104-116 REGENT STREET, REDFERN

Updated Environmental Wind Assessment - CoS DCP2012 Wind Criteria

Prepared for:

The Trust Company (Australia) Limited ATF WH Redfern Trust
c/o Antoniades Architects Pty Ltd
19a Boundary Street
DARLINGHURST NSW 2010

SLR Ref: 610.30265-R01
Version No: -v2.1
June 2022

PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Tenancy 202 Submarine School, Sub Base Platypus, 120 High Street
North Sydney NSW 2060 Australia

T: +61 2 9427 8100
E: sydney@slrconsulting.com www.slrconsulting.com

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with The Trust Company (Australia) Limited ATF WH Redfern Trust (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.30265-R01-v2.1	2 June 2022	Nikhil Pardeshi	Dr Peter Georgiou	Dr Neihad Al-Khalidy
610.18313-R01-v2.0	5 April 2022	Nikhil Pardeshi	Dr Peter Georgiou	Dr Neihad Al-Khalidy
610.30265-R01-v1.0	13 December 2021	Nikhil Pardeshi	Dr Peter Georgiou	Dr Neihad Al-Khalidy

EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR) was previously engaged by The Trust Company (Australia) Limited ATF WH Redfern Trust, to undertake a quantitative wind assessment of a proposed development at 104-116 Regent Street, Redfern, via an Environmental Wind Tunnel Study.

The assessment was carried out via a Discrete Sensor Environmental Wind Tunnel Study whereby wind tunnel measurements were made to investigate wind conditions throughout and around the proposed development (simulated via a 1:400 scale model) at areas to be used by visitors and occupants of the development itself.

The assessment of the proposed development also included testing of the Redfern Centre Urban Design Principles "Compliant" design conforming to standard CoS set-back and building podium/height requirements.

The previous wind analysis carried out by SLR was documented in:

- SLR Report 610.30265-R01-v1.0 Environmental Wind 20211213, *"104-116 Regent Street, Redfern, Environmental Wind Tunnel Test"*, December 2021.

City of Sydney Review of SLR Report 610.30265-R01-v1.0

In its response to DPE regarding the EIS submission for the Project (SSD 12618001), the City of Sydney requested clarifications covering a number of items, the most significant of which was a re-analysis using the wind criteria found in proposed amendments to the City's DCP2012.

This revised report addresses the clarifications requested by the City of Sydney.

Wind Assessment Criteria

The DCP2012 criteria referred to above are:

Category	Criterion	Description of Assessment Metric
Safety	24 m/s	Annual maximum peak 0.5-second gust wind speed in one hour measured between 6:00am and 10:00pm Eastern Standard Time
Comfort: Walking	8 m/s	Hourly mean wind speed, or gust equivalent mean (GEM) wind speed, whichever is greater, for each wind direction, with a 5% probability of occurrence measured between 6:00am and 10:00pm Eastern Standard Time (ie 292 hours per annum)
Comfort: Standing	6 m/s	Hourly mean wind speed, or gust equivalent mean (GEM) wind speed, whichever is greater, for each wind direction, with a 5% probability of occurrence measured between 6:00am and 10:00pm Eastern Standard Time (ie 292 hours per annum)
Comfort: Sitting	4 m/s	Hourly mean wind speed, or gust equivalent mean (GEM) wind speed, whichever is greater, for each wind direction, with a 5% probability of occurrence measured between 6:00am and 10:00pm Eastern Standard Time (ie 292 hours per annum)

EXECUTIVE SUMMARY

Redfern Wind Climate

The study has developed a site-specific statistical wind climate model based on long-term wind records obtained from nearby Bureau of Meteorology stations at Sydney Kingsford Smith Airport and Bankstown Airport.

For Redfern, SLR has determined that local winds have characteristics closer to Sydney (KS) Airport compared to Bankstown Airport, given Redfern's proximity to Sydney (KS) Airport and similar distance inland from the coastline.

Key prevailing wind directions of interest are the northeast, southeast and south for summer and mainly west quadrant winds for winter.

Previous Assessment

An initial assessment of the proposed development was carried out by SLR in July 2021. Mitigation recommendations were made to ensure a comfortable and safe wind environment within and surrounding the development.

Since the time of the initial assessment, the initial proposed preferred design was changed. Accordingly, SLR carried out retesting of the proposed development incorporating the latest design changes to assess its impact on the wind conditions throughout and around the proposed development.

Built Environment Scenarios Assessed

The proximity models used in the testing simulate the following three built environment "scenarios":

- "Baseline": Existing built environment
- "Future-P": "Baseline" + future proposed development (Preferred Design) with proposed trees
- "Future-C": as per "Future-P" but with City of Sydney "Compliant" Design

All of the above scenarios include the approved future developments lying to the immediate north and west of the site.

Assessment of the "Future-P" and "Future-C" scenarios versus DCP2021 Wind Criteria

In relation to compliance with Central Sydney DCP2012 Wind Criteria, the results discussed in detail in **Section 6** show that, for BOTH the "Future-P" and "Future-C" scenarios:

- ALL locations (external and internal) comply with the DCP2012 24 m/s Safety Criterion;
- ALL surrounding footpath areas comply with the DCP2012 Walking Comfort Criterion and the DCP2012 Standing Comfort Criterion at building entry points;
- Consideration could be given to improving the wind environments in the outdoor open areas of Level 2 and Level 16, specifically in areas where seated dining is planned.

EXECUTIVE SUMMARY

Already Planned Wind Amelioration

Figure 14 illustrates the existing and already planned landscaping for the Project (street level and elevated) as well as other wind mitigation treatments, eg street level awnings, etc.

Pedestrian Areas Surrounding the Site

Current plans for the proposed development incorporate an awning along the development's eastern façade (refer **Figure 2**) as well as the extensive landscaping shown in **Figure 14**. We recommend the following:

- The planned awning along Regent Street protecting ground level footpath areas below should be retained.
- Further, it is recommended that the proposed awning be continuous. Note that the awnings can be connected in a stepped manner if required to account for the change in ground elevations
- It is recommended that the large existing tree on Regent Street be retained.
- It is also recommended that all "proposed" trees on Margaret Street and the Through Site Link are retained and are of evergreen species, of similar foliage as existing trees.

Level 2 and Level 16 Outdoor Areas

The landscaping proposed for elevated outdoor areas (refer **Figure 14**) is effective in mitigating adverse wind conditions, given that the wind tunnel-predicted 5% exceedance levels satisfy the DCP2012 Comfort STANDING criterion. SLR therefore recommends:

- Retention of the proposed vertical façade screening along the perimeter of the development (from level 2 slab up to level 4 slab) – refer **Figure 11**.
- Retention of the proposed tree planting on the Level 2 communal area, the Level 4 outdoor area and the Level 16 communal area – refer **Figure 11**.
- The above proposed landscaping should be evergreen – refer **Figure 11**.

In relation to improving the wind environment in the outdoor open areas of Level 2 and Level 16, eg in any area where seating for outdoor eating is planned, the following is recommended:

- Localised horizontal protection (eg pergola, shade-cloth, umbrellas, etc) to protect any elevated terrace areas intended to be used for outdoor dining.

Noting that these elevated areas are already at the DCP2012 Comfort "Standing" level, there would be no doubt that the addition of horizontal windbreaks in seated, eating areas would mitigate winds even further, in fact to well below the DCP2012 Comfort "Sitting" level. Such areas would almost certainly satisfy the even more stringent Lawson Dining Comfort criterion level (5% exceedance level of 2.5 m/s).

SLR therefore see no discernible benefit in additional wind tunnel testing, given the certainty of achieving the target DCP2012 Comfort level relevant to the Project if all the wind recommendations noted above are implemented.

EXECUTIVE SUMMARY

Recent Design Refinement

Design refinements have recently occurred including the removal of a unit located at the northwest corner of the development on levels 4 to 18. As a result, the building shape now slightly differs at the northwest corner at these levels from the proposed design tested in December 2021 (Refer architectural drawing 20009DA, supplied in May 2022).

The above changes will have no impact on the results of the previous wind tunnel studies.

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1 Introduction

SLR Consulting Australia Pty Ltd (SLR) was previously engaged by The Trust Company (Australia) Limited ATF WH Redfern Trust, to undertake a quantitative wind assessment of a proposed development at 104-116 Regent Street, Redfern, via an Environmental Wind Tunnel Study.

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The assessment of the proposed development also included testing of the Redfern Centre Urban Design Principles "Compliant" design conforming to standard CoS set-back and building podium/height requirements.

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City of Sydney Review of SLR Report 610.30265-R01-v1.0

In its response to DPE regarding the EIS submission for the Project (SSD 12618001), the City of Sydney requested clarifications covering a number of items, the most significant of which was a re-analysis using the "Modified Lawson" criteria found in proposed amendments to the City's DCP2012.

This revised report addressed the clarifications requested by the City of Sydney.

1.1 Structure of the Report

The remainder of this report is structured as follows:

Section 2 … describes the proposed development and surrounds

Section 3 … describes Sydney's regional wind climate and the local site wind climate

Section 4 … presents the wind comfort and safety criteria used in the study

Section 5 … discusses the wind tunnel test methodology used in the study

Section 6 … presents the results of the testing

Section 7 … discusses the wind mitigation recommendations for the development

2 DESCRIPTION OF THE PROPOSED DEVELOPMENT

2.1 Location of Development Site

The proposed development is bounded by Regent Street to the east, Margaret Street to the south, and similar height future developments to the west and to the north. - refer **Figure 1**.

Figure 1 Satellite Image of the Proposed Development Site

Image Courtesy: Nearmap, May 2021

2.2 Proposed Development Description

The proposal comprises the redevelopment of the site as summarised below:

- Construction of an 18-storey building comprising a total of 9,562m² gross floor area with a mix of land use activities including:
  - Level 1: 72 m² of retail floorspace, 490m² of communal area for the student accommodation, 102 bicycle parking spaces, loading and waste management facilities and ancillary services and facilities.
  - Upper levels: student accommodation providing a total of 411 beds, including ensuite rooms, studios and two-bedroom configurations, with indoor and outdoor communal spaces on Levels 2, 4 and 16 and additional indoor communal areas on Levels 2 and 4.
- Hard and soft landscaping within the outdoor communal terraces on the roof-top of the podium level and Levels 4 and 16.
- Public domain improvements including provision of a landscaped through-site link connecting William Lane to Margaret Street and associated improvements to the Regent Street and Margaret Street frontages, including awnings and footpath upgrades.

Figure 2 Key Architectural Floor Plans of Interest and Representative Elevations

Level 1 (Ground)

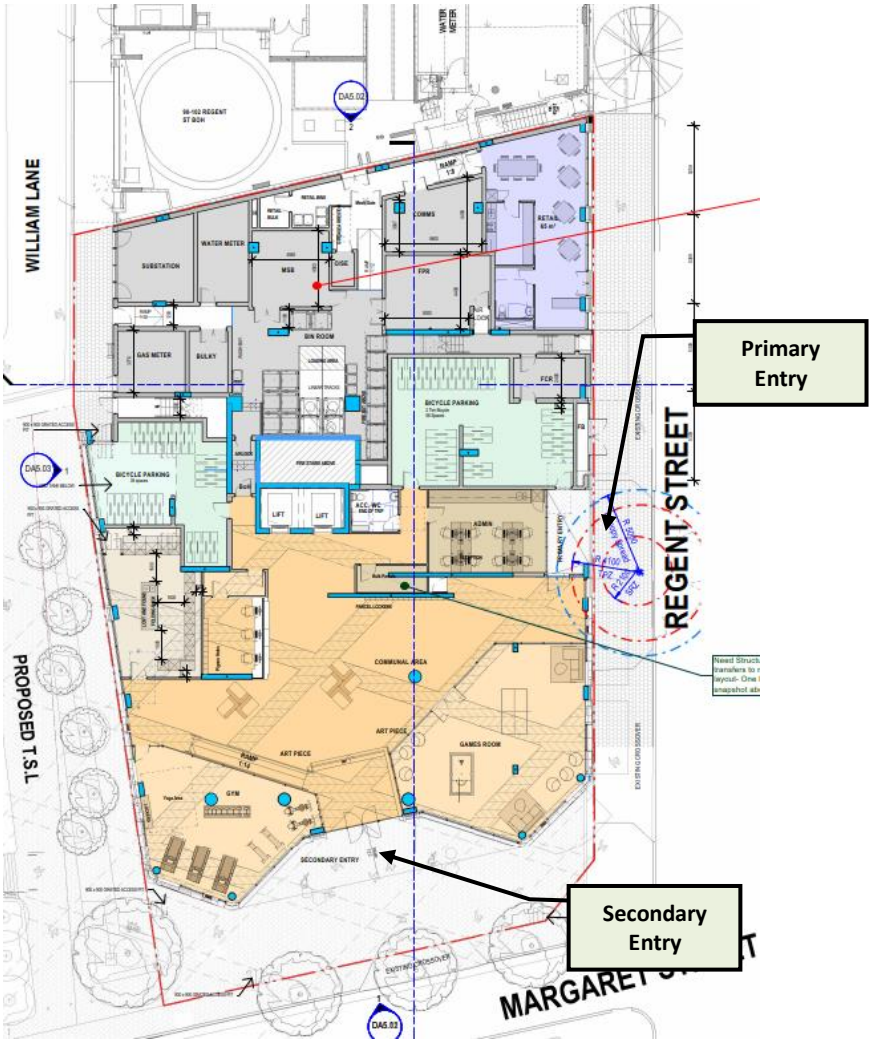
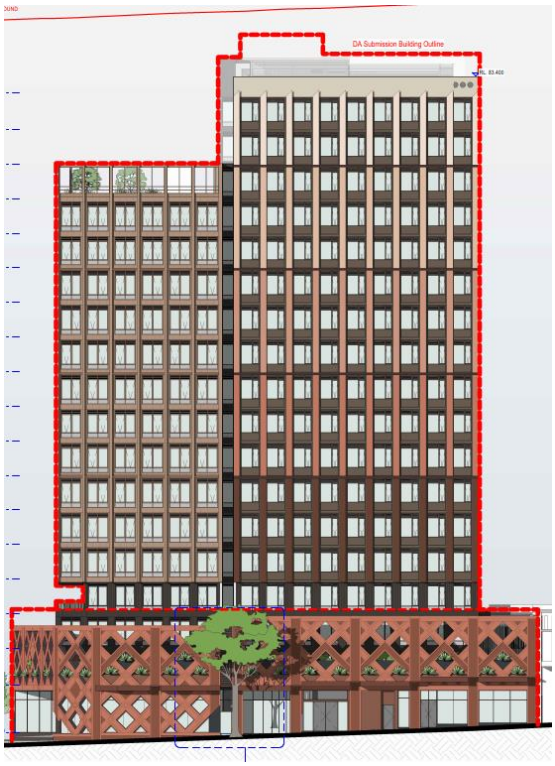


Fig.2 (cont'd)

Level 2

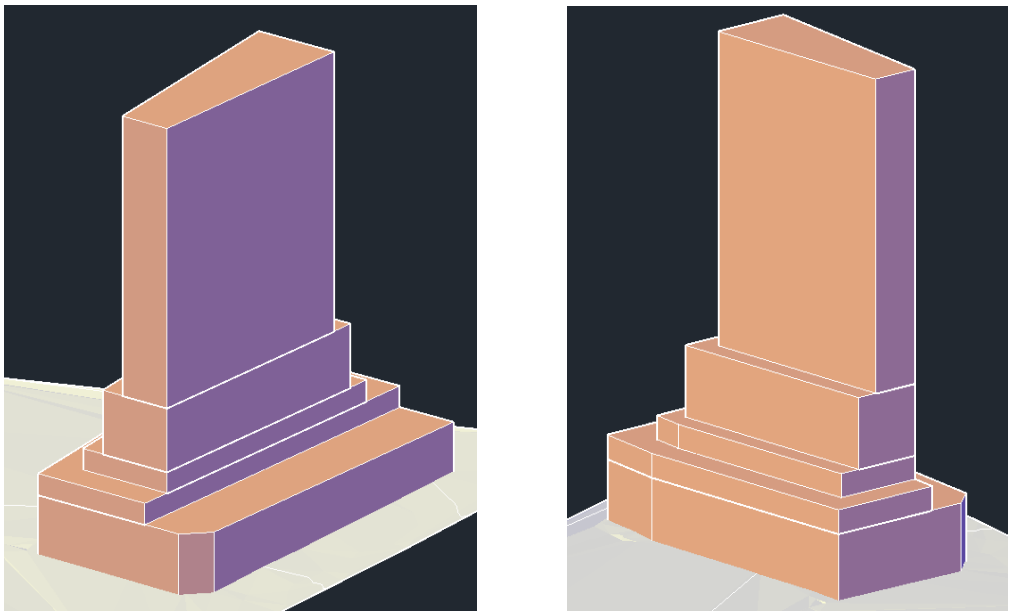
East (Regent Street) Elevation



South (Margaret Street) Elevation

The assessment of the proposed development also included testing of the Redfern Centre Urban Design Principles "Compliant" design conforming to standard CoS set-back and building podium/height requirements. This is shown in **Figure 3**.

Figure 3 Redfern Centre Urban Design Principles "Compliant" Design



2.3 The Surrounding Built Environment

In terms of surrounding buildings:

- Buildings surrounding site are generally low and mid-rise, comprising a mix of commercial, retail and residential buildings (several of similar height to the proposed development).
- Gibbons Street Reserve lies to the west with Redfern train station to the north-northwest.
- There are a number of planned and approved future developments of similar height located immediately to the north and west of the proposed development, running between Gibbons Street and Regent Street.
- Sydney's CBD area lies further to the north.

The terrain is undulating in the surrounding built environment, with no particularly significant topographical variations (ie hills, escarpments, etc) influencing local wind speeds.

These aspects are shown in representative views in **Photo 1**.

Photo 1 Representative Project Surrounds (Views towards Site, East and West of Site)

3 PROJECT DESIGN WIND SPEEDS

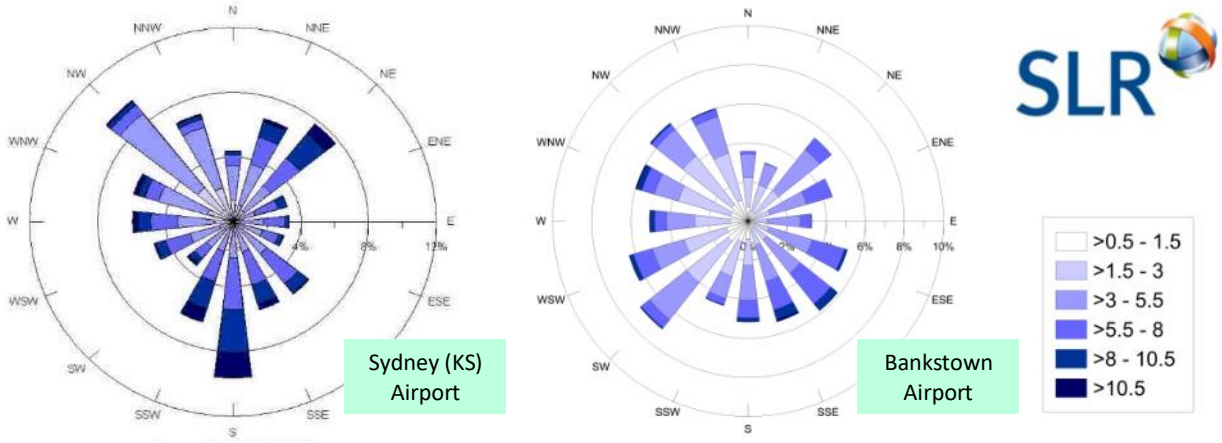
The data of interest in this study are the mean hourly wind speeds and largest gusts experienced throughout the year (especially higher, less frequent winds), how these winds vary with azimuth, and the seasonal break-up of winds into the primary Sydney Region wind seasons.

3.1 Sydney Region Wind Climate - Seasonal Variations

Key characteristics of Sydney's Regional Wind Climate are illustrated in two representative wind roses shown in **Figure 4**, taken from Bureau of Meteorology (BoM) data recorded during the period 1999-2017 at Sydney (Kingsford Smith) Airport and Bankstown Airport. The associated seasonal wind roses (refer **Appendix A**) show that Sydney is affected by two primary wind seasons with short (1-2 month) transition periods in between:

- Summer winds occur mainly from the northeast, southeast and south. While northeast winds are the more common prevailing wind direction (occurring typically as offshore land-sea breezes), southeast and southerly winds generally provide the strongest gusts during summer. Northeast sea breeze winds and stronger southerly winds associated with "Southerly Busters" and "East Coast Lows" typically have a significantly greater impact along the coastline. Inland, these systems lose strength and have altered wind direction characteristics.
- Winter/Early Spring winds occur mainly from west quadrants and to a lesser extent from the south. West quadrant winds provide the strongest winds during winter and in fact for the whole year, particularly at locations away from the coast.

Figure 4 Annual Wind Roses for Sydney (KS) Airport and Bankstown Airport (BoM Data)



3.2 Wind Exposure at the Site – the "Local" Wind Environment

Close to the ground, the "regional" wind patterns described above are affected by the local terrain, topography and built environment, all of which influence the "local" wind environment.

- As noted in **Section 1.3**, the site is currently surrounded by a mix of low to mid-rise retail, commercial and residential buildings, with a number of these of similar height to the proposed development. The site will therefore receive moderate wind shielding depending upon oncoming wind direction at lower levels with upper levels exposed to higher winds from most wind directions.

3.3 Local Project Site Design Wind Speeds

SLR has carried out a detailed study of Sydney Basin wind speeds using continuous records of wind speed and direction measured at the Bureau of Meteorology's (BoM) Sydney weather stations. The objective of this study was to develop statistical wind information for locations not situated in close proximity (ie within say approximately a kilometre) of BoM weather stations.

The study is described in detail in …

- SLR Technical Note: *"9300-TN-CW&E-v2.0 Sydney Region Design Winds"*, March 2018.

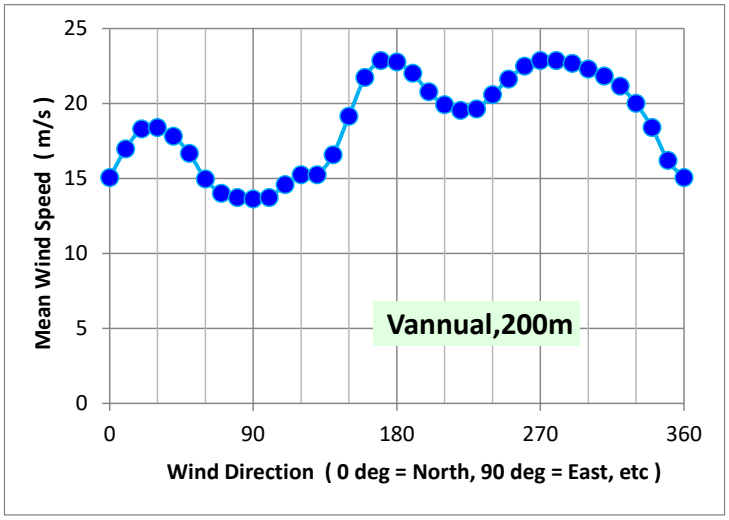
Wind records given particular emphasis were from weather stations with a "clean" surrounding exposure, eg stations such as Sydney (Kingsford Smith) Airport and Bankstown Airport, ie locations relatively free of immediately surrounding obstacles such as buildings, vegetation, trees, etc, which would otherwise distort the winds seen by the weather station anemometer.

For Redfern, SLR has determined that local winds have characteristics closer to Sydney (KS) Airport compared to Bankstown Airport, given Redfern's proximity to Sydney (KS) Airport and similar distance inland from the coastline. Key prevailing wind directions of interest are the northeast, southeast and south for summer and mainly west quadrant winds for winter.

3.4 Reference Height Wind Speeds

In the wind tunnel testing, the reference dynamic pressure used to record all wind speed data was measured at an equivalent (full-scale) height of 200 m above ground level (500 mm in the wind tunnel). Accordingly, conversion from wind tunnel speeds to full-scale speeds requires the determination of reference height design mean wind speeds for the site. These are shown in **Figure 5** and have been based on the adopted Liverpool wind model as described above. The winds shown in **Figure 5** have a once-per-year exceedance probability.

Figure 5 Reference Height (200 m) Annual Recurrence Mean Wind Speed at Project Site



4 WIND ACCEPTABILITY CRITERIA

The choice of suitable criteria for evaluating the acceptability of particular ground level conditions has been the subject of international research over recent decades.

4.1 Background - The "Melbourne " Wind Criteria for SAFETY

The safety acceptability criteria used for over four decades by many Australian Local Government Development Control Plans, are the so-called **Melbourne Criteria**, summarised in **Table 1**.

Table 1 Melbourne Wind Acceptability Criteria - SAFETY

Type of Criteria	Maximum Gust Wind Speed Occurring Once Per Year	Activity Concerned
Safety	24 m/s	Knockdown in Isolated Areas
	23 m/s	Knockdown in Public Access Areas

4.2 Background - The "Lawson" Wind Criteria for COMFORT

The most commonly used criteria for COMFORT used globally in the evaluation of pedestrian level winds are the so-called **Lawson** criteria which couple the probability of exceeding winds at given statistical levels with wind speed magnitudes and associated impacts originally related to the Beaufort Wind Speed Land Scale – refer **Appendix B**.

The Lawson Comfort criteria were developed over three decades ago and make use of the same Beaufort Scale to characterise issues of interest in terms of both pedestrian comfort and safety.

- The criteria relate a range of typical pedestrian activities such as purpose-walking, strolling, sitting, etc, to the local "GEM" wind speed which is exceeded on average 5% of the time, on an annual return period basis – refer **Table 2**.
- The Lawson Comfort Criteria "GEM" (Gust Equivalent Mean) wind speed is the maximum of the local mean hourly wind speed or the local gust speed divided by 1.85.

Table 2 Lawson Wind Acceptability Criteria – COMFORT

Comfort Level	Beaufort Equivalent	"GEM" Wind Speed 5% Annual Exceedance	Description (see also Notes)
C5	1	2.5 m/sec	Dining
C4	2	4 m/sec	Sitting
C3	3	6 m/sec	Standing
C2	4	8 m/sec	Leisure Walking (Strolling)
C1	5	10 m/sec	Business (Purpose) Walking
CX	> 5	> 10 m/sec	Exceeds Comfort Criteria

Comfort Level	Beaufort Equivalent	"GEM" Wind Speed 5% Annual Exceedance	Description (see also Notes)

Notes:
C4 is suitable for promenades, popular recreation areas with seating, reading newspapers, etc
C3 is suitable for locations where pedestrians will likely be waiting for relatively short periods, eg at building entrances, at pedestrian crossings, bus stops, etc
C2 is suitable for activities such as window-shopping
C1 is suitable for footpaths used for purposeful pedestrian traffic only (eg not where shops might induce slower activities like window-shopping)
CX suggest winds whose force can be felt by the body (branches on trees would be visibly swaying) and where walking will start to become inconvenient or challenging for certain classes of pedestrians, eg the frail, pedestrians holding parcels, parents holding children, etc.

4.3 Applying the Lawson Comfort Criteria - Significance Assessment

In an assessment of "Comfort-related" wind effects at measurement locations surrounding a development site, wind-tunnel predicted Comfort Levels at any particular location are compared with the target usage at the same location (eg sitting, strolling, leisure walking, etc) – refer **Table 2**.

- The proposed development is deemed to have a **"Beneficial"** impact at any particular location if predicted wind conditions are calmer than the target levels at that location.
- When predicted wind conditions at any particular location, with the addition of the proposed development, are close to the target levels, the impact is termed **"Negligible"**.
- The proposed development is deemed to have an **"Unfavourable"** impact at any particular location if predicted wind conditions are higher (windier) than the target levels at that location.

The Lawson Comfort Criteria are then applied as shown **Table 3**.

- All **"Unfavourable"** impacts (whether minor, moderate or major) are considered to be "significant", requiring consideration of mitigation for local conditions to become suitable for the intended use of the area.
- In considering mitigation under these such circumstances, "Baseline" wind conditions should also be considered if pre-existing conditions already exceed the target wind levels at the project site.

Table 3 Significance Assessment Actions Related to Lawson Comfort Criteria

Impact	Predicted Wind Microclimate
Beneficial – Major	Wind Conditions are 3-levels **calmer** than desired
Beneficial – Moderate	Wind Conditions are 2-levels **calmer** than desired
Beneficial – Minor	Wind Conditions are 1-level **calmer** than desired
Negligible	Wind Conditions are at the **same** level as desired
Unfavourable – Minor	Wind Conditions are 1-level **windier** than desired
Unfavourable – Moderate	Wind Conditions are 2-levels **windier** than desired
Unfavourable – Major	Wind Conditions are 3-levels **windier** than desired **OR** Wind Conditions are in the Lawson "CX" or "SX" category

4.4 Comments on the Application of the Acceptability Criteria

Approach for Areas Where Existing Wind Conditions Already Exceed Criteria

In many urban locations, either because of exposure to open upstream conditions or because of street "canyon" effects, etc, the relevant Comfort and Safety criteria may already be currently exceeded.

In such instances, standard practice is that a new development should:

- ideally not exacerbate existing adverse wind conditions; and
- wherever feasible and reasonable, ameliorate such conditions.

For this reason, in the assessment of wind tunnel predictions of wind conditions associated with a newly proposed development, it can be useful to compare the wind microclimate in the "Proposed" condition (ie with the proposed development) with the wind microclimate of the pre-existing "Baseline" condition – as has been done in the present study.

4.5 Central Sydney DCP2012 Wind Criteria

The Central Sydney DCP2012 criteria for wind, and as proposed in Draft Amendments to the DCP, appear to be a modified amalgam of the Melbourne Criteria for Safety and the Lawson Criteria for Comfort – refer **Table 4**.

Table 4 Central Sydney DCP2012 Wind Acceptability Criteria

Type of Criteria	Limiting Wind Speed	Wind Speed Assessment Metric
Safety "CoS-SAFE"	24 m/s	Annual maximum peak 0.5-second gust wind speed in one hour measured between 6:00am and 10:00pm Eastern Standard Time
Comfort – WALKING "Walking"	8 m/s	Hourly mean wind speed, or gust equivalent mean (GEM) wind speed, whichever is greater, for each wind direction, with a 5% probability of occurrence measured between 6:00am and 10:00pm Eastern Standard Time (ie 292 hours per annum)
Comfort – STANDING "Standing"	6 m/s	Hourly mean wind speed, or gust equivalent mean (GEM) wind speed, whichever is greater, for each wind direction, with a 5% probability of occurrence measured between 6:00am and 10:00pm Eastern Standard Time (ie 292 hours per annum)
Comfort – SITTING "Cos-SIT"	4 m/s	Hourly mean wind speed, or gust equivalent mean (GEM) wind speed, whichever is greater, for each wind direction, with a 5% probability of occurrence measured between 6:00am and 10:00pm Eastern Standard Time (ie 292 hours per annum)

4.6 Comment on DCP2012 Wind Criteria

As noted above, **Table 4** shows that the DCP2012 wind criteria are modified versions of the Melbourne Safety Criteria and the Lawson Comfort Criteria. The following divergences from the criteria as originally proposed by Melbourne and Lawson are noted.

Safety

The original Melbourne (1978) criteria governing public safety (ie people knockdown) were based on:

- The annual gust wind speed exceeded 0.1% of the time from any 22.5° wind direction sector: set at 23 m/s for public access areas and 24 m/s for normally inaccessible areas.

The DCP2012 criterion governing public safety (ie people knockdown) is based on:

- The peak 0.5-second annual gust wind speed at 24 m/s measured between 6:00am and 10:00pm Eastern Standard Time.

The reasons for altering the original (and extensively calibrated) Melbourne criteria are unknown to SLR. The following is observed:

- The DCP2012 criterion chooses a more stringent gust interval (0.5 seconds).
- The DCP2012 criterion chooses a less stringent acceptance level (24 m/s versus 23 m/s).
- The DCP2012 criterion chooses a less stringent acceptance period – the criterion only has to be satisfied during the hours of 6:00am to 10:00pm, rather than all day long.

Without the benefit of a detailed statistical analysis covering a variety of specific Sydney locations, it is not possible to state categorically whether the DCP2012 safety criterion is more or less stringent than the original Melbourne criteria for safety.

In the sections that follow, SLR has used the DCP2012 criterion for safety.

Comfort

The original Lawson criteria for public comfort were based on:

- The higher of the mean hourly wind speed and gust wind speed divided by 1.85, exceeded 5% of the time, taking into account ALL wind directions, and all day long.

The DCP2012 criteria governing public comfort are based on:

- The higher of the mean hourly wind speed and gust wind speed divided by 1.85, exceeded 5% of the time, for EACH wind direction, between 6:00am and 10:00pm Eastern Standard Time.

Again, the reasons for altering the original (and widely used) Lawson criteria are unknown to SLR. The following is observed:

- The DCP2012 criterion uses the same wind speed metric and exceedance level (5%).
- The DCP2012 criterion chooses a less stringent acceptance mode – the relevant 5% exceedance level only has to comply for “each wind direction”, whereas in the original Lawson formulation, the 5% exceedance level had to comply with the summation over ALL wind directions.

- No guidance is provided at to what "each wind direction" means, eg every 10°, 15°, 22.5°, 45°, etc.

Without the benefit of a detailed statistical analysis covering a variety of specific Sydney locations, it is not possible to state categorically whether the DCP2012 criteria are more or less stringent than the original Melbourne criteria. However, it is most likely that the DCP2012 definition is less stringent than the original Lawson formulation due to the former's less stringent wind direction and time of day definition.

Despite the DCP2012 wind criteria for Comfort being potentially less stringent than the original equivalent Lawson criteria (which are the ones generally used by SLR), in the sections that follow, SLR has used the DCP2012 criteria for Comfort, as recommended in the City of Sydney review to DPE.

4.7 Mitigation Using Landscaping

The Australasian Wind Engineering Society (AWES) *Guidelines for Pedestrian Wind Effects Criteria* includes advice related to the use of landscaping (trees, shrubs, etc) for mitigation of adverse wind conditions.

In particular, the AWES Guideline notes the following:

- Trees planted in locations where the 23 m/s safety criterion is exceeded are likely to experience wind speeds every 5 years or so which will be sufficient to destroy or severely damage many trees.
- Trees placed in high wind areas therefore have the potential to shed limbs during windstorms, thereby causing a public danger and a public nuisance.
- Moreover, landscaping planted in high wind locations rarely matures to its normal full height necessary for the assumed wind mitigation it will provide.
- Finally, trees located on public footpaths become the responsibility of the local municipality. Their maintenance, replacement following damage, loss of limbs, etc, can become burdensome financially (assuming the Municipality is even aware of such damage) and cannot be guaranteed.

Accordingly, the AWES Guideline does not recommend the use of landscaping when seeking to mitigate wind conditions that equal or exceed the public safety 23 m/s criterion.

5 WIND TUNNEL TEST METHODOLOGY

5.1 Simulation of Natural Wind

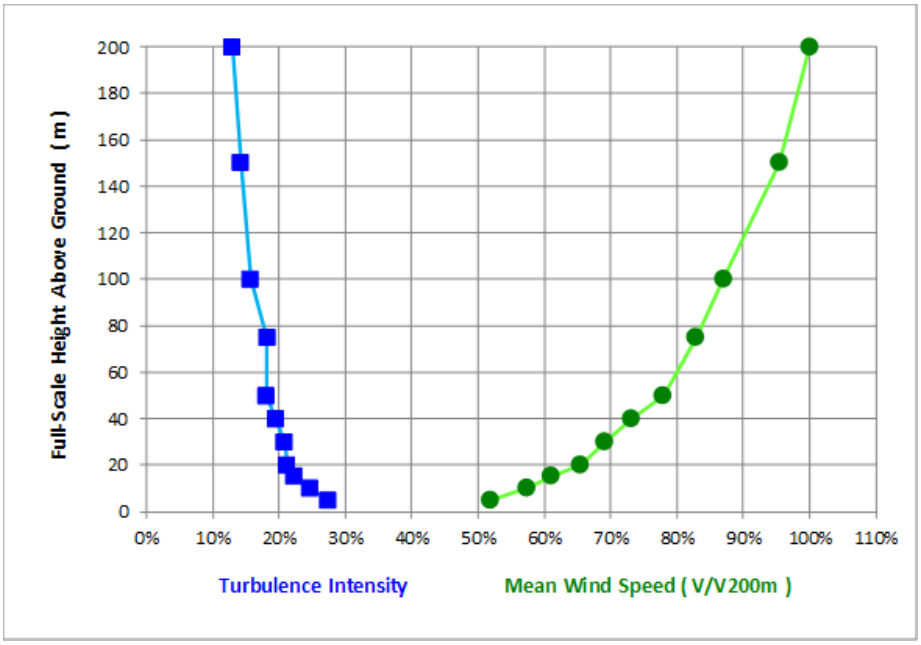
Similarity requirements between the wind tunnel model and prototype (ie full-scale) need to be fulfilled so that similitude in the flow conditions is satisfied. Usually all requirements cannot be satisfied and compromises need to be made. In this type of wind tunnel test it is possible to waive strict adherence to the full range of similarity parameters.

The wind tunnel test has been carried out using a geometric length scale of 1:400 for all dimensions (standard wind tunnel test scaling) and by scaling the boundary layer approach wind in the wind tunnel to the same scale as in the atmosphere.

The approach wind was modelled by matching terrain category conditions for all wind directions. In the wind tunnel, this is achieved by an almost 20-metre fetch of appropriate roughness elements.

The upstream profile conditions simulated in the present study is Terrain Category 3 associated with medium density suburban surroundings. The variation of mean wind speed (green curve) and turbulence intensity (blue curve) is shown in **Figure 6**.

Figure 6 Wind Tunnel Test Profiles for Mean Wind and Turbulence Intensity



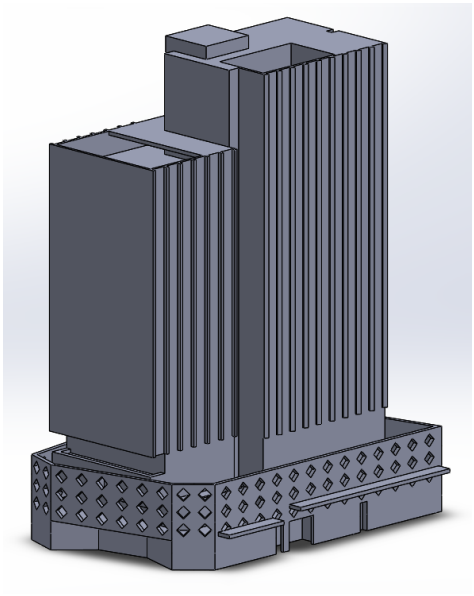
5.2 Development Models and Proximity Model

Development Models: November 2021 Latest Design & "Compliant" Design

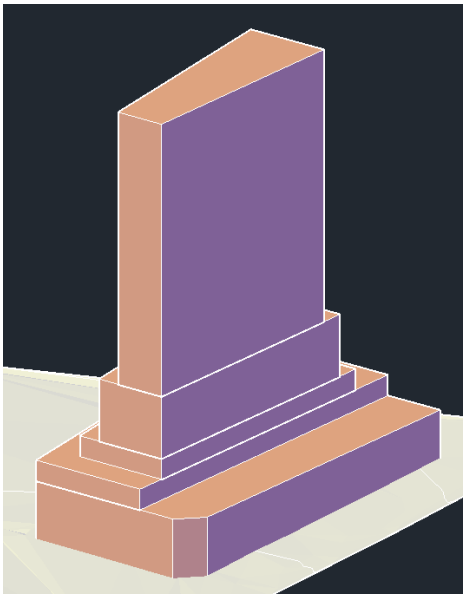
Two 1:400 scale models of the proposed development were built for the testing – refer **Figure 7** - for the latest (November 2021) proposed "Preferred" design and Redfern Centre Urban Design Principles "Compliant" design.

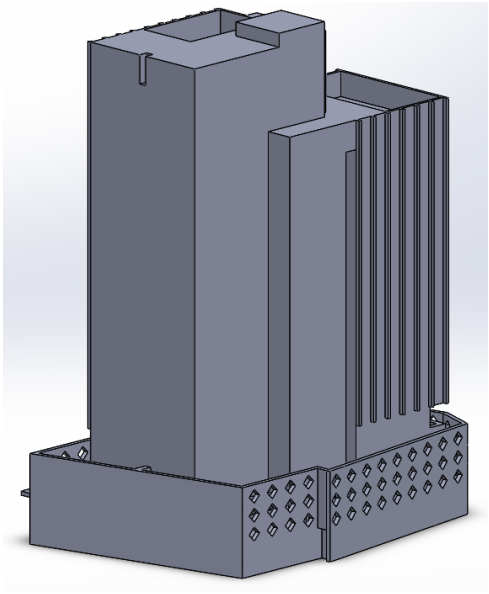
Figure 7 1:400 Scale Model of the Proposed Development

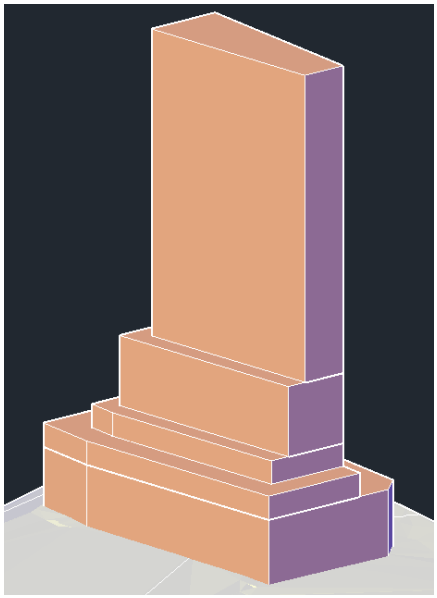
November 2021 Proposed development "Preferred" Design



November 2021 Redfern Centre Urban Design Principles "Compliant" Design







Proximity Model

To take into account the influence of the immediate surrounding physical environment, all neighbouring buildings and local topography within a diameter of almost 900 m around the site were included in the purpose-built 1:400 scale "proximity model" used for the test as shown in **Figure 8**.

The proximity models used in the present testing simulate the following three built environment "scenarios":

- "Baseline": Existing built environment
- "Future-P": "Baseline" + future proposed development (Preferred Design) with proposed trees
- "Future-C": as per "Future-P" but with City of Sydney "Compliant" Design

All of the above scenarios include the approved future developments lying to the immediate north and west of the site – refer **Figure 8**.

Figure 8 Proximity Models Used in the Wind Tunnel Testing

"Baseline" Scenario (Existing)

View from South

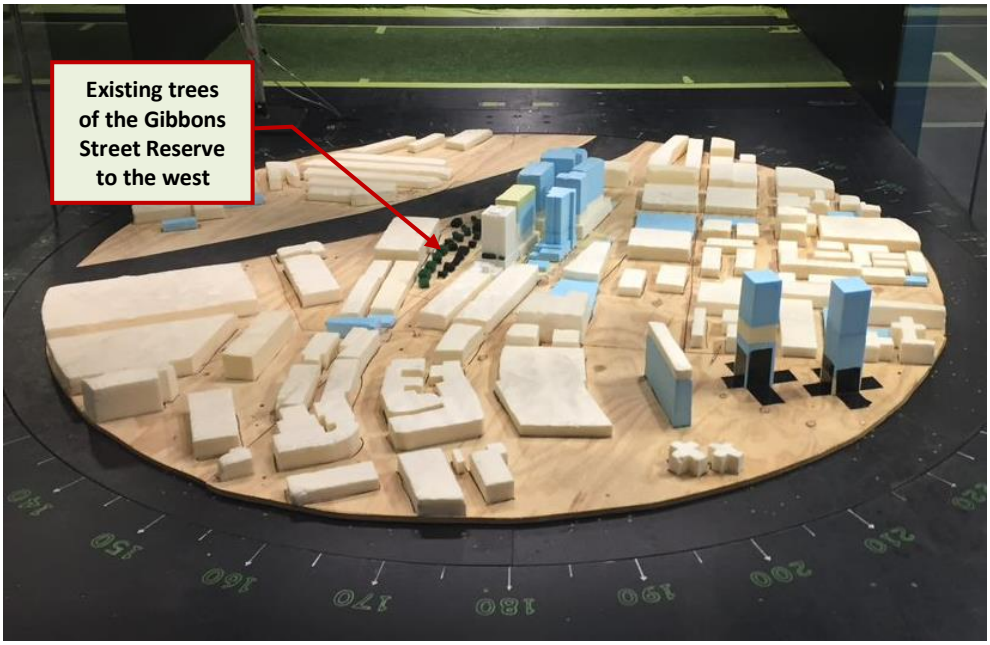
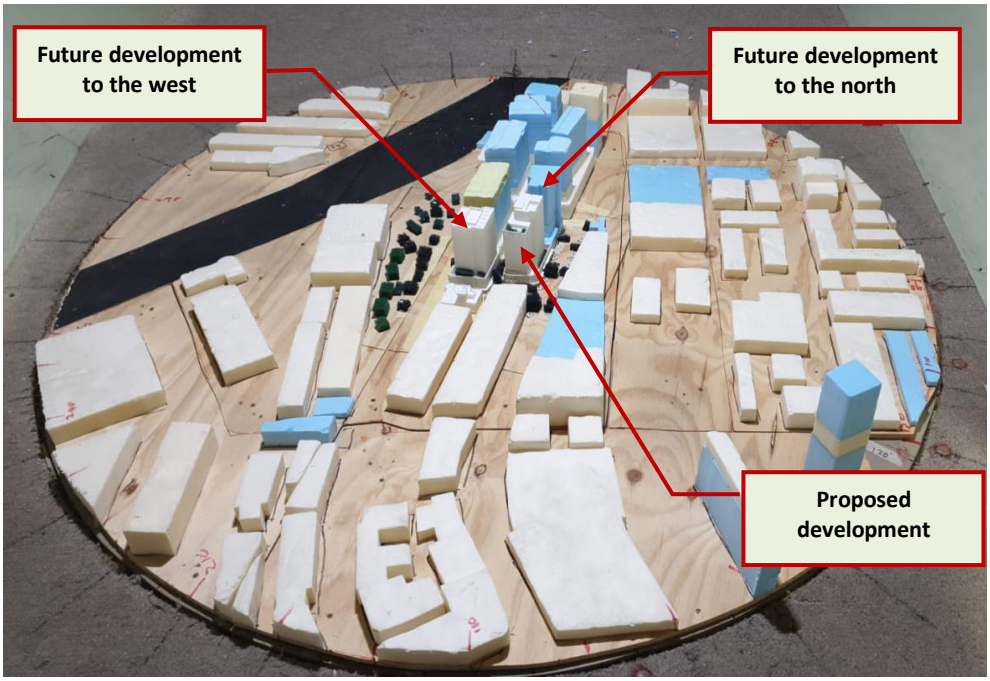


Fig.8 (cont'd)

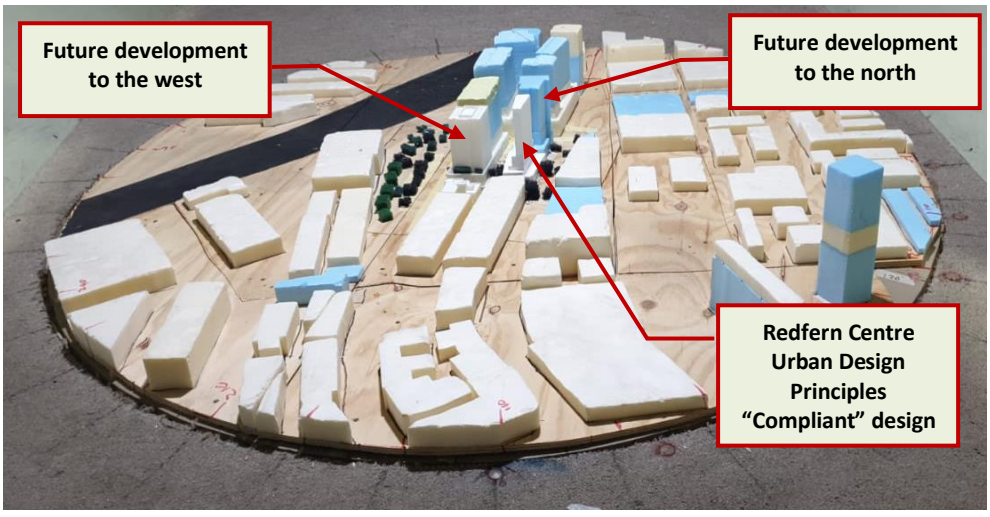
"Future-P" Scenario (with Proposed development)

View from South



"Future-C" Scenario (Redfern Centre Urban Design Principles "Compliant" design)

View from South



5.3 Data Processing

Wind speed measurements were taken at 10° intervals:
the 0° wind direction is from the north, with east at 90°, south at 180°, etc.

The wind speeds at the locations of interest are measured
in the wind tunnel using Irwin sensors.

Wind speeds in the wind tunnel were measured at a height
corresponding to approximately chest height (1.5 m) in full scale.

The sampling time for each measurement is 60 seconds.

Wind speed measurements are recorded as dimensionless ratios
of the mean and gust ground level velocity to a mean reference wind speed
at a (full-scale) height of 200 m above ground level.

The reader is referred to the publication referenced below for a full description of this technique and validation of Irwin sensor data using hot-wire anemometry.

- LTR-LA-242 *"A Simple Omni-Directional Sensor for Wind Tunnel Studies of Pedestrian Level Winds"* (Irwin, National Aeronautical Establishment, Ottawa, Canada, May 1980)

The wind tunnel output data is then processed using the directional wind speed information derived from the Redfern wind climate model to yield ground level wind speeds as a function of annual return period and directional mean reference wind speed – refer **Figure 5**.

The ground level wind speeds thus incorporate both the building and terrain/topographical aspects of the location as well as the directional probability of wind speed for the site.

The results have been computed on an annual exceedance basis, to compare to the adopted wind acceptability criteria, using the local Project-Site statistical wind data – refer **Figure 5**.

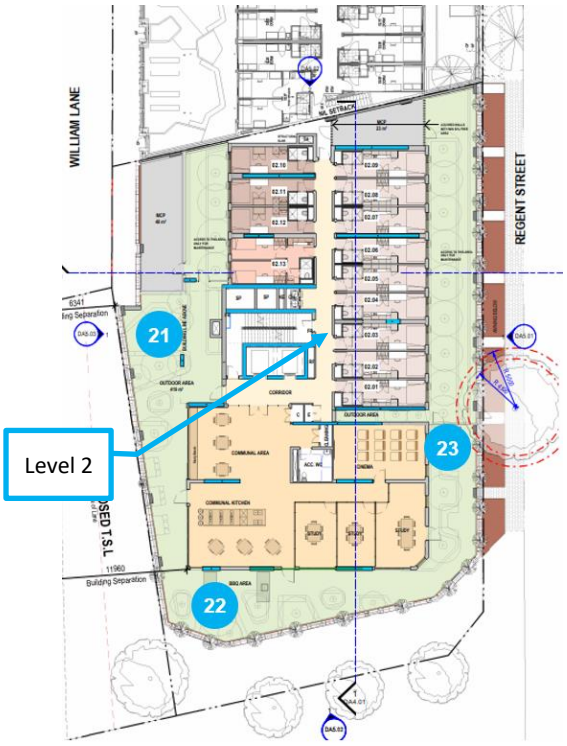
5.4 Test Method – Sensor Locations

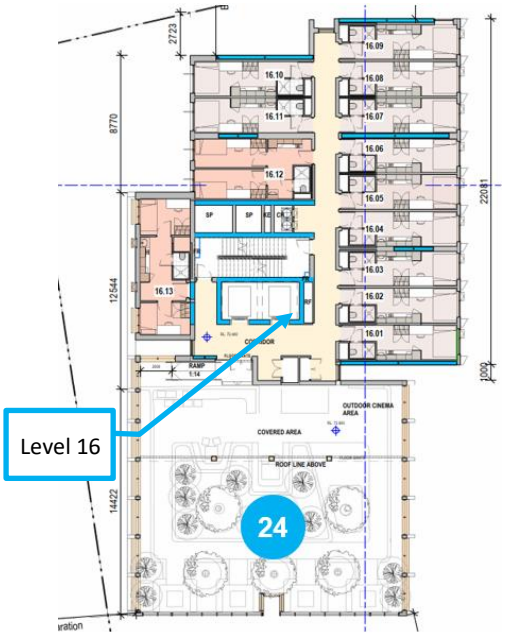
In the wind tunnel testing, Irwin wind sensors were positioned at the locations shown in **Figure 9**.

These locations were chosen as potentially susceptible to adverse wind conditions, eg near building corners, or represent locations of interest throughout the development, eg near primary building entrances and along footpaths.

- The 20 Ground level sensors are shown in Yellow – these were measured for all scenarios;
- The 4 sensors located on Level 2 and Level 16 shown in blue were only measured for the "Future-P" scenario.

Figure 9 Wind Tunnel Test Sensor Locations





5.5 Sample Test Result

An example of the test results and interpretation of these results is shown in **Figure 10**, illustrating the peak annual mean and gust wind speeds at:

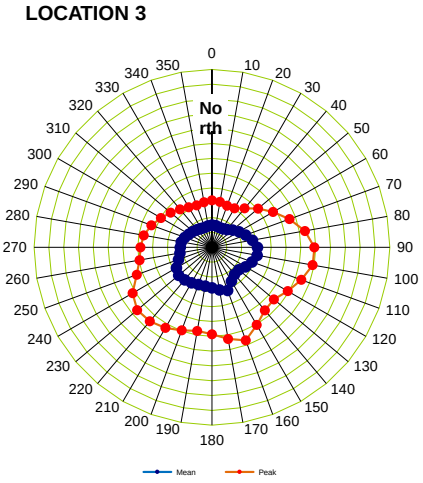
Sensor: **Location 3**
Location: William Lane, along western façade of proposed development

The polar diagram shows the output of the wind tunnel test results in terms of the ratio of mean wind speed and gust wind speed to reference height mean wind speed (Ht=200m):

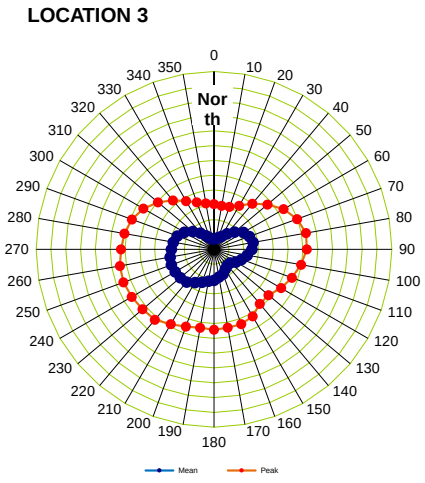
Mean wind speed: "navy blue" data points
Gust wind speed: "red" data points.

Figure 10 Sample Polar Plot Test Result – Location 3 – All Scenarios

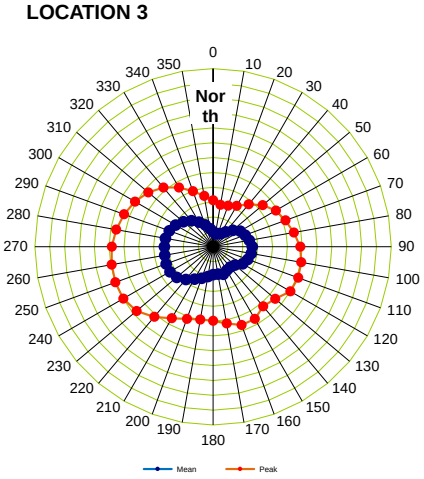
"Baseline" Scenario



"Future-P" Scenario



"Future-C" Scenario



For the **"Baseline"** scenario …

- Winds at Location 3 are strongest from the east and south-southeast, where winds from these directions can impact directly due to minimal shielding provided by the existing low height buildings at site.

For the **"Future-P"** scenario …

- With the addition of the proposed development ("Preferred" Design), winds at Location 3 decrease from the easterly direction due to the shielding provided by the proposed development itself.
- Increase in winds can be seen from the northwest to southwest wind directions as a result of slight downwash as well as increased funnelling effect where the winds side-stream along the western aspect of the development and channel along the William Lane.

For the **"Future-C"** scenario …

- At Location 3, wind responses for the Redfern Centre Urban Design Principles "Compliant" design are similar to the proposed design for almost all wind directions.
- Increase in winds can be seen from the northwest to southwest wind directions as a result of slight downwash as well as increased funnelling effect where the winds side-stream along the western aspect of the development and channel along the William Lane.

6 TEST RESULTS

6.1 DCP2012 Calculation Methodology

As described in previous sections, the wind tunnel results are processed as follows:

- The wind tunnel test data yield ratios of the local ground level wind speed (mean and peak gust) to the reference height (200 m full-scale) mean wind speed (refer **Figure 6**) in the wind tunnel.
- **Appendices C, D and E** show the relevant wind tunnel test result polar plots for all locations for the "Baseline" and the two "Future" Scenarios respectively.
- The local Project Site wind speed and wind direction probability distribution is then used to calculate the probability of occurrence of the "GEM" wind speeds at an annual exceedance level of 5% to compare to the DCP2012 Comfort Criteria and the peak annual gust to compare to the DCP2012 24 m/s Safety Criterion.

6.2 Predicted Wind Tunnel Results re DCP2012 Safety Criterion

As discussed in the previous SLR Reports covering the proposed development, the results of the combination of wind tunnel test results (local ground level wind speed ratios) with the wind speed and wind direction probability distribution (peak annual gust) relevant to safety yielded the following outcome:

- In the "Baseline" scenario, the peak annual gust at ALL locations within and around the site are below the 24 m/s criterion level;
- In the "Future-P" scenario, the peak annual gust at ALL locations within and around the site continue to remain below the 24 m/s criterion level; and
- In the "Future-C" scenario, the peak annual gust at ALL locations within and around the site also continue to remain below the 24 m/s criterion level.

It is concluded that both of the "future" development designs, the "Preferred" and "Compliant" satisfy the Central Sydney DCP2012 criterion for public safety.

6.3 Predicted Wind Tunnel Results re DCP2012 Comfort Criteria

Table 5 gives the wind tunnel-predicted 5% exceedance levels (higher of mean hourly wind speed and gust wind speed divided by 1.85) and compares to the target levels (refer **Table 4**) set for the project, which are:

- Pedestrian locations close to building entry points: Comfort STANDING (6 m/s)
- Pedestrian locations everywhere else: Comfort WALKING (8 m/s)
- Elevated Podium/Terrace locations Comfort STANDING/SITTING (6/4 m/s)

Results are given for the "Baseline", "Future-P" and "Future-C" built environment scenarios.

Table 5 Assessment of Impacts of the Proposed Development – DCP2012 Comfort Criteria

Location	DCP2012 Target Comfort Level	Wind Tunnel Predicted Comfort Levels			"Future-P" Impact (refer Table 4) Relative to Target Comfort Level
		Baseline	Future-P	Future-C	
1	Walking	Standing	Standing	Standing	Favourable
2	Walking	Standing	Standing	Standing	Favourable
3	Walking	Standing	Standing	Standing	Favourable
4	Walking	Standing	Standing	Standing	Favourable
5	Standing	Walking	Standing	Standing	Negligible
6	Walking	Walking	Walking	Walking	Negligible
7	Walking	Walking	Walking	Walking	Negligible
8	Walking	Walking	Walking	Standing	Negligible
9	Walking	Standing	Standing	Standing	Favourable
10	Walking	Standing	Standing	Standing	Favourable
11	Walking	Standing	Standing	Standing	Favourable
12	Walking	Standing	Standing	Standing	Favourable
13	Standing	Standing	Standing	Standing	Negligible
14	Walking	Standing	Standing	Standing	Favourable
15	Walking	Standing	Standing	Standing	Favourable
16	Walking	Standing	Standing	Standing	Favourable
17	Standing	Walking	Standing	Standing	Negligible
18	Walking	Standing	Walking	Walking	Negligible
19	Walking	Standing	Standing	Standing	Favourable
20	Walking	Standing	Standing	Standing	Favourable
21	Standing/Sitting	*Refer Note 1*	Standing	*Refer Note 1*	Negligible
22	Standing/Sitting		Standing		Negligible
23	Standing/Sitting		Standing		Negligible
24	Standing/Sitting		Standing		Negligible

Note 1 Locations 21-24 only exist in the "Future-P" scenario

6.4 Wind Impact Relative to Intended Usage (Target Comfort Level)

Pedestrian Footpath Areas Surrounding the Site

These locations (Regent Streetm Margaret Street and the Through Site Link) are all considered "Active".

Comfort Target Level: DCP2012 Comfort WALKING (5% exceedance 8 m/s)
except for Comfort STANDING (5% exceedeance 6 m/s) at Building Entries

In the "Future-P" scenario:

- ALL relevant ground level locations satisfy the target levels of "Walking" or "Standing".

This is the same for the "Future-C" scenario.

Podium Level 2

Comfort Target Level: DCP2012 Comfort STANDING / SITTING
(5% exceedeance of 6 m/s / 4 m/s)

For many wind directions, the outdoor Level 2 areas are relatively sheltered by the adjacent similar height buildings to the immediate north and west, the proposed vertical façade screening along the perimeter of the development (from level 2 slab up to level 4 slab) and the proposed development itself.

For some other restricted wind directions, Level 2 has the potential to experience elevated wind conditions as windflow accelerates past the proposed development's western and southern façades and is directed downwards as downwash.

It is important however to appreciate that, while some outdoor Level 2 areas have the potential to attract elevated winds from building floors above (downwash, etc), these winds are thereby prevented from generating the same impact at ground level locations immediately below. The Podium therefore plays an important role in ameliorating ground level wind conditions in surrounding pedestrian areas.

- In the "Future-P" scenario, ALL Level 2 locations are at the "Standing" level.

Elevated Terrace – Level 16

Comfort Target Level: DCP2012 Comfort STANDING / SITTING
(5% exceedeance of 6 m/s / 4 m/s)

Similar to the outdoor Level 2 areas, the Level 16 terrace receives sheltering from adjacent similar height buildings to the immediate north and west and the proposed full height screening at Level 16, as well as the proposed development itself. For some other restricted wind directions, the Level 16 terrace has the potential to experience elevated wind conditions as windflow accelerates past the proposed development's western and southern façades as accelerated shear flow.

- In the "Future-P" scenario, the Level 16 locations are at the "Standing" level.

7 MITIGATION TREATMENT RECOMMENDATIONS

In relation to compliance with Central Sydney DCP2012 Wind Criteria, the results discussed in **Section 6** show that:

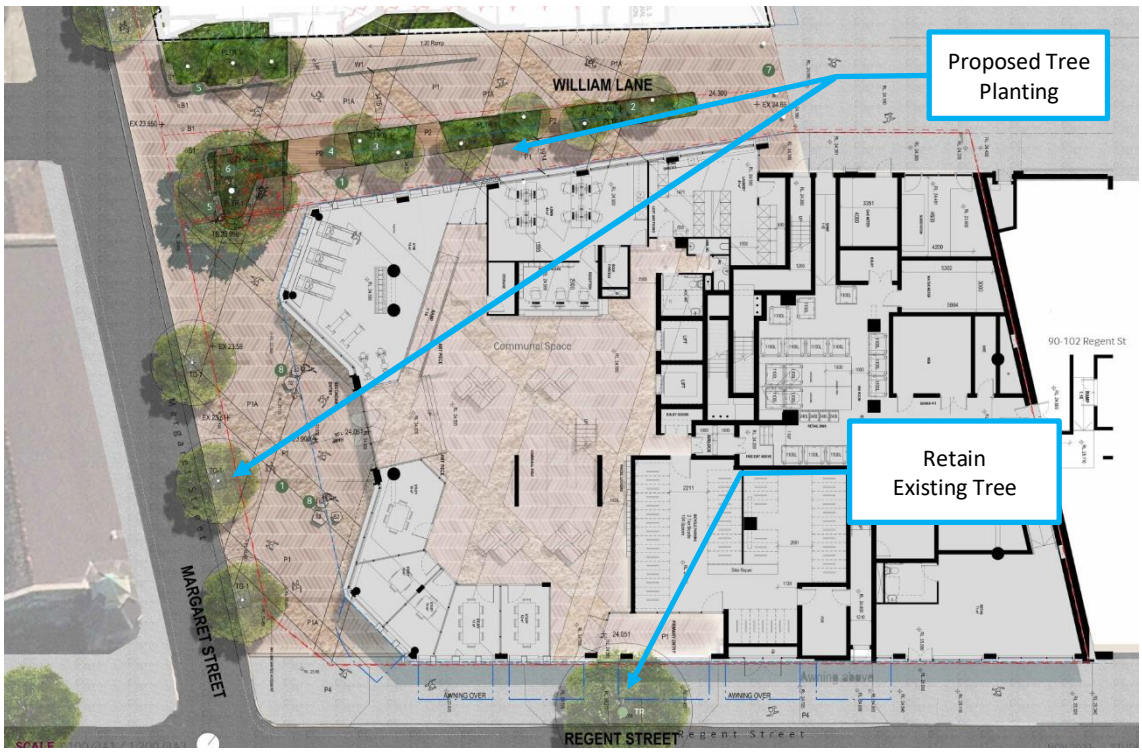
- ALL locations (external and internal) comply with the DCP2012 24 m/s Safety Criterion;
- ALL surrounding footpath areas comply with the DCP2012 Walking Comfort Criterion and the Standing Comfort Criterion at building entry points; and
- Consideration could be given to improving the wind environments in the outdoor open areas of Level 2 and Level 16, specifically in areas where outdoor, seated dining is planned.

7.1 Already Planned Wind Amelioration

Figure 11 illustrates the existing and currently planned landscaping for the Project (street level and elevated) as well as other wind mitigation treatments, eg street level awnings, etc.

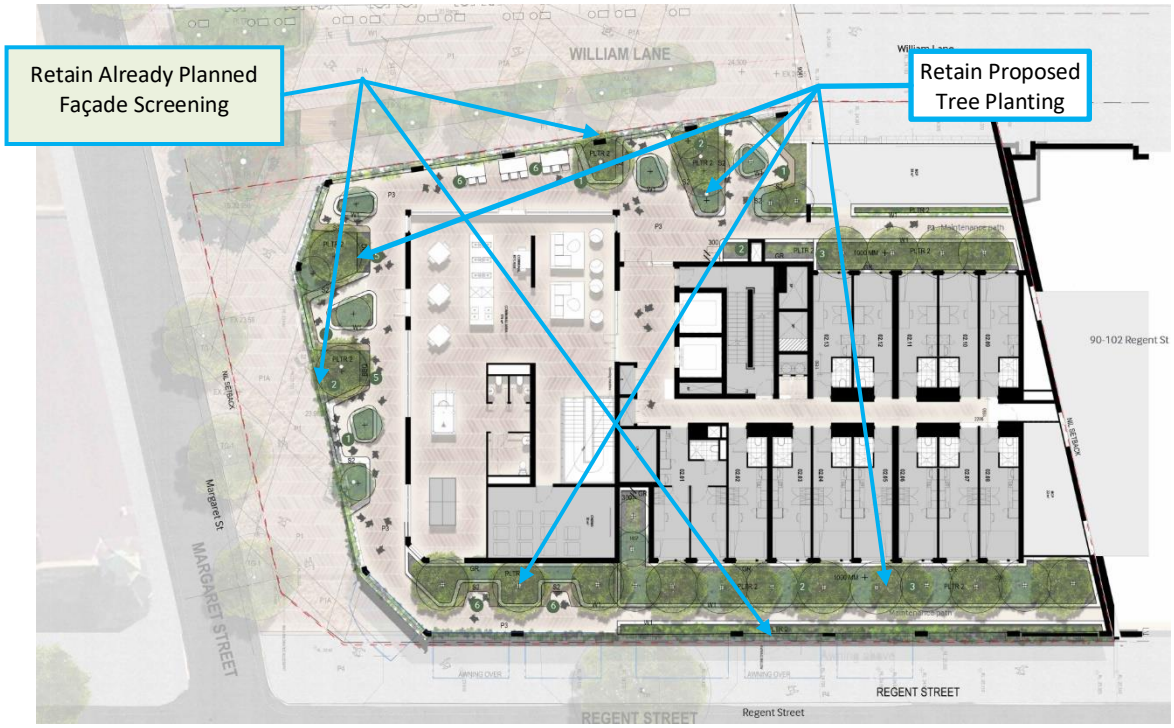
Figure 11 Project Proposed Landscape Treatments

Level 1 (Ground) Landscape Plan

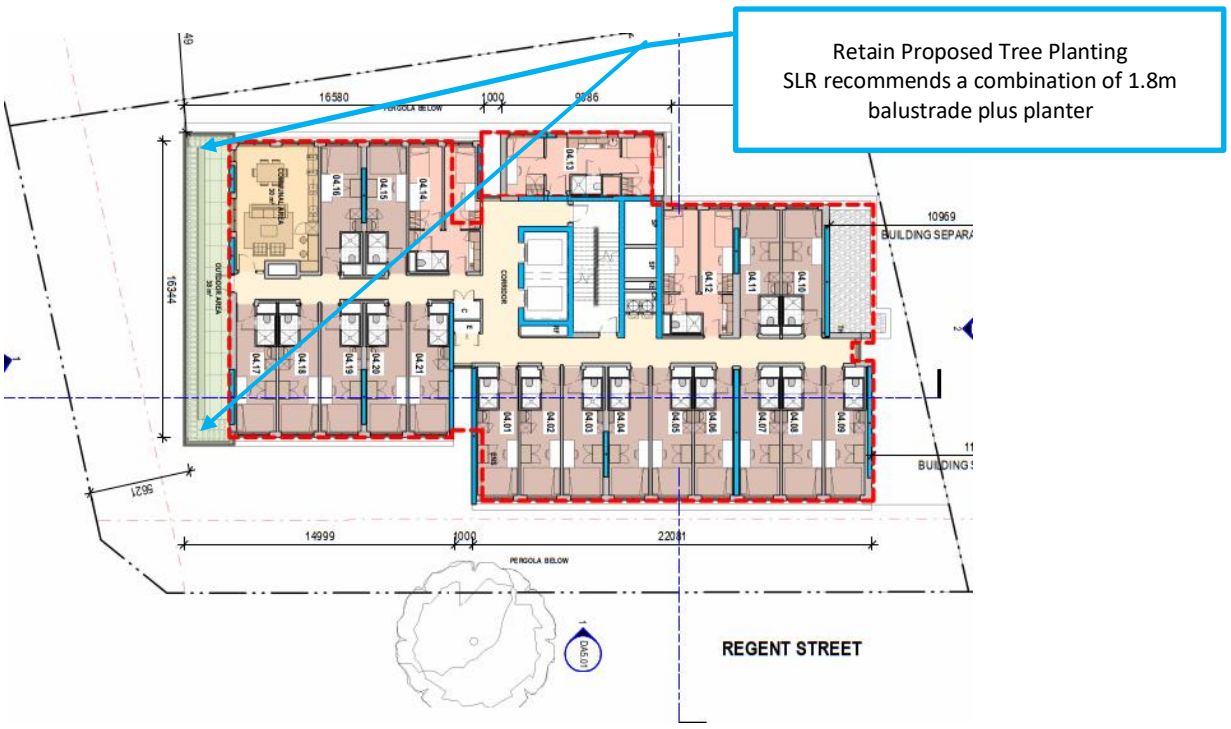


(Fig.11 cont'd)

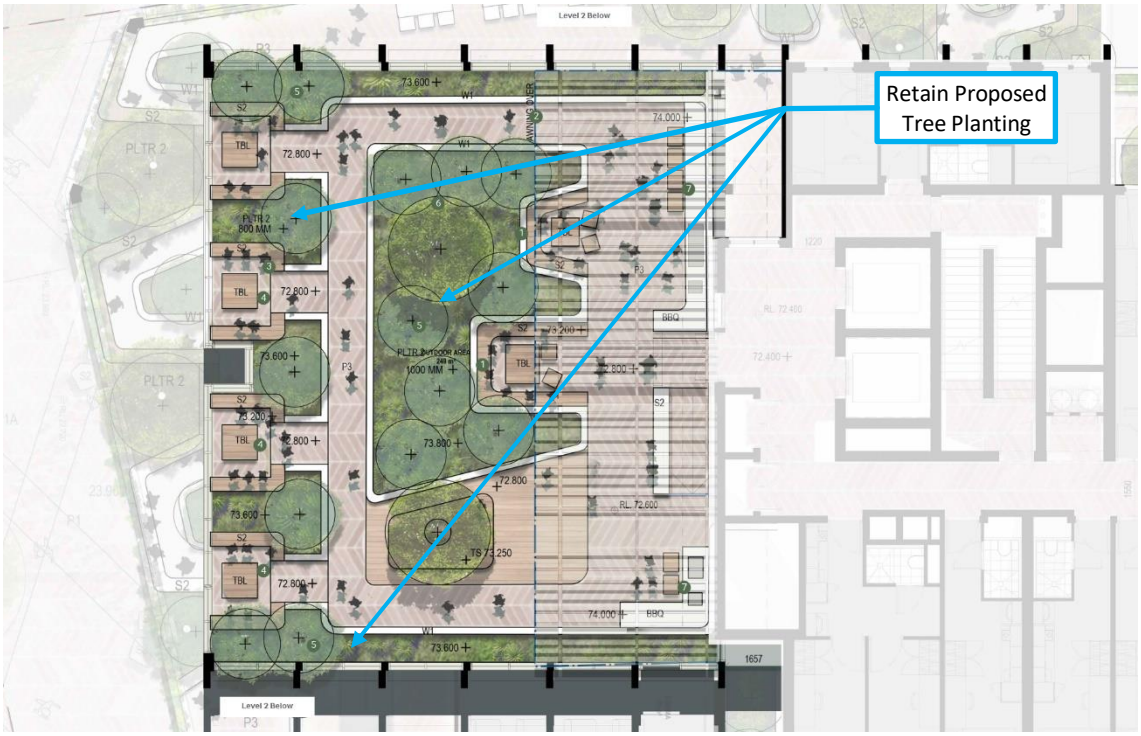
Level 2 Landscape Plan



Level 4 Landscape Plan



(Fig.11 cont'd) **Level 16 Landscape Plan**



7.2 Wind Mitigation Recommendations

Pedestrian Areas Surrounding the Site

Current plans for the proposed development incorporate an awning along the development's eastern façade (refer **Figure 2**) as well as the extensive landscaping shown in **Figure 11**.

We recommend the following:

- The planned awning along Regent Street protecting ground level footpath areas below should be retained.
- Further, it is recommended that the proposed awning be continuous. Note that the awnings can be connected in a stepped manner if required to account for the change in ground elevations
- It is recommended that the existing large tree on Regent Street be retained.
- It is also recommended that all other "proposed" trees on Margaret Street and the Through Site Link be retained and are of evergreen species, of similar foliage as existing trees.

Level 2 and Level 16 Outdoor Areas

The landscaping proposed for these outdoor areas (refer **Figure 11**) is effective in mitigating adverse wind conditions, given that the wind tunnel-predicted 5% exceedance levels satisfy the DCP2012 Comfort STANDING criterion. SLR therefore recommends:

- Retention of the proposed vertical façade screening along the perimeter of the development (from level 2 slab up to level 4 slab) – refer **Figure 11**.
- Retention of the proposed tree planting on the Level 2 communal area, Level 4 outdoor area and Level 167 communal area - refer **Figure 11**.
- The above proposed landscaping should be evergreen – refer **Figure 11**.

In relation to improving the wind environment in the outdoor open areas of Level 2 and Level 16, eg in any area where seating is planned, the following is recommended:

- Localised horizontal protection (eg pergola, shade-cloth, umbrellas, etc) to protect any elevated terrace areas intended to be used for outdoor dining.

Noting that these elevated areas are already at the DCP2012 Comfort "Standing" level, there would be no doubt that the addition of horizontal windbreak in seated, eating areas would mitigate winds even further, in fact to well below the DCP2012 Comfort "Sitting" level. Such areas would almost certainly satisfy the even more stringent Lawson Dining Comfort criterion level (5% exceedance level of 2.5 m/s).

SLR therefore see no discernible benefit in additional wind tunnel testing, given the certainty of achieving the target DCP2012 Comfort level relevant to the Project if all the wind recommendations noted above are implemented.

Recent Design Refinement

Design refinements have recently occurred including the removal of a unit located at the northwest corner of the development on levels 4 to 18. As a result, the building shape now slightly differs at the northwest corner at these levels from the proposed design tested in December 2021 (Refer architectural drawing 20009DA, supplied in May 2022).

The above changes will have no impact on the results of the previous wind tunnel studies

8 CLOSURE

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of The Trust Company (Australia) Limited ATF WH Redfern Trust. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR Consulting.

9 Feedback

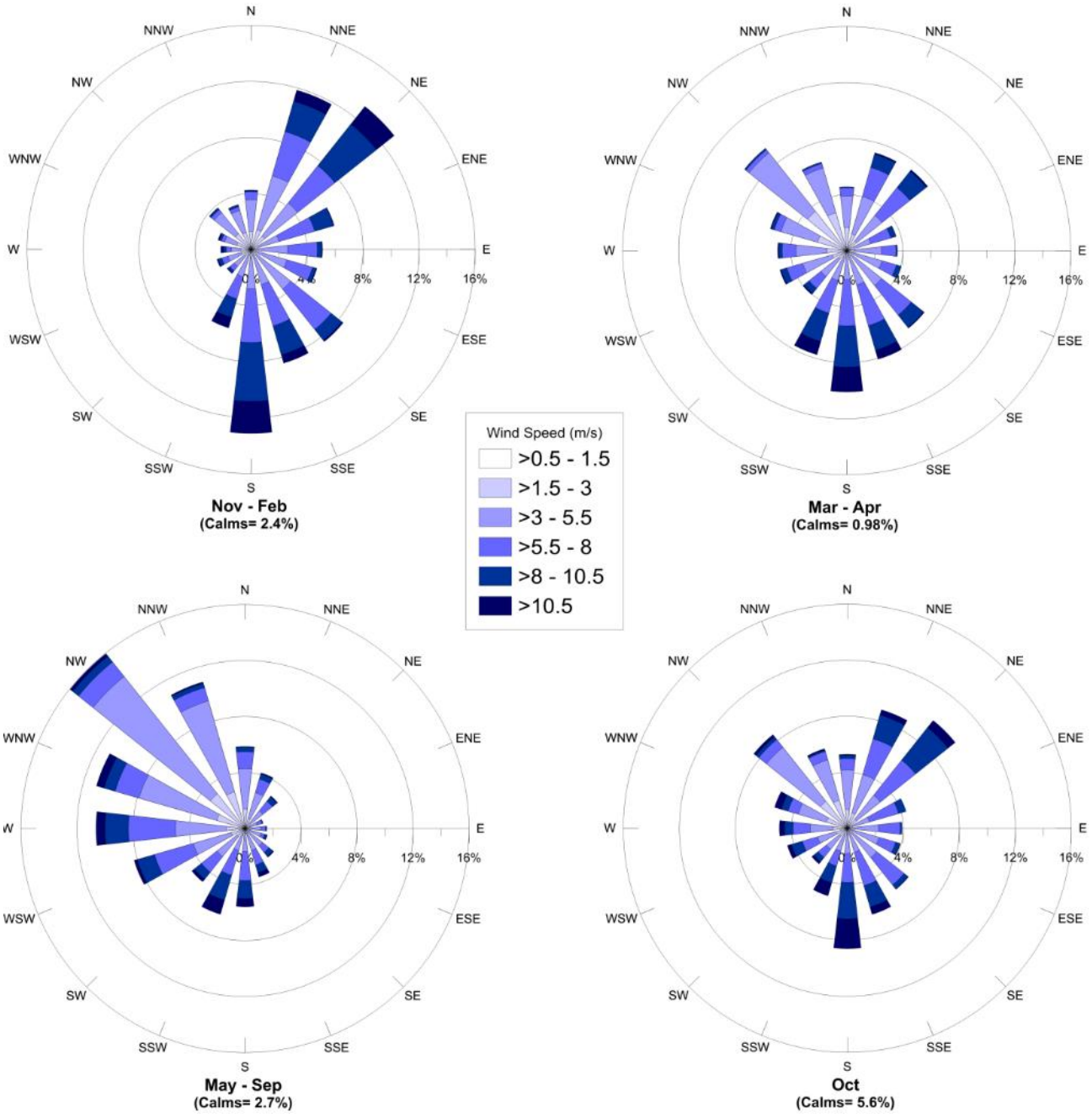
At SLR, we are committed to delivering professional quality service to our clients. We are constantly looking for ways to improve the quality of our deliverables and our service to our clients. Client feedback is a valuable tool in helping us prioritise services and resources according to our client needs.

To achieve this, your feedback on the team's performance, deliverables and service are valuable and SLR welcome all feedback via https://www.slrconsulting.com/en/feedback. We recognise the value of your time and we will make a $10 donation to our 2022 Charity Partner – Lifeline, for every completed form.

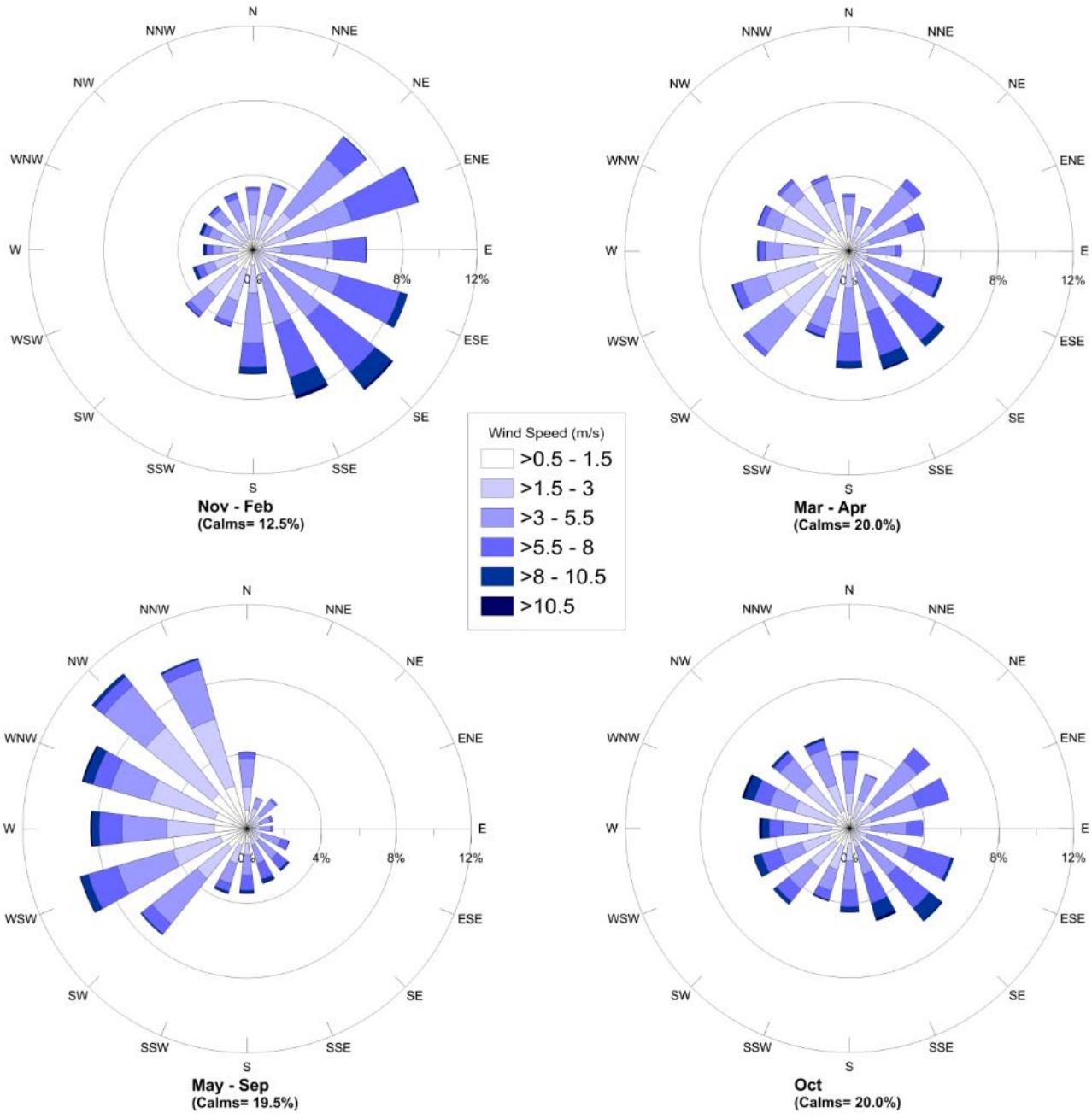
APPENDIX A

Seasonal Wind Roses for Bureau of Meteorology Met Stations at Sydney (Kingsford Smith) Airport and Bankstown Airport

Sydney Airport AWS
(Observations)
1999-2017
600.09300



Bankstown Airport AWS
(Observations)
1999-2017
600.09300



APPENDIX B

Beaufort Wind Speed LAND Scale

Table B-1 Beaufort Wind Speed LAND Scale

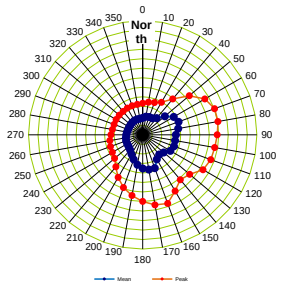
Beaufort Force	Hourly Average Wind Speed (m/s)	Description of Wind	Noticeable Wind Effect
0	< 0.45	Calm	Smoke rises vertically
1	0.45 to 1.55	Light air	Direction shown by smoke drift but not by wind vanes
2	1.55 to 3.35	Light breeze	Wind felt on face; leaves rustle; wind vanes begin to move
3	3.35 to 5.0	Gentle breeze	Leaves, small twigs in constant motion; Light flags extended
4	5.6 to 8.25	Moderate breeze	Raises dust and loose paper; small branches move
5	8.25 to 10.95	Fresh breeze	Small trees, in leaf, sway
6	10.95 to 14.10	Strong breeze	Large branches begin to move; telephone wires whistle Umbrellas used with difficulty
7	14.1 to 17.2	Moderate Gale	Whole trees in motion Inconvenience felt when walking against the wind.
8	17.2 to 20.8	Gale	Twigs break off trees; personal progress impeded
9	20.8 to 24.35	Strong/Severe Gale	Slight structural damage (chimney pots, slates removed)
10	24.35 to 28.4	Storm	Trees uprooted; considerable structural damage
11	28.4 to 32.4	Violent Storm	Widespread damage – unusual event
12	> 32.4	Hurricane	Devastation – only occurs in the tropics

APPENDIX C

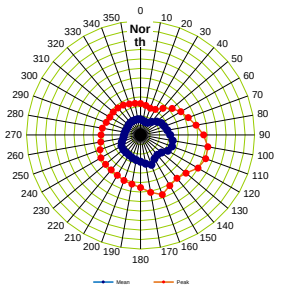
Wind Tunnel Test Results: BASELINE Scenario
Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

The polar diagram plots show the local (ground level) mean and peak gust wind speed as a ratio of the mean reference wind speed (at a full-scale height of 200 m).
The polar diagram circumferential lines representing gradations in 0.1 intervals, ie 10% ratios

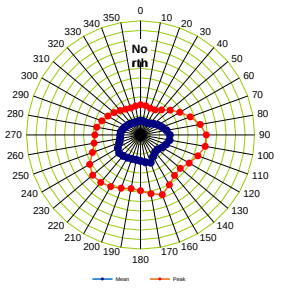
LOCATION 1



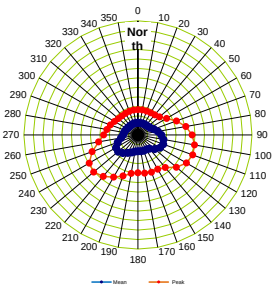
LOCATION 2



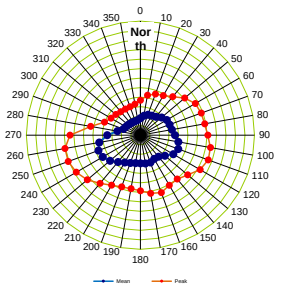
LOCATION 3



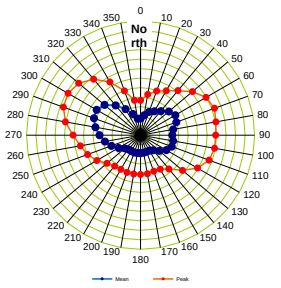
LOCATION 4



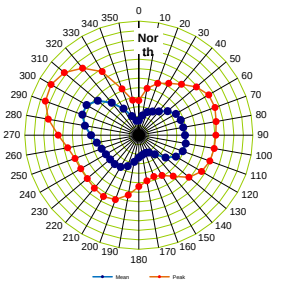
LOCATION 5



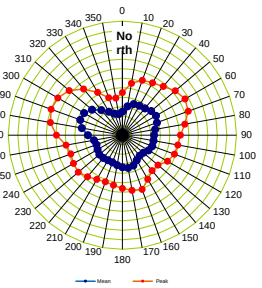
LOCATION 6



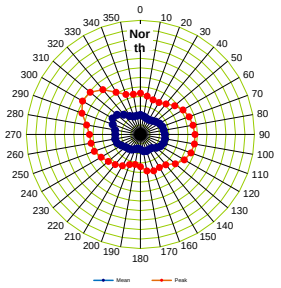
LOCATION 7



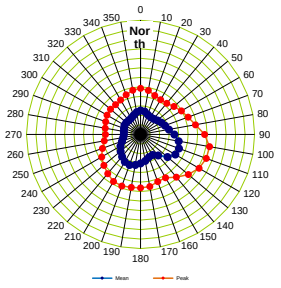
LOCATION 8



LOCATION 9



LOCATION 10



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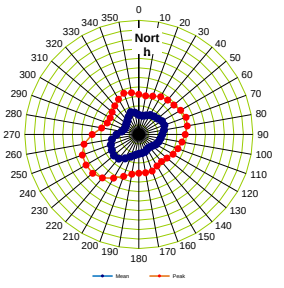

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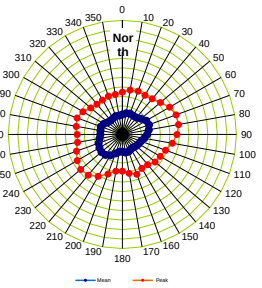

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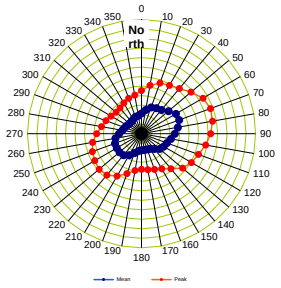

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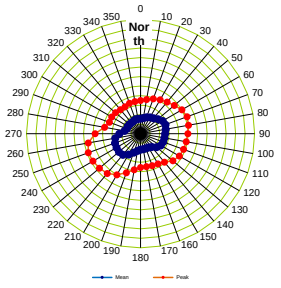

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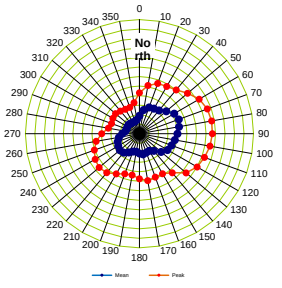

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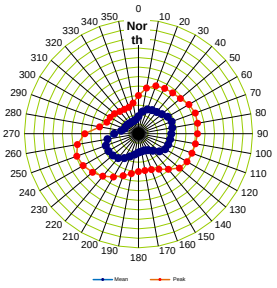

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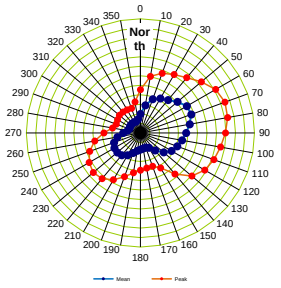

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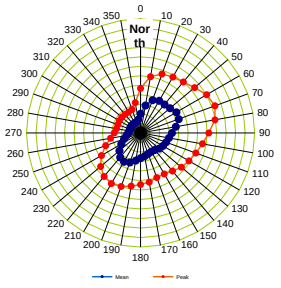

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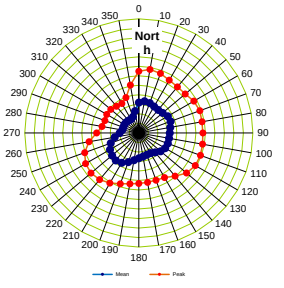

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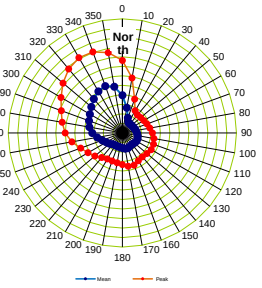

APPENDIX D

Wind Tunnel Test Results: FUTURE-P Scenario
Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

The polar diagram plots show the local (ground level) mean and peak gust wind speed as a ratio of the mean reference wind speed (at a full-scale height of 200 m).
The polar diagram circumferential lines representing gradations in 0.1 intervals, ie 10% ratios

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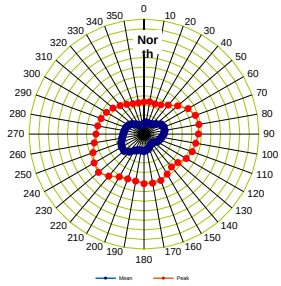

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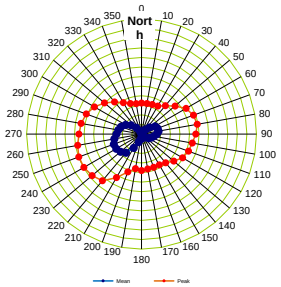

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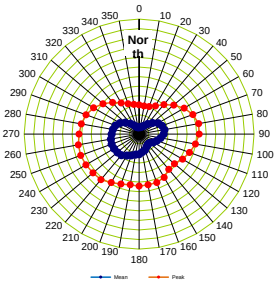

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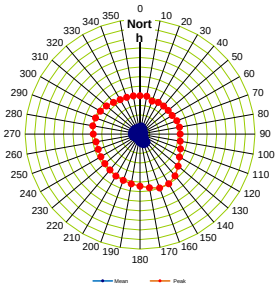

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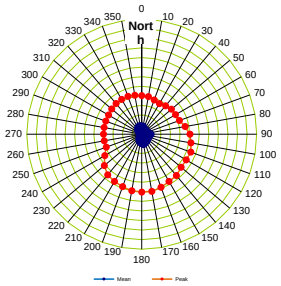

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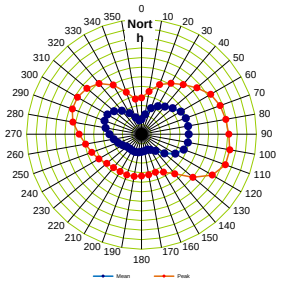

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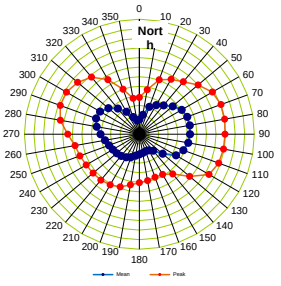

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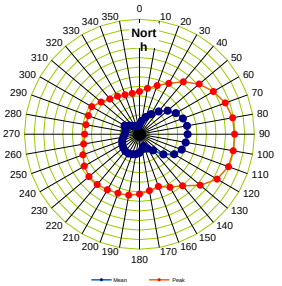

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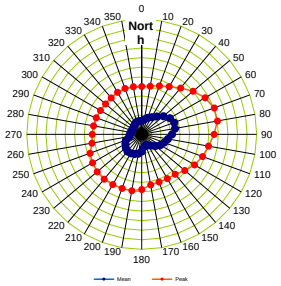

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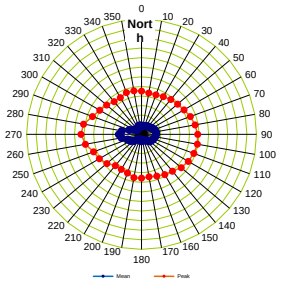

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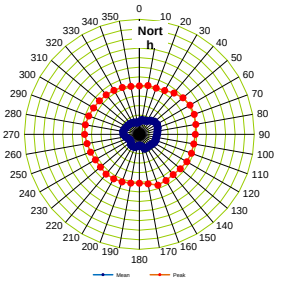

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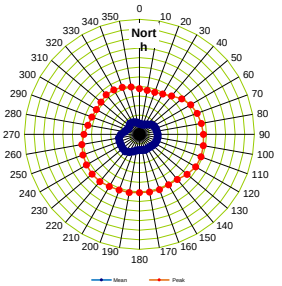

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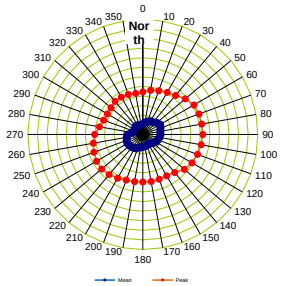

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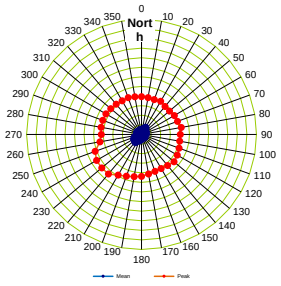

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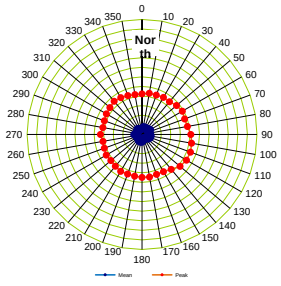

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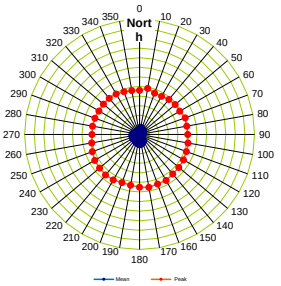

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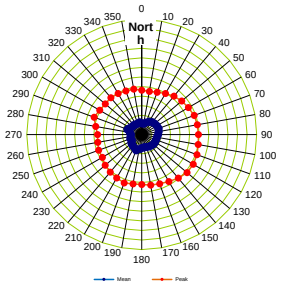

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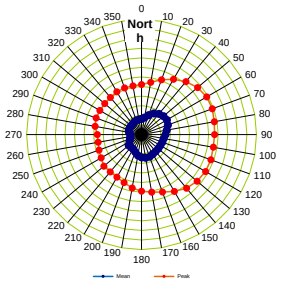

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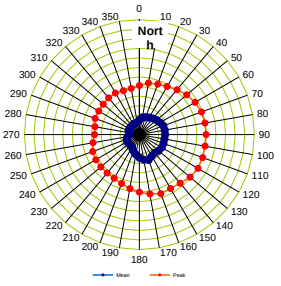

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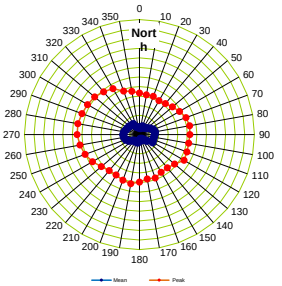

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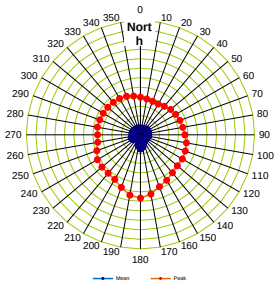

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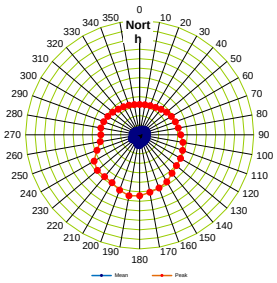

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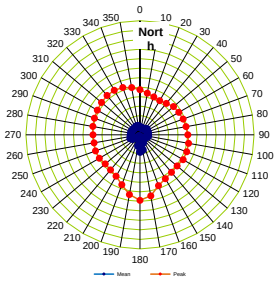

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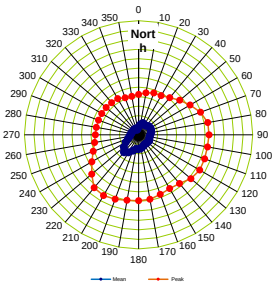
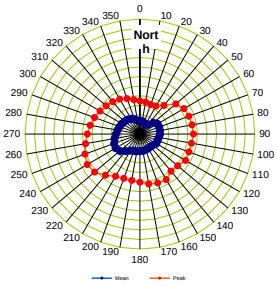


APPENDIX E

Wind Tunnel Test Results: FUTURE-C Scenario
Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

The polar diagram plots show the local (ground level) mean and peak gust wind speed as a ratio of the mean reference wind speed (at a full-scale height of 200 m).
The polar diagram circumferential lines representing gradations in 0.1 intervals, ie 10% ratios

LOCATION 1



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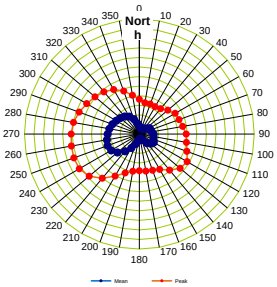

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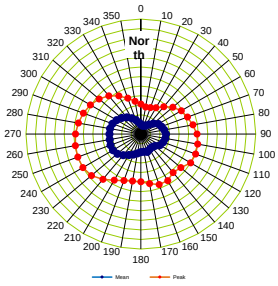

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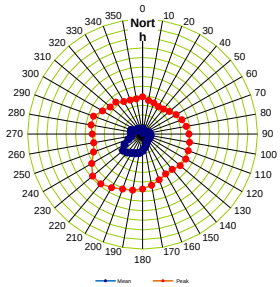

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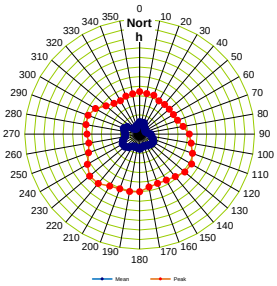

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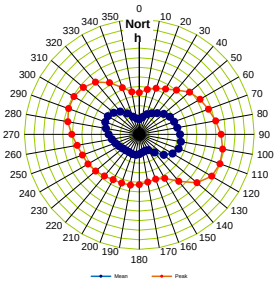

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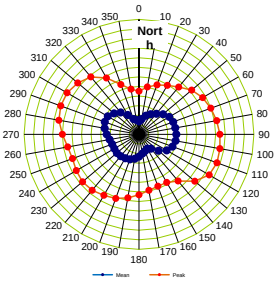

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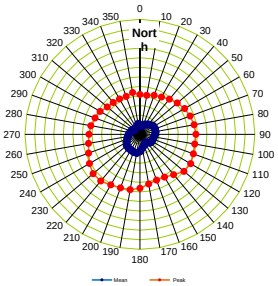

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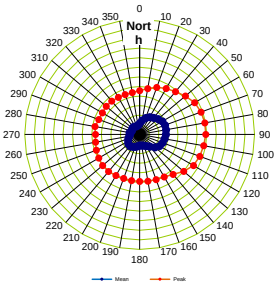

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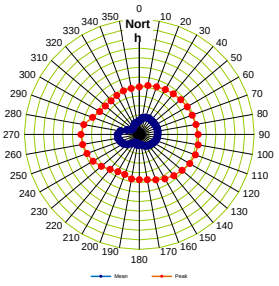

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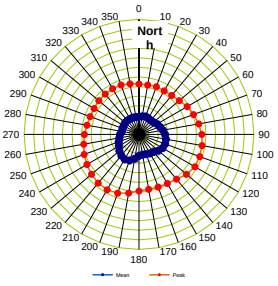

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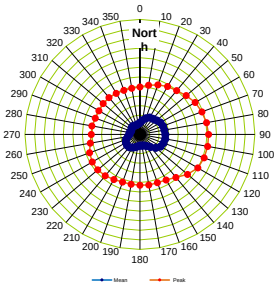

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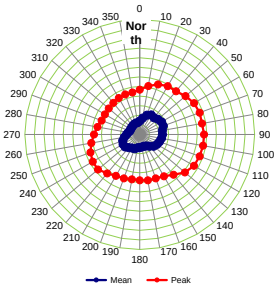

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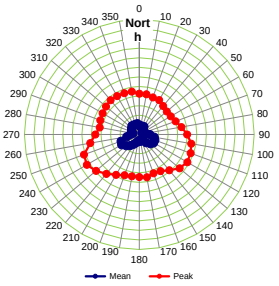

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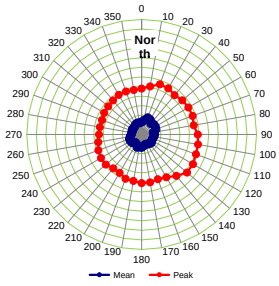

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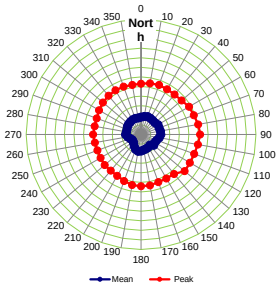

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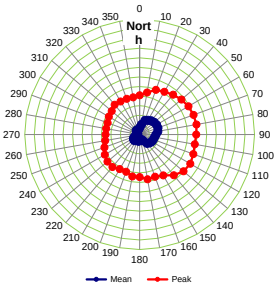

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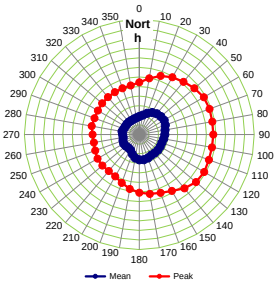

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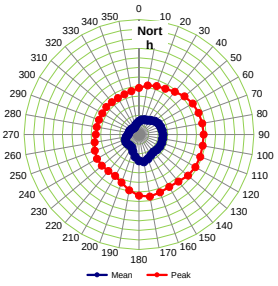

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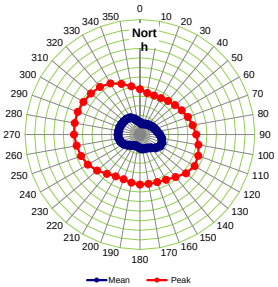

ASIA PACIFIC OFFICES

ADELAIDE
60 Halifax Street
Adelaide SA 5000
Australia
T: +61 431 516 449

BRISBANE
Level 16, 175 Eagle Street
Brisbane QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CAIRNS
Level 1 Suite 1.06
Boland's Centre
14 Spence Street
Cairns QLD 4870
Australia
T: +61 7 4722 8090

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
Unit 5, 21 Parap Road
Parap NT 0820
Australia
T: +61 8 8998 0100
F: +61 8 9370 0101

GOLD COAST
Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Level 11, 176 Wellington Parade
East Melbourne VIC 3002
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE CBD
Suite 2B, 125 Bull Street
Newcastle West NSW 2302
Australia
T: +61 2 4940 0442

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Grd Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

SYDNEY
Tenancy 202 Submarine School
Sub Base Platypus
120 High Street
North Sydney NSW 2060
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TOWNSVILLE
12 Cannan Street
South Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

WOLLONGONG
Level 1, The Central Building
UoW Innovation Campus
North Wollongong NSW 2500
Australia
T: +61 2 4249 1000

AUCKLAND
Level 4, 12 O'Connell Street
Auckland 1010
New Zealand
T: 0800 757 695

NELSON
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628

WELLINGTON
12A Waterloo Quay
Wellington 6011
New Zealand
T: +64 2181 7186

SINGAPORE
39b Craig Road
Singapore 089677
T: +65 6822 2203