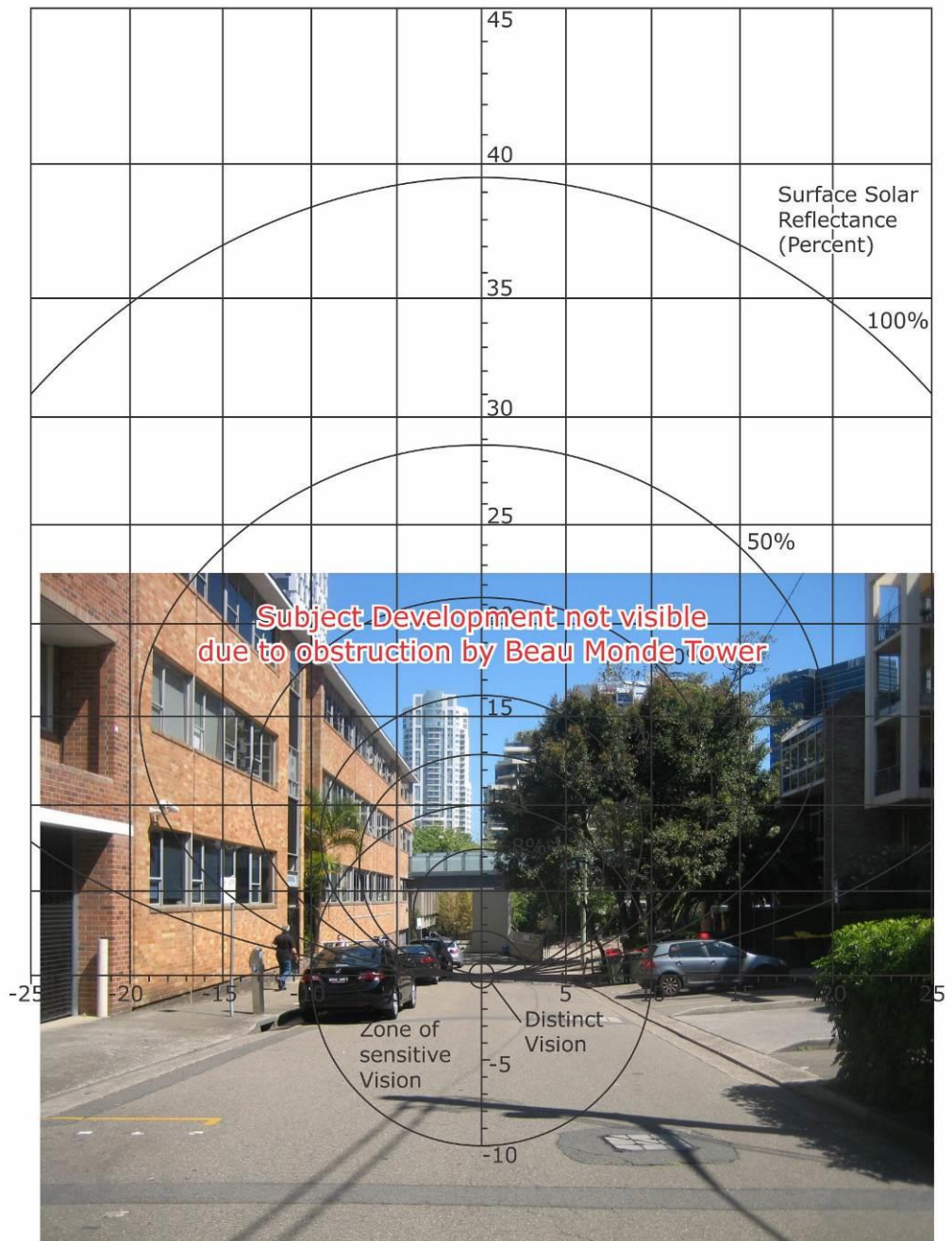


Figure A5: Glare Overlay for Point 5

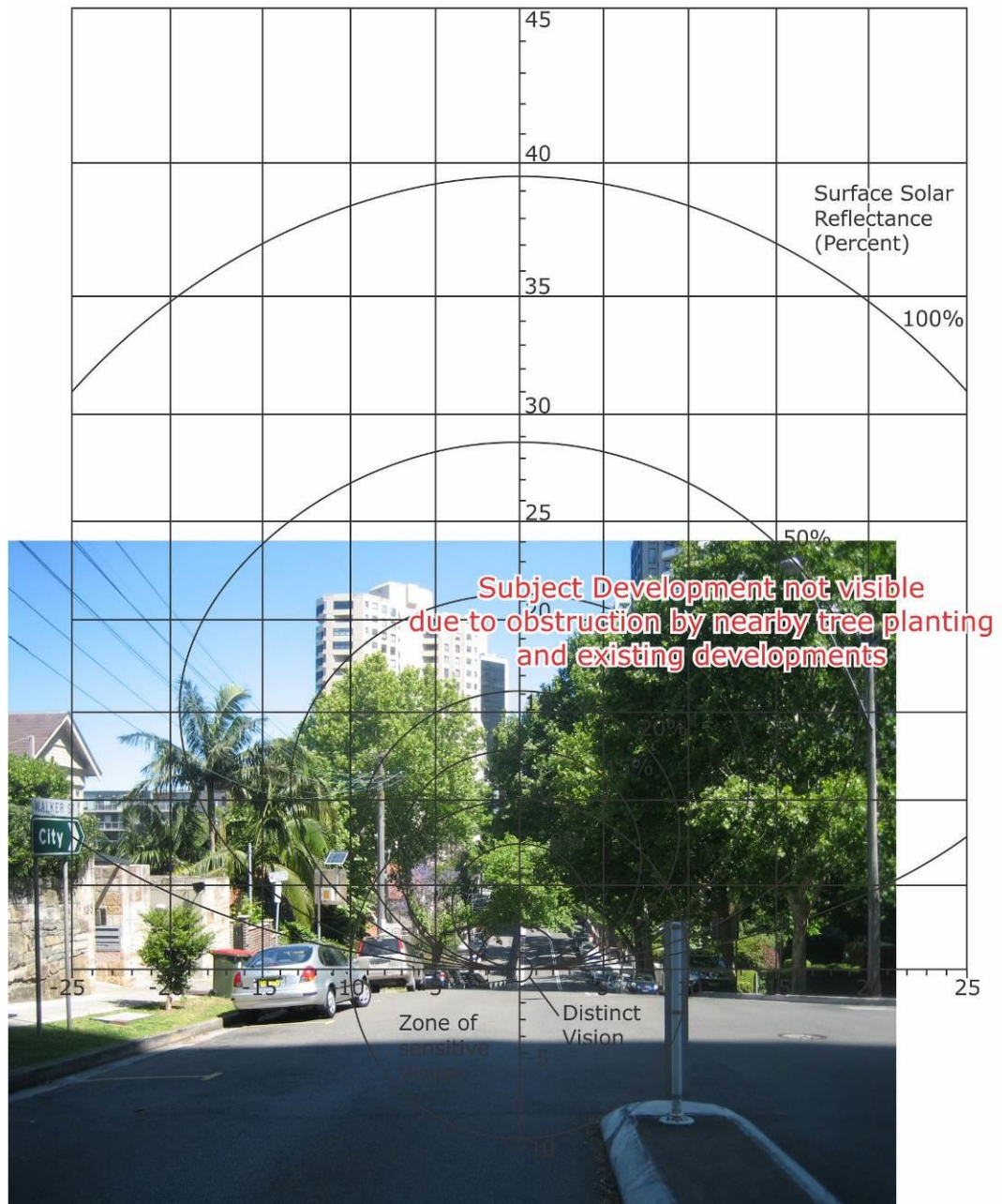


Figure A6: Glare Overlay for Point 6

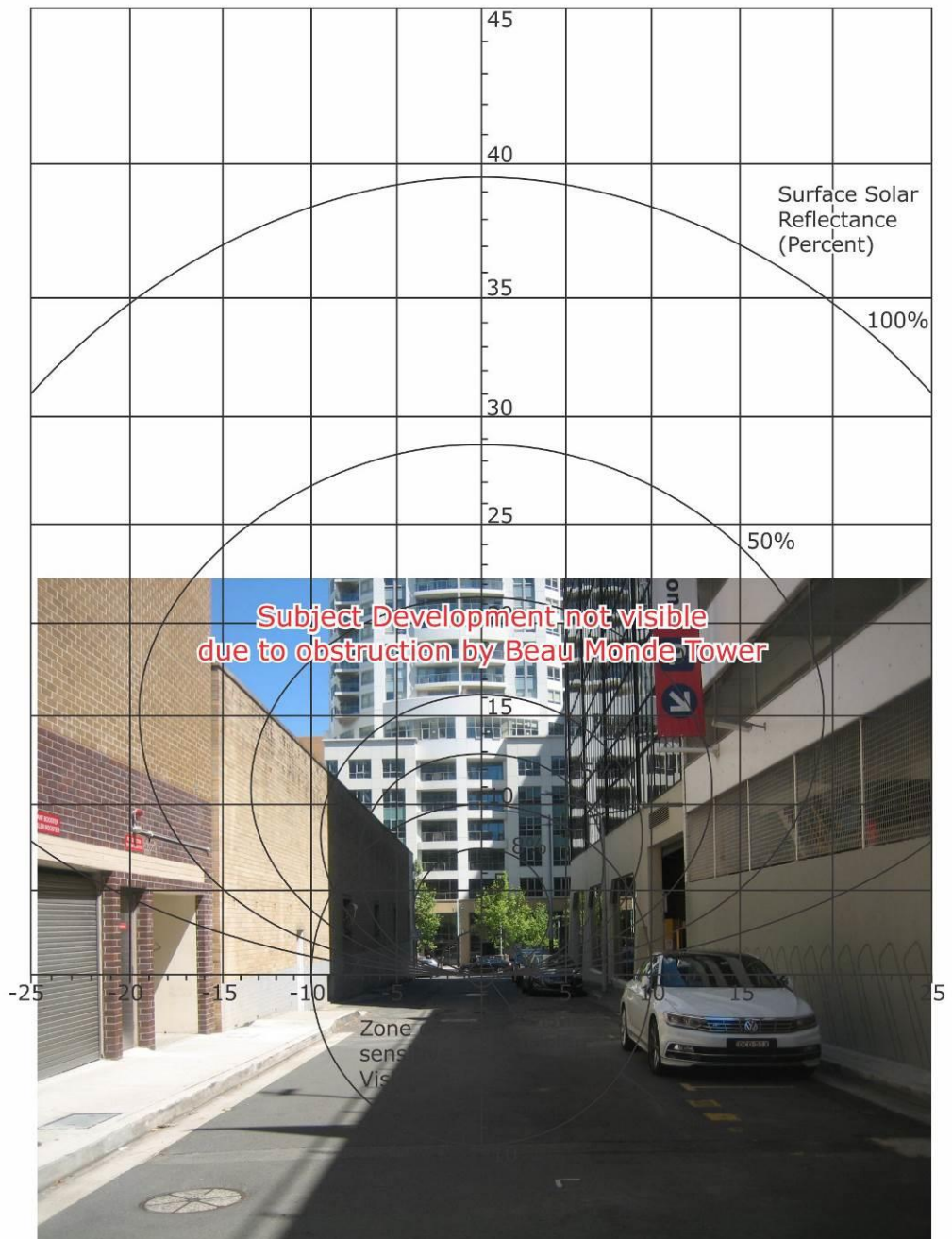


Figure A7: Glare Overlay for Point 7

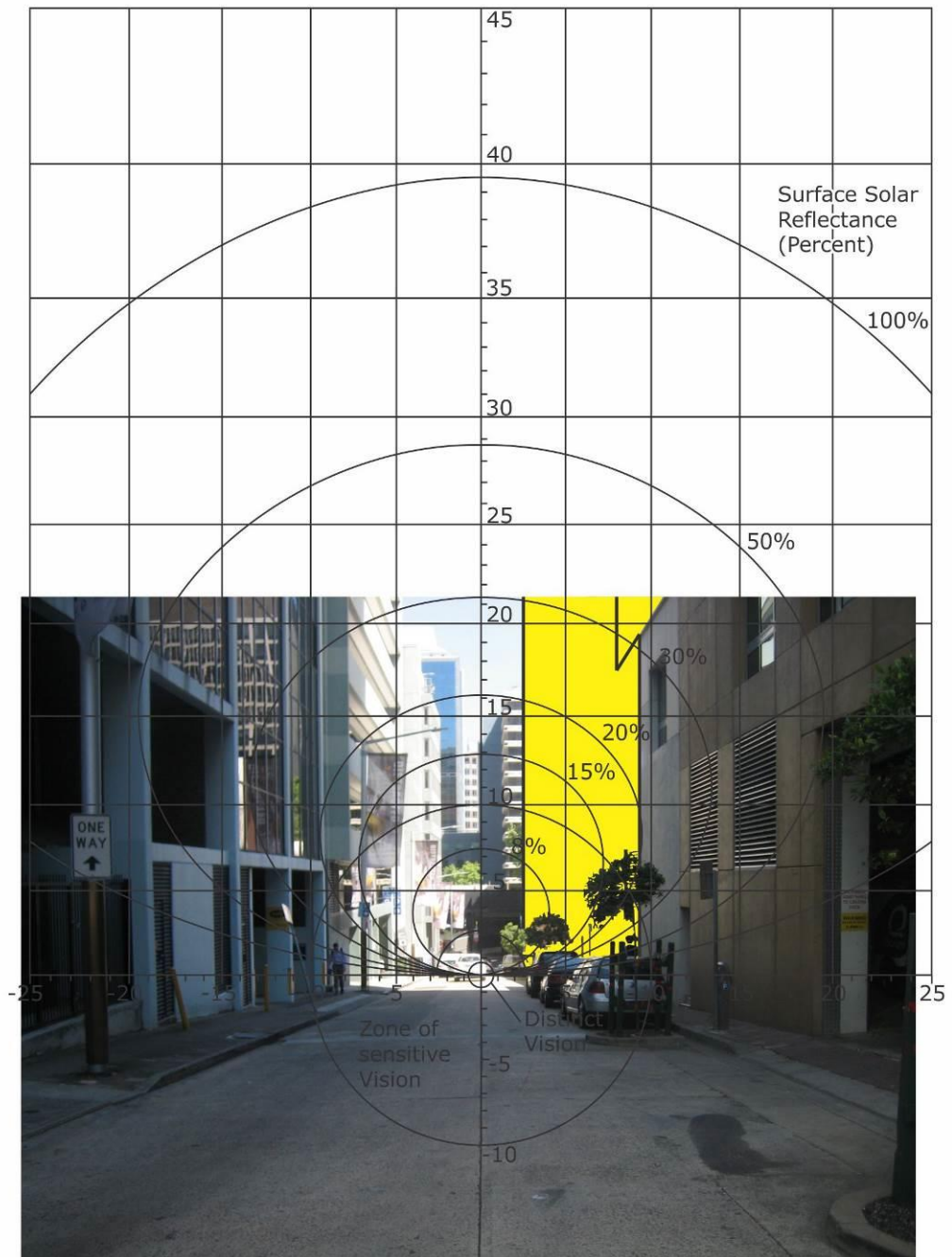


Figure A8: Glare Overlay for Point 8

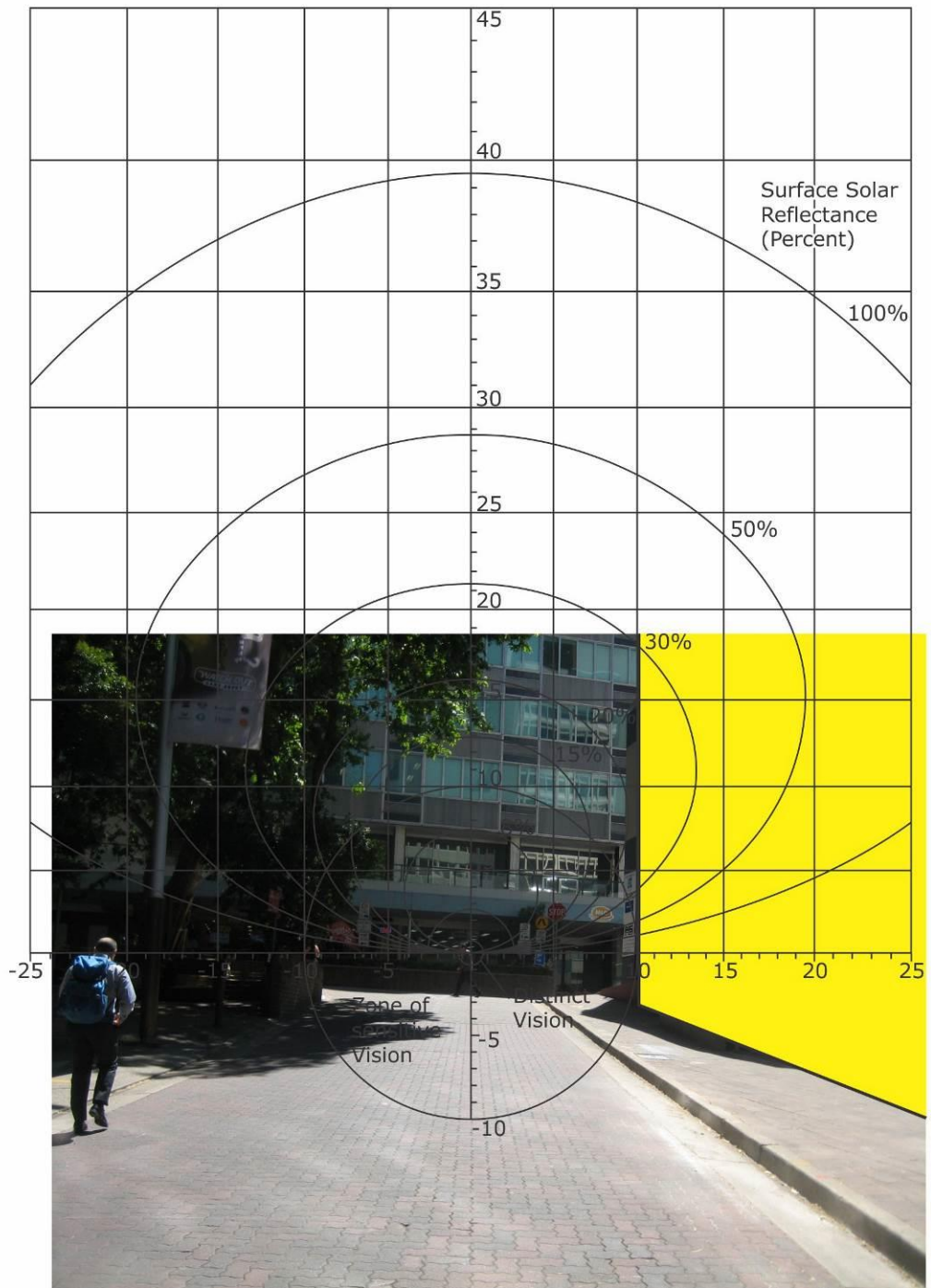


Figure A9: Glare Overlay for Point 9

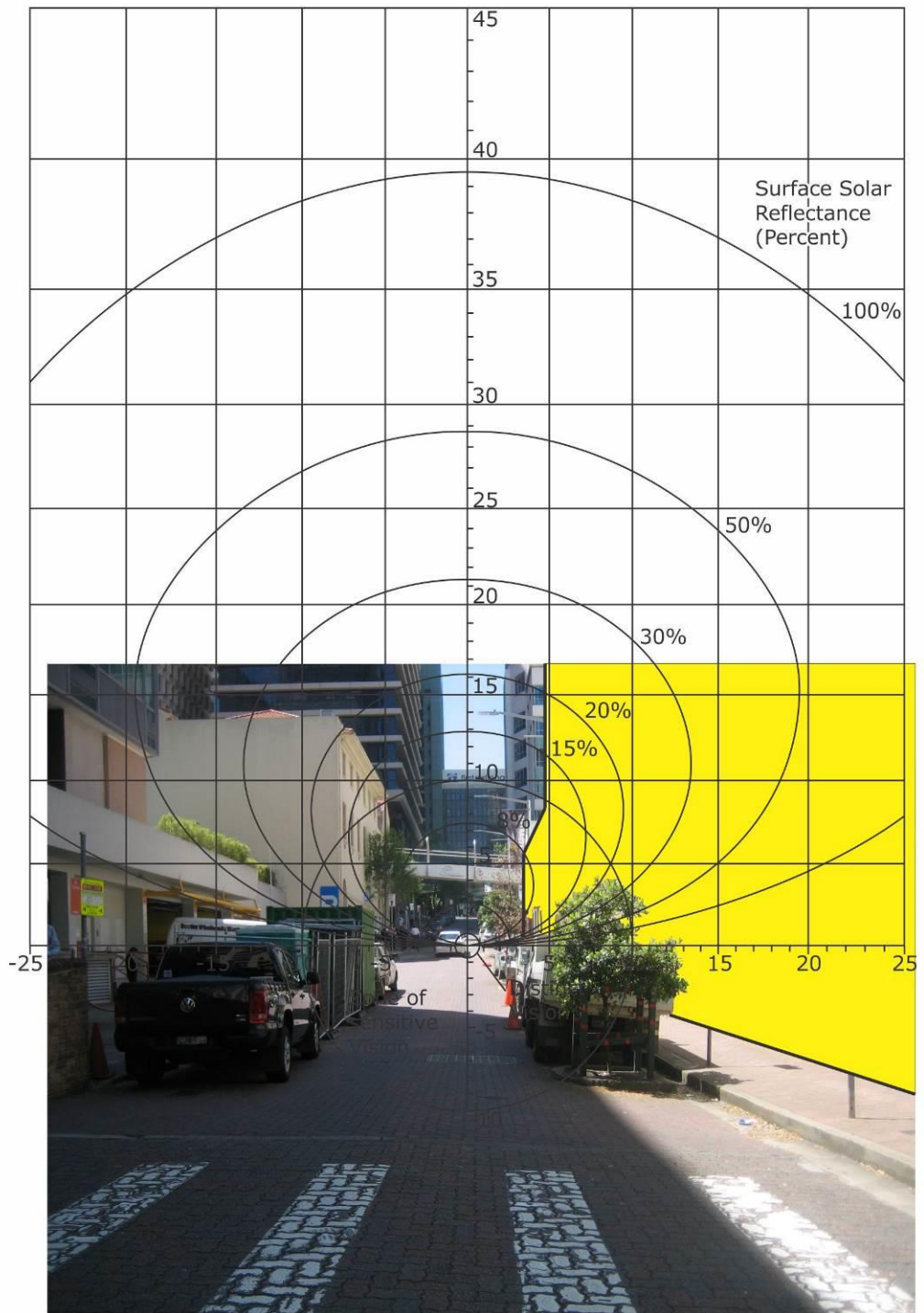


Figure A10: Glare Overlay for Point 10

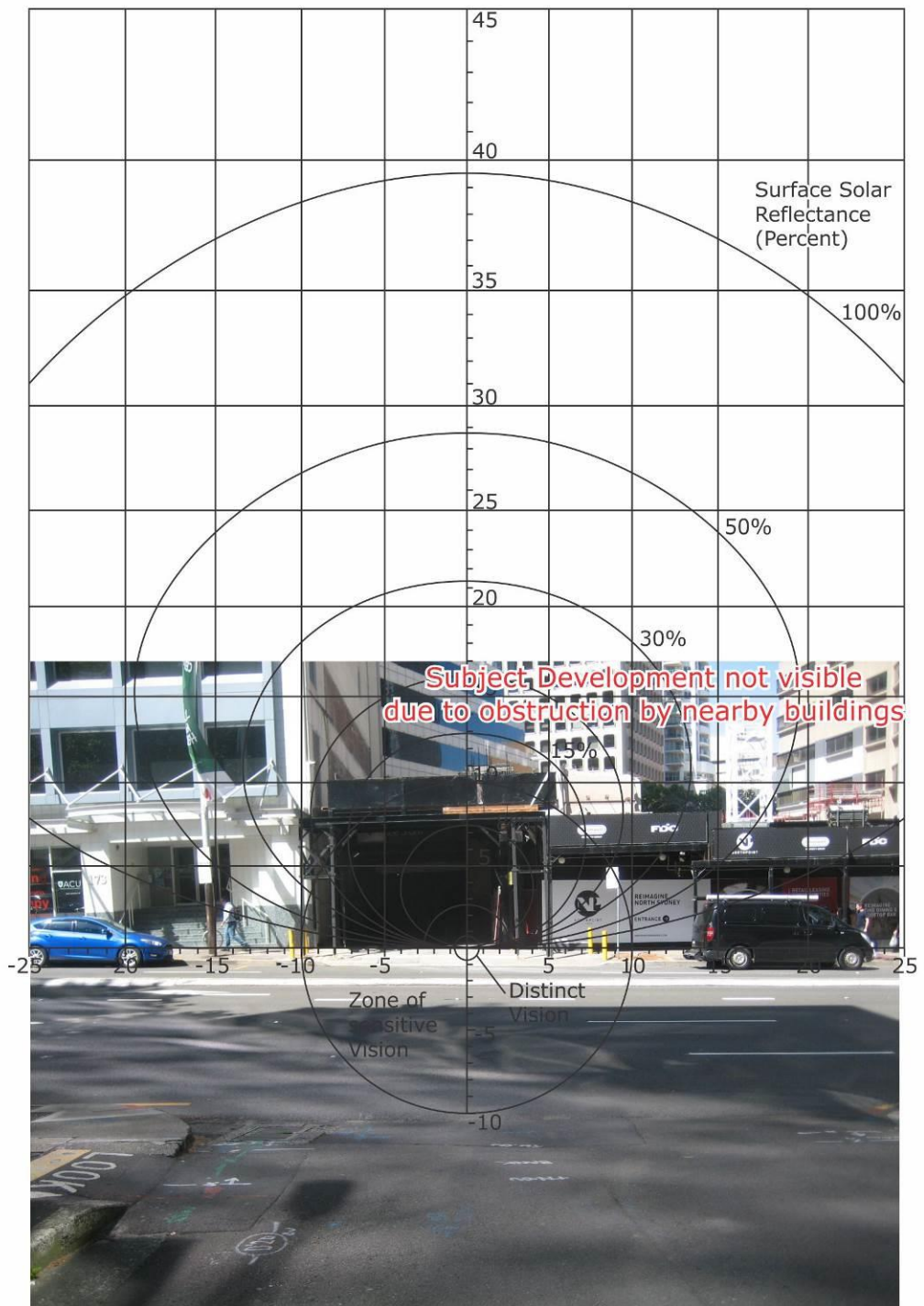


Figure A11: Glare Overlay for Point 11

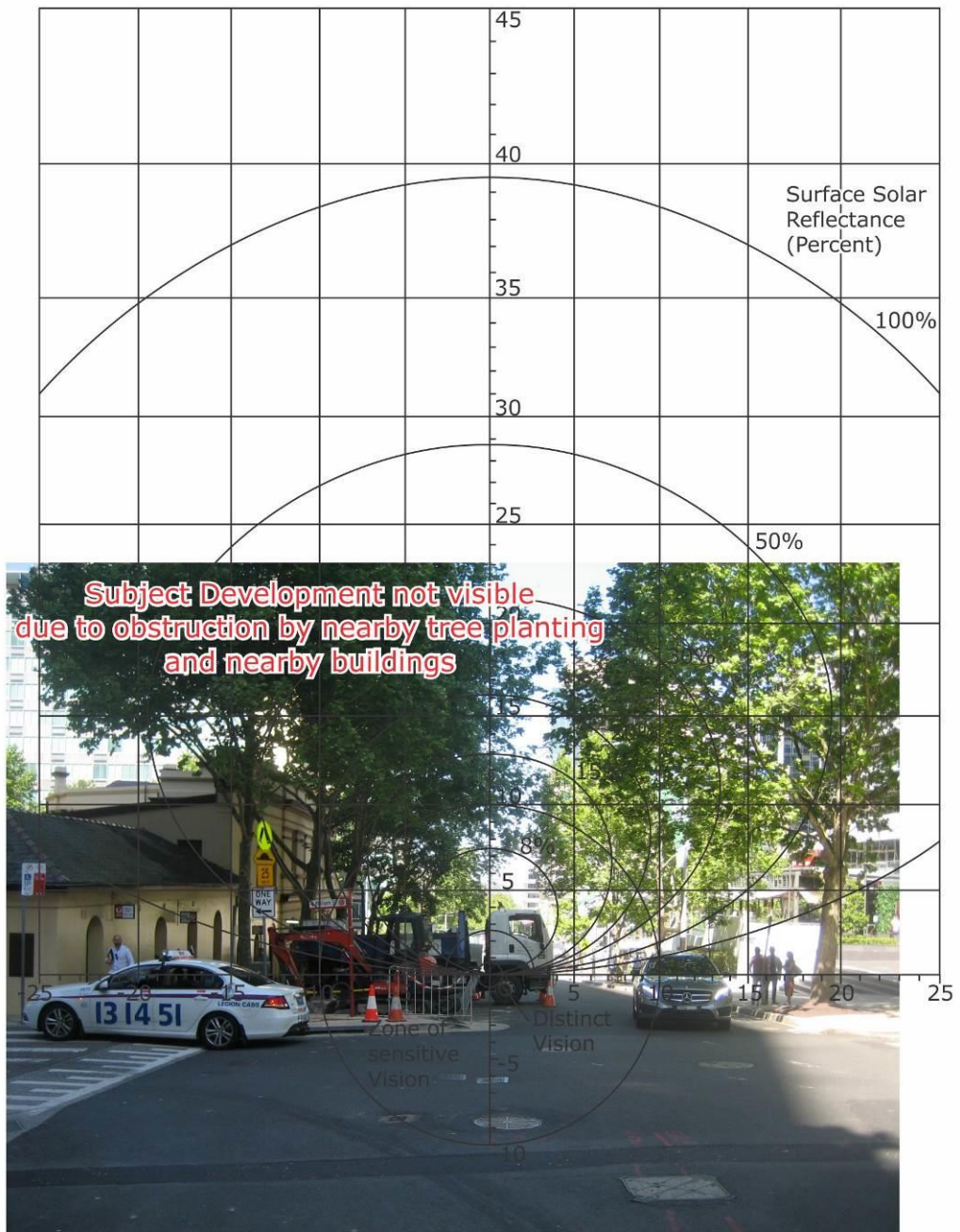


Figure A12: Glare Overlay for Point 12

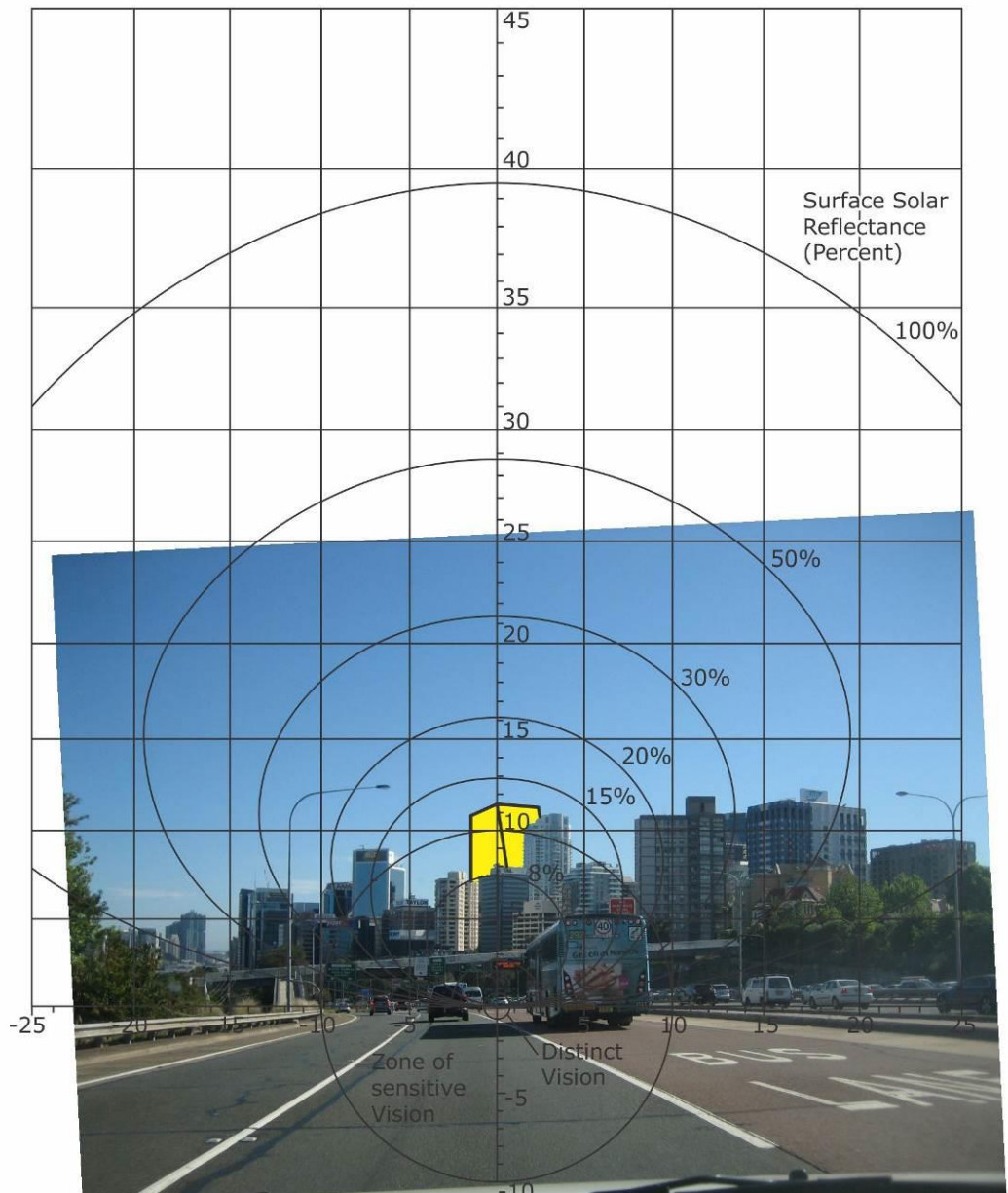


Figure A13: Glare Overlay for Point 13

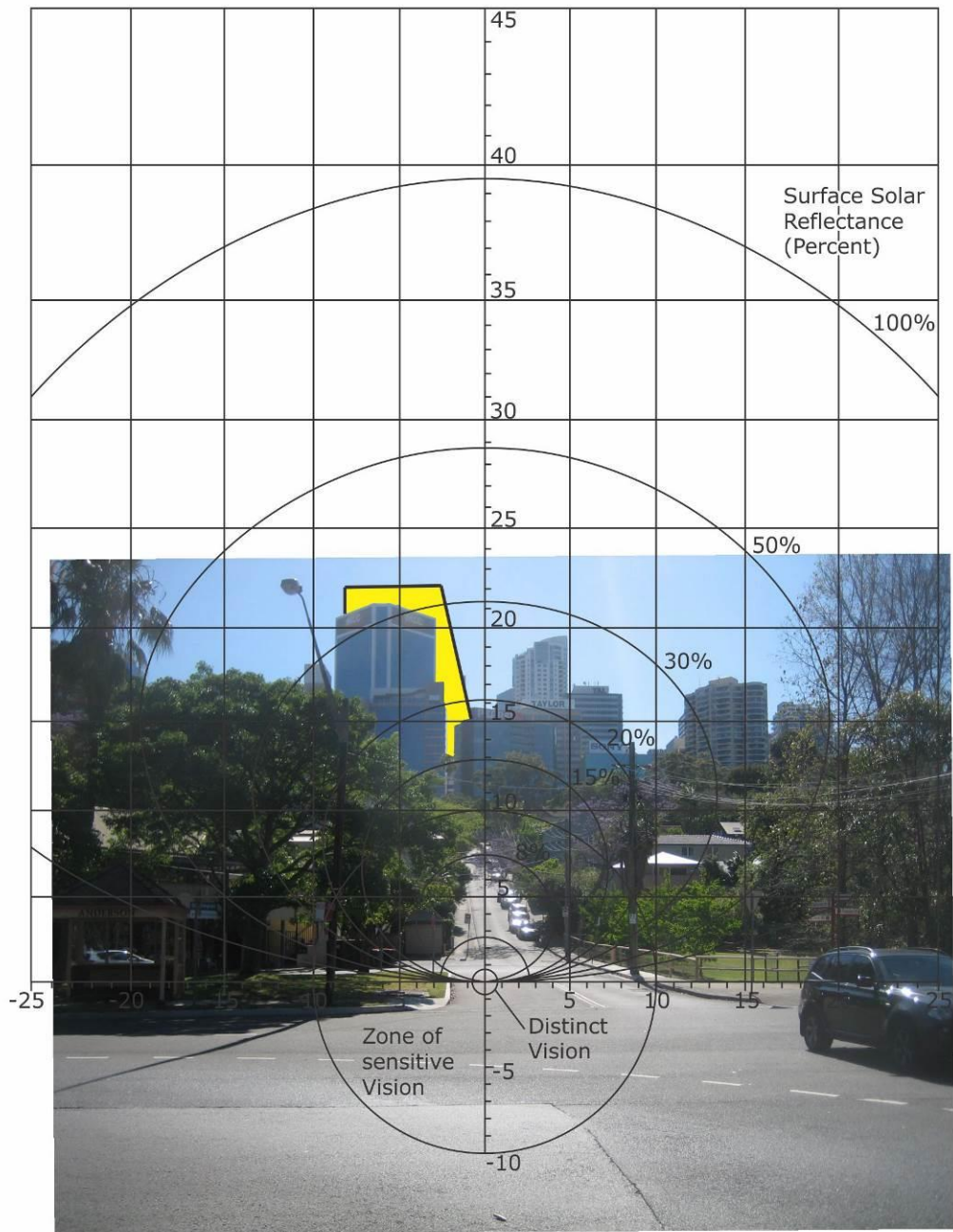


Figure A14: Glare Overlay for Point 14

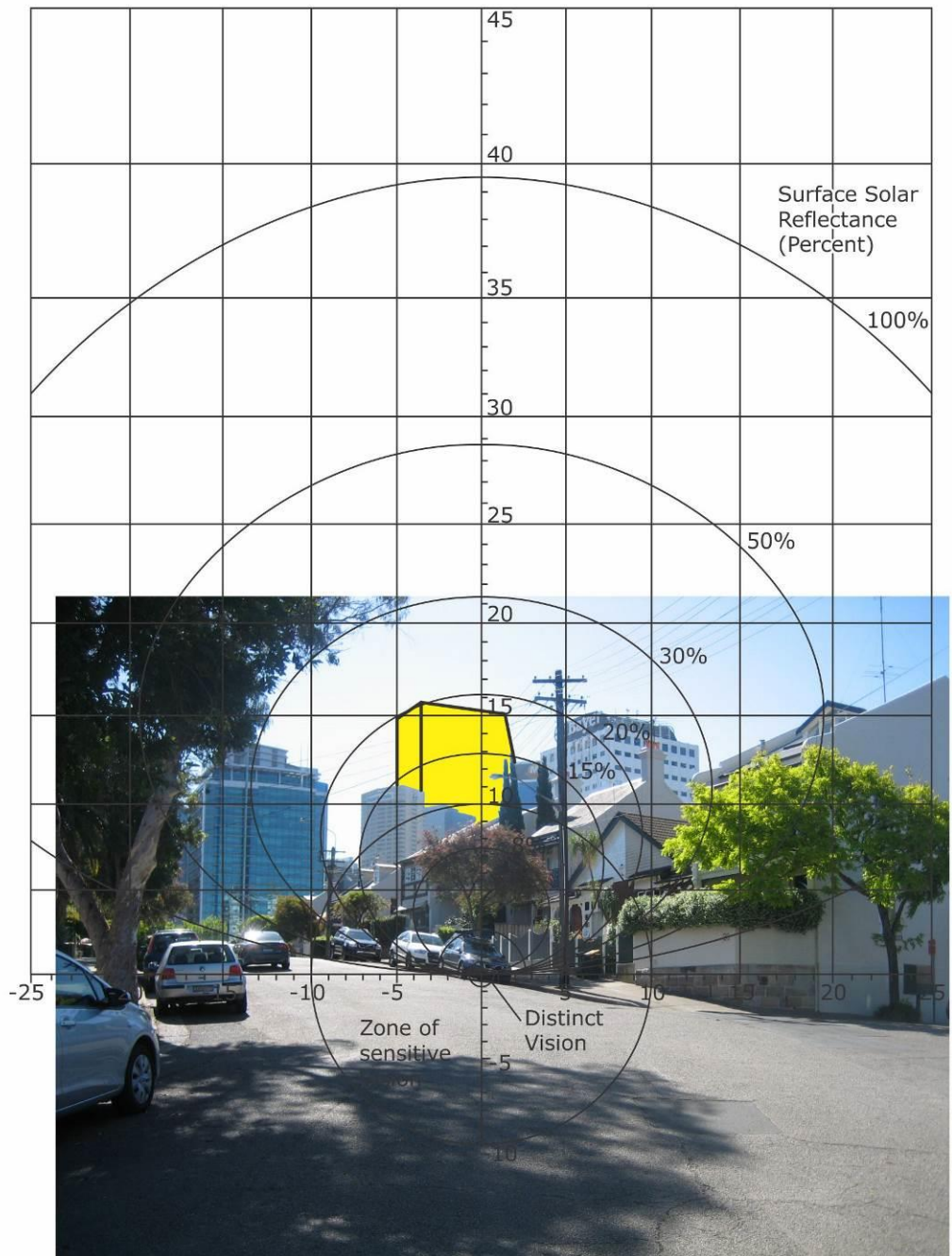


Figure A15: Glare Overlay for Point 15

APPENDIX B - SOLAR CHARTS FOR THE VARIOUS CRITICAL ASPECTS

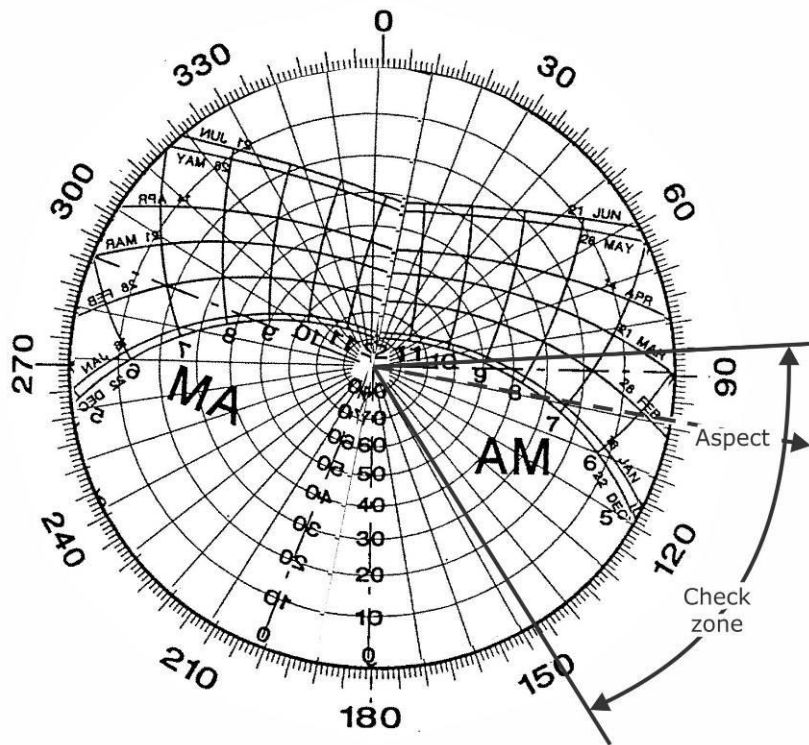


Figure B2: Sun Chart for Aspect 99°

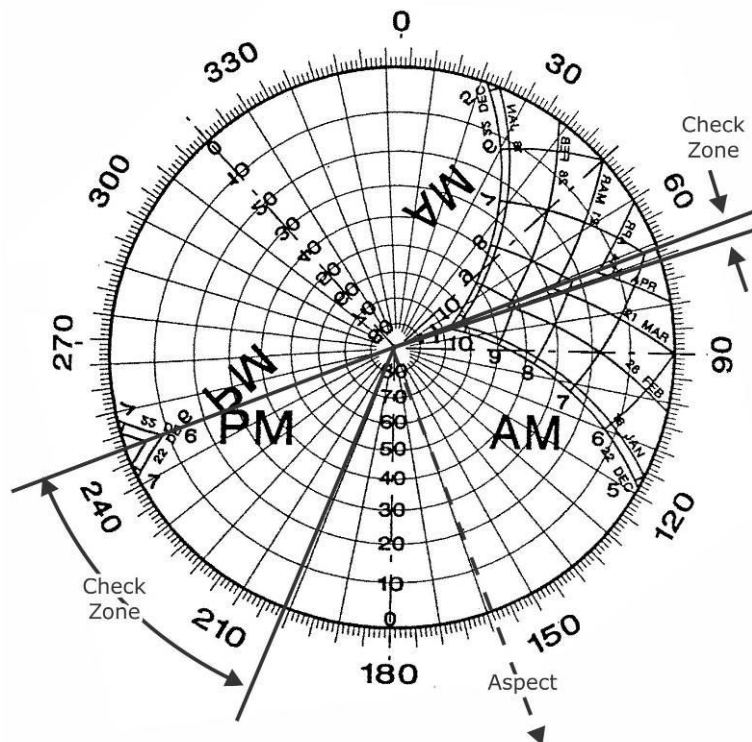


Figure B3: Sun Chart for Aspect 159°

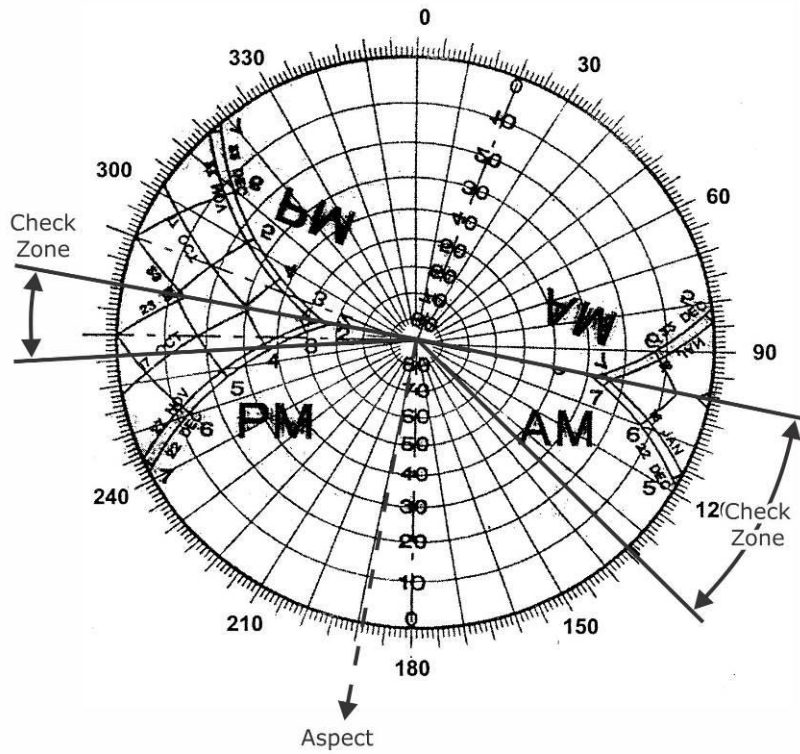


Figure B4: Sun Chart for Aspect 189°

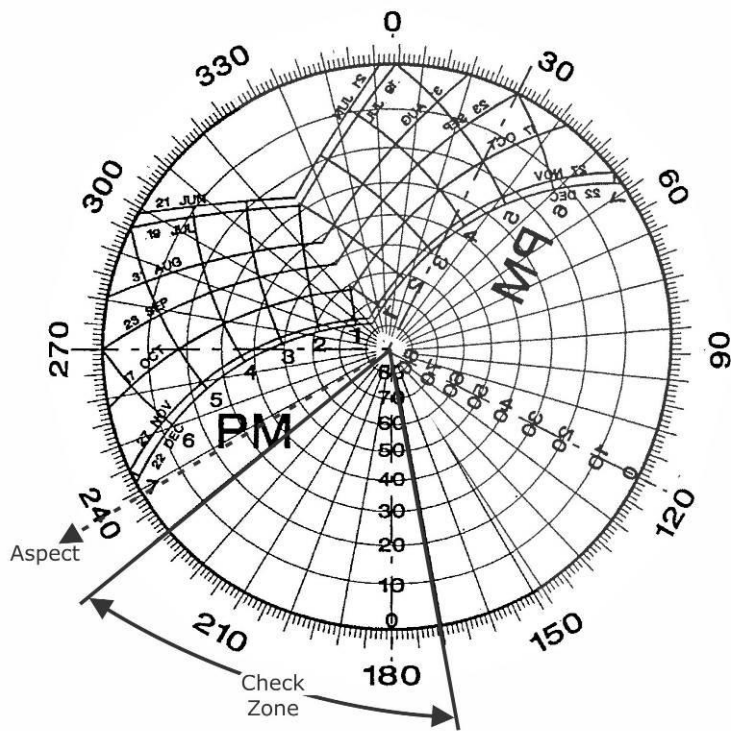


Figure B5: Sun Chart for Aspect 239°

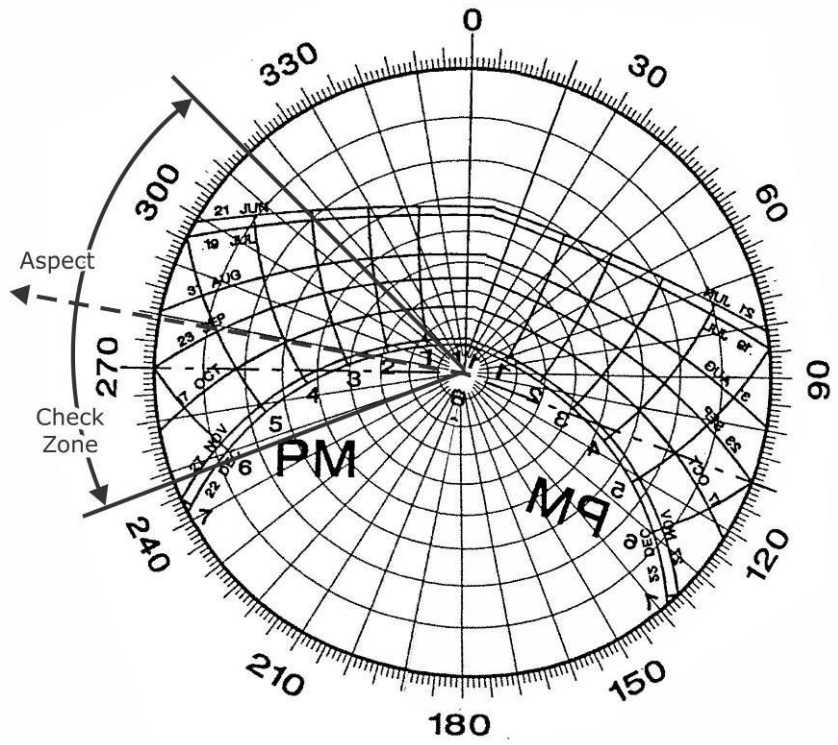


Figure B6: Sun Chart for Aspect 279°

APPENDIX C - STANDARD SUN CHART FOR THE SYDNEY REGION

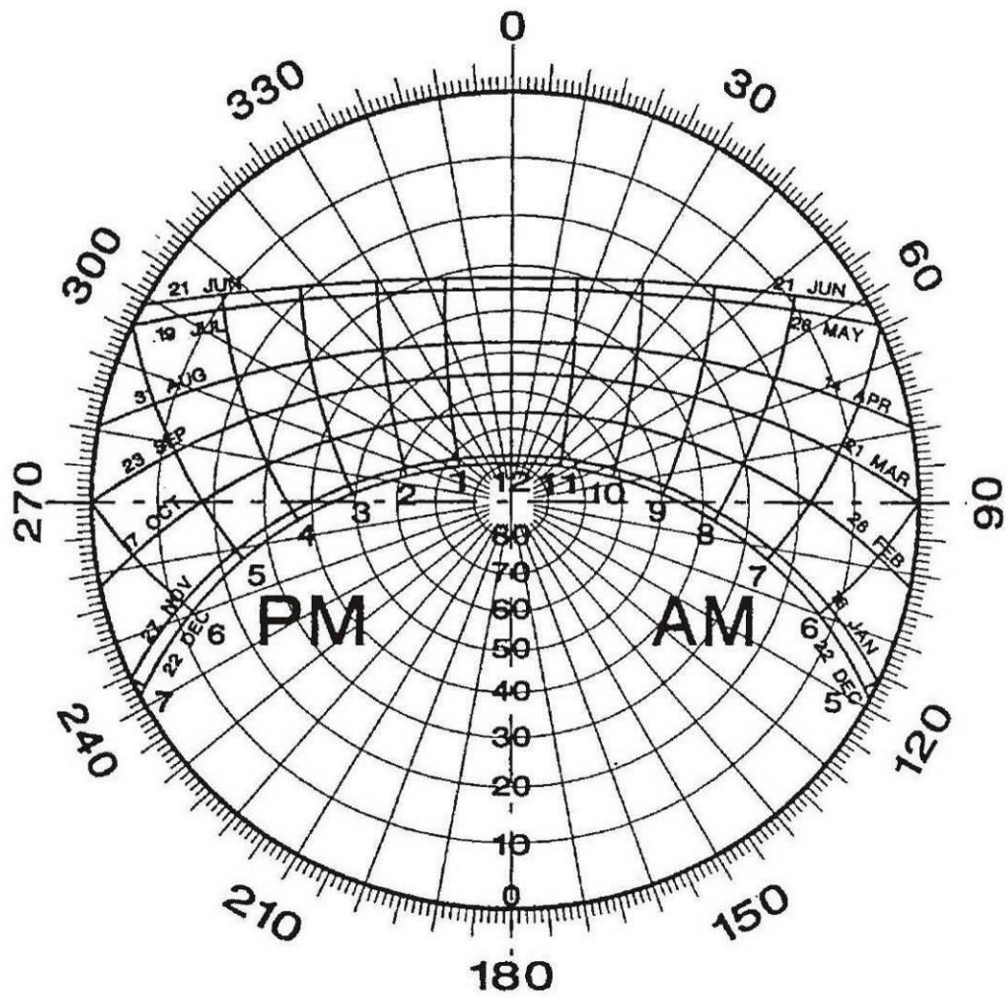


Figure C1: Standard Sun Chart for the Sydney Region