13-23 GIBBONS STREET, REDFERN

Environmental Wind Tunnel Test

Prepared for:

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

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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-R06-v1.0	13 December 2018	Dr Peter Georgiou	Dr Neihad Al-Khalidy	Dr Neihad Al-Khalidy

EXECUTIVE SUMMARY

SLR Consulting 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.

This assessment has been performed using 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 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 car parking level, a three-storey podium with external common areas at Level 2 (north facing) and Level 4 (overlooking Gibbons Street), and a 14-storey upper component, providing for 400 student units on Levels 1 to 18.

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.

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

Built Environment Scenarios Assessed

The study involved the testing of two built environment "scenarios":

- The "Baseline" scenario reflecting the existing built environment (as of December 2018); and
- The "Future" scenario, with the addition of the proposed development.

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

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"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 some channelling of northerly and southerly winds along Gibbons Street and channelling of easterly and westerly winds along Margaret Street.

- 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 16**. These would have an ameliorating (ie sheltering) effect, in some cases 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).

- Again, the absence of the mature and extensive vegetation and trees along the footpath areas of interest in the testing is noted – refer **Figure 16**, with their associated ameliorating (ie sheltering) effect on Gibbons Street winds in parrticular.

Through Site Link

With the exception of the southern end of the Through Site Link, winds in this thoroughfare are generally mild, well below the 16 m/s walking comfort criterion and in a number of locations below the 13 m/s criterion suitable for "standing-waiting=-window shopping" type activities.

- It is only at the southern end of the Through Site Link that winds exceed the nominated wind acceptability critieria, indeed slightly exceeding the 16 m/s walking comfort criterion.
- Furthermore, it is noted that wind conditions within the new Through Site Link were tested in the wind tunnel without the benefit of any of the landscaping, pergolas, etc, proposed for this area, although much of this is located centrally and may have limited benefit close to the southeast corner of the proposed development.

Podium Areas

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. This is most apparent near the northwest and southwest corners of the Podium.

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

- In terms of the nominated wind acceprtability critieria, the two corner Level 4 Podium locations may potentially exceed the 16 m/s walking comfort criterion, but remain below the 23 m/s safety criterion.

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

Already Planned and Existing Wind Mitigation

It has been noted that 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 16**;
- Extensive landscaping and pergolas planned for the Through Site Link – refer **Figure 17**; and
- Extensive landscaping planned for the Level 4 Podium – refer **Figure 18**.

Addition Wind Mitigation Recommendations – Surrounding Pedestrian Areas

Current plans for the proposed development retain the existing landscaping along Gibbons Street and included a full perimeter awning along the development's western façade – refer **Figure 19**.

It is also noted that the main Gibbons Street entry into the development comprises a 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 high localised winds occur at the two southern corners of the proposed development and along sections of Margaret Street:

- SW corner footpath – Gibbons Street and Margaret Street;
- Margaret Street footpath – along the proposed development's southern façade; and
- SE corner footpath – Margaret Street and Through Site Link.

Noting that these areas will be exposed to winds with both a horizontal and vertical component, we recommend retention of the existing awnings at Level 2 elevation, which as per previous recommendation extend out from the main building façade line as far as practicable over the footpath – refer **Figure 19**. Further, SLR recommends additional trees be added as shown in **Figure 19**.

Given the relatively low wind speeds predicted for the Through Site Link (apart from the southern end near Margaret Street), no additional mitigation is recommended beyond that already planned.

Addition Wind Mitigation Recommendations – Podium Level 2

The test results indicated that the potential for elevated winds within the open Level 2 Podium area facing north is minimal.

Given the relatively low wind speeds predicted and the already planned extensive landscaping, no additional mitigation is recommended beyond that already provided.

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Addition Wind Mitigation Recommendations - Podium Level 4

The wind tunnel testing showed that high localised winds occur at the north and south corners of the open Level 4 Podium area facing west.

Noting that these areas will be exposed to winds with both a horizontal and vertical component, we recommend retention of the proposed canopies protecting the Level 4 Podium over the corner areas and retention of provided planters and landscaping, refer **Figure 20**.

Addition Wind Mitigation Recommendations - Upper Level Balconies

The high-rise component of the proposed development has have balconies around all facades, including at building corners. It is almost certain, given the absence of nearby similar height buildings in some wind directions, that some of these balconies, especially those at upper levels and near building corners which are exposed to stronger southerly and westerly winds, will experience adverse wind conditions requiring wind treatment beyond standard height (ie code-compliant) balustrades.

Such treatments might include increased balustrade height or partial screening via moveable louvres, to take advantage of the beneficial of cooler, milder winds during summer, while providing the capacity to limit the impact of colder and potentially much stronger winds during winter.

The development drawings of the proposed development show movable balcony screens from Level 4 upwards – refer **Figure 2**. On this basis, no further recommendations are made to ameliorate potential high corner balcony wind speeds.

Addition Wind Mitigation Recommendations - Roof Level

The same consideration for upper-level balconies and associated recommendations would normally apply also to any public access areas located on the proposed development's Roof Level, where a combination of both vertical screening (eg solid balustrades, balustrades combined with planter boxes, etc) and horizontal screening might normally be required to ensure all-year-round amenity, especially areas exposed to 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.

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1 INTRODUCTION

SLR Consulting 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.

This assessment has been performed using 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.

1.1 Location of the Proposed Development

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

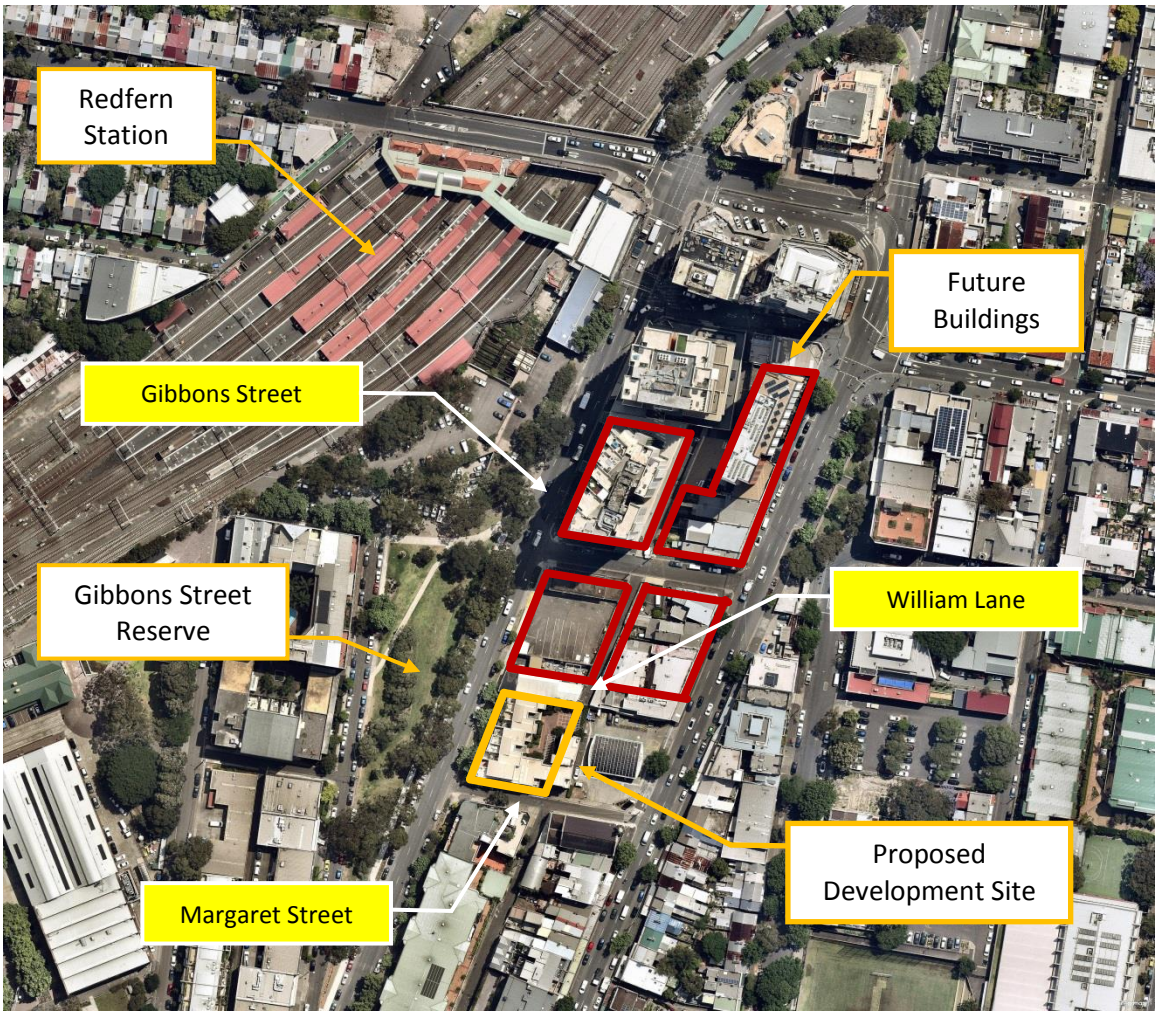


Image Courtesy: Nearmap, December 2018

1.2 Proposed Development Description

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

- One level of basement car parking;
- Ground Floor (Level 1) with common area, retail unit, bike shop and office space;
- Level 2 with internal and external common areas, student units;
- Level 4 with internal and external common areas, student units; and
- Levels 5-18 for student units

Figure 2 Architectural Plans and Elevation of Floors of Interest

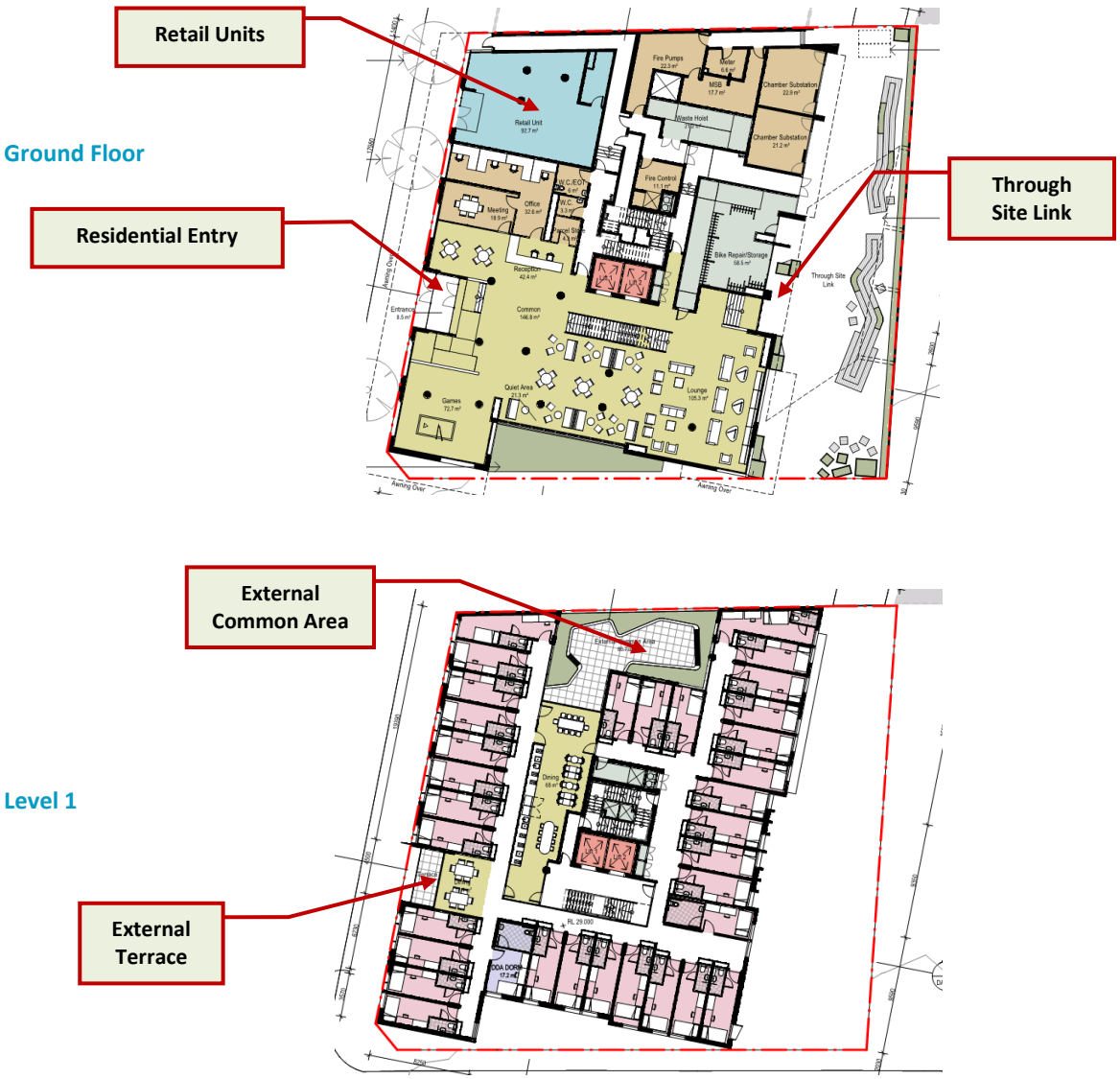


Fig.2 (cont'd)

Level 4

Southwest Perspective View

1.3 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)

2 SYDNEY'S REGIONAL WIND CLIMATE

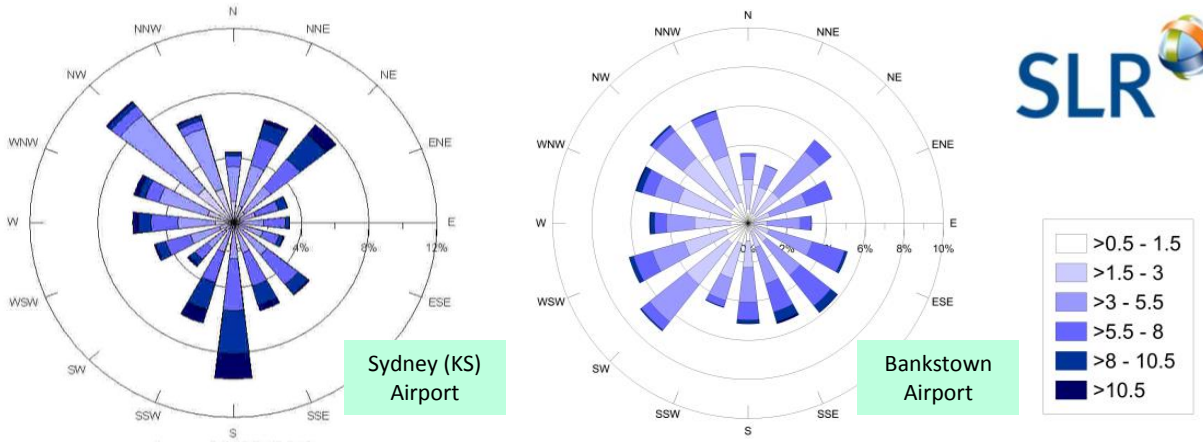
The data of interest in this study are the mean hourly wind speeds and largest gusts experienced throughout the year (especially higher, less frequent winds), how these winds vary with azimuth, and the seasonal break-up of winds into the primary Sydney Region wind seasons.

2.1 Seasonal Variations

Key characteristics of Sydney's Regional Wind Climate are illustrated in two representative wind roses shown in **Figure 3**, 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 3 Annual Wind Roses for Sydney (KS) Airport and Bankstown Airport (BoM Data)



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

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

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

3 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.

3.1 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 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 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).

4 DESIGN WIND SPEEDS

4.1 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 "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.

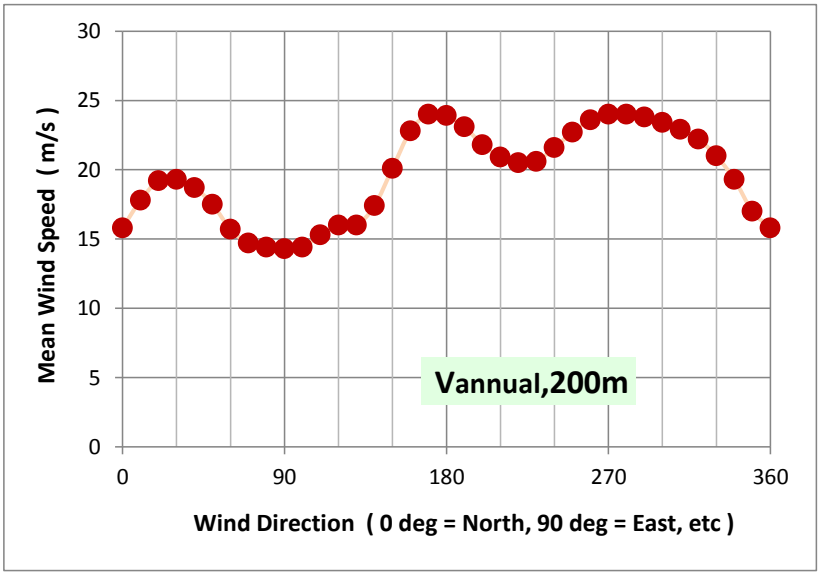
The above analysis is described in detail in …

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

4.2 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 4** and have been based on the adopted Liverpool wind model as described above. The winds shown in **Figure 4** have a once-per-year exceedance probability.

Figure 4 Reference Height (200 m) Annual Recurrence Mean Wind Speed at Liverpool



5 WIND TUNNEL TEST METHODOLOGY

5.1 Simulation of Natural Wind

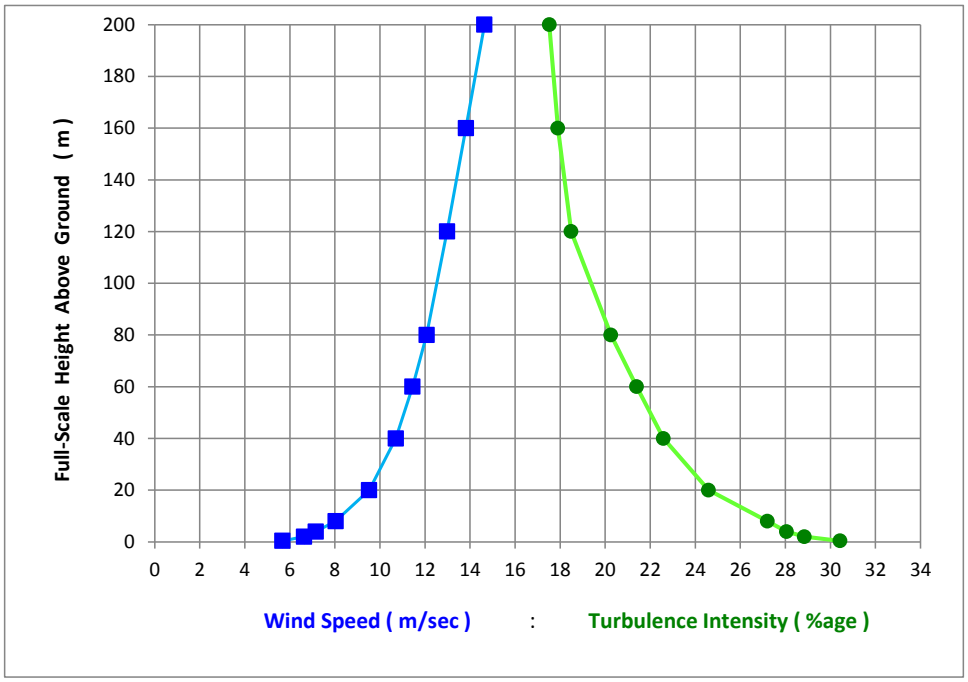
Similarity requirements between the wind tunnel model and prototype (ie full-scale) need to be fulfilled so that similitude in the flow conditions is satisfied. Usually all requirements cannot be satisfied and compromises need to be made. In this type of wind tunnel test it is possible to waive strict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

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

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

The upstream profile conditions simulated in the present study is Terrain Category 3 associated with medium density suburban surroundings. The variation of mean wind speed (blue curve) and turbulence intensity (green curve) is shown in **Figure 5**.

Figure 5 Wind Tunnel Test Profiles for Mean Wind and Turbulence Intensity



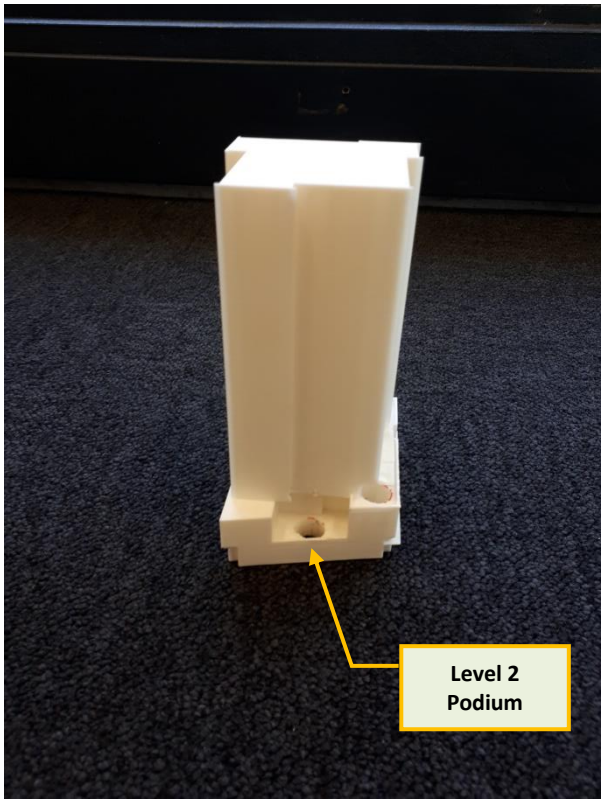
5.2 Development Model and Proximity Model

Development Model

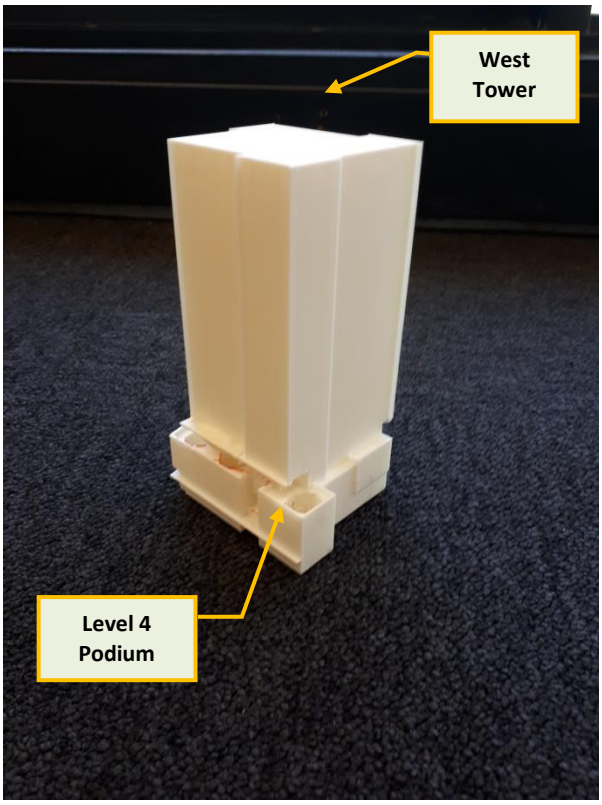
A 1:400 scale model of the proposed development was built (using 3D printing) for the testing – refer **Figure 6**.

Figure 6 1:400 Scale Model of the Proposed Development

View from North



View from Southwest



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 model simulates two built environment "scenarios":

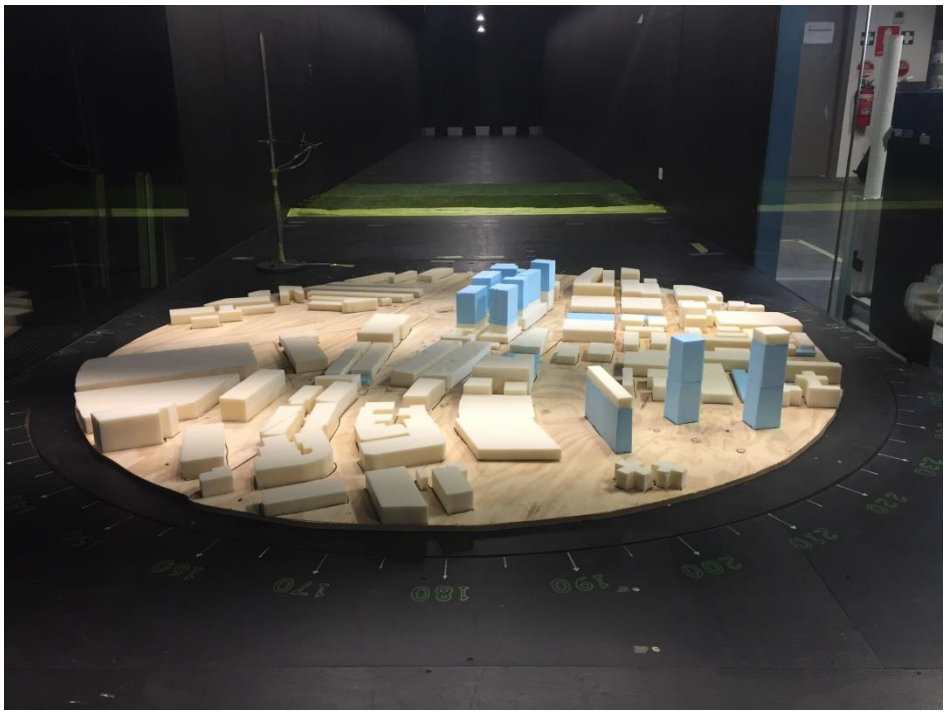
- "Baseline" scenario: simulating the existing built environment (as of December 2018); and
- "Future" scenario: which includes the addition of the future proposed development.

Both scenarios included the proposed and approved future developments lying to the immediate north of the site – refer **Figure 1**.

Figure 7 Proximity Models Used in the Wind Tunnel Testing

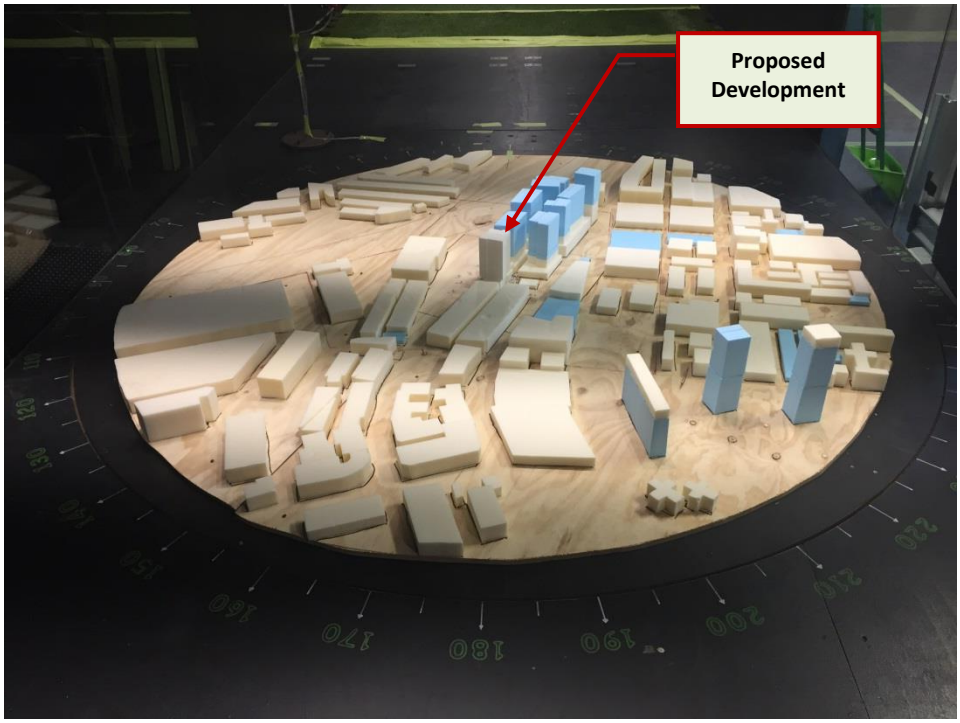
"Baseline" Scenario (Existing)

View from South



"Future" Scenario (with Proposal)

View from South



5.3 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 4**.

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 Liverpool statistical wind data.

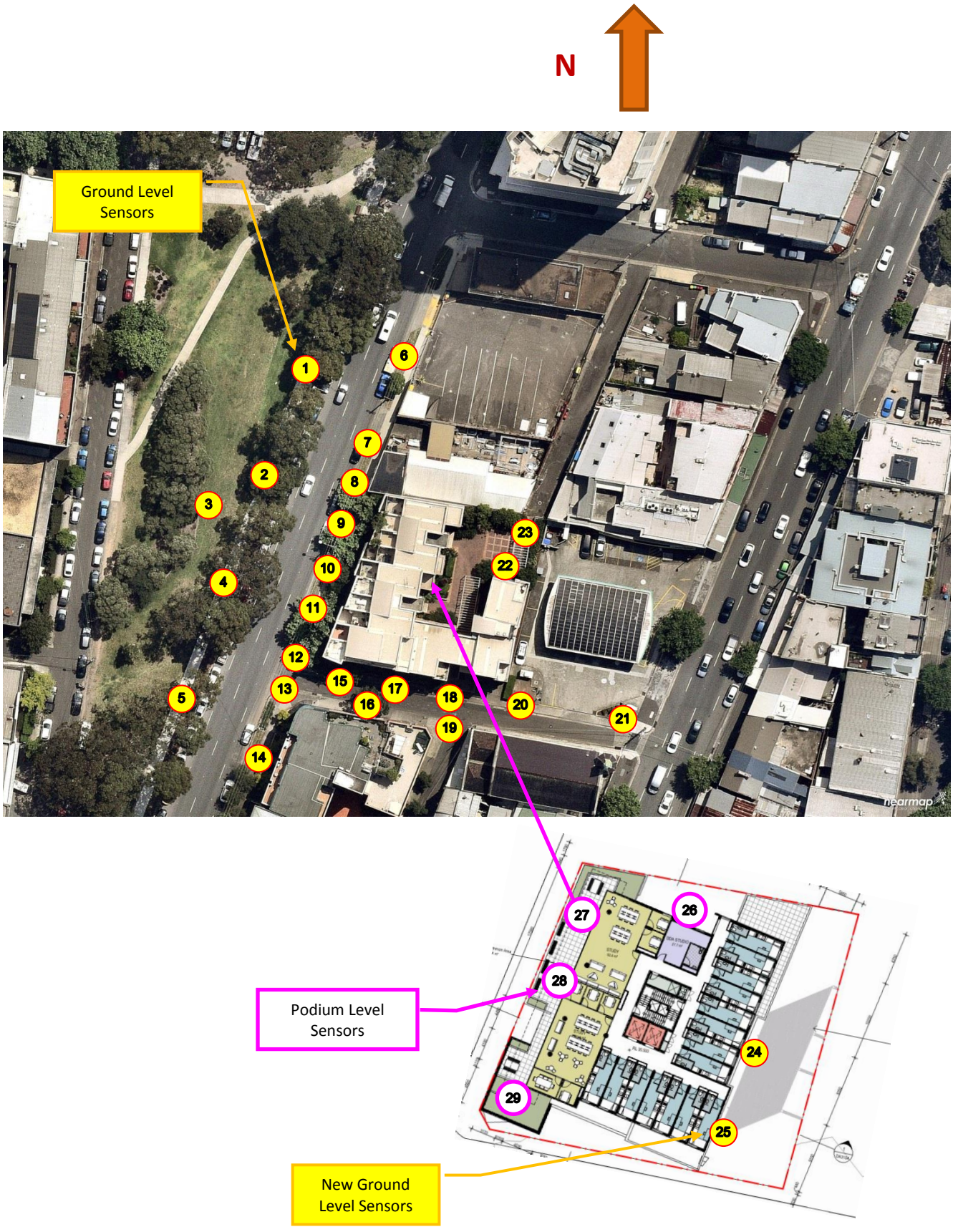
5.4 Test Method – Sensor Locations

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 both the "Baseline" and "Future" scenarios;
- Locations 24-25 were only measured for the "Future" scenarios;
- The 4 Podium level sensors, Locations 26 to 29 are shown separately (purple circles); these positions are located on the newly proposed development Podium and were measured only for the "Future" scenario; and
- Location 26 is located at the Level 2 Podium, Locations 27 to 29 are located at the Level 4 Podium.

Figure 8 Wind Tunnel Test Sensor Locations



5.5 Sample Test Result

An example of the test results and interpretation of these results is shown in **Figure 9**, 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:

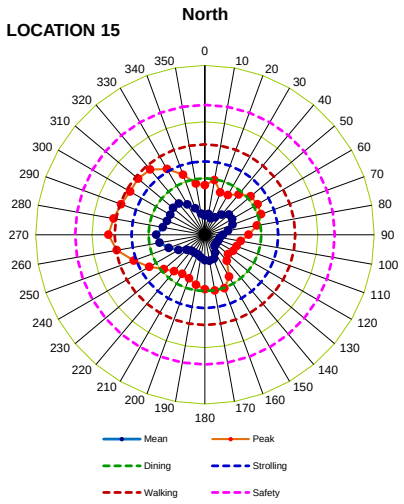
Mean wind speed:	"navy blue" data points
Gust wind speed:	"red" data points.

The polar diagram also includes three circumferential lines representing criteria for:

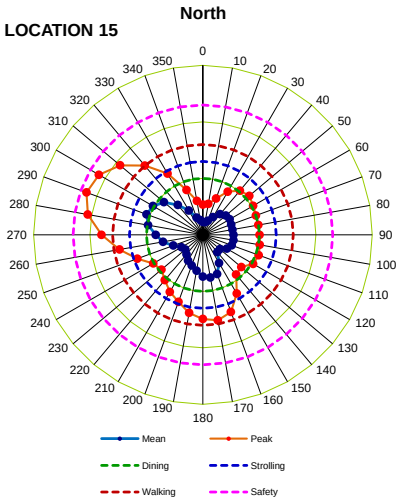
Public Safety:	23 m/s (purple)
Walking Comfort:	16 m/s (ochre)
Strolling Comfort:	13 m/s (blue)
Dining Comfort:	10 m/s (green)

Figure 9 Sample Polar Plot Test Result – Location 15 – "Baseline" & "Future" Scenarios

"Baseline" Scenario



"Future" Scenario



For the **"Baseline"** scenario …

- Winds at Location 15 are strongest from the west around to the northwest, where winds from these directions can approach the site over rail lines, low height buildings, Gibbons Street Reserve and then can channel along Margaret Street.

For the **"Future"** scenario …

- With the addition of the proposed development, winds at Location 15 increase from both the west-northwest and south-southeast, where winds are accelerated around the development's southwest corner or deflected downwards as downwash respectively.

6 TEST RESULTS

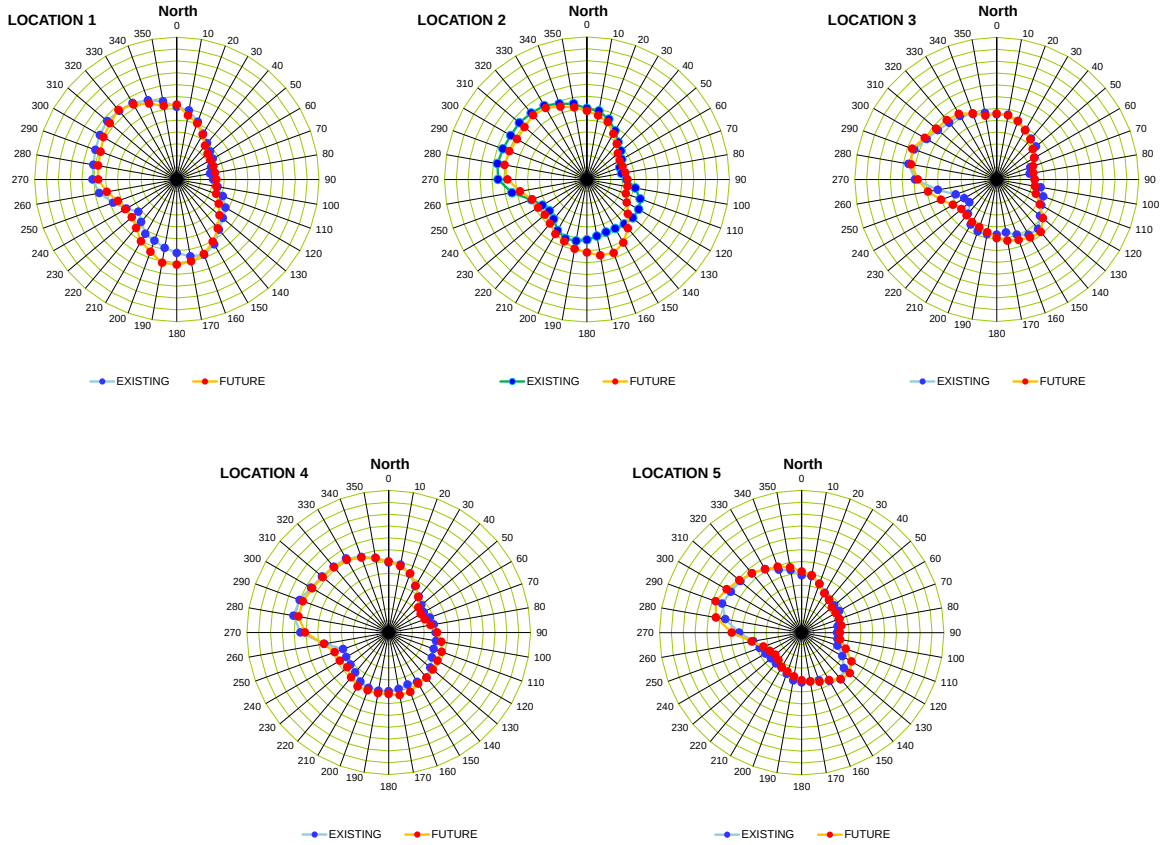
Appendices B & C shows the relevant wind tunnel test result polar plots respectively for all locations for the "Baseline" (existing built environment) and "Future" (with the proposal) scenarios.

It should be noted that no landscaping was incorporated in the "Baseline" and "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.

6.1 Sensor Locations: Gibbons Street (west side) - Fig.10

- 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 minimal change in existing winds
- With the proposed development downstream for northwest winds, these remain unaffected.
- There is a very slight increase in southerly winds at location north of the site, reflecting a modest change in winds deflected off the proposed development's southwest corner.

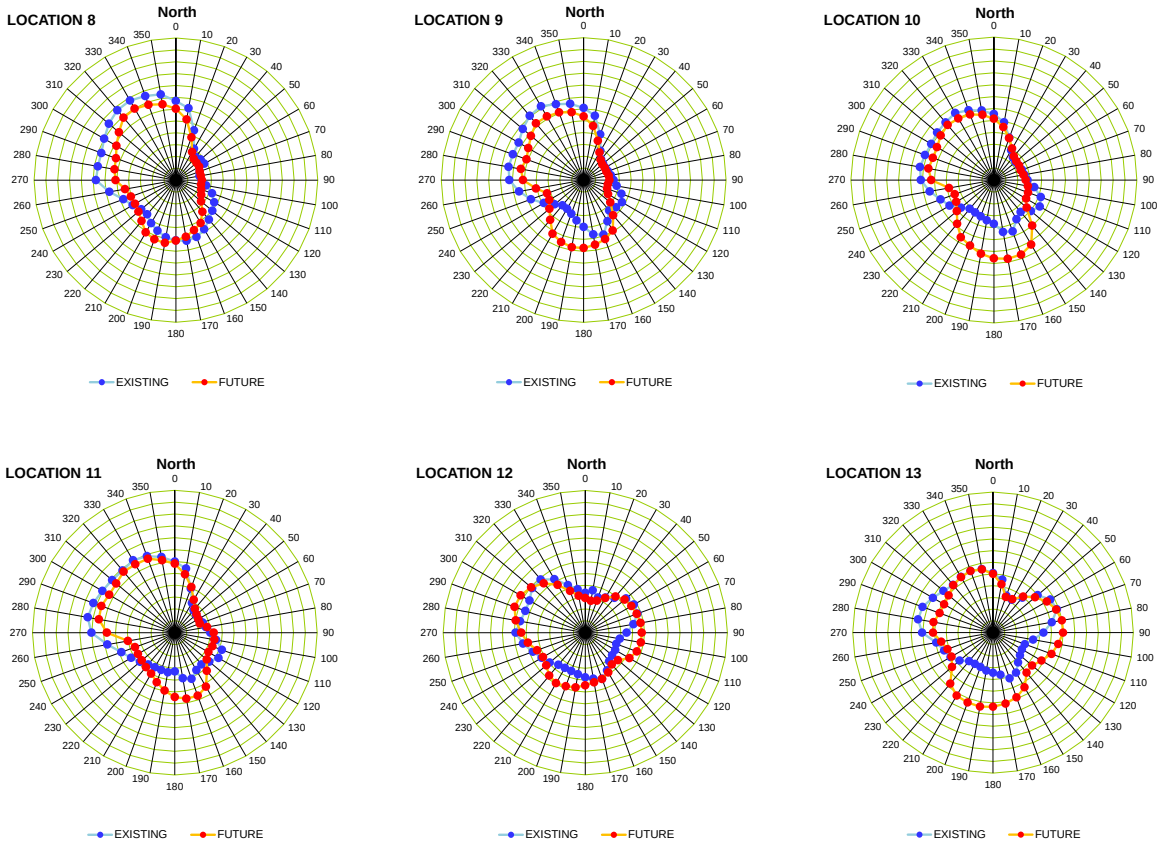
Figure 10 Peak Annual Gusts V/Vref: "Baseline" versus "Future" Scenario – Locations 1-5



6.2 Sensor Locations: Gibbons Street (adjacent to development) - Fig.11

- c
- With the addition of the proposed development, winds from the northwest remain unaffected.
- Winds from the south however experience an increase, reflecting accelerated windflow past the proposed development's southwest corner and downwash off the proposed development's western façade. The increase in southerly winds along Gibbons Street is not uniform or significant for all locations, reflecting the beneficial impact of the proposed development's Level 4 Podium set-back.

Figure 11 Peak Annual Gusts V/Vref: "Baseline" versus "Future" Scenario – Locations 8-13

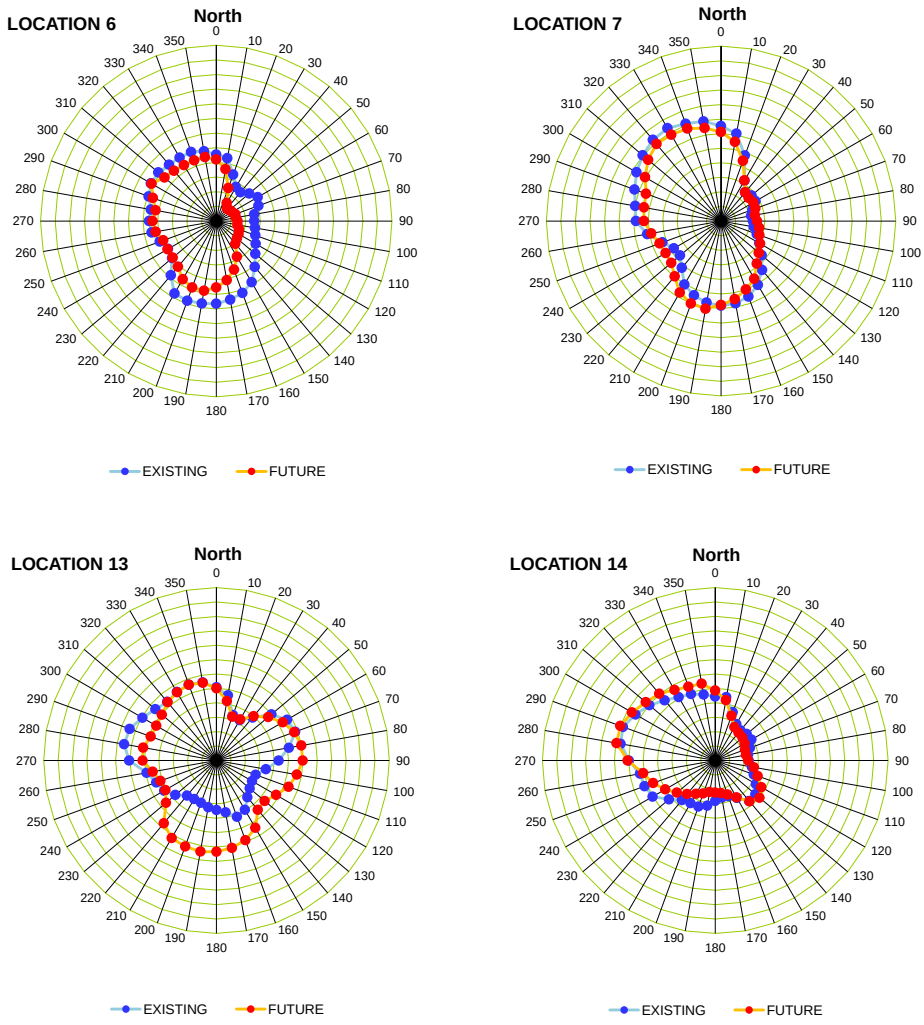


6.3 Sensor Locations: Gibbons Street (north and south of site) - Fig.12

- Winds along the Gibbons Street footpath north of the site (Locations 6 and 7) are highest for northwest winds, where there are low rise buildings, the rail line and Gibbons Street Reserve upstream, hence minimal upstream sheltering. There is also modest channelling of winds from the south along Gibbons Street. East quadrant winds are shielded by the development site itself.
- Winds along the Gibbons Street footpath south of the site (Locations 13 and 14) exhibit a range of direction-related wind responses with some east-west increased winds at Location 13 reflecting windflow along Margaret Street.
- With the addition of the proposed development, winds north of the site are essentially unaffected.
- Winds close to the Margaret Street intersection (Location 13) are predicted to experience an increase for southerly winds and easterly winds.

Figure 12 Peak Annual Gusts V/Vref: "Baseline" versus "Future" Scenario – Locations 9-13, 23-24

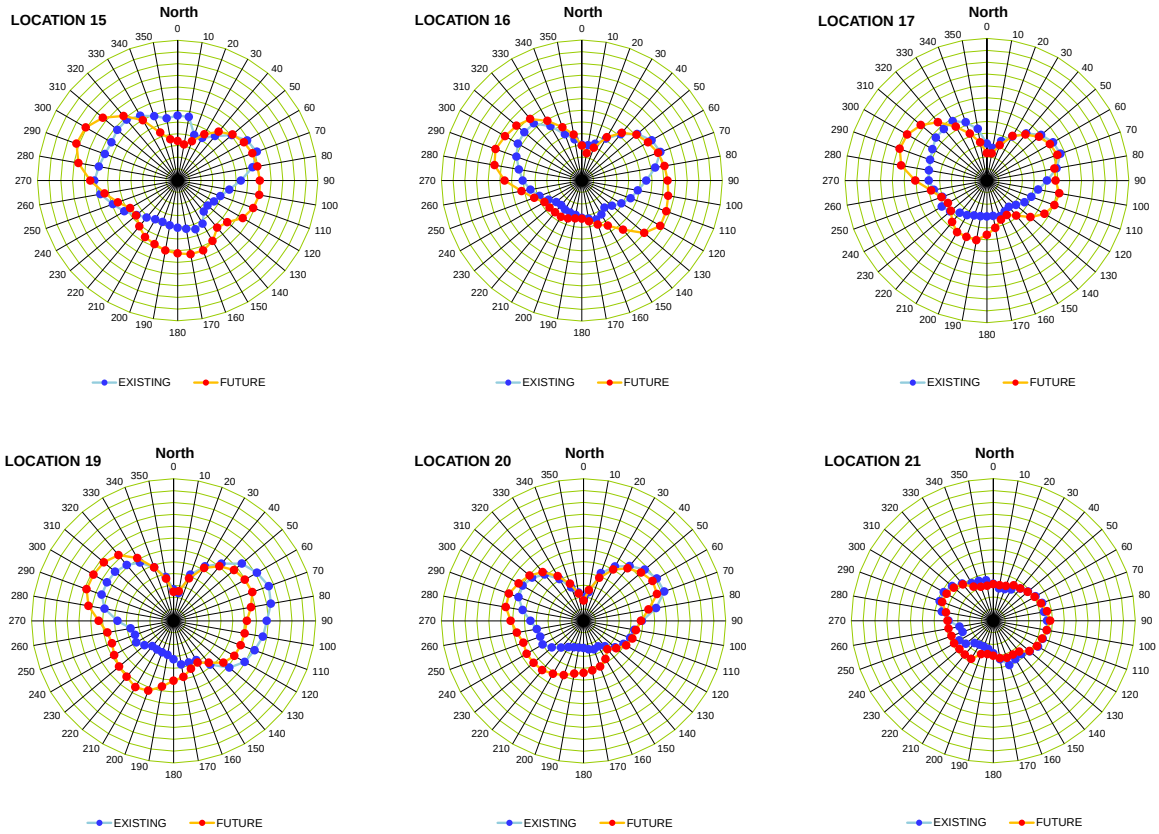
1



6.4 Sensor Locations: Margaret Street - Fig.13

- Winds along Margaret Street in the vicinity of the development site are highest from the east and west, reflecting channelling of winds along this thoroughfare. Winds from northerly and southerly quadrants are shielded by adjacent buildings. Wind closer to Regent Street are modest and do not exhibit strong wind channelling characteristics.
- With the addition of the proposed development, winds are predicted to increase from both east and west quadrants, reflecting the acceleration and downward influence of the proposed development's southern façade: west winds increasing as windflow passes the southwest corner of the proposed development and east winds increasing as windflow passes the southeast corner of the proposed development.

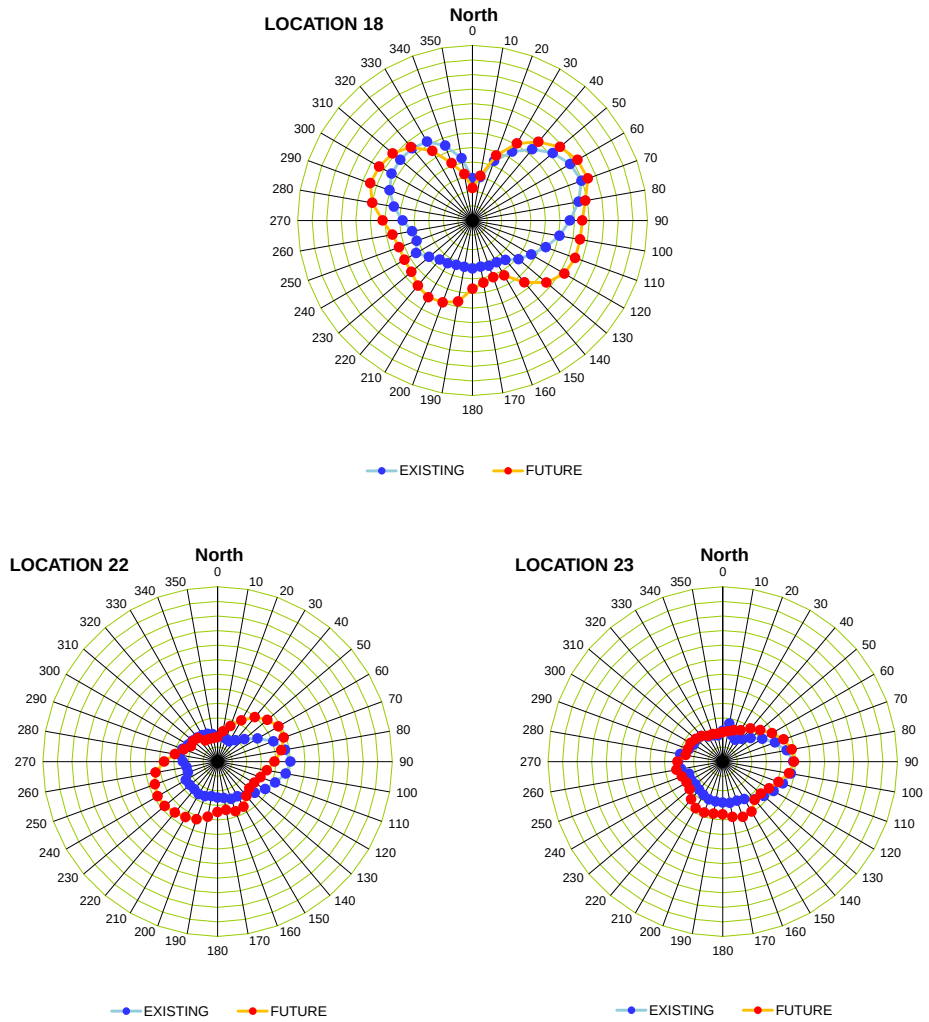
Figure 13 Peak Annual Gusts V/Vref: "Baseline" versus "Future" Scenario – Locations 15-17, 19-21



6.5 Sensor Locations: Through Site Link - Fig.14

- Winds at Location 18, at the southern of the Through Site Link exhibit the same characteristics as Margaret Street winds, higher winds for east and west channelling winds. At the northern end of the Throughout Site Link, winds are generally mild from all directions, reflecting the sheltering at these locations from buildings in all directions.
- With the addition of the proposed development, winds at Location 18 are predicted to increase only very modestly from east and west quadrants, with a slightly greater increase for southerly quadrant winds (south-southwest and southeast).
- Wind speed changes at the northern end of the Through Site Link are modest, with minimal increase close to William Lane and a slightly greater increase further to the south along the link.

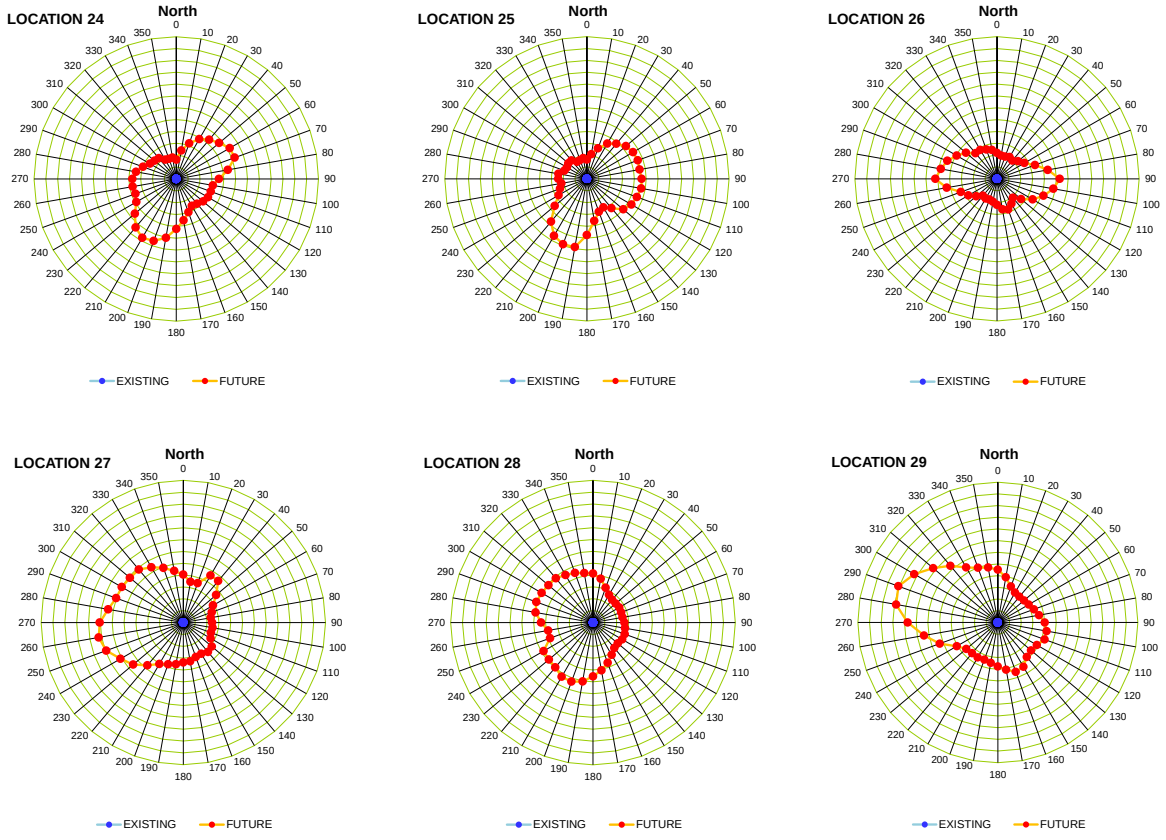
Figure 14 Peak Annual Gusts V/Vref: "Baseline" versus "Future" Scenario – Locations 18, 22-23



6.6 "Future" Location, including Podium Sensor Locations - Fig.15

- These are all "Future" scenario locations located at ground level (Through Site Link) and the two exposed Podium locations at Level 2 (facing north) and Level 4 (facing west).
- Winds at the new Through Site Link positions (Locations 24-25) are mostly impacted by windflow from the south-southwest and northeast, reflecting windflow off the development's eastern façade.
- Winds at Location 26, located on the Level 2 Podium (facing north) are shielded to the north and south by the adjacent building and the development site itself, with noticeable winds only from the eat and west.
- Winds at Locations 27-29 on the Level 4 Podium (facing west) are highest near the proposed development's northwest and southwest corners, reflecting a combination of accelerated corner windflow and downwash off the proposed development's western façade.

Figure 15 Peak Annual Gusts V/Vref: "Baseline" versus "Future" Scenario – Locations 24-29



7 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 Gust Wind Speeds at all Sensor Locations

Sensor No and Location Description (refer Error! Reference source not found.)		Peak Annual Gust (m/s)	
		"BASELINE"	"FUTURE"
1	Gibbons Street – west footpath, north of site	17.5	17
2	Gibbons Street – west footpath, opposite NW corner of development	18.5	17
3	Gibbons Street Reserve – opposite development	18	18
4	Gibbons Street – west footpath, opposite SW corner of development	19.5	18.5
5	Gibbons Street – west footpath, south of site	17	18.5
6	Gibbons Street – east footpath, north of site	13.5	12
7	Gibbons Street – east footpath, north of site	16	15.5
8	Gibbons Street – east footpath, NW corner of development	17	15.5
9	Gibbons Street – east footpath, midway between Locs. 8 & 10	15.5	14
10	Gibbons Street – east footpath, midway along development west facade	15	16
11	Gibbons Street – east footpath, midway between Locs. 10 & 12	18	15.5
12	Gibbons Street – east footpath, SW corner of development	14	15
13	Gibbons Street – east footpath, southern side of Margaret Street	15.5	15
14	Gibbons Street – east footpath, south of site	16	16.5
15	Margaret Street – along development southern facade	17	22
16	Margaret Street – along development southern facade	15	18.5
17	Margaret Street – along development southern facade	13	18.5
18	Margaret Street & Through Site Link – SE corner of development	15	18
19	Margaret Street & William Lane	15.5	18.5
20	Margaret Street – east of development site	14	16
21	Margaret Street – east of development site (close to Regent Street)	11.5	11
22	Through Site Link – along eastern façade of development	7	10.5
23	Through Site Link – NE corner of development (close to William Lane)	7.5	9
24	Through Site Link – along eastern façade of development	*Refer Note 2*	12
25	Through Site Link – along eastern façade of development		13.5
26	Level 2 Podium – facing north, midway along façade		12.5
27	Level 4 Podium – near NW corner of development		17
28	Level 4 Podium – midway along western façade		12
29	Level 4 Podium – near SW corner of development		21.5

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 (26-29) locations which only exist in the "Future" scenario

7.1 Wind Impact Relative to Intended Usage

Pedestrian Footpath Areas Surrounding the Site

Wind category objective: 16 m/s Walking Comfort criterion

Ground level locations surrounding the site (Gibbons Street, Margaret Street, Through Site Link) are predicted to experience both modest increase 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 16**. These would have a significant ameliorating (ie sheltering) effect on local wind speeds (throughout the year if of evergreen species) for BOTH of the test scenarios – "Baseline" and "Future".

Figure 16 Vegetation and Trees along Surrounding Footpath Areas

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

With the exception of the southern end of the Through Site Link, winds in this thoroughfare are generally mild, well below the 16 m/s walking comfort criterion and in a number of locations below the 13 m/s criterion for "standing-waiting=-window shopping" type activities.

- It is only at the southern end of the Through Site Link that winds exceed the nominated wind acceptability critieria, indeed slightly exceeding the 16 m/s walking comfort criterion.

Observation:

- It is noted that wind conditions within the new Through Site Link were tested in the wind tunnel without the benefit of any of the landscaping, pergolas, etc, proposed for this area, although much of this is located centrally and may have limited benefit close to the southeast corner of the proposed development.

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 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. This is most apparent near the northwest and southwest corners of the Podium. The Level 2 Podium is significantly sheltered by the proposed development itself and the adjacent similar height building to the immediate north.

- In terms of the nominated wind acceprtability critieria, the two corner Level 4 Podium locations may potentially exceed the 16 m/s walking comfort criterion, but remain below the 23 m/s safety criterion.

Observation:

- It is important to note that 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), 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.

8 MITIGATION TREATMENT RECOMMENDATIONS

Sections 6 and 7 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).

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;
- The southern end of the Through Site Link (close to Margaret Street), and
- The NW and SW corner areas of the Level 4 Podium.

8.1 Existing and Planned Wind Amelioration

It has been noted that 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 16**;
- Extensive landscaping and pergolas planned for the Through Site Link – refer **Figure 17**; and
- Extensive landscaping planned for Level 2 and Level 4 Podium – refer **Figure 18**.

Figure 17 Already Planned Through Site Link Landscaping and Pergolas/Awnings

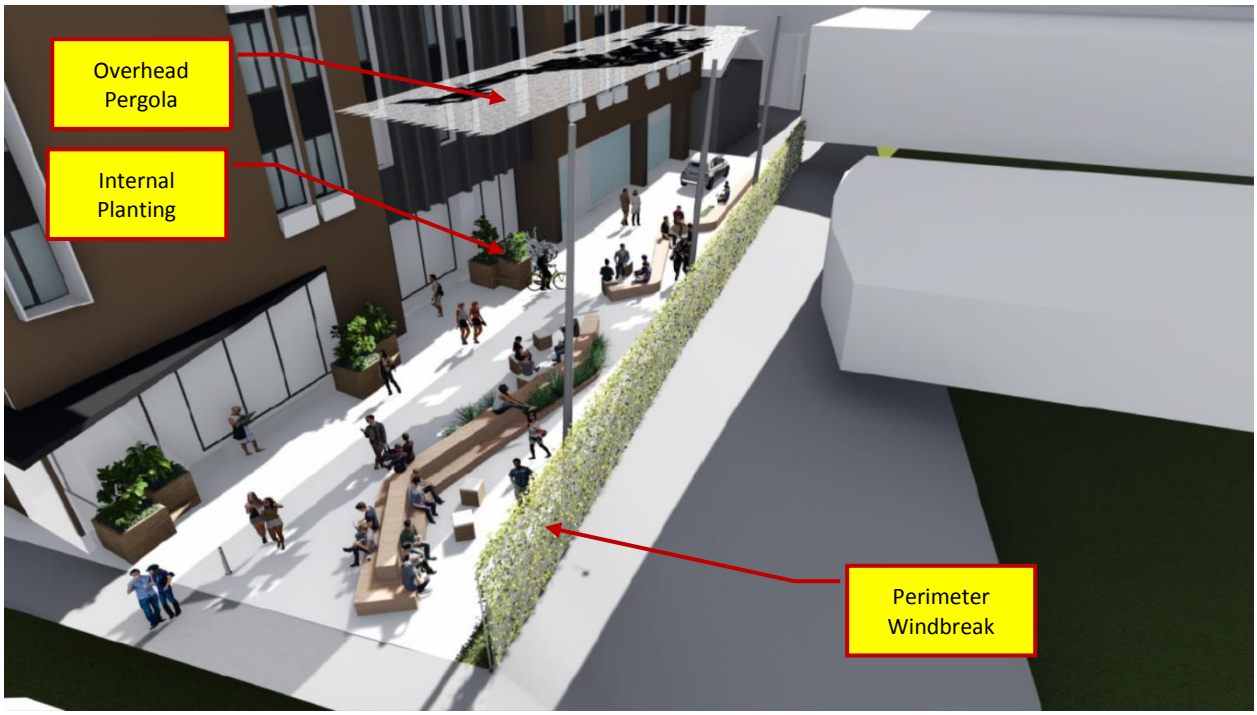
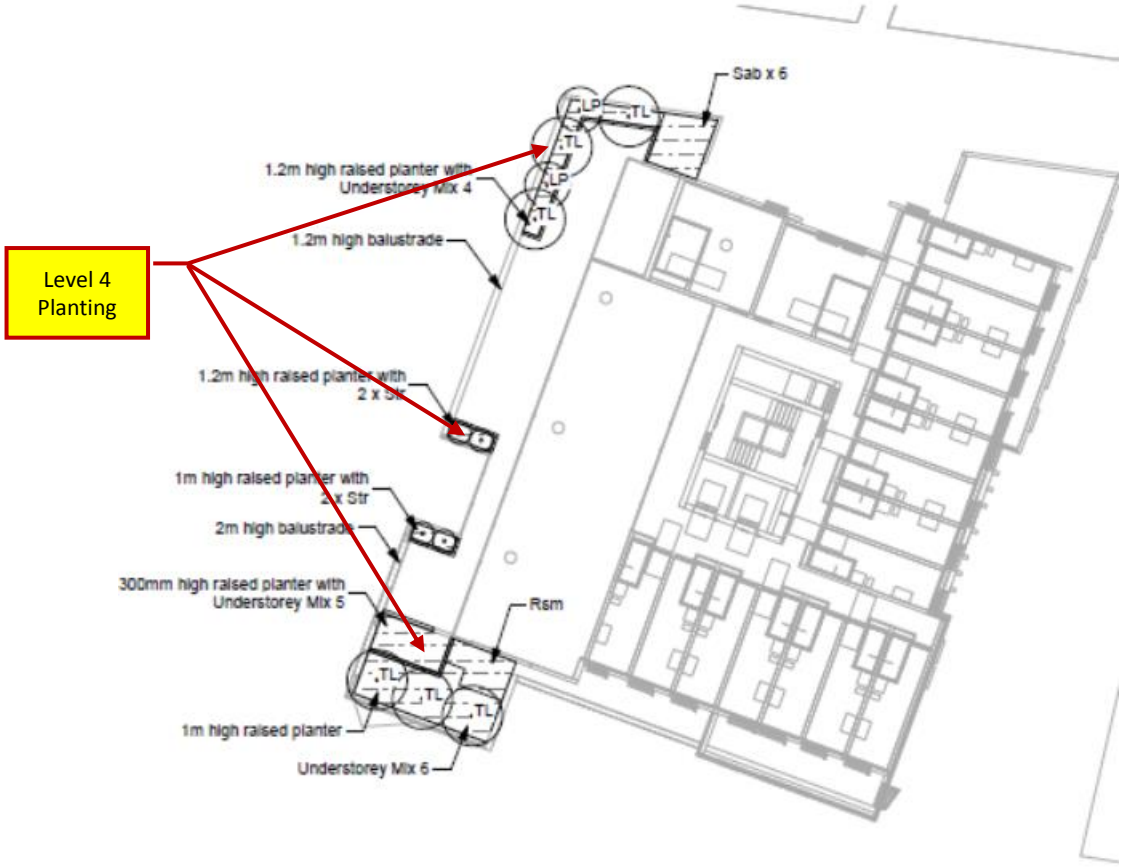


Figure 18 Already Planned Landscaping for Level 2 and Level 4 Podium

Level 2

Level 4



8.2 Additional Wind Mitigation Recommendations

Pedestrian Areas Surrounding the Site

Current plans for the proposed development retain the existing landscaping along Gibbons Street and included a full perimeter awning along the development's western façade – refer **Figure 19**.

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

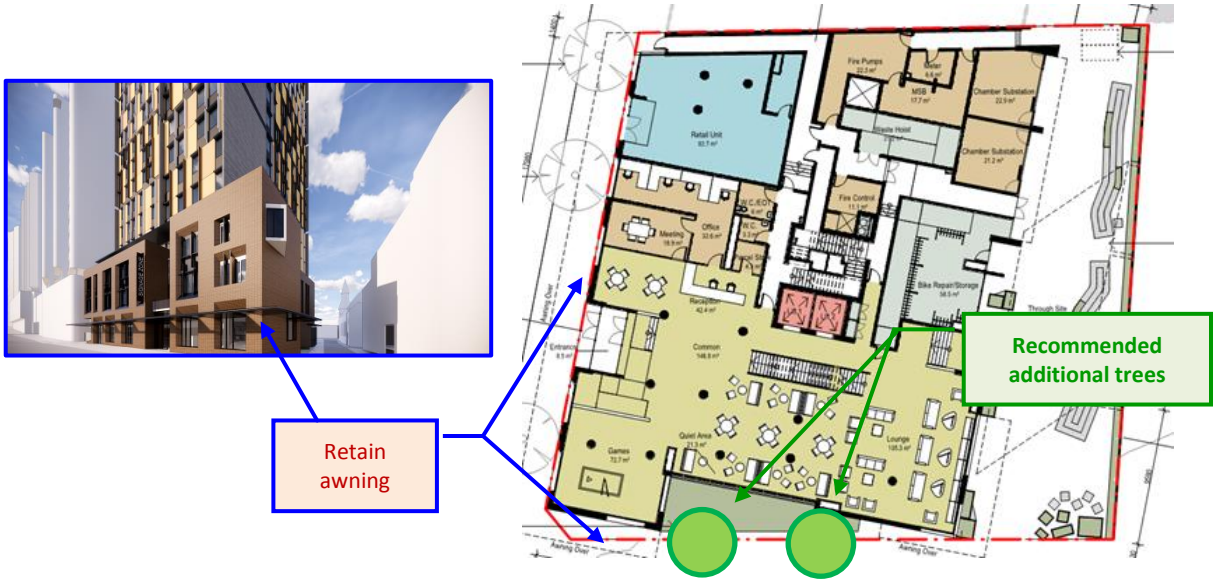
The wind tunnel testing showed that high localised winds occur at the two southern corners of the proposed development and along sections of Margaret Street:

- SW corner footpath – Gibbons Street and Margaret Street;
- Margaret Street footpath – along the proposed development's southern façade; and
- SE corner footpath – Margaret Street and Through Site Link.

Noting that these areas will be exposed to winds with both a horizontal and vertical component, we recommend retention of the existing awnings at Level 2 elevation, which as per previous recommendation extend out from the main building façade line as far as practicable over the footpath – refer **Figure 19**. Further, SLR recommends additional trees be added as shown in **Figure 19**.

Given the relatively low wind speeds predicted for the Through Site Link (apart from the southern end near Margaret Street), no additional mitigation is recommended beyond that already planned.

Figure 19 Proposed Additional Ground Level Windbreaks



Podium – Level 2

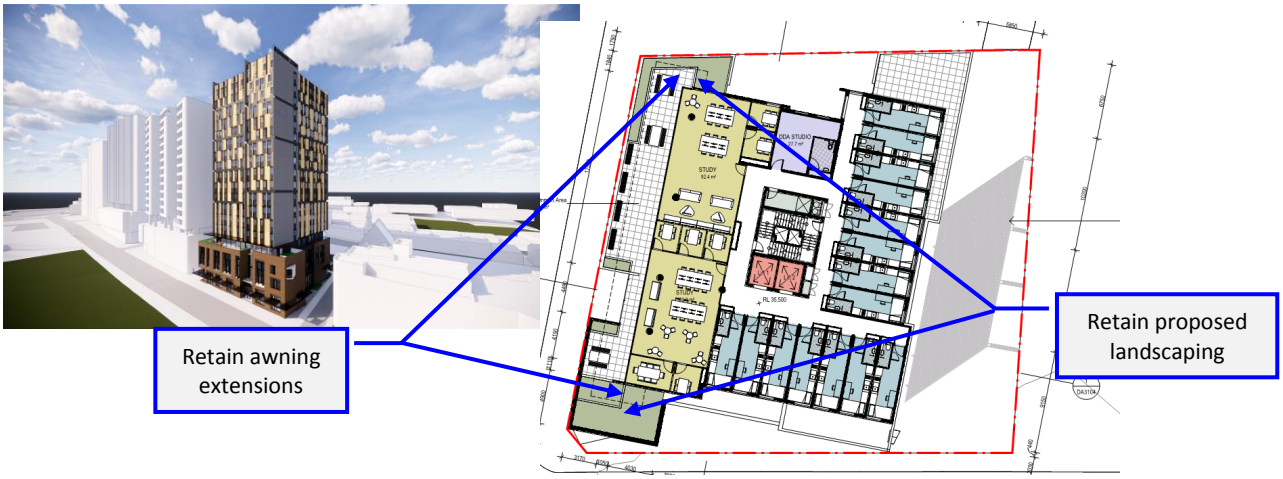
The test results indicated that the potential for elevated winds within the open Level 2 Podium area facing north is minimal. Given the relatively low wind speeds predicted and the already planned extensive landscaping (refer **Figure 18**), no additional mitigation is recommended beyond that already provided.

Podium – Level 4

The wind tunnel testing showed that high localised winds occur at the north and south corners of the open Level 4 Podium area facing west.

Noting that these areas will be exposed to winds with both a horizontal and vertical component, we recommend retention of the proposed canopies protecting the Level 4 Podium over the corner areas and retention of provided planters and landscaping, refer **Figure 20**.

Figure 20 Proposed Additional Level 4 Awning (or Alternative) Extensions



8.3 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:

- Balconies throughout the proposed development's high-rise components; and
- The proposed development's Roof Levels which currently show no areas of public access on the development drawings.

Upper Level Balconies

The high-rise component of the proposed development has have balconies around all facades, including at building corners.

It is almost certain, given the absence of nearby similar height buildings in some wind directions, that some of these balconies, especially those at upper levels and near building corners which are exposed to stronger southerly and westerly winds, will experience adverse wind conditions requiring wind treatment beyond standard height (ie code-compliant) balustrades.

Such treatments might include increased balustrade height or partial screening via moveable louvres, to take advantage of the beneficial of cooler, milder winds during summer, while providing the capacity to limit the impact of colder and potentially much stronger winds during winter.

The development drawings of the proposed development show movable balcony screens from Level 4 upwards – refer **Figure 2**. On this basis, no further recommendations are made to ameliorate potential high corner balcony wind speeds.

Roof Level

The same consideration for upper-level balconies and associated recommendations would normally apply also to any public access areas located on the proposed development's Roof Level, where a combination of both vertical screening (eg solid balustrades, balustrades combined with planter boxes, etc) and horizontal screening might normally be required to ensure all-year-round amenity, especially areas exposed to 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.

9 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.

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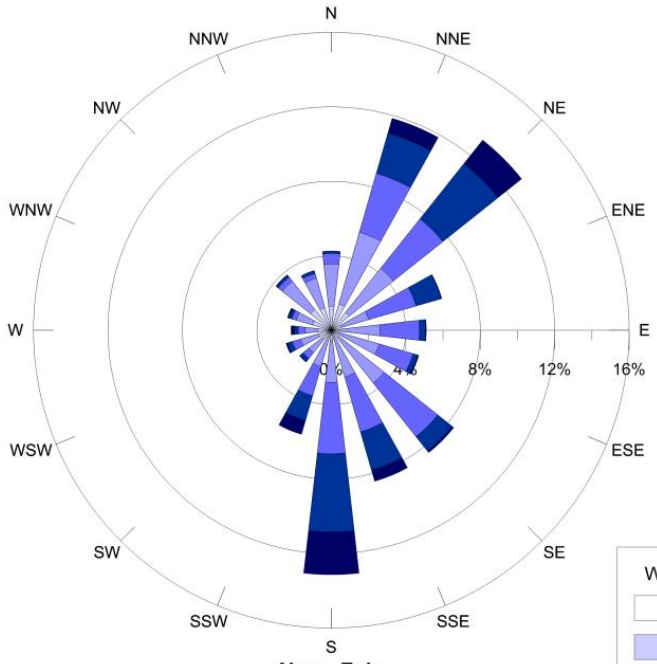
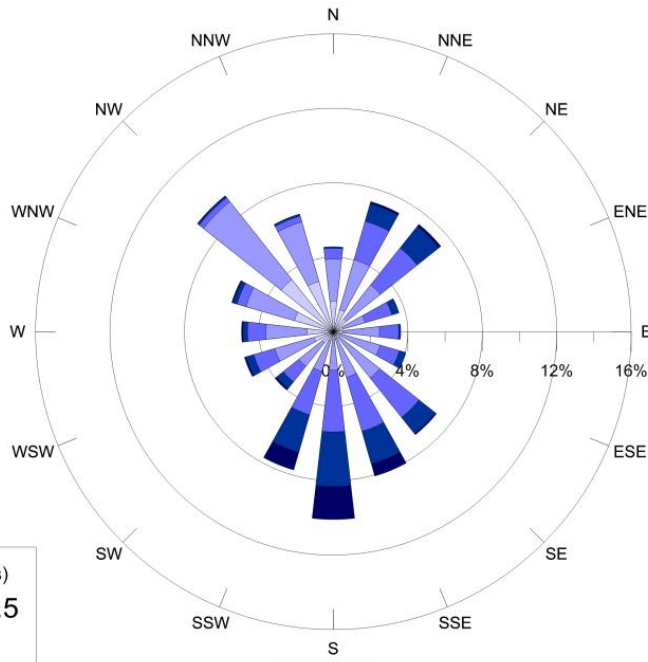
APPENDIX A

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

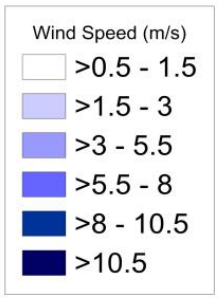
Sydney Airport AWS
(Observations)
1999-2017
600.09300

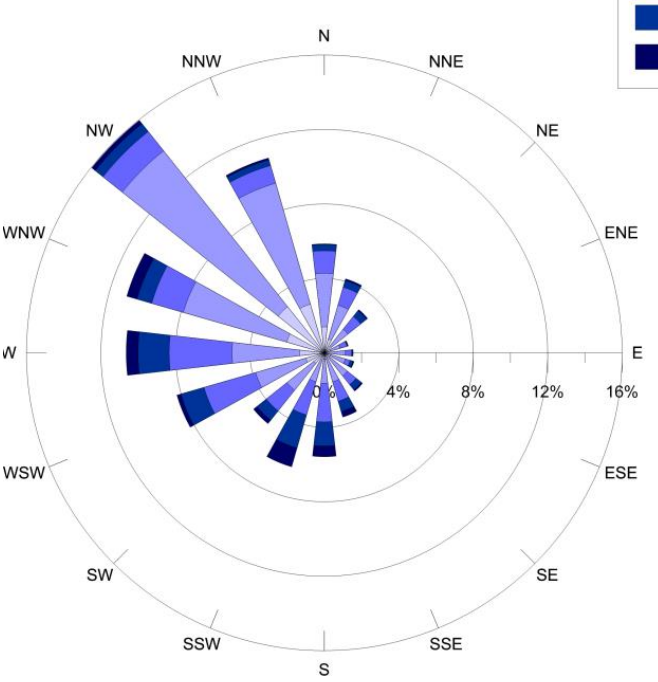


Nov - Feb
(Calms= 2.4%)

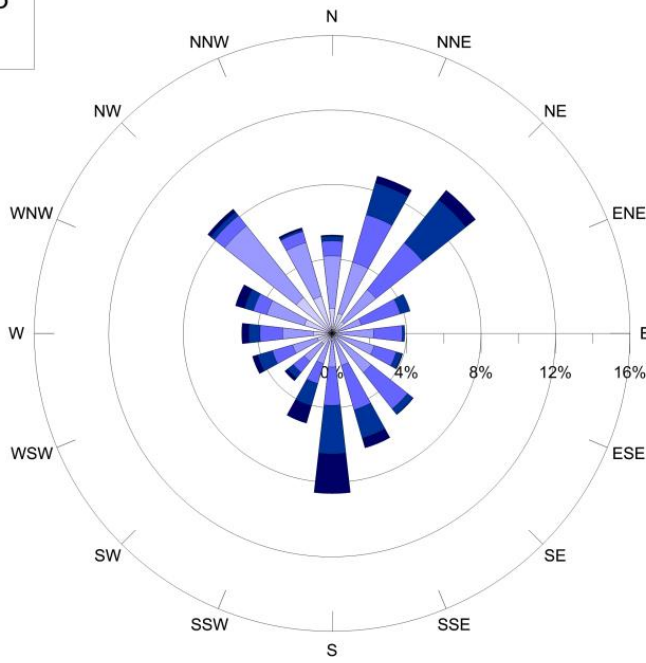


Mar - Apr
(Calms= 0.98%)





May - Sep
(Calms= 2.7%)

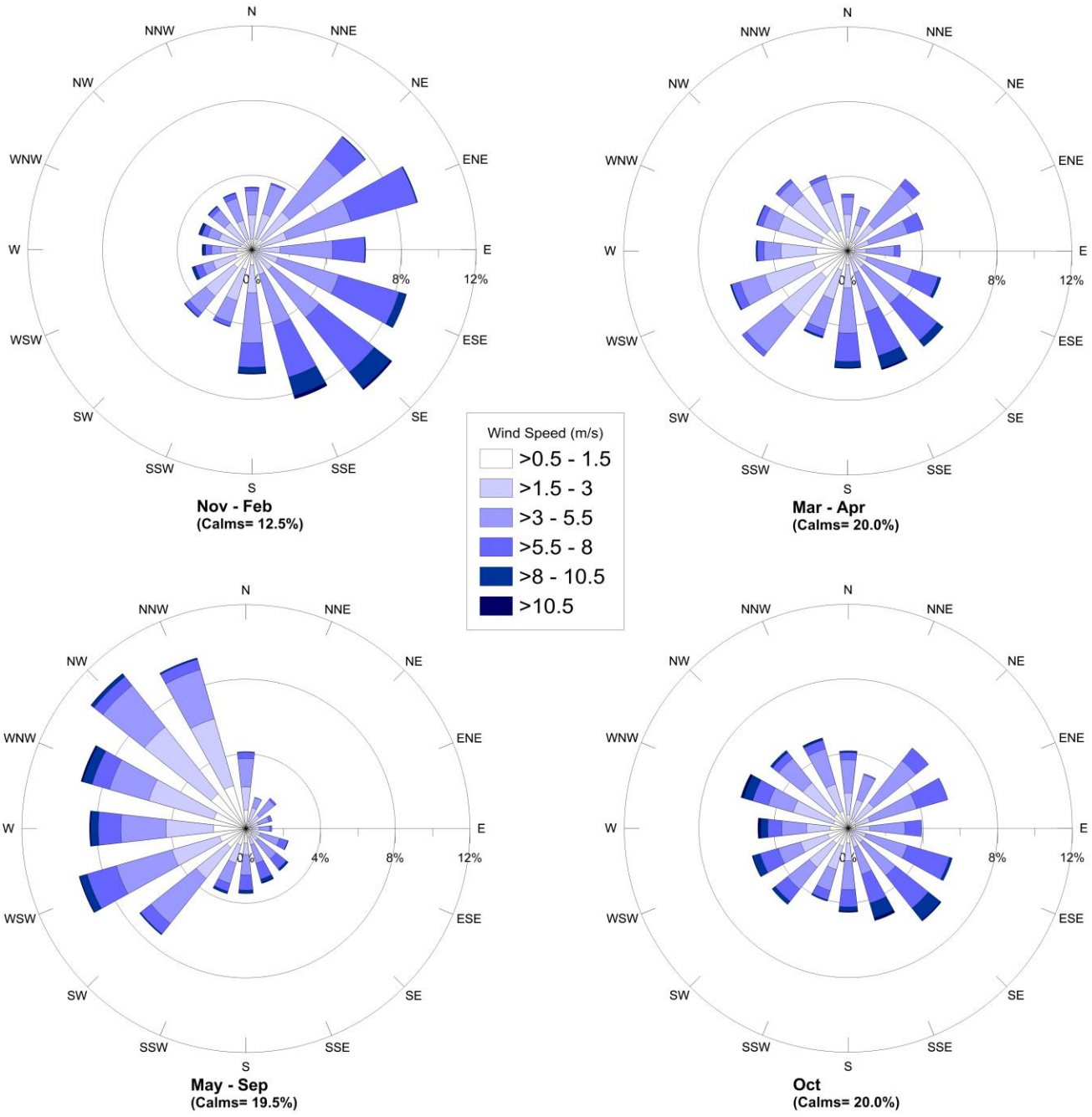


Oct
(Calms= 5.6%)

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

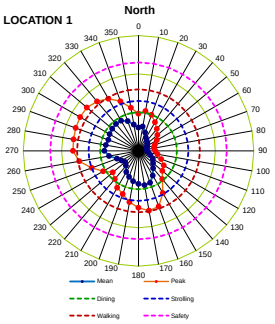


APPENDIX B

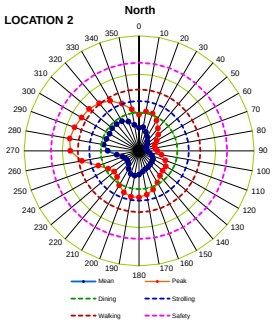
Wind Tunnel Test Results: BASELINE Scenario

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

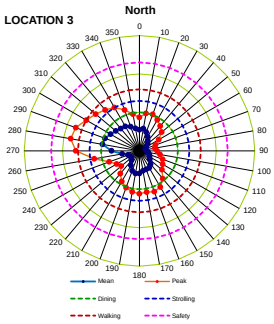
LOCATION 1



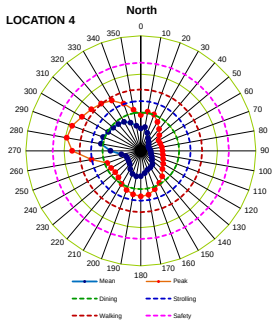
LOCATION 2



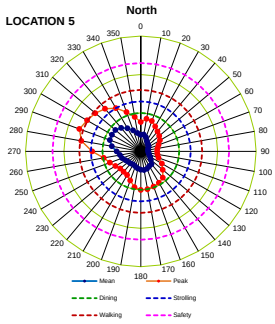
LOCATION 3



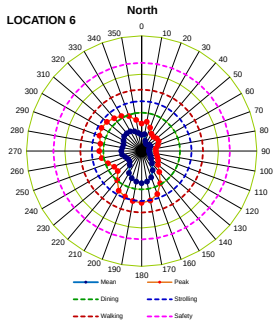
LOCATION 4



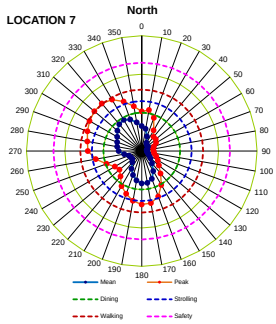
LOCATION 5



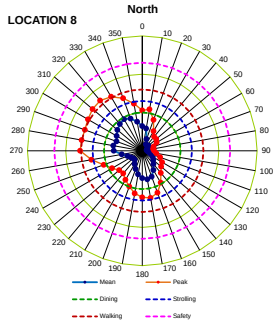
LOCATION 6



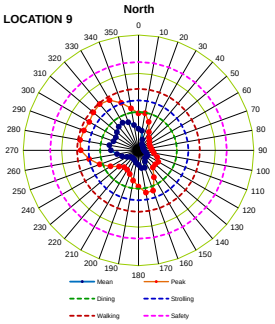
LOCATION 7



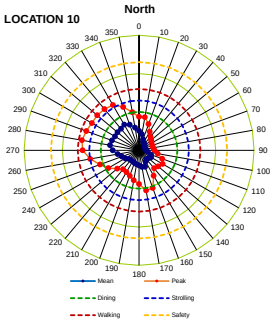
LOCATION 8



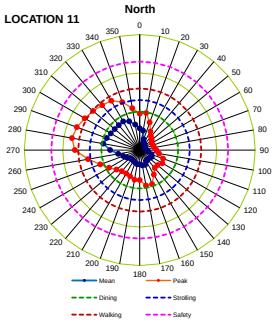
LOCATION 9



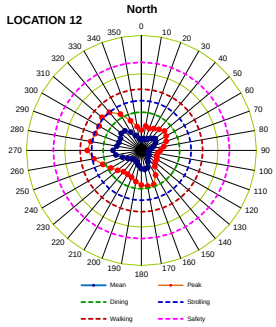
LOCATION 10



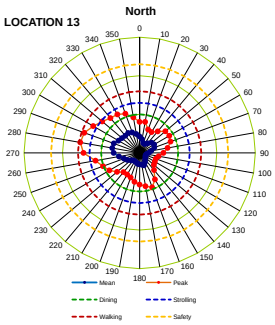
LOCATION 11



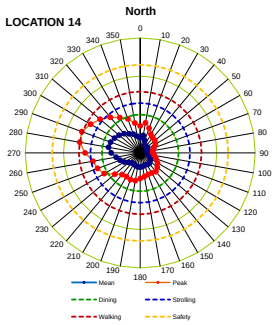
LOCATION 12



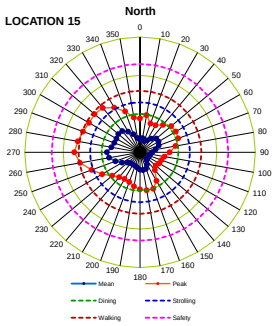
LOCATION 13



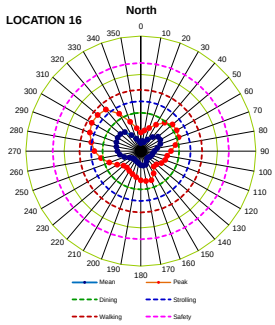
LOCATION 14



LOCATION 15



LOCATION 16

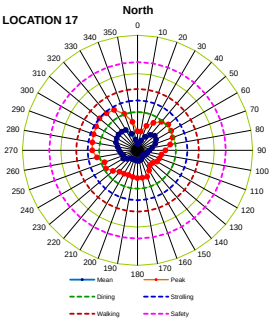


APPENDIX B

Wind Tunnel Test Results: BASELINE Scenario

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

LOCATION 17



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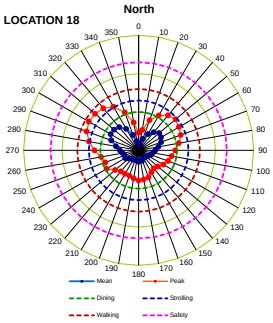

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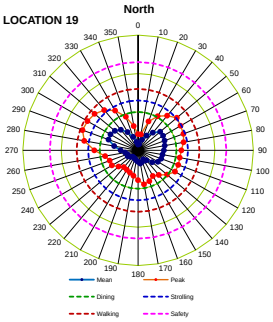

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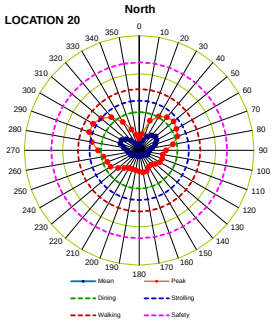

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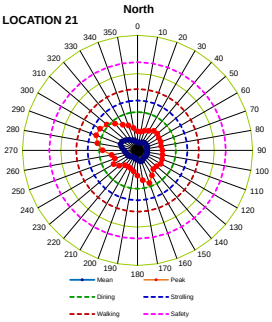

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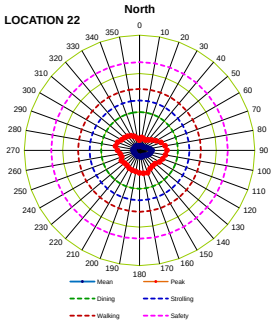

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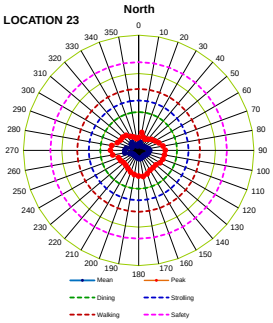

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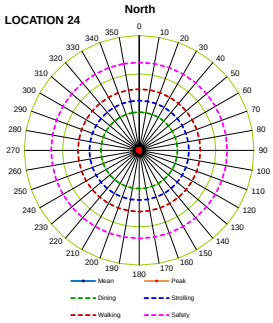

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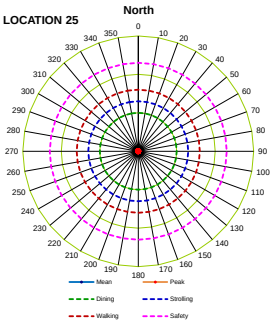

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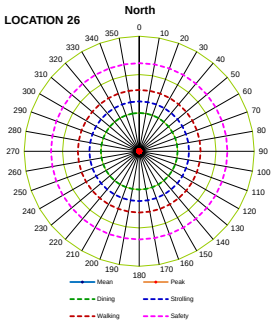

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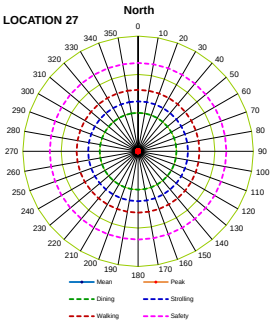

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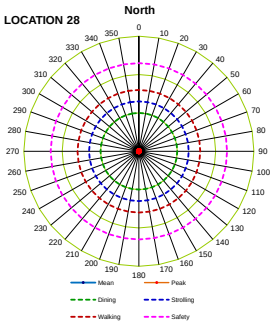

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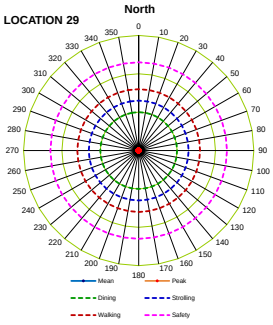

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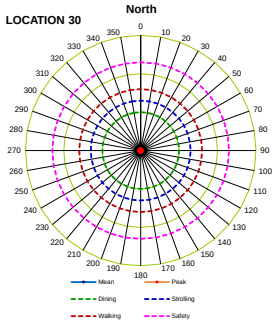

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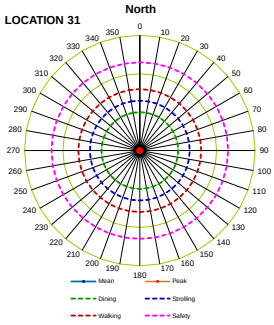

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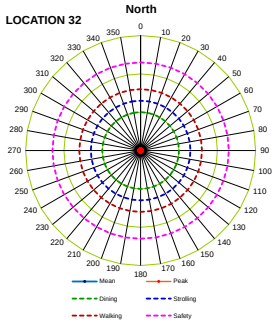
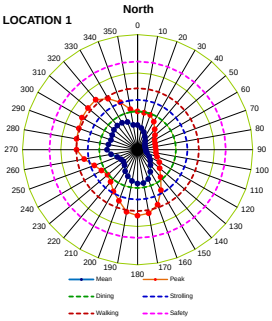


APPENDIX C

Wind Tunnel Test Results: FUTURE Scenario

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

LOCATION 1



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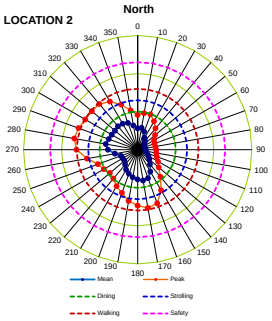

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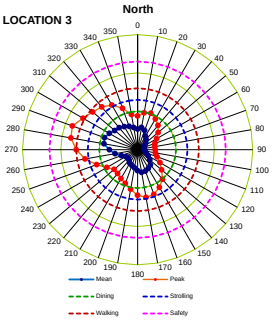

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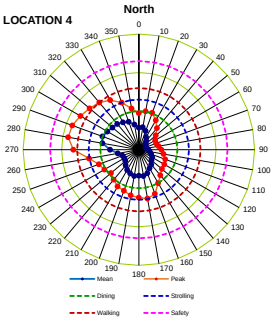

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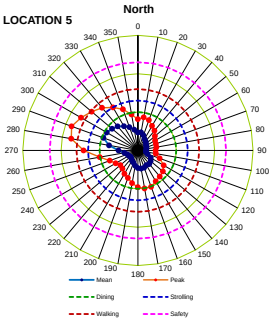

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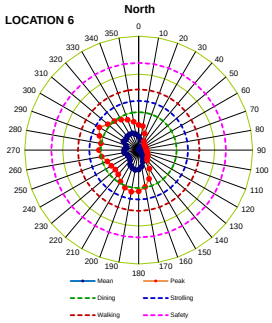

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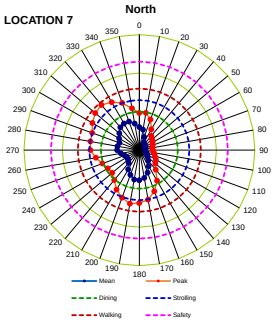

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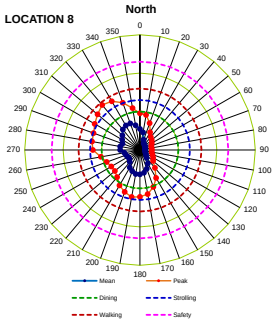

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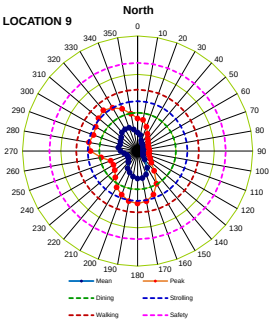

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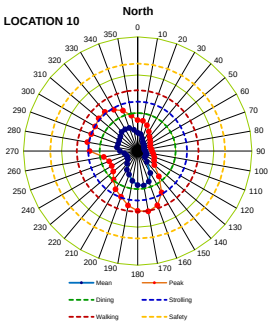

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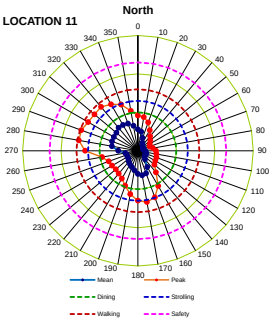

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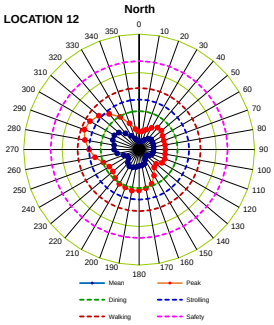

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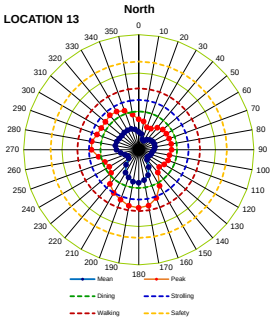

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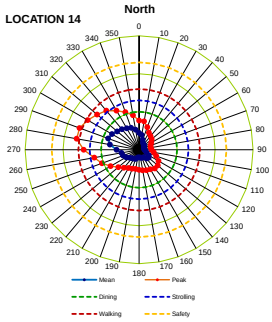

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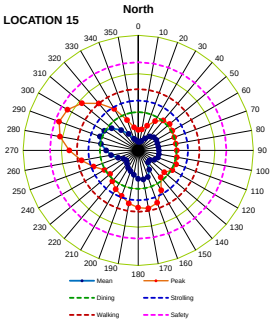

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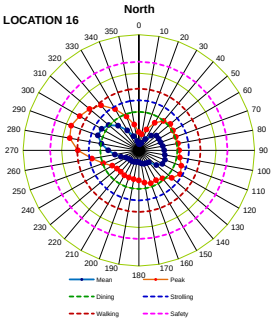
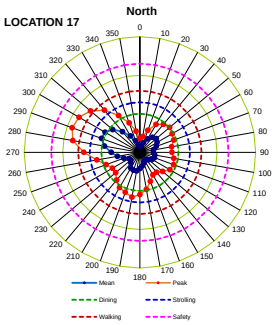


APPENDIX C

Wind Tunnel Test Results: FUTURE Scenario

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

LOCATION 17



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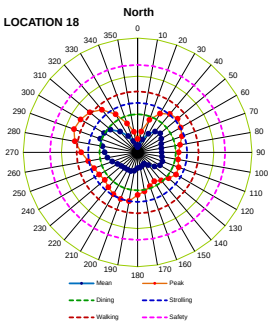

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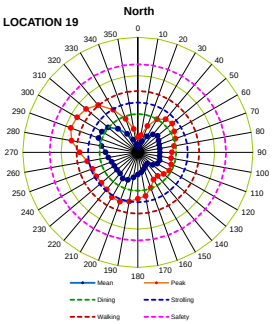

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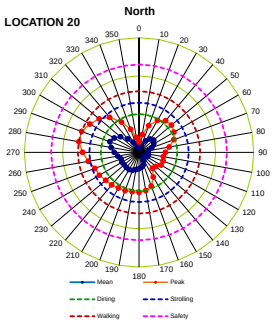

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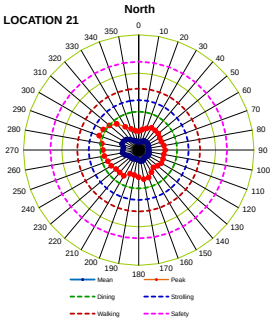

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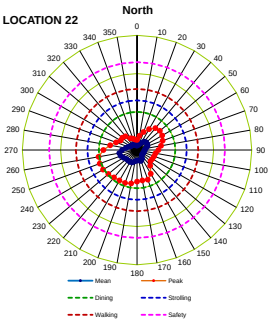

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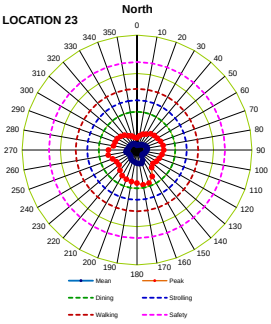

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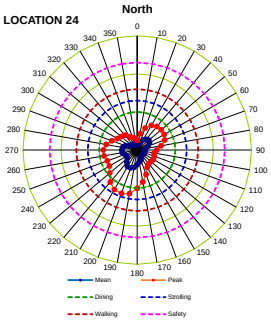

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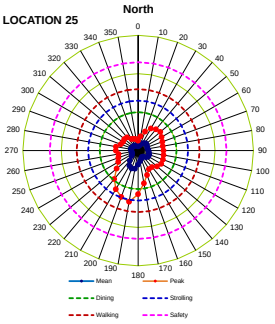

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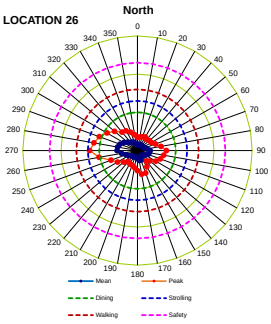

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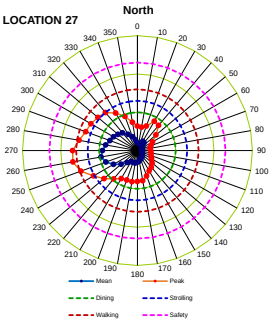

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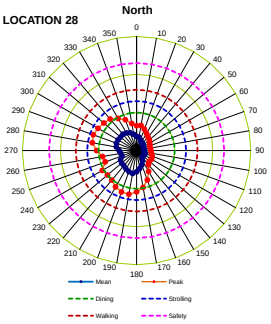

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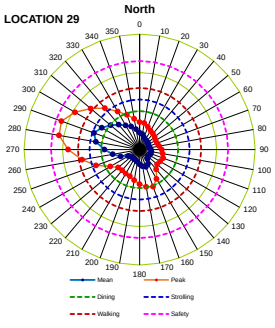

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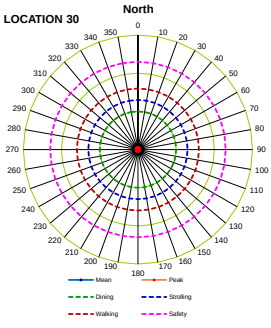

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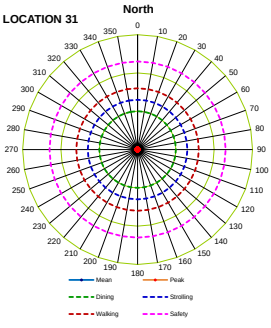

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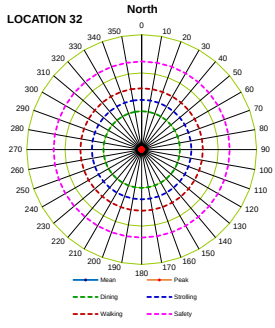

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