13-23 GIBBONS STREET, REDFERN

Environmental Wind Tunnel Test
Re-Test of Modified Building Geometry with Mitigation

Prepared for:

The Trust Company (Australia) Ltd ATF WH Gibbons Trust
c/o Allen Jack + Cottier
79 Myrtle Street
CHIPPENDALE NSW 2008

SLR Ref: 610.18313-R08
Version No: -v4.0
July 2020

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 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) Ltd ATF WH Gibbons 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
610.18313-R08-v4.0	10 July 2020	Andy Huynh	Dr Peter Georgiou	Dr Neihad Al-Khalidy
610.18313-R08-v2.1	20 April 2020	Dr Peter Georgiou	Dr Neihad Al-Khalidy	Dr Neihad Al-Khalidy
610.18313-R08-v2.0	19 November 2019	Dr Peter Georgiou	Dr Neihad Al-Khalidy	Dr Neihad Al-Khalidy

EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by Allen, Jack + Cottier, on behalf of The Trust Company (Australia) Ltd ATF WH Gibbons Trust, to assess the ground level wind environment around a proposed student village located at 13-23 Gibbons Street, Redfern.

2018 Wind Tunnel Testing

In late 2018, an initial assessment was made via a Discrete Sensor Environmental Wind Tunnel Study whereby wind tunnel measurements were made to investigate wind conditions within 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 study was documented in:

- SLR Report 610.18313-R06-v1.0, *"13-23 Gibbons Street, Redfern – Environmental Wind Tunnel Test"*, December 2018.

2019 Additional Wind Tunnel Testing

Following design changes to the bulk envelope of the building, a second Environmental Wind Study was undertaken in late 2019, again via wind tunnel testing, using architectural drawings dated September 2019. This second study included the following additional aspects:

- The second round of testing included new assessment points on the nearest residential building to the south of the site, No.1 Margaret Street, Redfern, including its roof level terrace areas.; and
- The re-testing included additional testing of a Redfern Centre Urban Design Principles "Compliant" bulk envelope building form.

2020 Revised Wind Tunnel Testing

Since the time of testing of the September 2019 building envelope, revisions to the proposal have been made – refer the updated architectural model dated May 2020. The amended proposed development has undergone further wind tunnel testing, also including proposed mitigation treatments – these resulted in an improvement to several key ground level wind conditions.

Surrounds

The proposed development is bounded by Gibbons Street to the west, Margaret Street to the south and William Lane to the east. It will comprise a basement level, a four-storey podium with external common areas at Levels 2, 3 and Level 4 (overlooking Gibbons Street), and a 14-storey upper component, providing for 419 student units on Levels 1 to 18.

Buildings surrounding site are a mix of low and medium-rise, including commercial, retail and residential buildings (many of similar height to the proposed development). Gibbons Street Reserve lies immediately to the west with Redfern train station to the north-northwest.

There are a number of planned and approved future residential developments of similar height located immediately to the north of the proposed development, running between Gibbons Street and Regent Street. Sydney's CBD area lies to the north and the proposed SSD Waterloo Precinct development to the south-southeast.

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 very close 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.

Wind Acceptability Criteria

The present study has again adopted the so-called "Melbourne" criteria for assessment, currently referenced by many Australian Local Government Development Control Plans in relation to wind impact.

In addition, the present study has assessed the impact of the development with respect to the City of Sydney's understanding of the intent of RWUDP (Redfern-Waterloo Design Principles) with respect to wind conditions.

Built Environment Scenarios Assessed

The present study involved the testing of three built environment "scenarios":

- "Baseline" scenario: simulating the existing built environment (as of October 2019); and
- "Future-R" scenario: with the addition of the future proposed development (updated for the latest May 2020 architectural design);
- "Future-C" scenario: with the addition of a Redfern Centre Urban Design Principles "Compliant" bulk envelope design; and
- "Mitigation" scenario: with the addition of the future proposed development and proposed mitigation.

All scenarios included the proposed and approved future developments lying to the immediate north of the site.

"Baseline" (Existing) Wind Environment

With the existing built environment, a number of pedestrian areas in surrounding thoroughfares were found to lie above the adopted 16 m/s walking comfort criterion (but below the 23 m/s safety criterion). The testing showed channelling of northerly and southerly winds along Gibbons Street and channelling of easterly and westerly winds along Margaret Street (particularly westerly winds).

- Wind conditions predicted in the wind tunnel testing did not have the advantage of the mature and extensive vegetation and trees along some of the footpath areas of interest (in particular Gibbons Street) – refer **Figure 17**. These would have an ameliorating (ie sheltering) effect, in some cases potentially significant, on local wind speeds; and throughout the year, provided they comprise evergreen species.

"Future" Wind Environment – Surrounding Pedestrian Footpath Areas

Ground level locations surrounding the site continue to have the potential to experience wind speeds above the adopted 16 m/s walking comfort criterion (but below the 23 m's safety criterion).

EXECUTIVE SUMMARY

- Again, the absence of the mature and extensive vegetation and trees along the footpath areas of interest in the testing is noted, refer **Figure 17**, with their associated ameliorating (ie sheltering) effect on Gibbons Street winds in particular.

Future-Revised & Future-Compliant Compared to 16 m/sec Walking Comfort

- For most of the locations where the Future-Revised Design peak annual gust was above 16 m/s, the peak annual gust was also above 16 m/s for the Future-Compliant Design
- There was one instance (Location 14) where the Future-Revised Design peak annual gust was above 16 m/s, and the peak annual gust was below 16 m/s for the Future-Compliant Design
- There were four instances (Locations 11, 12, 13 and 20) where the Future-Revised Design peak annual gust was below 16 m/s, and the peak annual gust was above 16 m/s for the Future-Compliant Design

On the basis of the above, it is concluded that the "Future-Revised" Design performs comparably, wind-wise, to the "Future-Compliant" Design and overall slightly better.

Through Site Link

- Peak annual gusts within the Through Site Link for the "Future-Revised" Design are all below the 13 m/sec level.
- Peak annual gusts within the Through Site Link for the "Future-Compliant" Design are also below the 13 m/sec level except at Location 22 (14 m/s).

Observation:

- In the "Future-R" and Future-C" testing, wind conditions within the new Through Site Link were tested without the benefit of any of the landscaping, or "Public Artwork Canopy" proposed for this area.
- In the "Mitigation" testing, with these features added to the model, wind levels improved.

Podium Areas

The Level 2 Podium is significantly sheltered by the proposed development itself and the adjacent similar height building to the immediate north.

The proposed development's Level 4 Podium has the potential to experience elevated wind conditions as windflow accelerates past the western façade of the proposed development's high-rise component and is directed downwards as downwash and accelerated shear flow.

In the original (2018) tested model, this was most apparent at both the northwest and southwest corners of the Podium, especially at the southwest corner (peak predicted annual gust of 21 m/s). In the "Future-R" (2020) model, considerable improvement has been achieved at the southwest corner where the peak predicted annual gust is now 15.5 m/s. Winds at the northwest corner remain the same as the previously tested model.

Observation:

- Wind conditions on the new "Future-R" Podium were tested in the wind tunnel without the benefit of any of the landscaping already proposed for the Podium -

EXECUTIVE SUMMARY

- It is also important to appreciate that, while the Podium has the potential to attract elevated winds from building floors above (downwash, etc), especially at the norethwest corner, these winds are thereby prevented from generating the same impact at ground level locations immediately below. The Podium therefore plays a potentially important role in ameliorating ground level wind conditions in surrounding pedestrian areas.

No.1 Margaret Street Terrace Areas

Predicted peak annual gusts for the No.1 Margaret Street roof terrace test Locations 31-33 are (respectively):

- 11.5 m/s, 11.5 m/s and 15 m/s for the "Future-Revised" Design
- 10 m/s, 14 m/s and 17 m/s for the "Future-Compliant" Design

As for the ground level locations surrouding the site, it is concluded that the "Future-Revised" Design performs comparably, wind-wise, to the "Future-Compliant" Design and overall slightly better.

Already Planned and Existing Wind Mitigation

The current round of wind tunnel testing did not include the following features, all of which would have had an ameliorating impact on local wind speeds:

- Vegetation and trees along Gibbons Street and the Gibbons Street Reserve - refer **Figure 17**;
- Extensive landscaping and pergolas planned for the Through Site Link – refer **Figure 2**;
- Additional trees for Margaret Street - refer **Figure 2**; and
- Extensive landscaping planned for the Level 4 Podium – refer **Figure 2**.

Current plans for the proposed development show tree planting along Gibbons Street and Margaret Street as well as a full perimeter awning along the development's western façade - refer **Figures 18 and 19**. It is also noted that the main Gibbons Street entry into the development comprises a recessed, double-door (ie "airlock") design. This feature and the western façade awning will ensure acceptable wind conditions at this location.

The wind tunnel testing for the "Baseline" and two "Future" scenarios showed that elevated winds can potentially occur at selected ground level locations along both Gibbons Street and Margaret Street.

- It has been noted that these results were obtained in the absence of existing trees and landscaping
- Further, the two "Future" results did not include the planned additional trees along Margaret Street.

Mitigation Testing Results

To assess the above, a further round of testing (all locations, 0° to 360°) was undertaken – the "Mitigation" scenario. Landscaping planned for the development site and awnings were included in this testing.

The "Mitigation" scenario results are discussed in **Section 10**.

EXECUTIVE SUMMARY

The "Mitigation" round of testing demonstrates that all of the areas identified within the "Future-R" scenario as requiring consideration of windbreak treatment can successfully be addressed through a combination of:

- Landscaping (especially ground level public access areas);
- Awnings, Canopies and pergolas(especially for internal development areas likely to be used for extended duration "sitting" type activities); and
- Increased Balustrade height (for locations close to elevated areas exposed to elevated winds).

Other Areas

It is almost certain, given the absence of nearby similar height buildings in some wind directions, that the Roof Level will experience elevated wind conditions, especially for stronger southerly and westerly winds, potentially requiring wind treatment beyond standard height (ie code-compliant) balustrades, if this area is to be used for public access usage (eg a Roof Garden). Such treatments might include a combination of both vertical screening (eg increased height solid balustrades, balustrades combined with planter boxes, etc) and horizontal screening to ensure all-year-round amenity, particularly for southerly and westerly winds.

The development drawings do not currently show any public access areas at Roof Level. Accordingly, no wind mitigation is recommended for these areas.

"Future-Revised" versus "Future-Compliant" Design

On the basis of the test results at all ground level locations and the new No.1 Margaret Street roof terrace test locations it has been concluded that

- On average, the "Future-Revised" Design performs comparably, wind-wise, to the "Future-Compliant" Design; and
- Taking into account predicted wind speed increases and decreases, the "Future-Revised" Design performs overall slightly better than the "Future-Compliant" Design.

Taking into account all of the above, it is believed that the proposed development
will comply with the adopted wind acceptability criteria
at all pedestrian and public access locations within and around the development.

CONTENTS

CONTENTS

DOCUMENT REFERENCES

FIGURES

CONTENTS

TABLES

PHOTOS

APPENDICES

1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by Allen, Jack + Cottier, on behalf of The Trust Company (Australia) Ltd ATF WH Gibbons Trust, to assess the ground level wind environment around a proposed student village located at 13-23 Gibbons Street, Redfern.

In late 2018, an initial assessment was made via a Discrete Sensor Environmental Wind Tunnel Study whereby wind tunnel measurements were made to investigate wind conditions within 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 study was documented in:

- SLR Report 610.18313-R06-v1.0, *"13-23 Gibbons Street, Redfern – Environmental Wind Tunnel Test"*, December 2018.

Following design changes to the bulk envelope of the building, a second Environmental Wind Study was undertaken in late 2019, again via wind tunnel testing, using architectural drawings dated September 2019. This second study included the following additional aspects:

- The second round of testing included new assessment points on the nearest residential building to the south of the site, No.1 Margaret Street, Redfern, including its roof level terrace areas.; and
- The re-testing included additional testing of a Redfern Centre Urban Design Principles "Compliant" bulk envelope building form.

Since the time of testing of the September 2019 building envelope, revisions to the proposal have been made – refer the updated architectural model dated May 2020. The amended proposed development has undergone further wind tunnel testing, also including proposed mitigation treatments – these resulted in an improvement to several key ground level wind conditions.

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

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

Section 5 … describes the local wind climate characteristics expected at the site

Section 6 … discusses the wind tunnel test methodology used in the study

Section 7 … presents the results of the testing

Section 8 … presents a summary of the results compared to the adopted acceptability criteria

Section 9 … 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 Gibbons Street to the west, Margaret Street to the south and William Lane to the east - refer **Figure 1**.

Figure 1 Satellite Image of the Proposed Development Site

Image Courtesy: GoogleEarth, October 2019

2.2 Proposed Development Description

The proposal comprises (refer **Figure 2**):

- One level of basement car parking;
- Level 1 (Ground Floor) with building entry, common areas, retail unit;
- Level 4 (Podium) with external common areas, student units;
- Levels 2-3 and 5-18 for student units; and
- Roof Level (Plant and Equipment)

Figure 2 Key Architectural Floor Plans of Interest and Representative Elevations

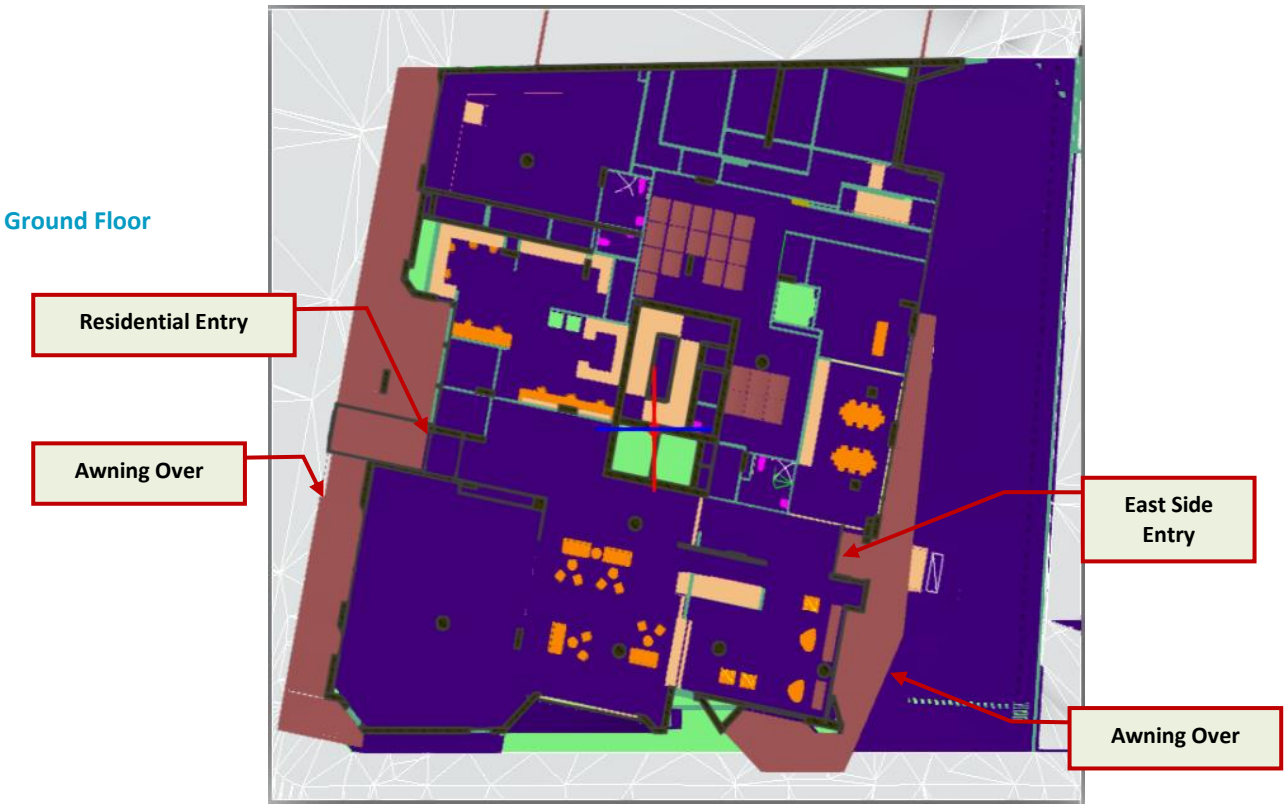
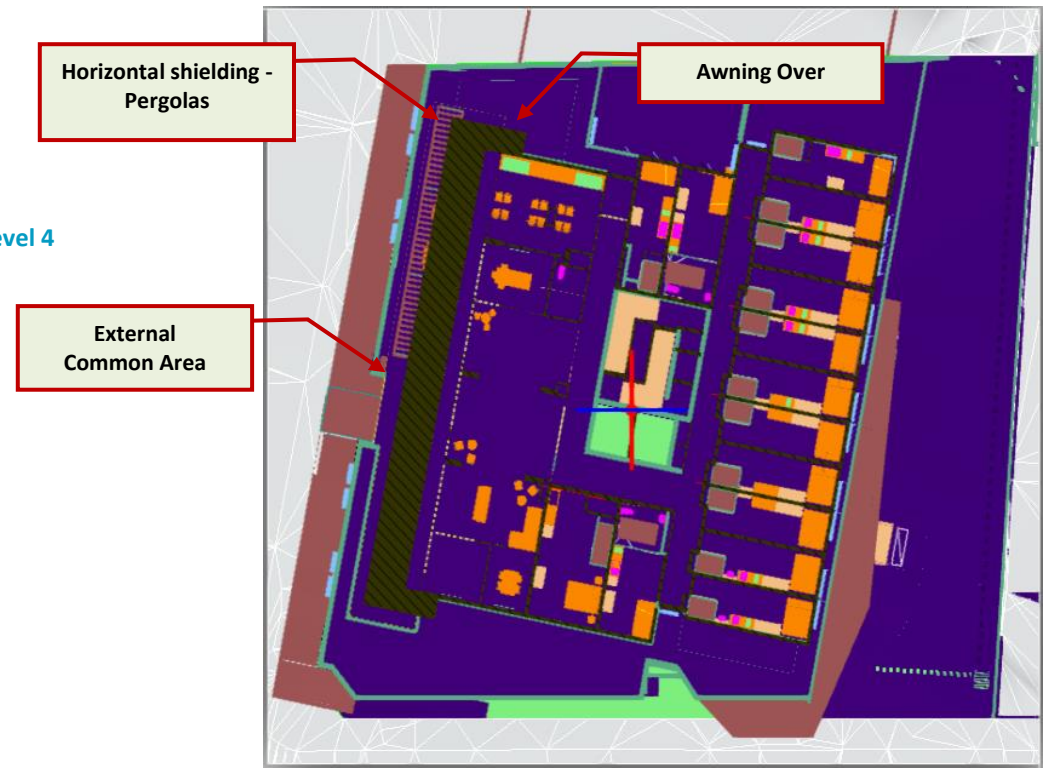
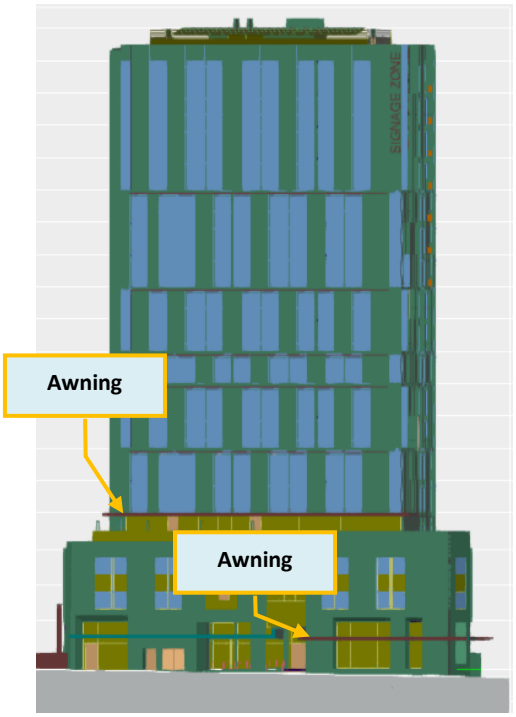


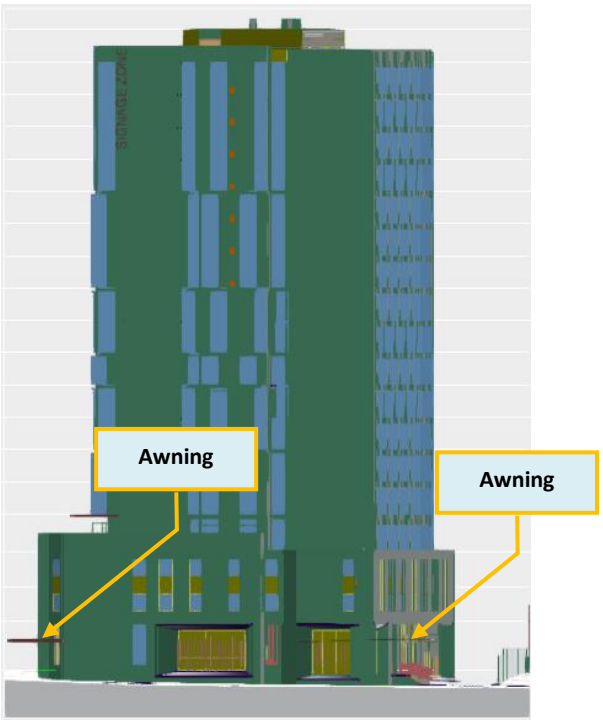
Fig.2 (cont'd)



East (Regent Street) Elevation

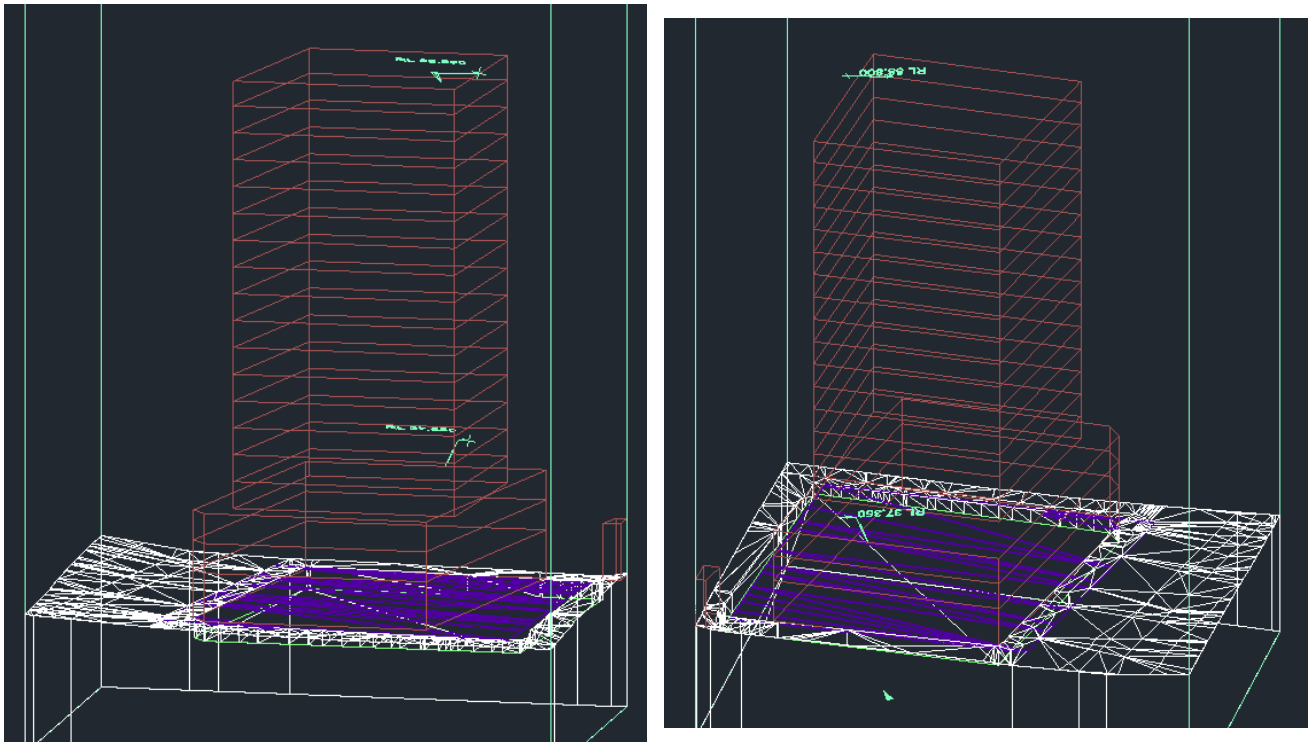


North (Marian Street) Elevation



The revised assessment of the proposed development included testing of a 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" Bulk Envelope 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 immediately to the west with Redfern train station to the north-northwest.
- There are a number of planned and approved future residential developments of similar height located immediately to the north of the proposed development, running between Gibbons Street and Regent Street.
- Sydney's CBD area lies to the north and the proposed SSD Waterloo Precinct development to the south-southeast.

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 SYDNEY'S REGIONAL WIND CLIMATE

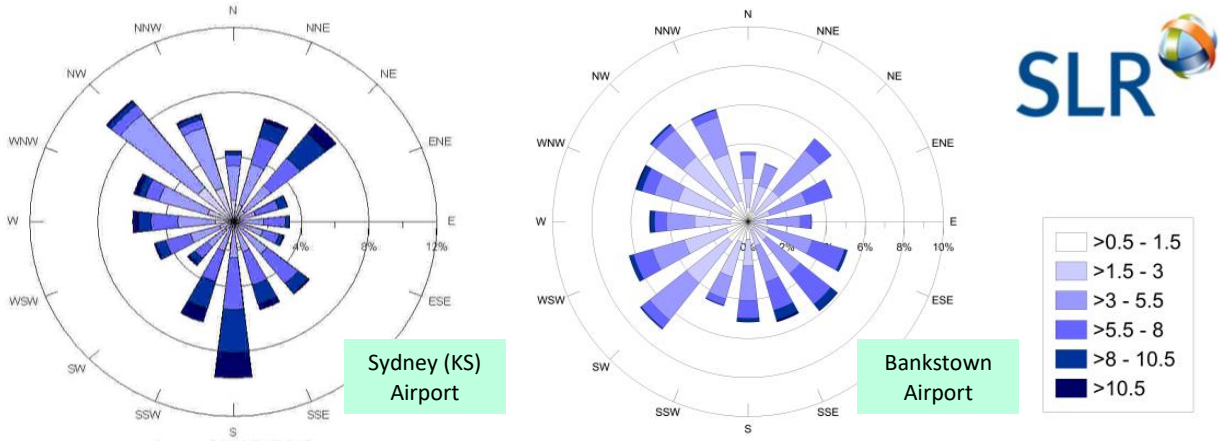
The data of interest in this study are the mean hourly wind speeds and largest gusts experienced throughout the year (especially higher, less frequent winds), how these winds vary with azimuth, and the seasonal break-up of winds into the primary Sydney Region wind seasons.

3.1 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.

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 The "Melbourne" Wind Criteria

One of the acceptability criteria developed from this research, and currently referenced by many Australian Local Government Development Control Plans, are the so-called "Melbourne" criteria, summarised in **Table 1**.

Table 1 Melbourne-Derived Wind Acceptability Criteria

Type of Criteria	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
Comfort	16 m/s	Comfortable Walking
	13 m/s	Standing, Waiting, Window Shopping
	10 m/s	Dining in Outdoor Restaurant

The following objectives relate to the above wind impact criteria:

- The general objective for pedestrian areas is for annual 3-second gust wind speeds to remain at or below the 16 m/s "walking comfort" criterion. Whilst this magnitude may appear somewhat arbitrary, its value represents a level of wind intensity above which the majority of the population would find unacceptable for comfortable walking on a regular basis.
- In many urban locations, either because of exposure to open coastal conditions or because of street "channelling" effects, etc, the 16 m/s criterion may already be currently exceeded. In such instances a new development should ideally not exacerbate existing adverse wind conditions and, wherever feasible and reasonable, ameliorate such conditions.
- The recommended criteria for spaces designed for activities such as seating, outdoor dining, etc, are lower (ie more stringent) than for "walking comfort".

The **Table 1** criteria, in particular those related to "comfort", should not be viewed as *"hard"* numbers as the limiting values were generally derived from subjective assessments of wind acceptability. Such assessments have been found to vary with the height, strength, age, etc, of the pedestrian concerned.

A further factor for consideration is the extent of windy conditions, and some relaxation of the above criteria may be acceptable for small areas under investigation which are infrequently used, provided the general site satisfies the relevant criteria.

Finally, it is noted that the wind speed criteria in **Table 1** are based on the maximum wind gust occurring (on average) once per year. Winds occurring more frequently, eg monthly winds, weekly winds, etc, would be of lesser magnitude. So for example, a location with a maximum annual gust of 10 m/s would experience winds throughout the year of a much lower and hence generally mild nature, conducive to stationary activities (seating, dining, etc).

5 DESIGN WIND SPEEDS

5.1 Methodology

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.

Wind records given particular emphasis were from weather stations with a relatively "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 very close 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.

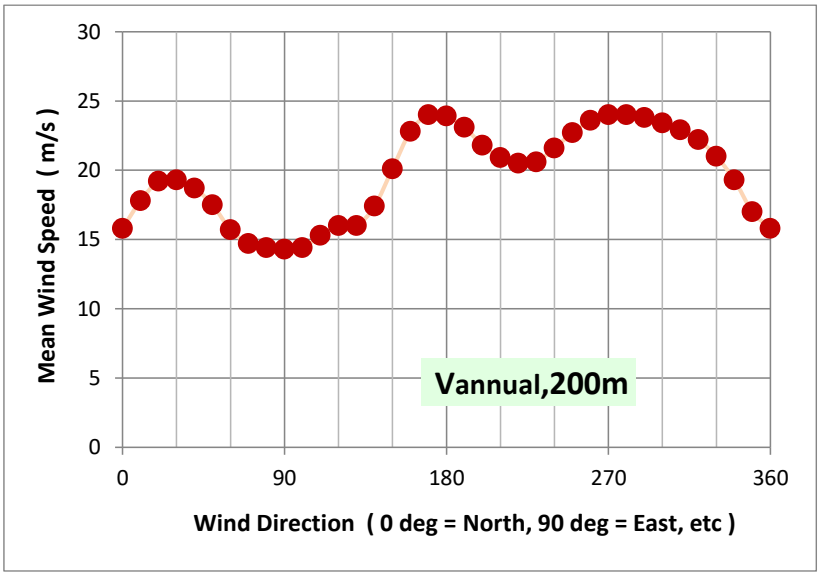
The above analysis is described in detail in …

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

5.2 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 Redfern 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 Liverpool



6 WIND TUNNEL TEST METHODOLOGY

6.1 Simulation of Natural Wind

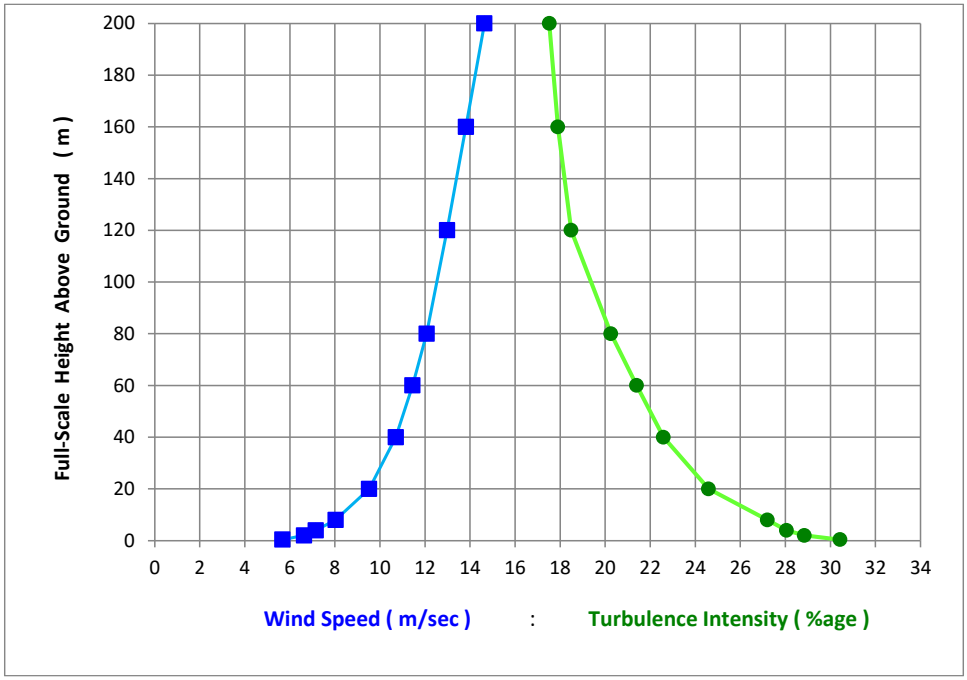
Similarity requirements between the wind tunnel model and prototype (ie full-scale) need to be fulfilled so that similitude in the flow conditions is satisfied. Usually all requirements cannot be satisfied and compromises need to be made. In this type of wind tunnel test it is possible to waive strict 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 (blue curve) and turbulence intensity (green curve) is shown in **Figure 6**.

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



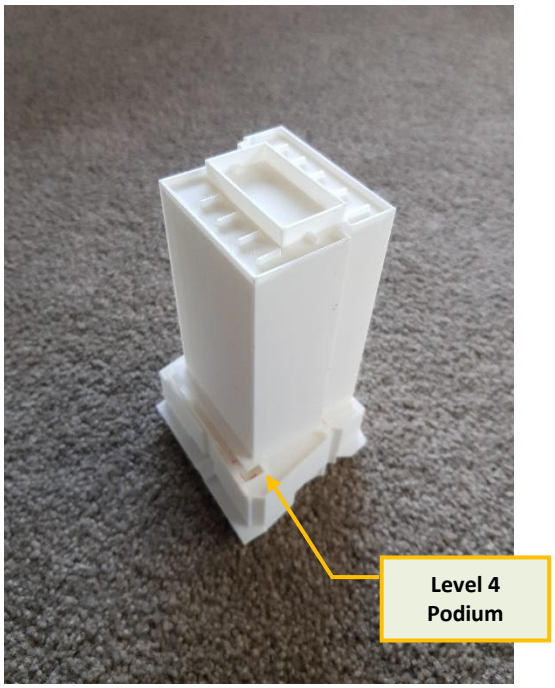
6.2 Development Models and Proximity Model

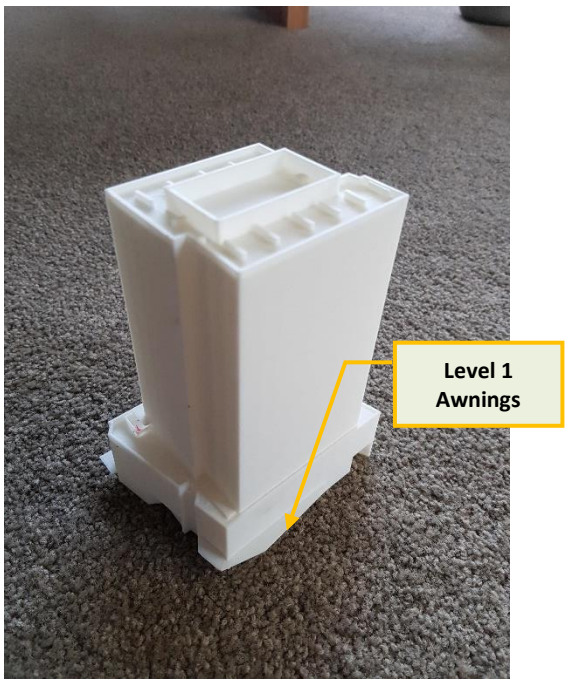
Development Models: May 2020 Revised Design & "Compliant" Design

Two 1:400 scale models of the proposed development were built (using 3D printing) for the testing – refer **Figure 7** - for the latest (May 2020) design and a Redfern Centre Urban Design Principles "Compliant" bulk envelope design.

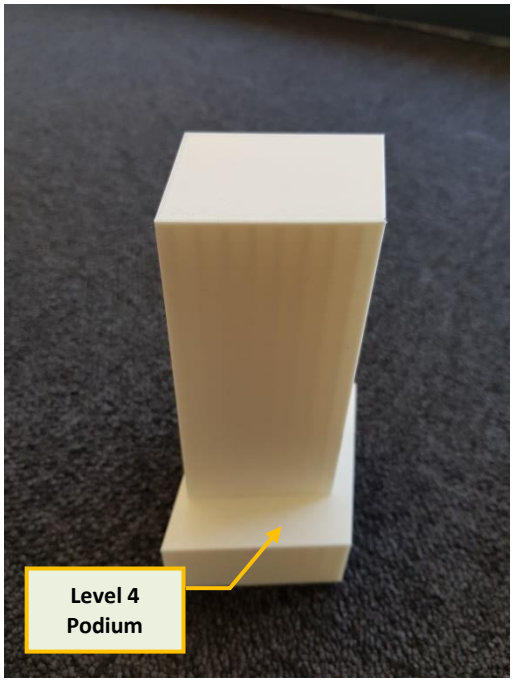
Figure 7 1:400 Scale Model of the Proposed Development

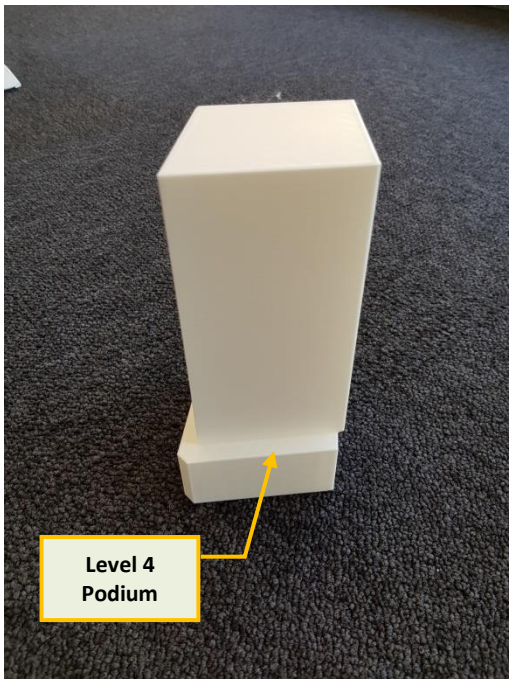
May 2020 Design





CoS "Bulk 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 7**.

The proximity models simulate the following built environment "scenarios":

- "Baseline" scenario: simulating the existing built environment (as of October 2019); and
- "Future-R" scenario: with the addition of the future proposed development (updated for the latest May 2020 architectural design);
- "Future-C" scenario: with the addition of a Redfern Centre Urban Design Principles "Compliant" bulk envelope design; and
- "Mitigation" scenario: with the addition of the future proposed development and proposed mitigation.

All of the above included the proposed and approved future developments lying to the immediate north of the site – refer **Figure 8**.

Figure 8 Proximity Models Used in the Wind Tunnel Testing

"Baseline" Scenario (Existing)

View from South

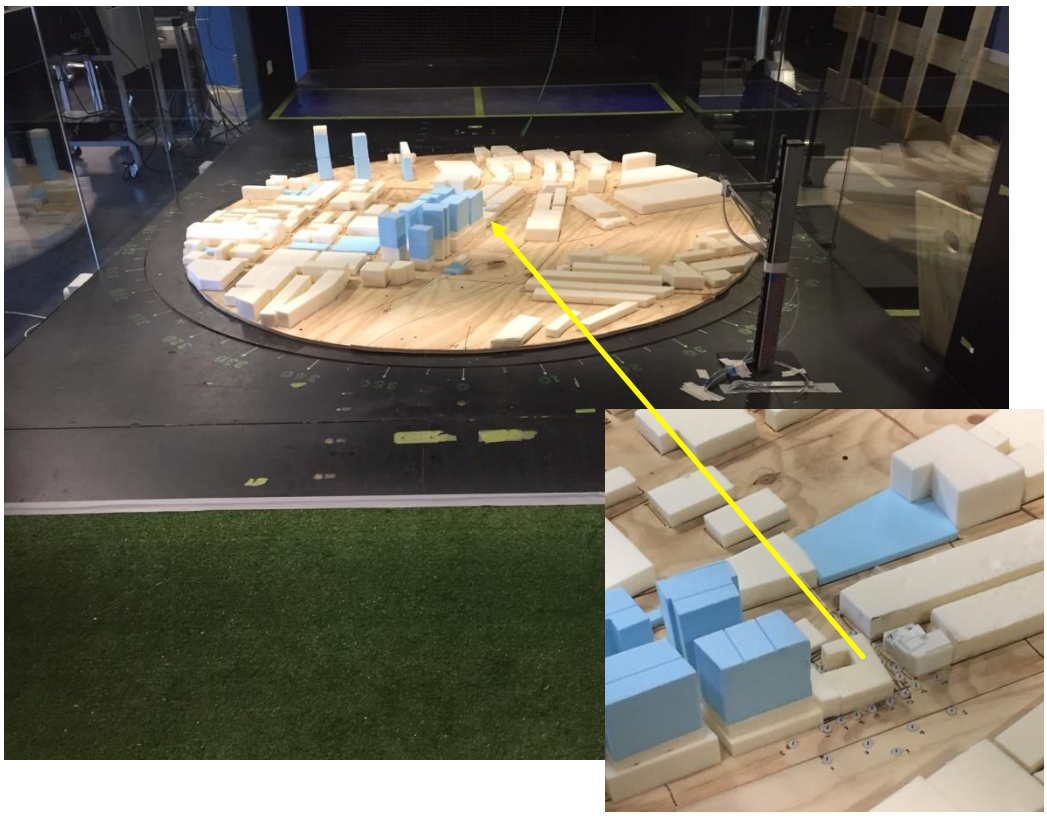
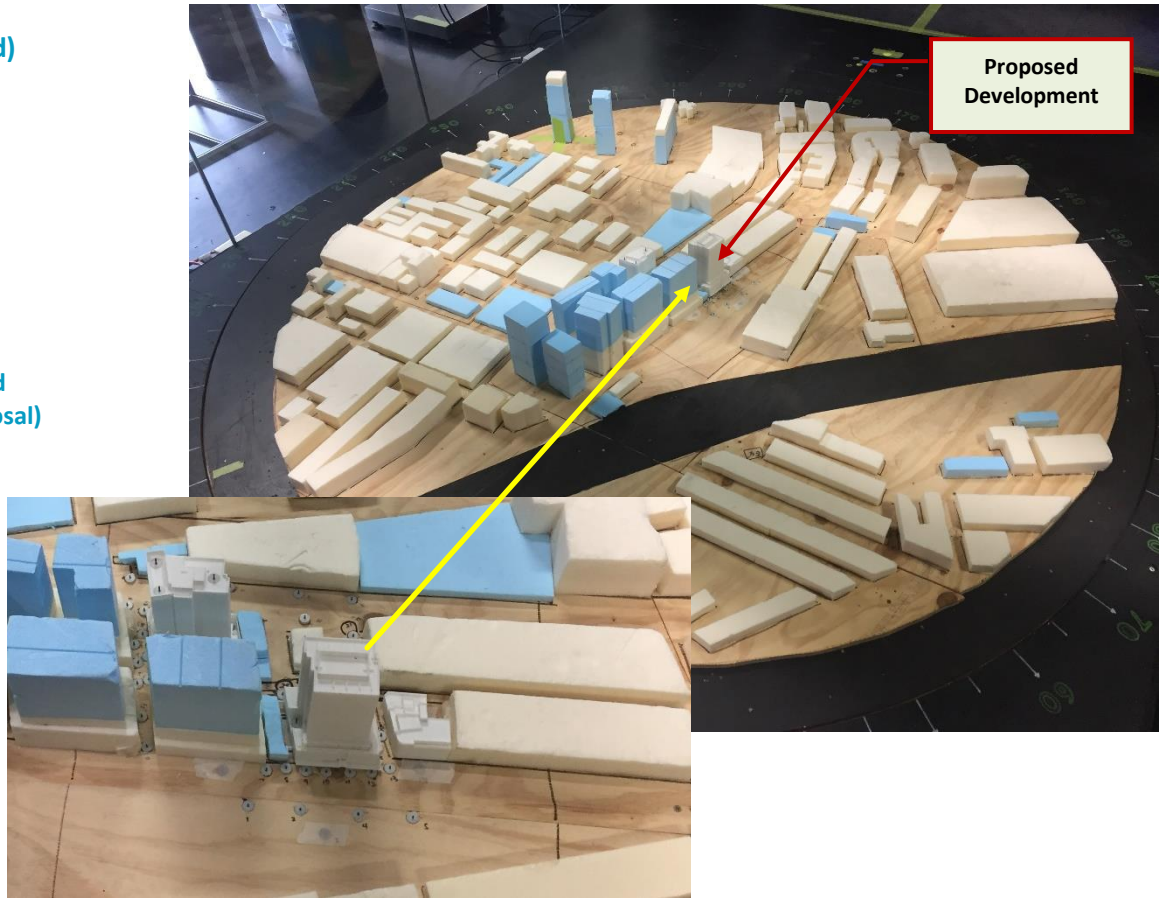
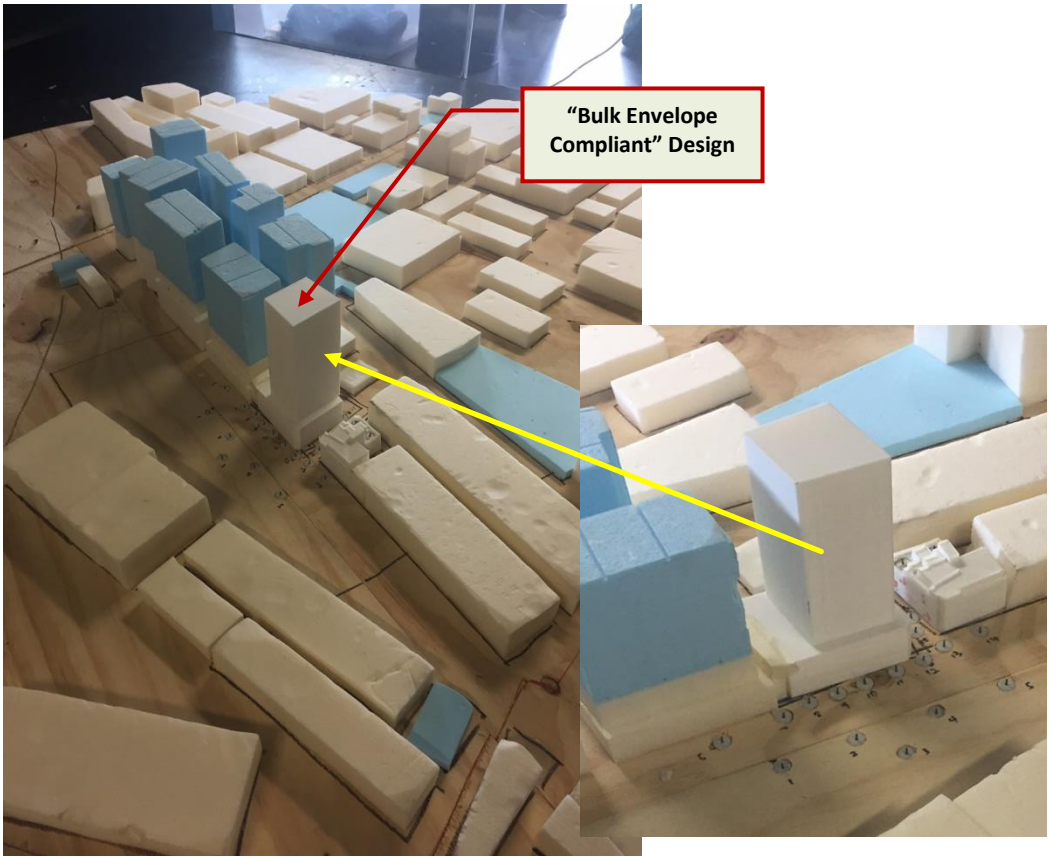


Fig.8 (cont'd)

"Future-R" Scenario (with Revised Design Proposal)



"Future-C" Scenario (with Cos "Compliant Design")



6.3 Data Processing

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

Wind speeds in the wind tunnel …

- were measured at a height corresponding to approximately chest height (1.5 m) in full scale;
- were measured at 10° intervals (north is at 0°, east at 90°, south at 180°, etc).

The 90-second sampling duration velocities are recorded as dimensionless ratios of the mean and gust ground level velocity to a mean reference wind speed at a height of 200 m above ground level. The 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**.

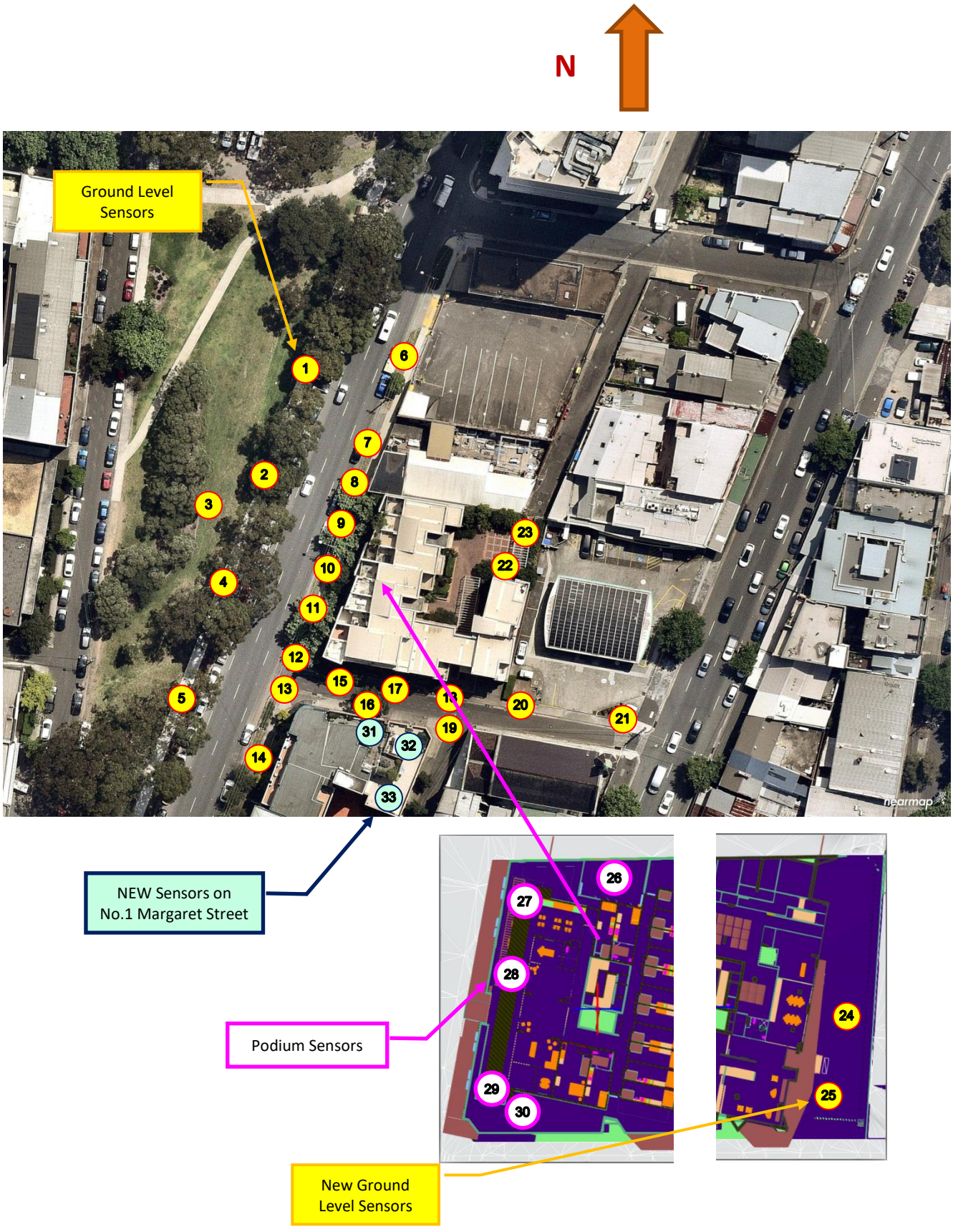
6.4 Test Method – Sensor Locations

In the wind tunnel testing, Irwin wind sensors were positioned at the locations shown in **Figure 8**.

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 25 Ground level sensors are shown in yellow;
- Locations 1 to 23 were measured for both the "Baseline" and the two "Future" scenarios;
- Locations 24-25 were only measured for the two "Future" scenarios;
- The 5 Podium level sensors, Locations 26 to 30 are shown separately (purple circles); these positions are located on the newly proposed development Podium and were measured only for the "Future-R" scenario; and
- Locations 31-33 were measured on the roof terraces of No.1 Margaret Street and were assessed for the "Baseline", "Future-R" and "Future-C" scenarios.

Figure 9 Wind Tunnel Test Sensor Locations



6.5 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:

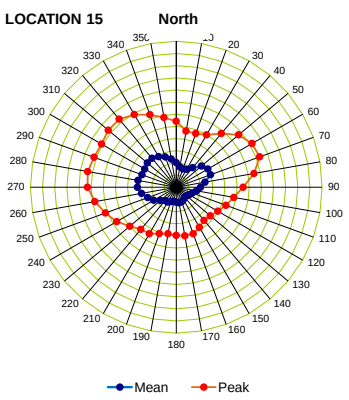
Sensor:	**Location 15**
Location:	Margaret Street – close to Gibbons Street intersection

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):

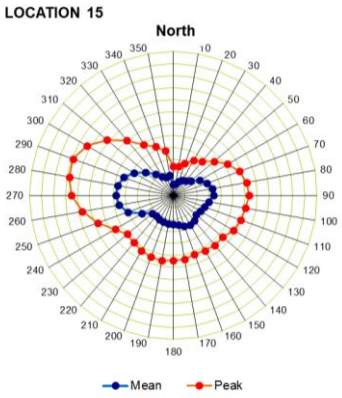
Mean wind speed:	"navy blue" data points
Gust wind speed:	"red" data points.

Figure 10 Sample Polar Plot Test Result – Location 15 – "Baseline" & "Future" Scenarios

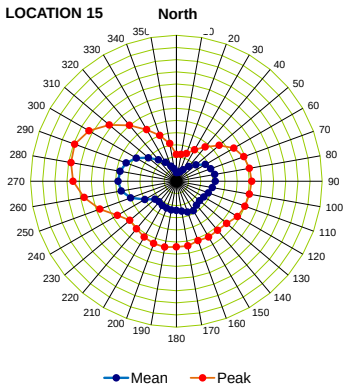
"Baseline" Scenario



"Future-R" Scenario



"Future-C" Scenario



For the **"Baseline"** scenario …

- Winds at Location 15 are strongest from the east, northwest and west, where winds from these directions can approach the site over low height buildings or open areas like Gibbons Street Reserve and then can channel along Margaret Street.

For the two **"Future"** scenarios …

- With the addition of the proposed (revised design) development, winds at Location 15 decrease slightly from the northeast, thanks to shielding from the development itself, and increase from the west-northwest, where winds can accelerate around the development's southwest corner.
- At Location 15, wind responses for the Redfern Centre Urban Design Principles "Compliant" bulk envelope design are virtually identical to the revised design.

7 TEST RESULTS

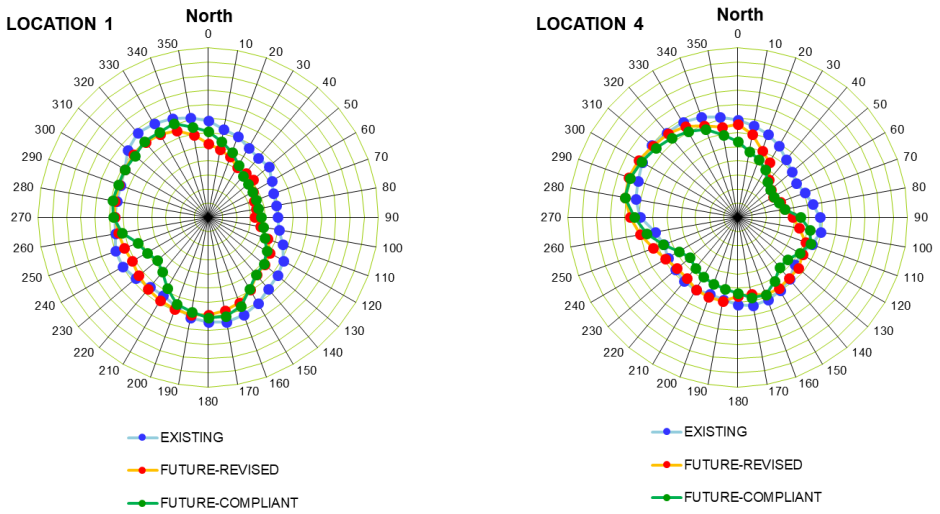
Appendices B, C & D shows the relevant wind tunnel test result polar plots respectively for all locations for the "Baseline" (existing built environment), "Future-R" (with the proposal) and "Future-C" ("compliant") scenarios.

It should be noted that no landscaping was incorporated in the "Baseline" and two "Future" proximity models. This is done to provide a clear insight as to the approach angles resulting in potential adverse wind conditions and the magnitude of such adverse conditions. This information can then be used to develop effective additional windbreak mitigation options such as increased landscaping, additional canopies, awnings, etc.

7.1 Sensor Locations: Gibbons Street (west side) – (representative locations Fig.11)

- Winds along the western footpath of Gibbons Street and within Gibbons Street Reserve are currently highest for directions where winds approach the relevant locations within minimal or modest upstream shielding, eg from the northwest.
- The addition of the proposed development produces only modest changes in existing winds
- With the proposed development downstream for northwest winds, these remain unaffected.
- There is a modest decrease in easterly winds at locations opposite and south of the site, reflecting increased sheltering from the proposed development – this occurs for both of the "Future" scenarios.

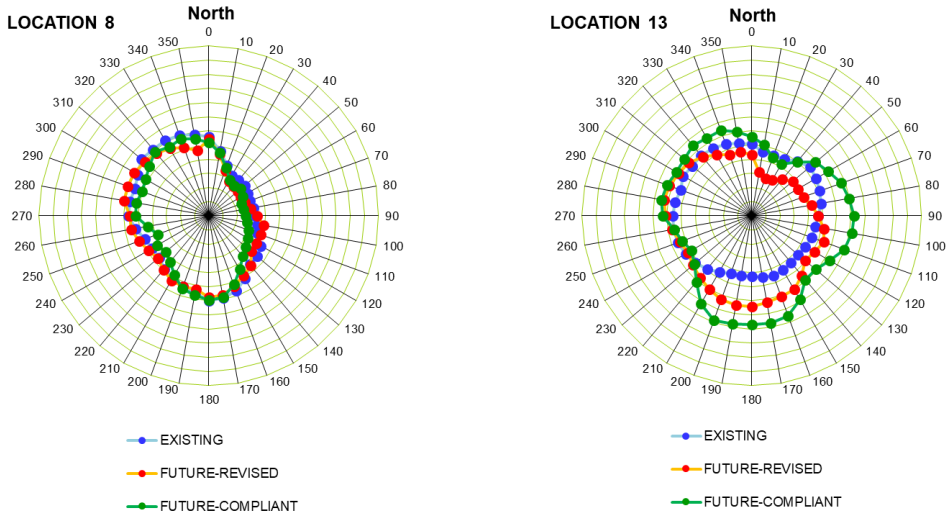
Figure 11 Peak Annual Gusts V/Vref: "Baseline" versus "Future" Scenarios Representative Location



7.2 Sensor Locations: Gibbons Street (east side) - (representative locations Fig.12)

- Winds along the eastern footpath of Gibbons Street and within Gibbons Street Reserve are currently highest for directions where winds approach the relevant locations within minimal or modest upstream shielding, eg from the northwest and south.
- With the addition of the proposed Revised Design development, winds from the northwest remain unaffected away from the development and increase right in front of the development reflecting downwash off the development's western facade.
- Winds from the south increase with the proposed development at and north of the site, reflecting increased downwash and accelerated floor of the development's western façade.
- Winds for the two future scenarios ("Revised Design" and "Compliant Design") are essentially the same for most of these locations, with the exception of Location 13, where winds are higher for both easterly and southerly winds.

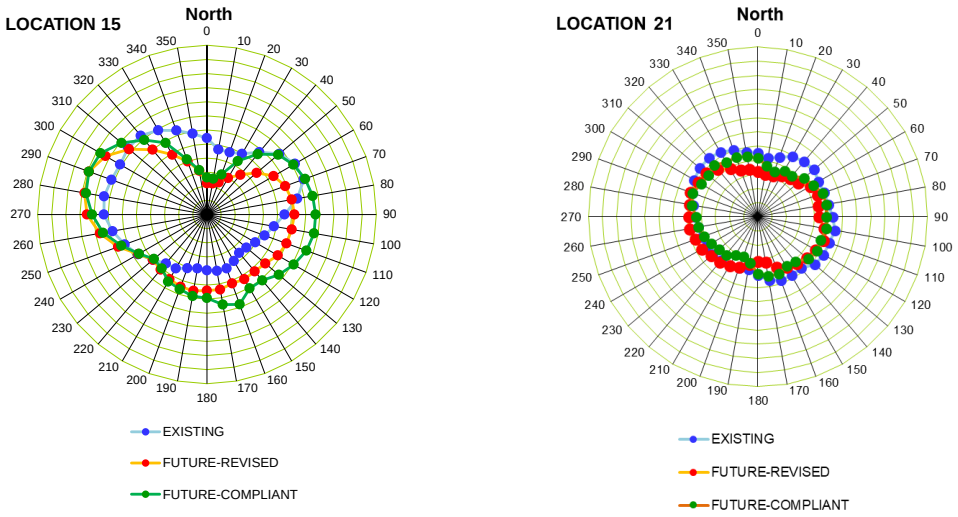
Figure 12 Peak Annual Gusts V/Vref: "Baseline" versus "Future" Scenarios Representative Locations



7.3 Sensor Locations: Margaret Street - (representative locations Fig.13)

- Winds along Margaret Street in the vicinity of the development site are currently highest from the east and west, reflecting channelling of winds along this thoroughfare. Winds from northerly and southerly quadrants are shielded by adjacent buildings. Margaret Street winds close to Regent Street are modest and do not exhibit strong wind channelling characteristics.
- With the addition of the proposed Revised Design development, Margaret Street winds close to Gibbons Street are predicted to increase from the west, reflecting the acceleration and downward influence of the proposed development's southern façade. Margaret Street winds close to Regent Street remain the same or reduce from the northeast.
- Winds for the two future scenarios ("Revised Design" and "Compliant Design") are similar for most of these locations, with slightly higher winds for easterly winds for the Compliant Design.

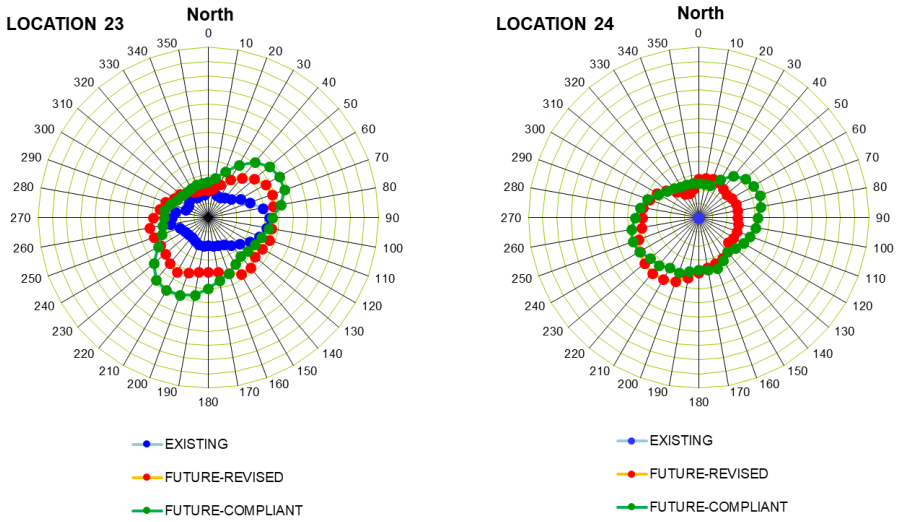
Figure 13 Peak Annual Gusts V/Vref: "Baseline" versus "Future" Scenarios Representative Locations



7.4 Sensor Locations: Through Site Link - (representative locations Fig.14)

- Winds within the Through Site Link are generally mild from all directions, reflecting the sheltering at these locations from buildings in all directions except from the east.
- With the addition of the proposed Revised Design development, winds remain the same from the east and increase from the northeast and southwest.
- Winds for the two future scenarios ("Revised Design" and "Compliant Design") vary somewhat with winds increasing for the Compliant Design at Location 23 and decreasing modestly at Location 24.

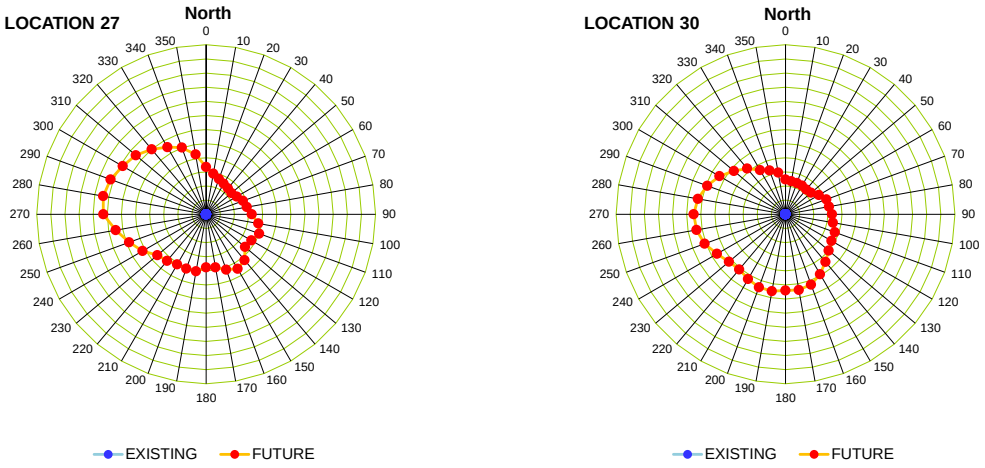
Figure 14 Peak Annual Gusts V/Vref: "Baseline" versus "Future" Scenarios Representative Locations



7.5 "Future" Locations - Podium Locations - (representative locations Fig.15)

- These are all "Future" scenario Podium locations (they do not exist in the "Baseline" scenario.
- Winds on the Podium are highest from the west where they occur as downwash winds off the development's Gibbons Street façade.
- In the previous (2018) testing, winds at Location 30 were significantly higher than with the Revised Design, which has benefitted from a more extensive canopy protecting this Podium area (southwest corner of building).

Figure 15 Peak Annual Gusts V/Vref: "Future" Scenario Representative Locations

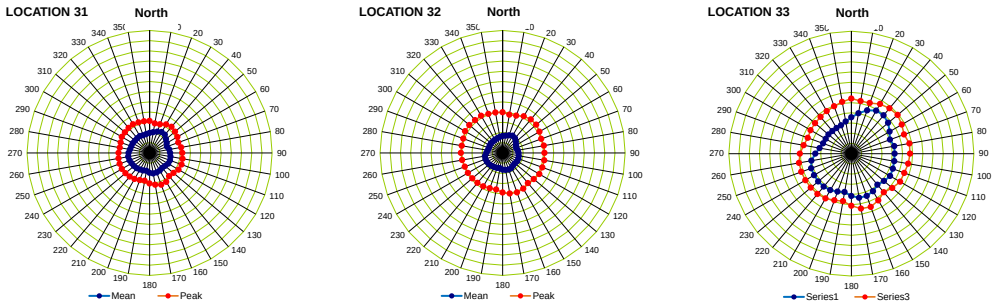


7.6 Sensor Locations – No.1 Margaret Street Roof Terraces

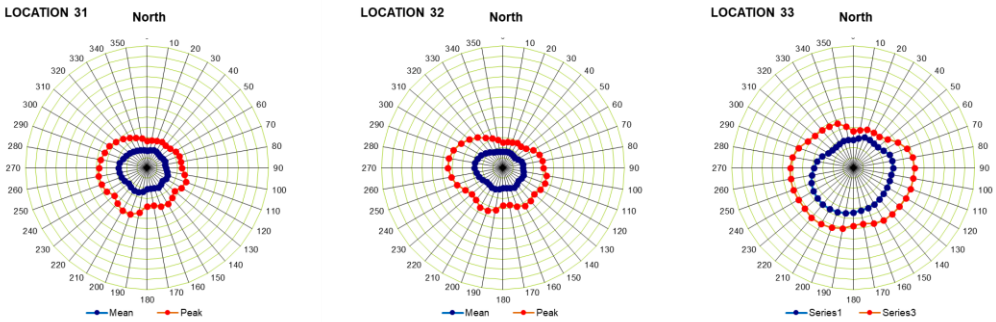
- In the current built environment, No.1 Margaret Street roof terrace wind conditions range from moderate winds in the centre to higher winds close to the eastern end of the building.
- Winds increase slightly in both of the Future scenarios in the central area and in the eastern area as well, especially for the Future-Compliant scenario.

Figure 16 Peak Annual Gusts V/Vref: "Future" Scenarios Representative Locations

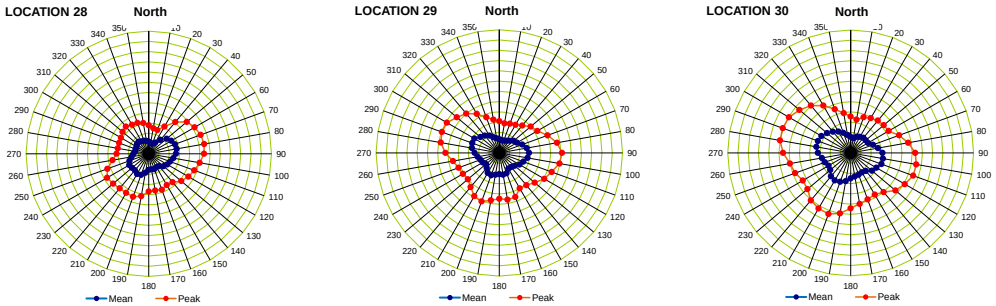
"Existing" Scenario



"Future-Revised" Scenario



"Future-Compliant" Scenario



8 OVERALL WIND IMPACT

Table 2 gives the peak annual gust wind speeds predicted to occur at the test sensor locations for the "Baseline" and "Future" built environment scenarios, relevant to assessment of the Melbourne Criteria.

Table 2 Predicted Peak Annual Gust Wind Speeds at all Sensor Locations

Sensor No and Location Description (ref Fig.9)	Peak Annual Gust (m/s)		
	BASELINE	FUTURE REVISED	FUTURE COMPLIANT
1 Gibbons Street – west footpath, north of site	17.5	16.5	17.0
2 Gibbons Street – west footpath, opposite NW corner of development	18.5	17.0	19.0
3 Gibbons Street Reserve – opposite development	18	20.0	19.0
4 Gibbons Street – west footpath, opposite SW corner of development	19.5	19.5	19.5
5 Gibbons Street – west footpath, south of site	17	17.0	16.5
6 Gibbons Street – east footpath, north of site	13.5	15.5	15.5
7 Gibbons Street – east footpath, north of site	16	15.5	14.0
8 Gibbons Street – east footpath, NW corner of development	17	14.5	14.0
9 Gibbons Street – east footpath, midway between Locs. 8 & 10	15.5	14.0	16.5
10 Gibbons Street – east footpath, midway along development west facade	15	16.0	15.5
11 Gibbons Street – east footpath, midway between Locs. 10 & 12	18	15.0	18.5
12 Gibbons Street – east footpath, SW corner of development	14	15.5	16.5
13 Gibbons Street – east footpath, southern side of Margaret Street	15.5	15.5	18.5
14 Gibbons Street – east footpath, south of site	16	17.0	13.5
15 Margaret Street – along development southern facade	17	21.0	21.0
16 Margaret Street – along development southern facade	15	20.0	21.5
17 Margaret Street – along development southern facade	13	18.5	21.0
18 Margaret Street & Through Site Link – SE corner of development	15	19.0	19.5
19 Margaret Street & William Lane	15.5	19.0	19.0
20 Margaret Street – east of development site	14	15.5	17.0
21 Margaret Street – east of development site (close to Regent Street)	11.5	12.0	11.5
22 Through Site Link – along eastern façade of development	7	11.5	14.0
23 Through Site Link – NE corner of development (close to William Lane)	7.5	10.0	13.0
24 Through Site Link – along eastern façade of development	*Refer Note 2*	10.5	11.5
25 Through Site Link – along eastern façade of development		12.5	11.0
26 Level 2 Podium – facing north, midway along façade		13.5	*Refer Note 3*
27 Level 4 Podium – near NW corner of development		18.0	
28 Level 4 Podium – midway along western façade		13.0	
29 Level 4 Podium – near SW corner of development		14.0	

Sensor No and Location Description (ref Fig.9)		Peak Annual Gust (m/s)		
		BASELINE	FUTURE REVISED	FUTURE COMPLIANT
30	Level 4 Podium – near SW corner of development		15.5	
31	No.1 Margaret Street Roof Terrace (central)		11.5	10.0
32	No.1 Margaret Street Roof Terrace (northeast)		11.5	14.0
33	No.1 Margaret Street Roof Terrace (southeast)		15.0	17.0

Note 1: Peak Gust Values rounded off to the nearest 0.5 m/s (the experimental error in results is ±0.5 m/s)

Note 2: Locations 24-29 are Ground Level (24-25) and Podium (26-30) locations which only exist in the "Future" scenario

Note 3: Podium locations 26-30 were not tested for the "Revised-Compliant" model due to space constraints with the Podium width

8.1 Wind Impact Relative to Intended Usage

Feedback received from the City of Sydney (CoS) regarding the original 2018 Wind Report included the following:

a) So as to comply with the intent of the Redfern-Waterloo Urban Design Principles (RWUDP), an 'active frontage' criteria is to be adopted for Gibbons Street of maximum 13m/s. This must not be exceeded;

b) A maximum of 16m/s is to be adopted for Margaret Street. This must not be exceeded; and

c) For sitting areas in the through site link, the more stringent criteria of 10m/s maximum is to be adopted. The analysis must take into account that an awning capable of deflecting wind is currently proposed in this location.

There is no mention in the project SEARs of compliance with RWUDP. There is reference in the Project SEARs: Section 1 - "Key Issues" to consideration of the relevant provisions, goals and objectives in … *"Redfern Centre Urban Design Principles"*. There is also a direct reference to wind effects in the Project SEARs: Section 5 - "Amenity Issues" as follows:

> **5. Amenity**
> • Detail the impacts of the development on view loss, sunlight/overshadowing, wind impacts, reflectivity, visual and acoustic privacy to achieve a high level of environmental amenity.

With regarding to Gibbons Street, SLR notes that Gibbons Street is a highly trafficked thoroughfare.

Furthermore, from SLR's Wind Studies (2018 to 2020), the following has been established:

- In terms of its existing (current) wind environment north and south of the site:
  - peak annual gusts along the western footpath of Gibbons Street range from 17 m/sec to 19.5 m/sec; and
  - peak annual gusts along the eastern footpath of Gibbons Street range from 14 m/sec to 16.5 m/sec.
- With the addition of the proposed development:
  - peak annual gusts along the western footpath of Gibbons Street generally decrease, and
  - peak annual gusts along the eastern footpath of Gibbons Street experience both modest increases and decreases.

Given the above, SLR recommends that the standard "Walking Comfort" criterion of 16 m/sec (peak annual gust) should be retained for Gibbons Street, particularly in view of the existing conditions prevailing at the site.

For the above same reasons, SLR does not concur with the recommendation that the suggested criteria for Gibbons Street and Margaret Street … *"must not be exceeded"*, in view of the fact that the suggested criteria are almost certainly already being exceeded in the existing conditions.

It has been standard practice with all regulatory bodies (including CoS) that, in urban locations where the walking comfort 16 m/s criterion is already being exceeded, a new development should ideally not exacerbate existing adverse wind conditions and, wherever feasible and reasonable, ameliorate such conditions.

Pedestrian Footpath Areas Surrounding the Site

Wind category objective: 16 m/s Walking Comfort criterion (recommended by SLR)

Ground level locations surrounding the site (Gibbons Street, Margaret Street, Through Site Link) are predicted to experience both modest increases and decreases in wind speed for key prevailing wind directions (northeast, southeast, south and west).

- In terms of the Melbourne Criteria, a number of these locations currently experience peak annual gusts which lie above the 16 m/s walking comfort criterion, but well below the 23 m/s safety criterion.
- In the "Future" scenario, most of these locations remain above the 16 m/s walking comfort criterion, and continue to remain below the 23 m/s safety criterion.

Observation:

- Wind conditions predicted in the wind tunnel testing did not have the advantage of the mature and extensive vegetation and trees along some of the footpath areas of interest, in particular Gibbons Street and the Gibbons Street Reserve – refer **Figure 17**. These would have a significant ameliorating (ie sheltering) effect on local wind speeds (throughout the year if of evergreen species) for ALL of the tested scenarios.

Figure 17 Vegetation and Trees along Surrounding Footpath Areas

Future-Revised versus Future-Compliant

- There were 8 ground level locations where the Future-Compliant Design peak annual gust was lower than the Future-Revised Design (differences typically around 1 m/s)
- There were 4 ground level locations where the Future-Compliant Design peak annual gust was the same as the Future-Revised Design
- There were 13 ground level locations where the Future-Compliant Design peak annual gust was higher than the Future-Revised Design (differences typically around 1 m/s)

Future-Revised & Future-Compliant Compared to 16 m/sec Walking Comfort

- For most of the locations where the Future-Revised Design peak annual gust was above 16 m/s, the peak annual gust remained above 16 m/s for the Future-Compliant Design
- There was one instance (Location 14) where the Future-Revised Design peak annual gust was above 16 m/s, and the peak annual gust was below 16 m/s for the Future-Compliant Design
- There were four instances (Locations 11, 12, 13 and 20) where the Future-Revised Design peak annual gust was below 16 m/s, and the peak annual gust was above 16 m/s for the Future-Compliant Design

On the basis of the above, it is concluded that the "Future-Revised" Design performs comparably, wind-wise, to the "Future-Compliant" Design and overall slightly better.

Through Site Link

Wind category objective: 16 m/Walking Comfort criterion
Ideally 13 m/s Standing-Waiting-Window Shopping criterion, and
The 10 m/s Outdoor Dining criterion for seating areas intended for dining

- Peak annual gusts within the Through Site Link for the "Future-Revised" Design are all below the 13 m/sec level.
- Peak annual gusts within the Through Site Link for the "Future-Compliant" Design are also below the 13 m/sec level exceopt at Lociation 22 (14 m/s).

Observation:

- It is noted that Through Site Link wind conditions in the "Future-R" and "Future-C" scenarios were tested without the benefit of any of the landscaping, or "Public Artwork Canopy" proposed for this area.

Podium Areas

Wind category objective: 13 m/s Standing-Waiting-Window Shopping criterion
Ideally 10 m/s Outdoor Dining criterion for seating areas intended for dining

The Level 2 Podium is significantly sheltered by the proposed development itself and the adjacent similar height building to the immediate north.

The proposed development's Level 4 Podium has the potential to experience elevated wind conditions as windflow accelerates past the western façade of the proposed development's high-rise component and is directed downwards as downwash and accelerated shear flow.

In the original (2018) tested model, this was most apparent at both the northwest and southwest corners of the Podium, especially at the southwest corner (peak predicted annual gust of 21 m/s).

In the "Future-R" (2020) model, consderable improvement has been achieved at the southwest corner where the peak predicted annual gust is now 15.5 m/s. Winds at the northwest corner remain the same as the original (2018) tested model.

Observation:

- Wind conditions on the new Podium were tested in the wind tunnel without the benefit of any of the landscaping already proposed for the Podium.
- It is also important to appreciate that, while the Podium has the potential to attract elevated winds from building floors above (downwash, etc), especially at the norethwest corner, these winds are thereby prevented from generating the same impact at ground level locations immediately below. The Podium therefore plays a potentially important role in ameliorating ground level wind conditions in surrounding pedestrian areas.

No.1 Margaret Street Terrace Areas

Predicted peak annual gusts for the No.1 Margaret Street roof terrace test Locations 31-33 are (respectively):

- 11.5 m/s, 11.5 m/s and 15 m/s for the "Future-Revised" Design
- 10 m/s, 14 m/s and 17 m/s for the "Future-Compliant" Design

As for the ground level locations surrouding the site, it is concluded that the "Future-Revised" Design performs comparably, wind-wise, to the "Future-Compliant" Design and overall slightly better.

9 MITIGATION TREATMENT RECOMMENDATIONS

Sections 7 and 8 provided guidance as to the areas where the adopted wind acceptability criteria had the potential to be exceeded and an indication as to the likely local optimum wind treatment strategy, eg whether the wind condition of interest is likely to arise from accelerating winds which require vertical windbreaks (such as landscaping) or downwash winds which require horizontal windbreaks (such as awnings, canopies), or a combination of both.

The wind conditions of potential concern in relation to the proposed development revealed by the wind tunnel study are:

- Selected footpath areas along Margaret Street; and
- The NW corner of the Level 4 Podium.

9.1 Existing and Planned Wind Amelioration

It has been noted that the "Future-R" and "Future-C" rounds of wind tunnel testing did not include the following features, all of which would have had an ameliorating impact on local wind speeds:

- Vegetation and trees along Gibbons Street and the Gibbons Street Reserve - refer **Figure 17**;
- Extensive landscaping and pergolas planned for the Through Site Link – refer **Figure 2**;
- Additional trees for Margaret Street - refer **Figure 2**; and
- Extensive landscaping planned for the Level 4 Podium – refer **Figure 2**.

Figure 18 Representative 3D Perspective Views of Project Site Landscaping

View from Southwest

View from Margaret Street

9.2 Additional Wind Mitigation Recommendations

Pedestrian Areas Surrounding the Site

Current plans for the proposed development show tree planting along Gibbons Street and Margaret Street as well as a full perimeter awning along the development's western façade. Refer **Figures 18 and 19**.

It is also noted that the main Gibbons Street entry into the development comprises a recessed, double-door (ie "airlock") design. This feature and the western façade awning will ensure acceptable wind conditions at this location.

The wind tunnel testing showed that potentially high localised winds occur at selected ground level locations along both Gibbons Street and Margaret Street ("Baseline" and the two "Future" scenarios).

- It has been noted that these results were obtained in the absence of existing trees and landscaping
- Further, the "Future-R" results did not include the planned additional trees along Margaret Street.

We recommend retention of the existing awnings protecting ground level footpaths and all of the trees and landscaping, existing and planned.

It is noted that, in the most recent design of the development, a combination of both "high" and "low" landscaping has been positioned close to the building and building entry points to maximise their effectiveness in relation to wind mitigation.

- Given that the landscaping strategy on Gibbons Street involves replacement of some existing trees, it is recommended that all "replacement" trees are evergreen and of similar foliage as the existing trees.

On the basis of the above, and given the relatively low wind speeds predicted for the Through Site Link in the "Future-R" Design and the observation that this was in the absence of planned landscaping and the Public Artwork Canopy, no additional mitigation is recommended beyond that already planned.

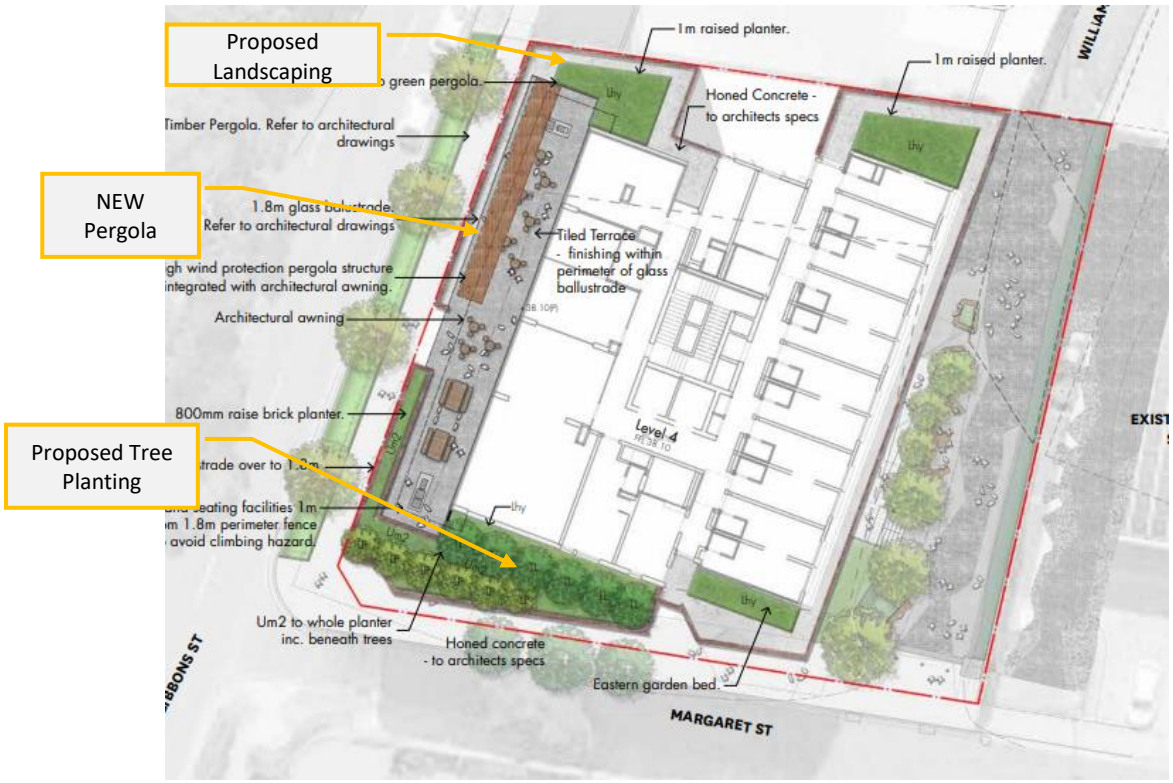
Podium – Level 4

The wind tunnel testing showed that high localised winds occur at the northwest corner of the Level 4 Podium area facing west – refer **Figure 18**. This corner will be exposed to winds with both a horizontal and vertical component. As a result, wind mitigation here should include both horizontal protection (eg awnings, canopies, etc) and vertical protection (balustrades, vertical screens, landscaping, etc).

Since the recent round of wind tunnel testing, the design of the Level 4 Podium external space has progressed with (i) the addition of 1.8 m high balustrades and (ii) an extended pergola (3 m high), also shown **Figure 19**.

The effectiveness of these mitigation measures was investigated in the "Mitigation" scenario testing.

Figure 19 Recently Proposed Level 4 Mitigation



10 ADDITIONAL TESTING – "MITIGATION" SCENARIO

The proposed windbreak treatments were assessed by carrying out a further round of wind tunnel testing – 0° to 360°, all sensor locations – with treatments at the locations indicated in **Section 6.4**.

- This testing has been termed the … "Mitigation" built scenario

The dimensionless polar plot ratios of ground level wind speed to reference height wind speed for the "Mitigation" scenario are shown in **Appendix D**.

Discussion of Results – Ground Level

The two "Future" scenarios indicated peak annual gust wind speeds within this area – Locations 1 to 26 - slightly windier than the Target levels for these areas. Accordingly, a "scaled" level of additional windbreak treatment was added to the model in the "Mitigation" scenario:

- Proposed tree planting and landscaping – refer to **Figure 19 and 20**;

The impact of these treatments can be seen in **Figure 21**, where:

- Wind decrease for Locations 9 to 26, with a significant reduction for the northwest winds for Gibbons Street and Margaret Street.
- No Change for Locations 1 to 7.

The following is noted:

- In relation to locations within Gibbons Street Reserve (Nos.1-5) and Gibbons Street locations to the north of the site (No. 6-7), the wind directions which influence the overall peak annual gusts are from the west quadrants. The proposed development has essentially no impact on these locations for westerly winds, as can be seen from the test results.
- In relation to Gibbons Street and Margaret Street footpath winds immediately surrounding the site, vertical windbreaks (ie trees, shrubs, screens, etc) have a highly localised impact.

It should also be noted that wind tunnel testing in the "Mitigation" scenario had utilised tree planting provided immediately surrounding the site to treat the horizontal oncoming northwesterly winds. SLR recommends that the proposed landscaping be of evergreen in nature in order to mitigate winds effectively all year round.

Peak annual gust wind speeds are shown in **Table 3**, outlining the effectiveness on the Locations surrounding the immediate development site.

Along Gibbons Street there was no change in regards to the winds with the inclusion of the mitigations surrounding the immediate site for Locations 1 to 8. The dominant winds in these areas are from the north west which are away from the site.

Additionally, with the inclusion of the proposed tree planting immediately surrounding the site there is a decrease in the peak annual gust wind speeds within suitable levels for comfortable walking activity at several locations.

Accordingly, with the additional landscaping along Gibbons Reserve this is expected to provide further wind mitigation for the horizontal winds experienced along Gibbons Street and Margaret Street.

Table 3 Predicted Peak Annual Gust Wind Speeds for Locations 9 to 25

Sensor No and Location Description (ref Fig.9)		FUTURE-R	MITIGATION
9	Gibbons Street – east footpath, midway between Locs. 8 & 10	14.0	10.5
10	Gibbons Street – east footpath, midway along development west facade	16.0	12.0
11	Gibbons Street – east footpath, midway between Locs. 10 & 12	15.0	13.0
12	Gibbons Street – east footpath, SW corner of development	16.0	15.5
13	Gibbons Street – east footpath, southern side of Margaret Street	15.5	15.0
14	Gibbons Street – east footpath, south of site	17.0	16.0
15	Margaret Street – along development southern facade	21.0	13.5
16	Margaret Street – along development southern facade	20.0	16.0
17	Margaret Street – along development southern facade	18.5	10.0
18	Margaret Street & Through Site Link – SE corner of development	19.0	16.0
19	Margaret Street & William Lane	19.0	17.0
20	Margaret Street – east of development site	15.5	13.5
21	Margaret Street – east of development site (close to Regent Street)	12.0	10.5
22	Through Site Link – along eastern façade of development	11.5	10.0
23	Through Site Link – NE corner of development (close to William Lane)	10.0	7.0
24	Through Site Link – along eastern façade of development	10.5	10.0
25	Through Site Link – along eastern façade of development	12.5	12.0

Figure 20 Treatments implemented onto Ground Level

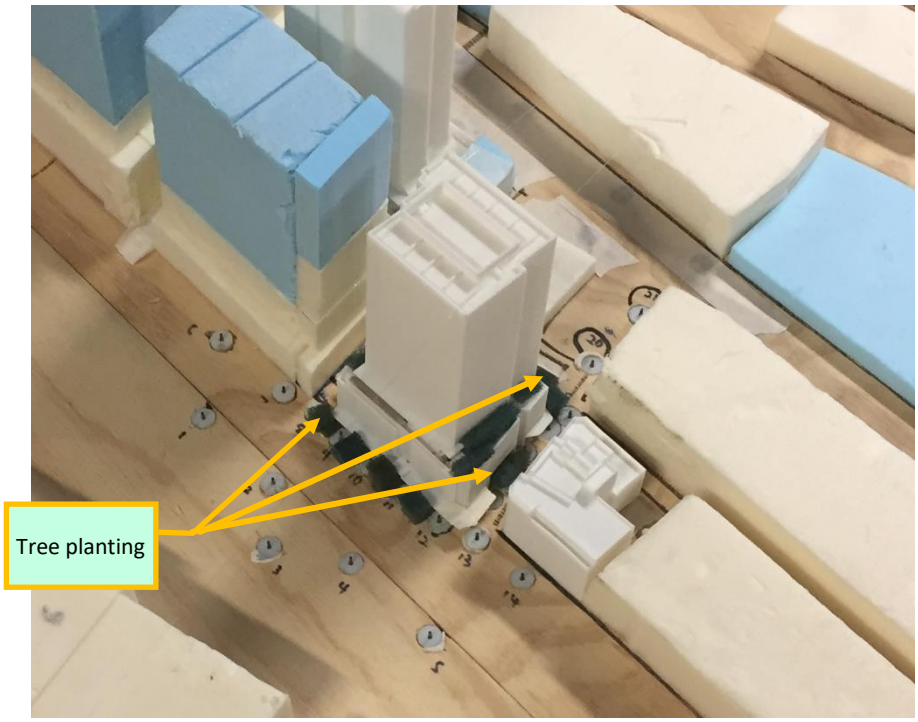
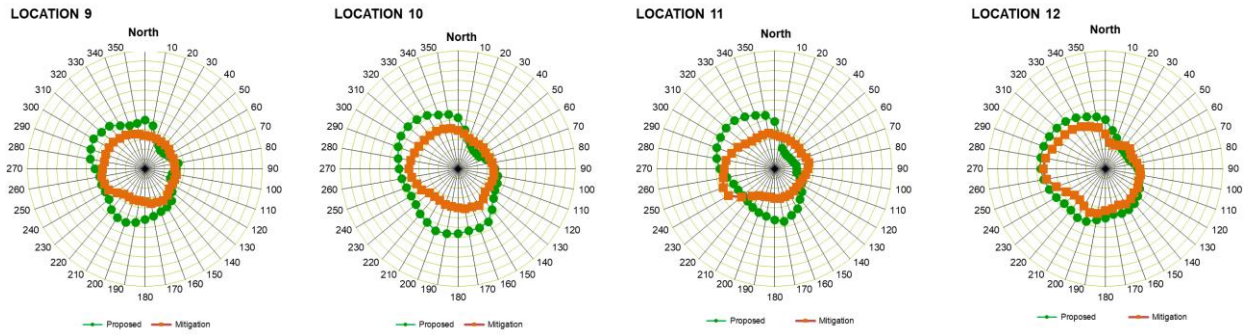


Figure 21 Sample Polar Plot Wind Tunnel Test Results: Locations 9-12

"Future-R" (green) and "Mitigation" (orange) comparison



Discussion of Results – Level 2 and 4 Podium

The "Future-R" scenario indicated peak annual gust wind speeds within this area – Locations 26 to 29 - slightly windier than the Target levels for these areas. Accordingly, a "scaled" level of additional windbreak treatment was added to the model in the "Mitigation" scenario:

- Impermeable pergola over the outside seating area – refer to **Figure 22.**
- Tree planting and landscaping – refer to **Figure 22**.

The impact of these treatments can be seen in **Figure 23**, where:

- Winds decrease for Locations 26 to 29.

In this area, it can be seen that the combination of horizontal and vertical windbreaks (canopies, shadecloth, screens, etc) over areas likely to be used for extended "sitting" type activities would have the greatest impact on local winds.

- At elevated levels the horizontal wind component receives minimal shielding from the northwest to west upstream. The 1.8m vertical screen and landscaping aid in the mitigation of local winds in this area.
- Furthermore, the vertical wind component is ameliorated through the use of the awning and pergola as wind speeds are shown to decrease to the suitable dining criteria.
- Peak annual gust wind speeds have dropped from **17.8m/s, 13.2m/s and 13.9m/s** to **9.9m/s, 10.0m/s and 12.8m/s** for Locations 27, 28 and 29 respectively. It should be noted that if Location 29 was to be used for long term dining, the use of a pergola would be beneficial in wind mitigation to reduce the vertical winds experienced in this area (similar to Locations 27 and 28).

With the proposed landscaping and the treatments outlined in **Section 9.2,** wind conditions will satisfy the relevant Melbourne Comfort Criteria.

Figure 22 Treatments implemented onto Level 4 Podium

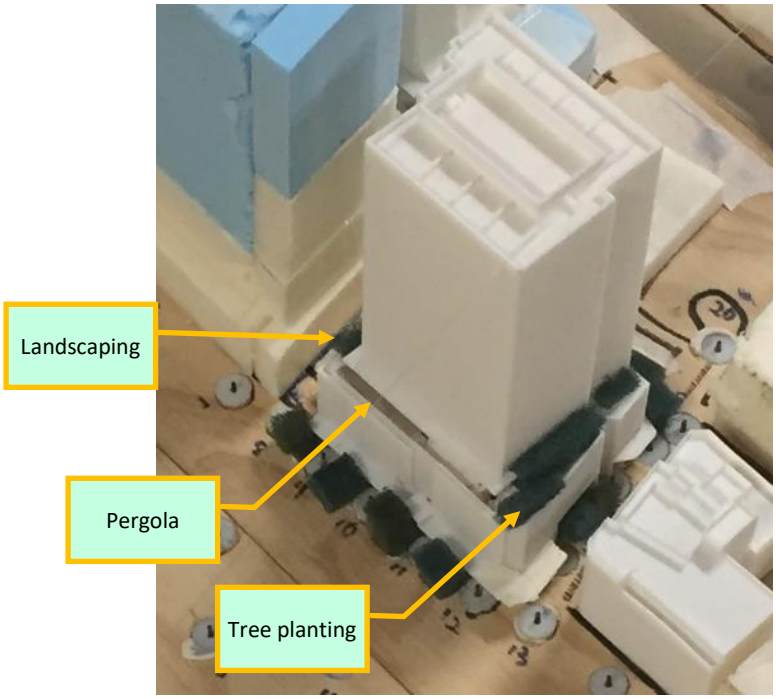
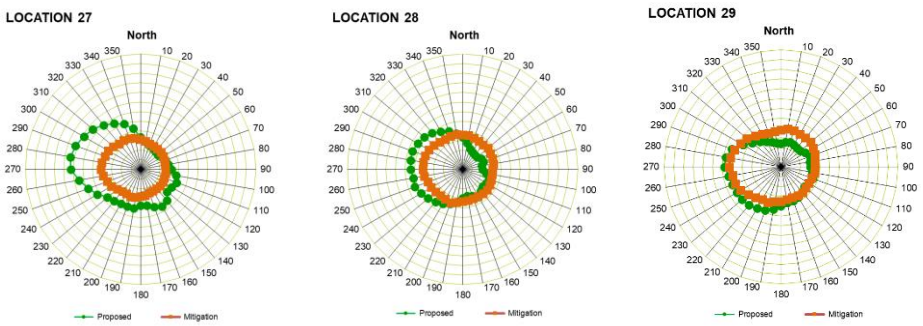


Figure 23 Sample Polar Plot Wind Tunnel Test Results: Locations 26 to 29

"Proposed" and "Mitigation" comparison



11 RESULTS SUMMARY

11.1 "Future-R" versus "Future-C" Design

On the basis of the test results at all ground level locaions and the new No.1 Margaret Street roof terrace locations it has been concluded that

- On average, the "Future-Revised" Design performs comparably, wind-wise, to the "Future-Compliant" Design; and
- Taking into account predicted wind speed increases and decreases, the "Future-Revised" Design performs overall marginally better than the "Future-Compliant" Design. For example, the highest terrace area winds on No.1 Margaret Street were 15 m/s and 17 m/s for the "Future-Revised" and Future-Compliant" designs respectively.

11.2 Mitigation Scenario Testing

The "Mitigation" scenario demonstrates that all of the areas identified within the "Future-R" scenario as requiring consideration of windbreak treatment can successfully be addressed through a combination of:

- Landscaping (especially ground level public access areas);
- Awnings, Canopies and pergolas(especially for internal development areas likely to be used for extended duration "sitting" type activities); and
- Increased Balustrade height (for locations close to elevated areas exposed to elevated winds).

11.3 Areas Not Assessed Via Wind Tunnel Testing

Due to currently intended usages (or rather absence of public access usage) and the physical constraints associated with the scale used in the testing, a number of areas were not tested in the present DA-phase assessment, including:

- The proposed development's Roof Level which currently shows no areas of public access on the development drawings.

It is almost certain, given the absence of nearby similar height buildings in some wind directions, that the Roof Level will experience elevated wind conditions, especially for stronger southerly and westerly winds, potentially requiring wind treatment beyond standard height (ie code-compliant) balustrades, if this area is to be used for public access usage (eg a Roof Garden). Such treatments might include a combination of both vertical screening (eg increased height solid balustrades, balustrades combined with planter boxes, etc) and horizontal screening to ensure all-year-round amenity, particularly for southerly and westerly winds.

The development drawings do not currently show any public access areas at Roof Level. Accordingly, no wind mitigation is recommended for these areas.

Taking into account all of the above, it is believed that the proposed development
will comply with the adopted wind acceptability criteria
at all pedestrian and public access locations within and around the development.

12 CLOSURE

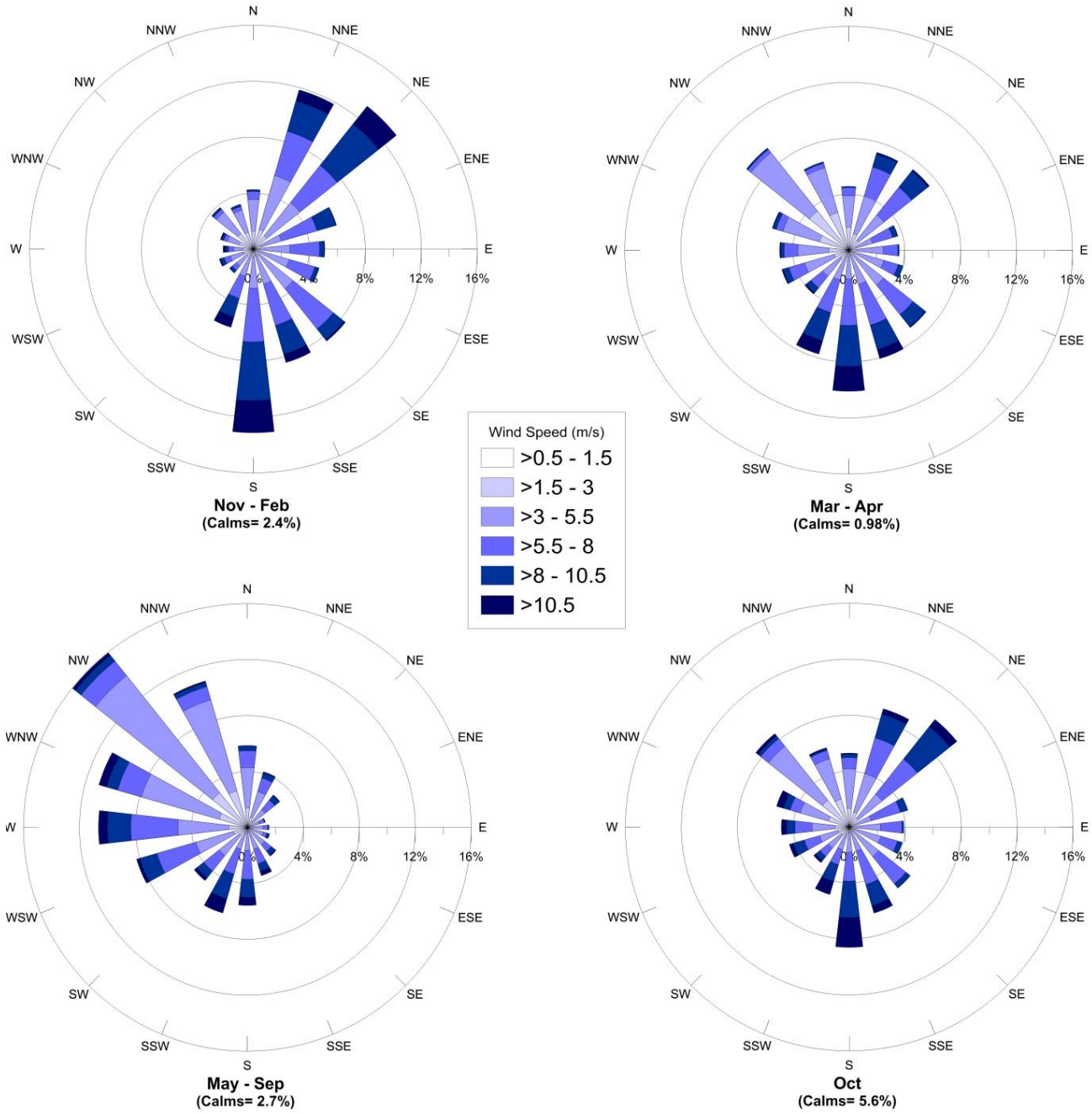
This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted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

This report is for the exclusive use of The Trust Company (Australia) Ltd ATF WH Gibbons 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.

APPENDIX A

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

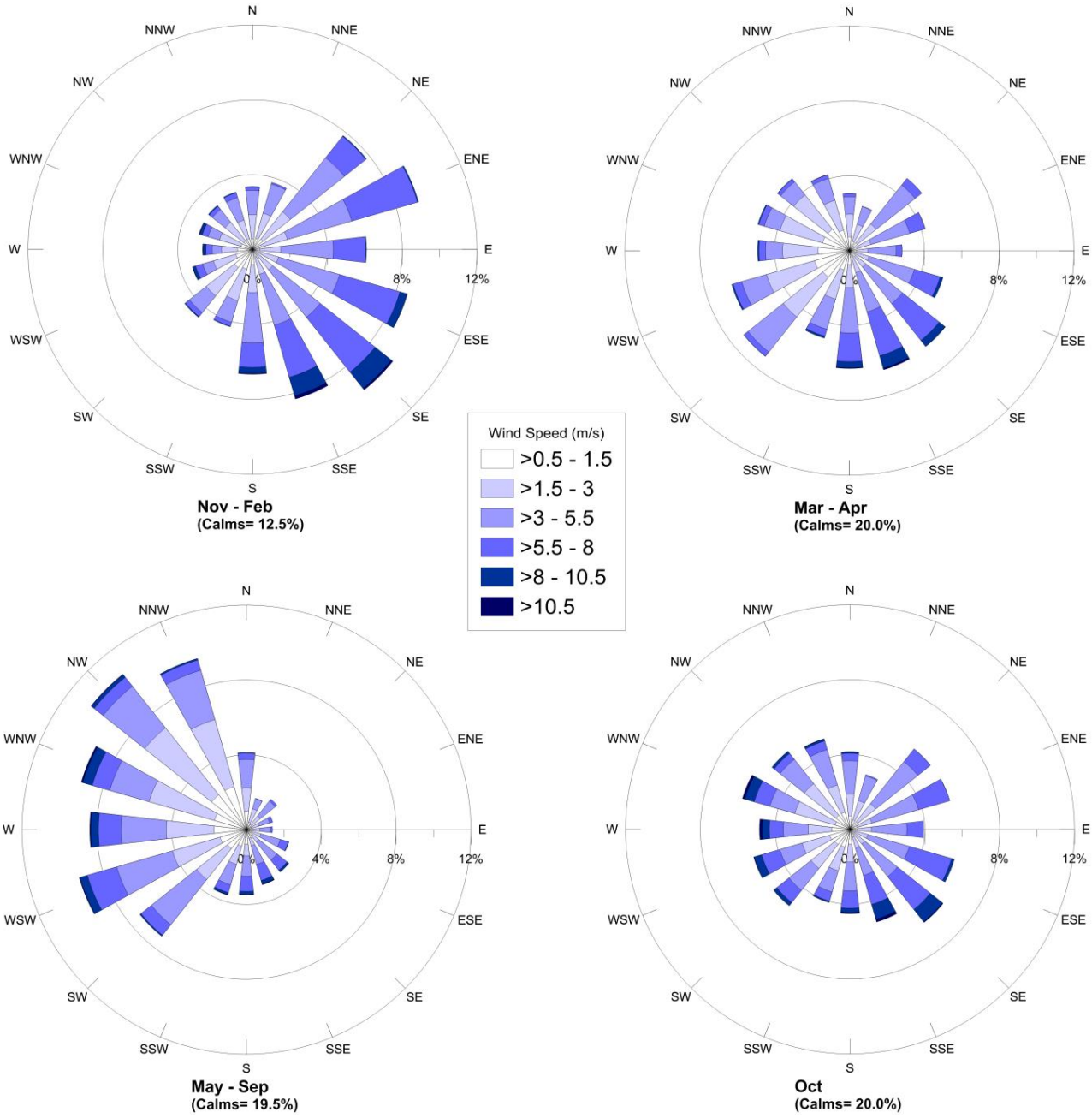
Sydney Airport AWS
(Observations)
1999-2017
600.09300



APPENDIX A

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

Bankstown Airport AWS
(Observations)
1999-2017
600.09300

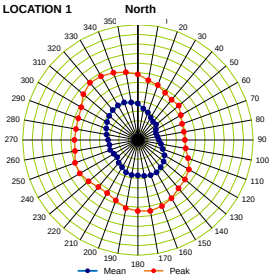


APPENDIX B

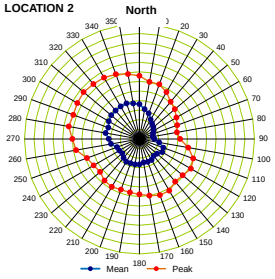
Wind Tunnel Test Results: BASELINE Scenario

Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

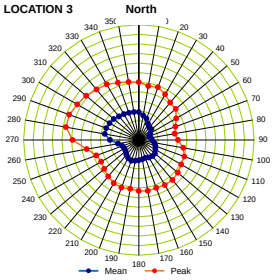
LOCATION 1



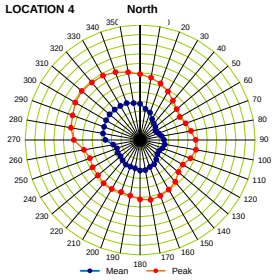
LOCATION 2



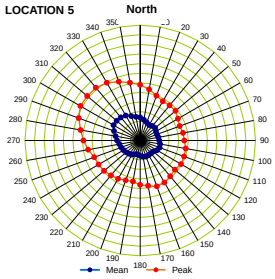
LOCATION 3



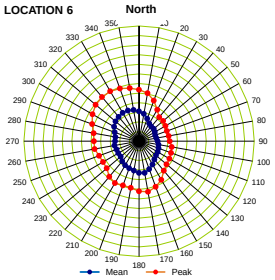
LOCATION 4



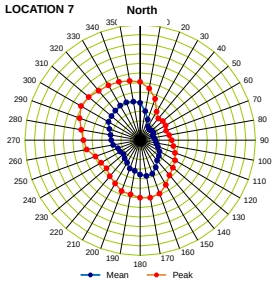
LOCATION 5



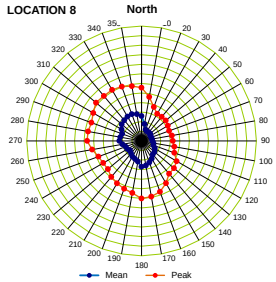
LOCATION 6



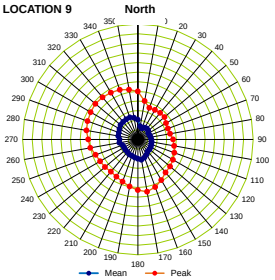
LOCATION 7



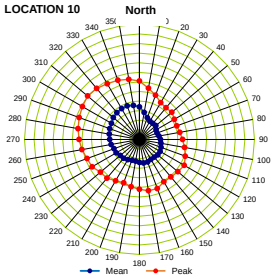
LOCATION 8



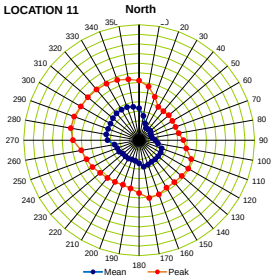
LOCATION 9



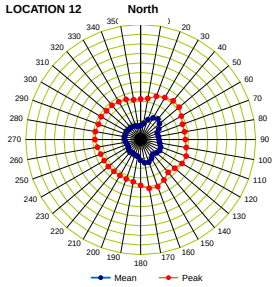
LOCATION 10



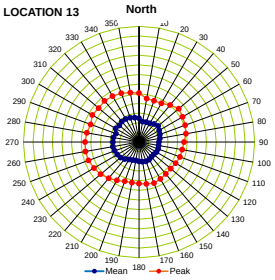
LOCATION 11



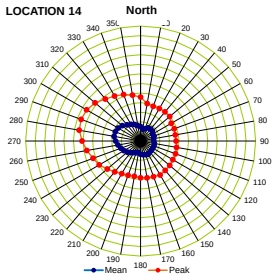
LOCATION 12



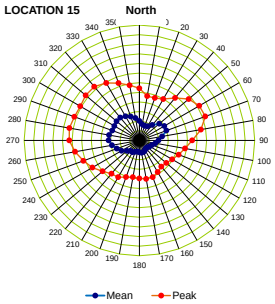
LOCATION 13



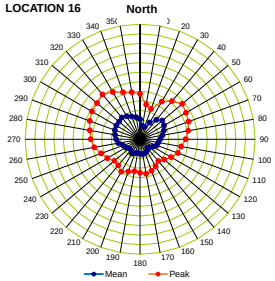
LOCATION 14



LOCATION 15



LOCATION 16

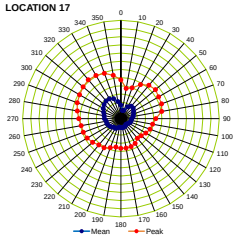


APPENDIX B

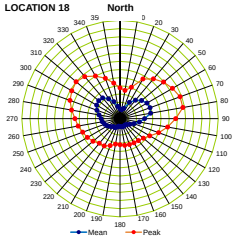
Wind Tunnel Test Results: BASELINE Scenario

Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

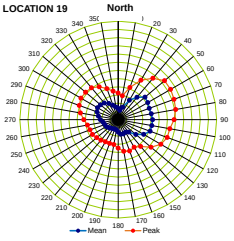
LOCATION 17



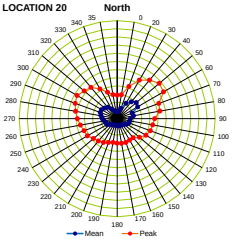
LOCATION 18



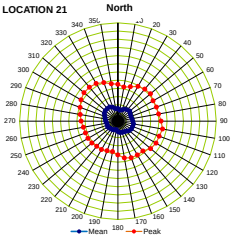
LOCATION 19



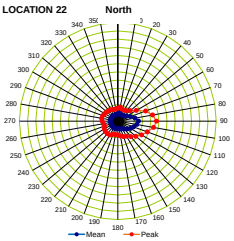
LOCATION 20



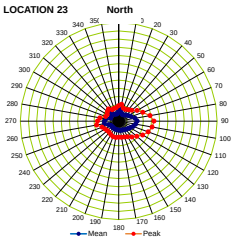
LOCATION 21



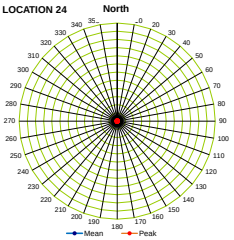
LOCATION 22



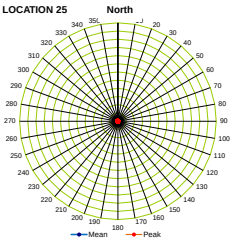
LOCATION 23



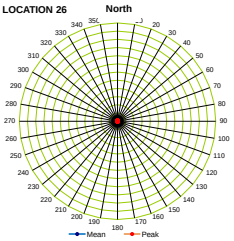
LOCATION 24



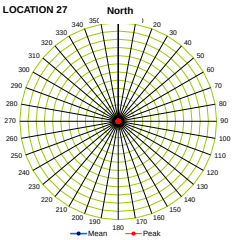
LOCATION 25



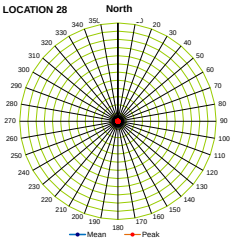
LOCATION 26



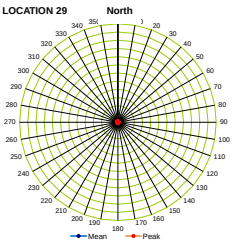
LOCATION 27



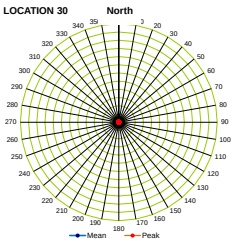
LOCATION 28



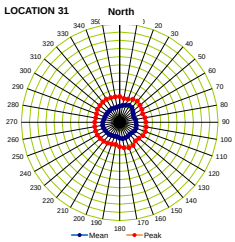
LOCATION 29



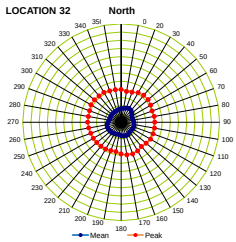
LOCATION 30



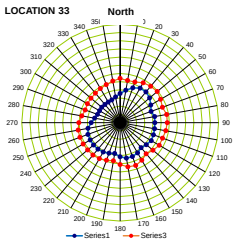
LOCATION 31



LOCATION 32



LOCATION 33



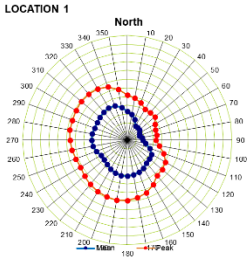
APPENDIX C

Wind Tunnel Test Results: FUTURE Scenario

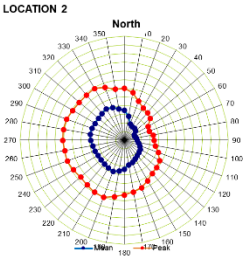
Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

Future-REVISED Design

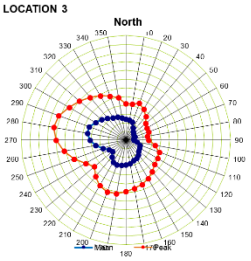
LOCATION 1



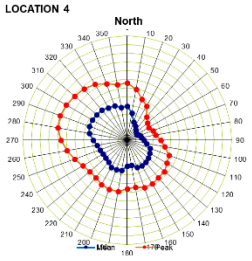
LOCATION 2



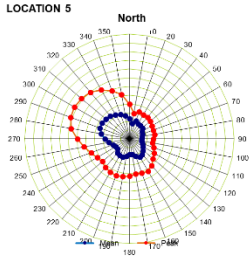
LOCATION 3



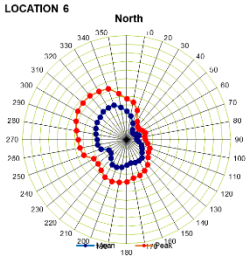
LOCATION 4



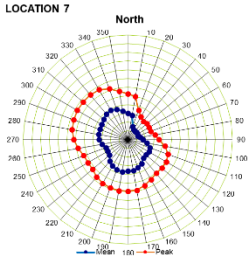
LOCATION 5



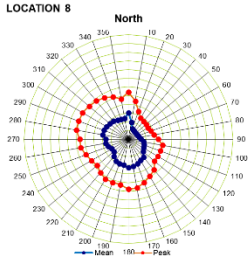
LOCATION 6



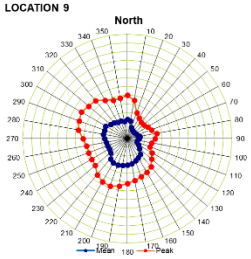
LOCATION 7



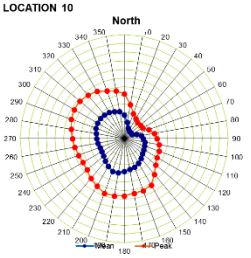
LOCATION 8



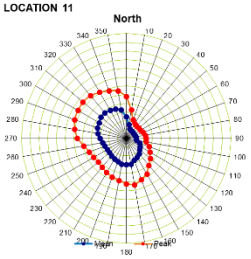
LOCATION 9



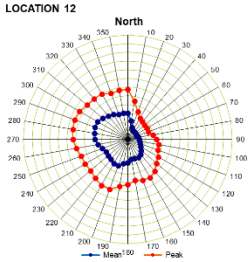
LOCATION 10



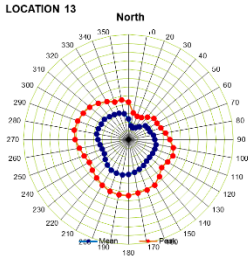
LOCATION 11



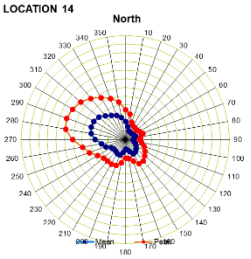
LOCATION 12



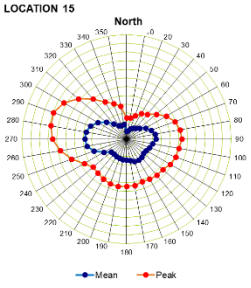
LOCATION 13



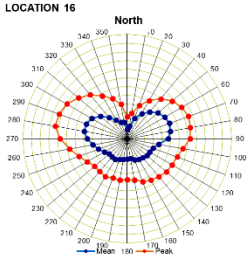
LOCATION 14



LOCATION 15



LOCATION 16



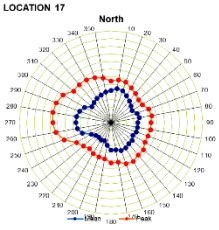
APPENDIX C

Wind Tunnel Test Results: FUTURE Scenario

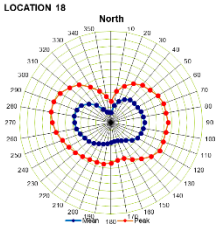
Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

Future-REVISED Design

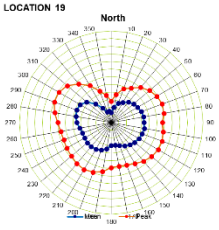
LOCATION 17



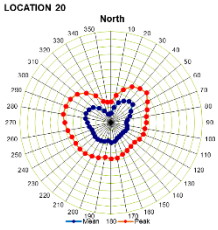
LOCATION 18



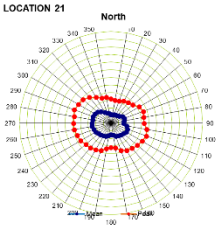
LOCATION 19



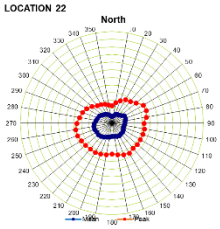
LOCATION 20



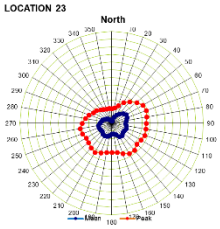
LOCATION 21



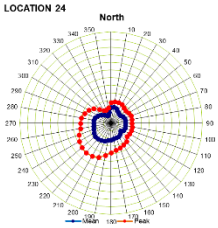
LOCATION 22



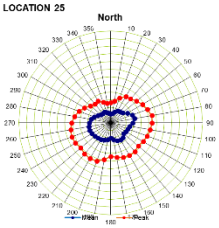
LOCATION 23



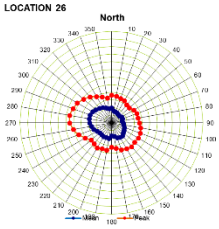
LOCATION 24



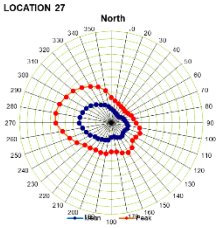
LOCATION 25



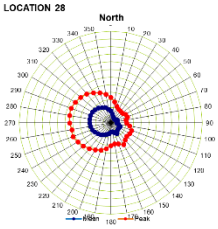
LOCATION 26



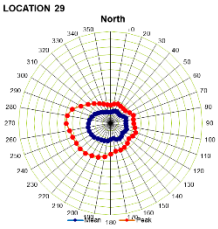
LOCATION 27



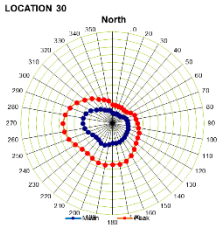
LOCATION 28



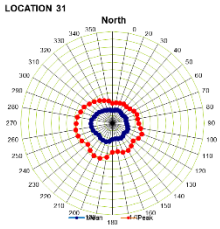
LOCATION 29



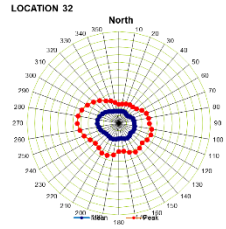
LOCATION 30



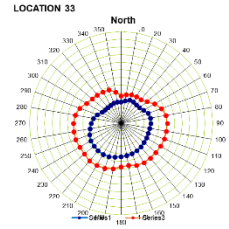
LOCATION 31



LOCATION 32



LOCATION 33



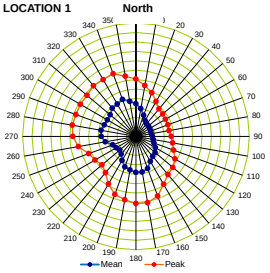
APPENDIX C

Wind Tunnel Test Results: FUTURE Scenario

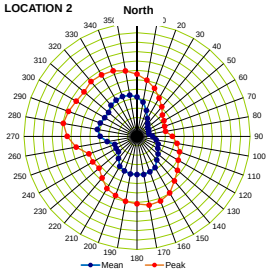
Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

Future-COMPLIANT Design

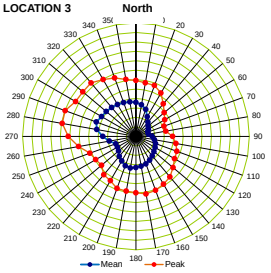
LOCATION 1



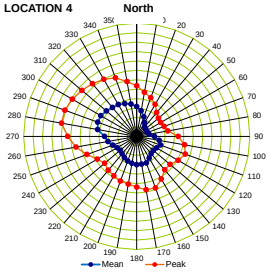
LOCATION 2



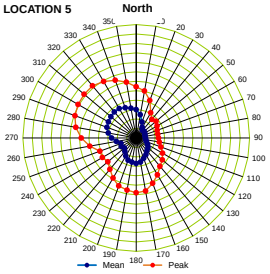
LOCATION 3



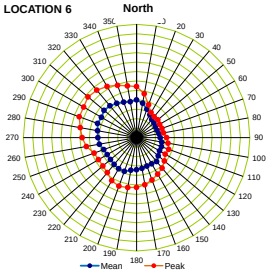
LOCATION 4



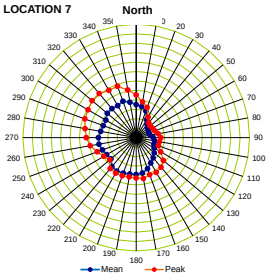
LOCATION 5



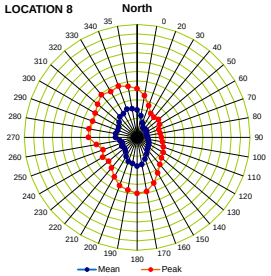
LOCATION 6



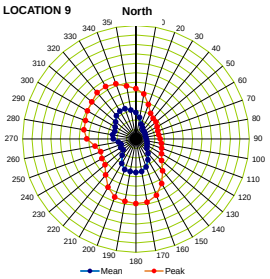
LOCATION 7



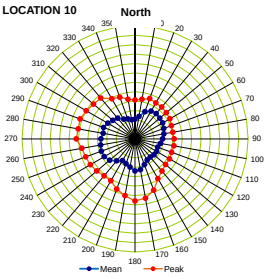
LOCATION 8



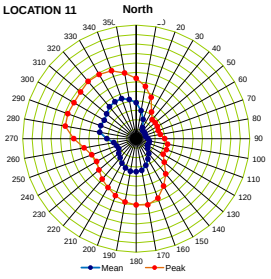
LOCATION 9



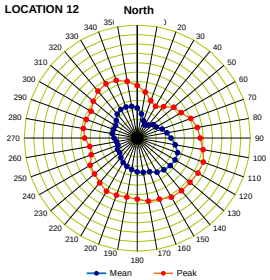
LOCATION 10



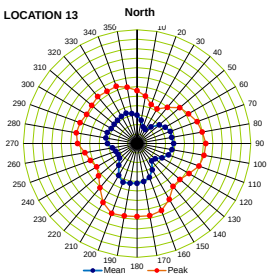
LOCATION 11



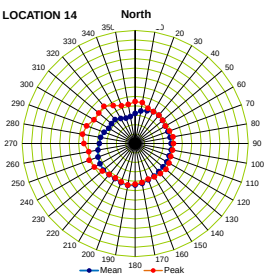
LOCATION 12



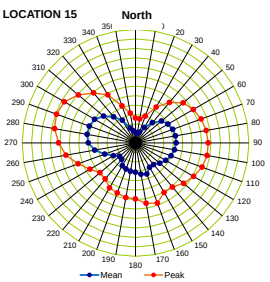
LOCATION 13



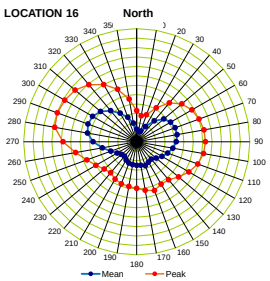
LOCATION 14



LOCATION 15



LOCATION 16



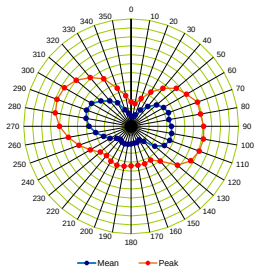
APPENDIX C

Wind Tunnel Test Results: FUTURE Scenario

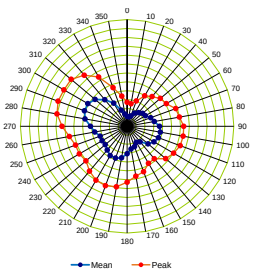
Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

Future-COMPLIANT Design

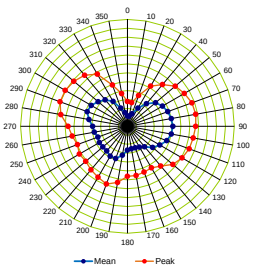
LOCATION 17



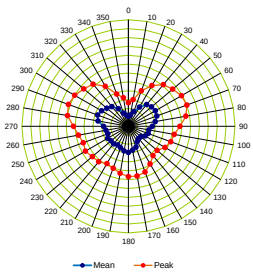
LOCATION 18 North



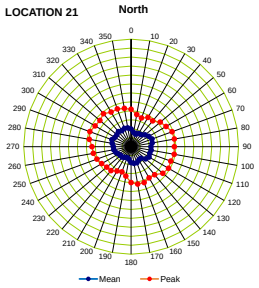
LOCATION 19 North



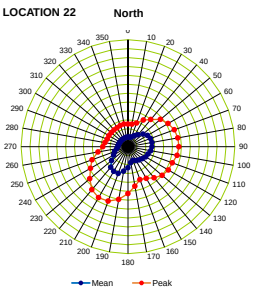
LOCATION 20 North



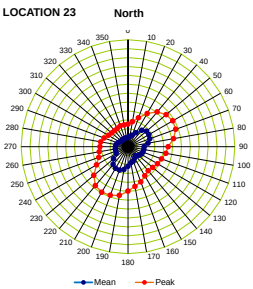
LOCATION 21 North



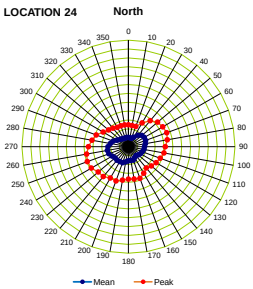
LOCATION 22 North



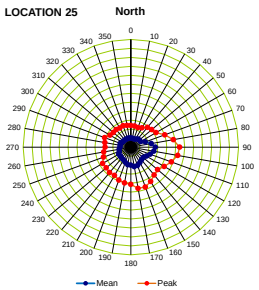
LOCATION 23 North



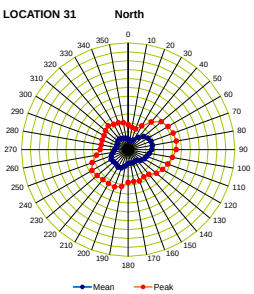
LOCATION 24 North



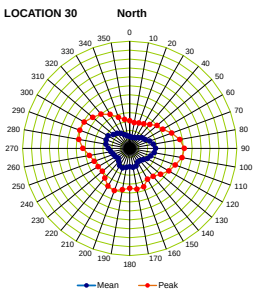
LOCATION 25 North



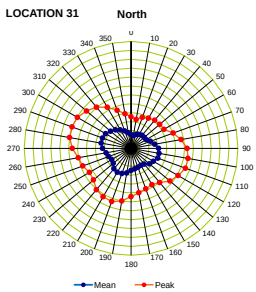
LOCATION 31 North



LOCATION 30 North



LOCATION 31 North

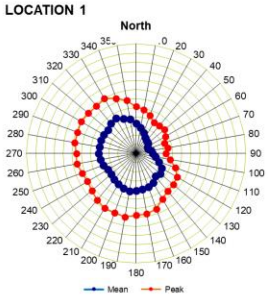


APPENDIX C

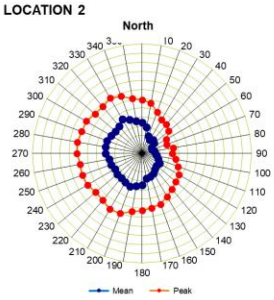
Wind Tunnel Test Results: FUTURE Scenario

Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

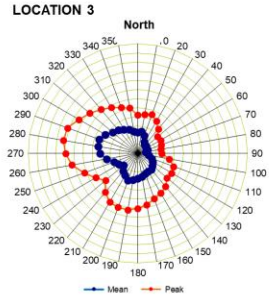
LOCATION 1



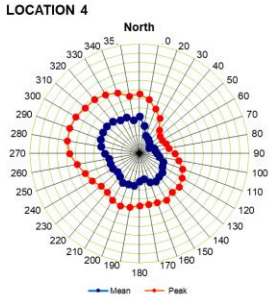
LOCATION 2



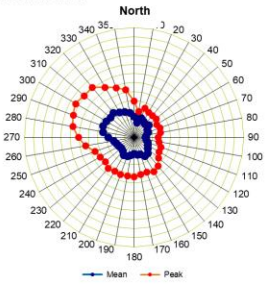
LOCATION 3



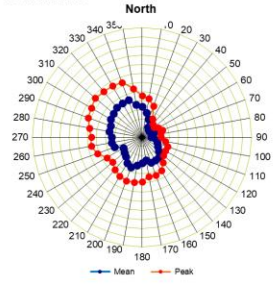
LOCATION 4



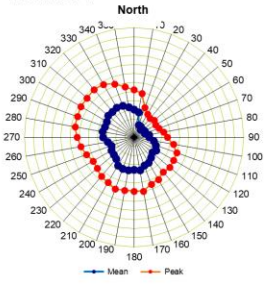
LOCATION 5



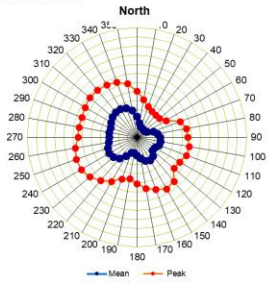
LOCATION 6



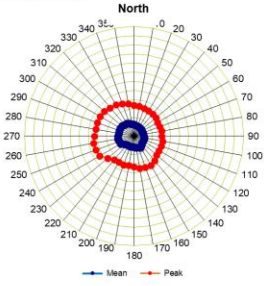
LOCATION 7



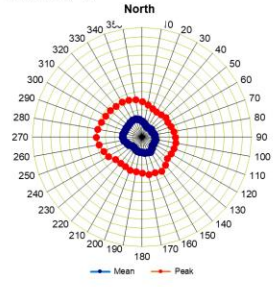
LOCATION 8



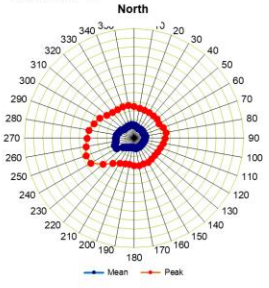
LOCATION 9



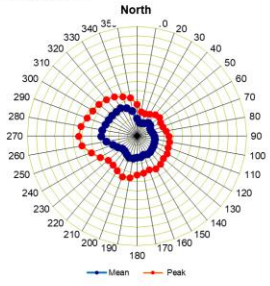
LOCATION 10



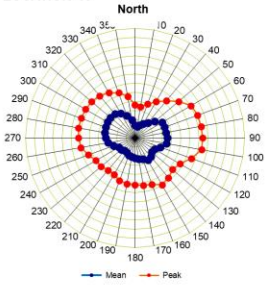
LOCATION 11



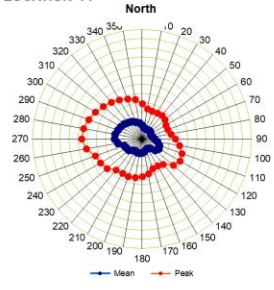
LOCATION 12



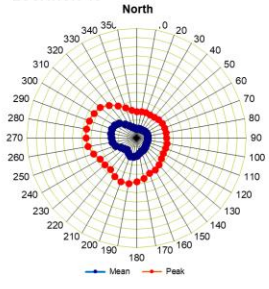
LOCATION 13



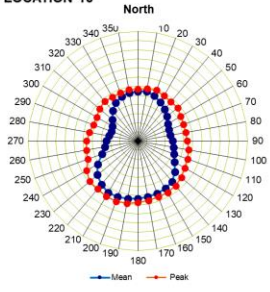
LOCATION 14



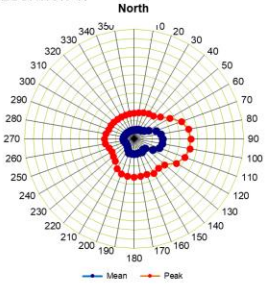
LOCATION 15



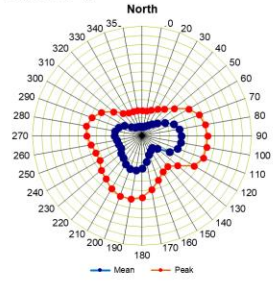
LOCATION 16



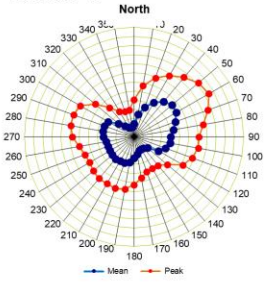
LOCATION 17



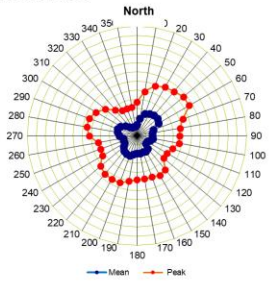
LOCATION 18



LOCATION 19



LOCATION 20

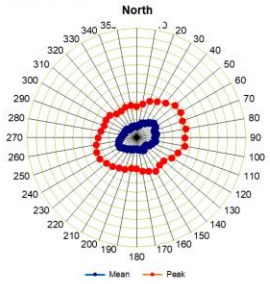


APPENDIX C

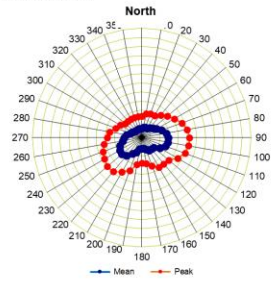
Wind Tunnel Test Results: FUTURE Scenario

Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

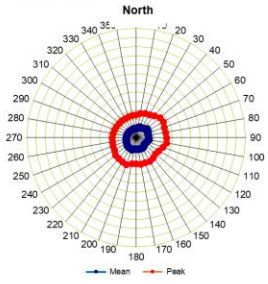
LOCATION 21



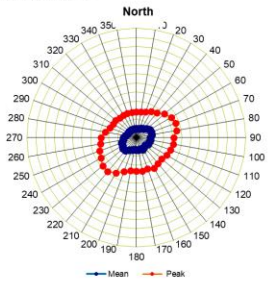
LOCATION 22



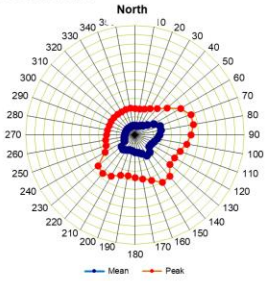
LOCATION 23



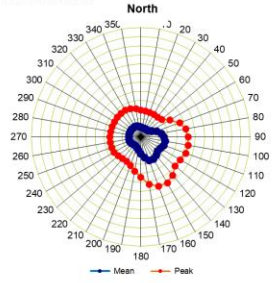
LOCATION 24



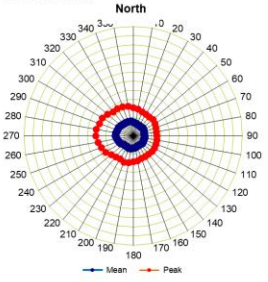
LOCATION 25



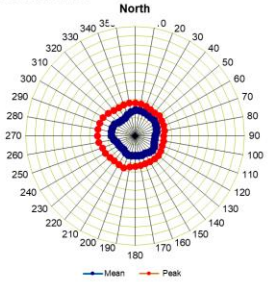
LOCATION 26



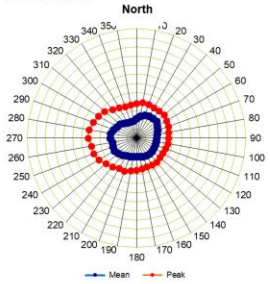
LOCATION 27



LOCATION 28



LOCATION 29



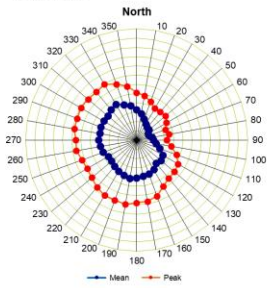
APPENDIX C

Wind Tunnel Test Results: FUTURE Scenario

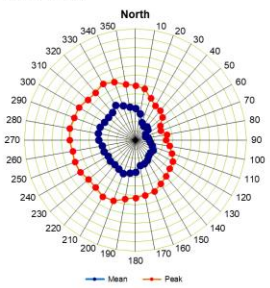
Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

MITIGATION

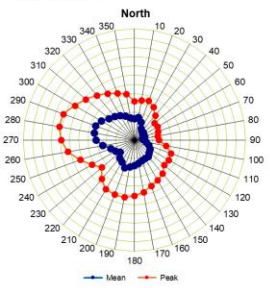
LOCATION 1



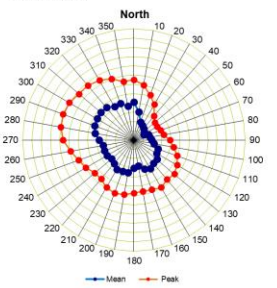
LOCATION 2



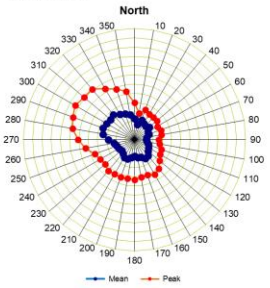
LOCATION 3



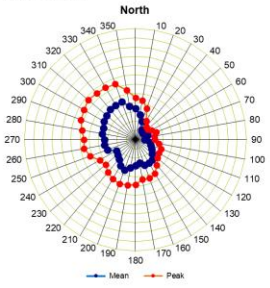
LOCATION 4



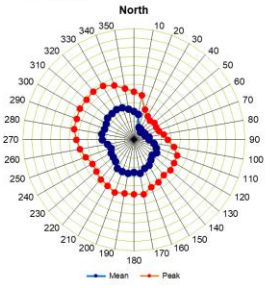
LOCATION 5



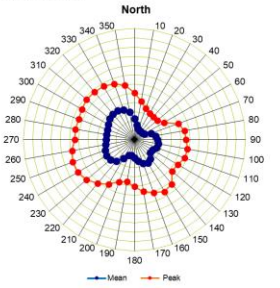
LOCATION 6



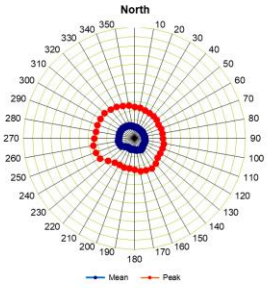
LOCATION 7



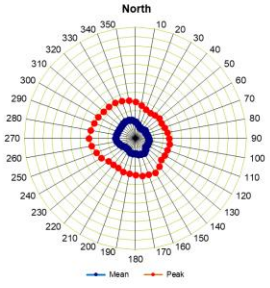
LOCATION 8



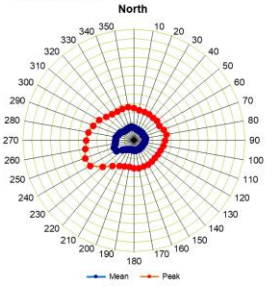
LOCATION 9



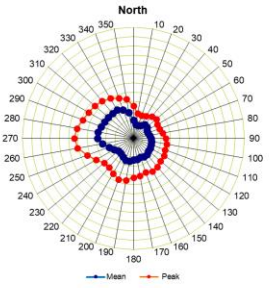
LOCATION 10



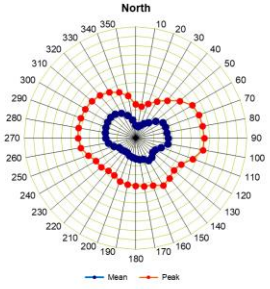
LOCATION 11



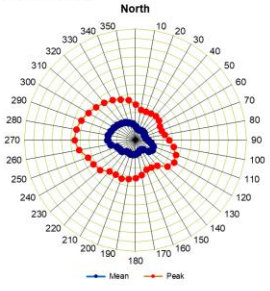
LOCATION 12



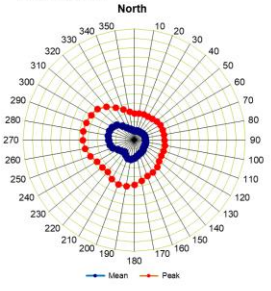
LOCATION 13



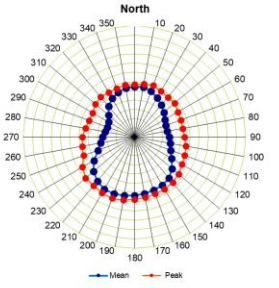
LOCATION 14



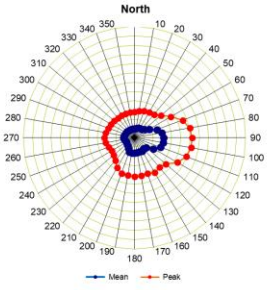
LOCATION 15



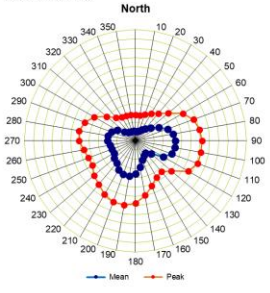
LOCATION 16



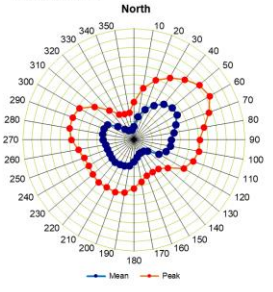
LOCATION 17



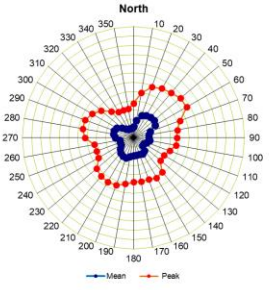
LOCATION 18



LOCATION 19



LOCATION 20

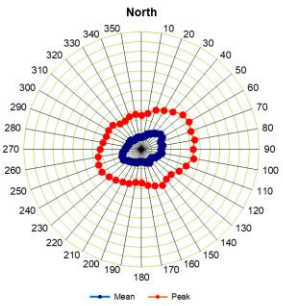


APPENDIX C

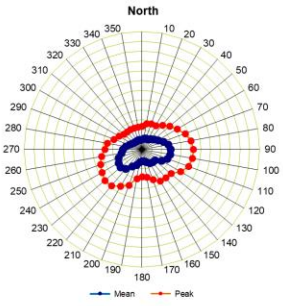
Wind Tunnel Test Results: FUTURE Scenario

Polar Plots: Ratio of Ground Level Wind Speed to Reference Wind Speed

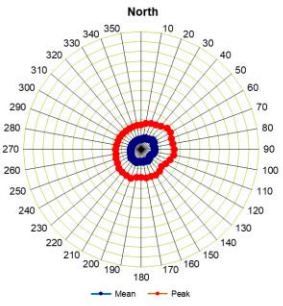
LOCATION 21



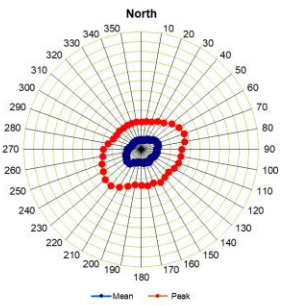
LOCATION 22



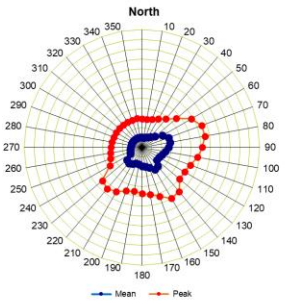
LOCATION 23



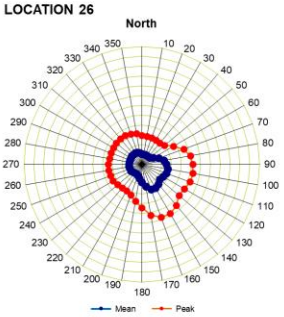
LOCATION 24



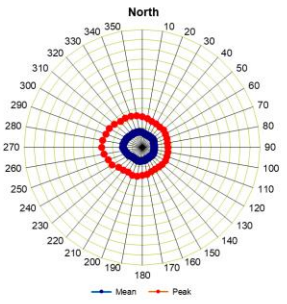
LOCATION 25



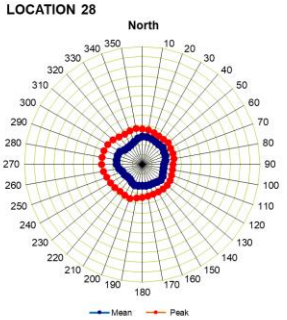
LOCATION 26



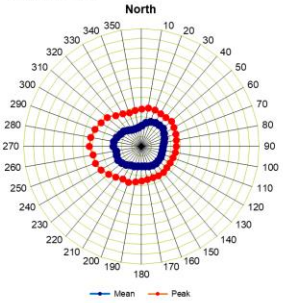
LOCATION 27



LOCATION 28



LOCATION 29



ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

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

DARWIN
5 Foelsche Street
Darwin NT 0800
Australia
T: +61 8 8998 0100
F: +61 2 9427 8200

GOLD COAST
Ground Floor, 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
Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

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

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

ROCKHAMPTON
rockhampton@slrconsulting.com
M: +61 407 810 417

SYDNEY
2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TAMWORTH
PO Box 11034
Tamworth NSW 2340
Australia
M: +61 408 474 248
F: +61 2 9427 8200

TOWNSVILLE
Level 1, 514 Sturt Street
Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: +64 27 441 7849

NELSON
5 Duncan Street
Port Nelson 7010
New Zealand
T: +64 274 898 628

NEW PLYMOUTH
Level 2, 10 Devon Street East
New Plymouth 4310
New Zealand
T: +64 0800 757 695