IVANHOE STAGE 2 - BUILDING C2 C3 C4

Environmental Wind Tunnel Study

Prepared for:

Frasers Property Australia Pty Ltd
Level 2, 1C Homebush Bay Drive
RHODES NSW 2138

SLR Ref: 610.30337-R02
Version No: -v1.0
December 2021

PREPARED BY

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

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

BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Frasers Property Australia Pty Ltd (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
610.30337-R02-v1.0	24 December 2021	Nikhil Pardeshi	Dr Peter Georgiou	Dr Neihad Al-Khalidy

EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Frasers Property Australia, to undertake a quantitative wind assessment of a proposed Ivanhoe Stage 2 development, located off Epping Road, Macquarie Park, via an Environmental Wind Tunnel Study.

Within the context of the Ivanhoe Site, Site 2 will comprise development across Subject Sites C2, C3 and C4. The Stage 2 development site is bounded by Main Street to the north with Sites B2 and B3 across the street, Neighbourhood Street to the south and to the east of Site C3, Site C1 to the west, and existing bushland with Shrimptons Creek to the east. Across the Neighbourhood Street to south are Sites D2, D3 and D4.

The Ivanhoe Estate is situated to the northeast of Epping Road, with surrounds consisting of dense urban development of varying heights to surrounding aspects.

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

Macquarie Park Wind Climate

Using long-term wind records obtained from nearby Bureau of Meteorology stations at Bankstown Airport and Sydney Kingsford Smith Airport, SLR has determined that Macquarie Park has local wind characteristics in between Bankstown Airport and Sydney (KS) Airport, given Macquarie Park's distance inland from the coast (15 km) compared to Bankstown Airport (25 km) and Sydney Airport (5 km). Accordingly, the adopted Macquarie Park wind model has slightly lower strength characteristics from the northeast and south compared to Sydney (Kingsford Smith) Airport and correspondingly higher strengths from the southeast and southwest/northwest compared to Sydney (KS) Airport.

Built Environment Scenarios Assessed

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

- Scenario 1 – **"Baseline"** Existing built environment
- Scenario 2 – **"Proposed"** "Baseline" + Proposed Development
- Scenario 3 – **"Mitigation"** "Proposed" + recommended wind mitigation treatments

Wind Acceptability Criteria

The criteria adopted for the present study are:

- **"Comfort"** Lawson (2001) Comfort Criteria;
- **"Safety"** Melbourne (1978) 23 m/s Safety Criterion.

"Baseline" (Existing) 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 overall Ivanhoe site is currently surrounded by low-rise residential dwellings to the west anti-clockwise around to the south-southeast, and a mix of low to mid-rise residential/commercial buildings further to the northwest clockwise around to the southeast.
- The overall Ivanhoe site will therefore receive only modest wind shielding from most of the wind directions with increased sheltering (especially at lower levels) from northwest and southeast direction.
- There are however a number of future proposed developments within the overall Ivanhoe site that are surrounding the Stage 2 development sites, as shown in **Figure 2**. These future developments are expected to provide relatively significant shielding, especially from north anticlockwise through to the south.

Already Planned Wind Amelioration Treatments

The following features, all of which would have a significant ameliorating impact on local wind conditions, are either existing or have already been planned for the proposed development:

- The existing and significant landscaping along Epping Road – refer **Figure 16-A**;
- The existing and significant landscaping located within the adjacent bushland, along the south-eastern perimeter of the site boundary – refer **Figure 16-B**; and
- The proposed landscaping within and around the site at Ground Level locations – refer **Figure 16-C**.
- The proposed landscaping within various upper-level open areas such as rooftops, forest rooms, or outdoor communal spaces.

It is recommended to retain all proposed landscaping within and around the development. The proposed landscaping is recommended to be evergreen and densely foliated to maintain its effectiveness throughout the year.

Additional Wind Mitigation Recommendations

Recommendations have been made for confirmed and/or additional wind mitigation in the following areas:

Building C2 Ground Level Area

- It is recommended to include horizontal protection (eg pergola, shade-cloth, canopies, operable louvered roof, etc) to protect the areas at the northern end of Building C2 that are intended to be used for longer duration activities such as sitting/outdoor dining – refer Figure 17
- It is recommended to include localised vegetation or planting within the central part of the “Village Green” area between Building C2 and C3 – refer **Figure 17**.

Building C4 Ground Level Area

- It is recommended to include horizontal protection (eg pergola, shade-cloth, canopies, operable louvered roof, etc) to protect the areas of the central courtyard “The Grove” of Building C4 that are intended to be used for longer duration activities such as sitting/outdoor dining – refer **Figure 18**.

Building C4 Social Rooftop Area (Level 17)

- It is recommended to include at least 1.8m high perimeter screening around the northern end of the rooftop at Level 17 – refer **Figure 19**.

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

CONTENTS

CONTENTS

DOCUMENT REFERENCES

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Frasers Property Australia, to undertake a quantitative wind assessment of a proposed Ivanhoe Stage 2 development, located off Epping Road, Macquarie Park, via an Environmental Wind Tunnel Study.

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

1.1 Location and Context of the Development Site

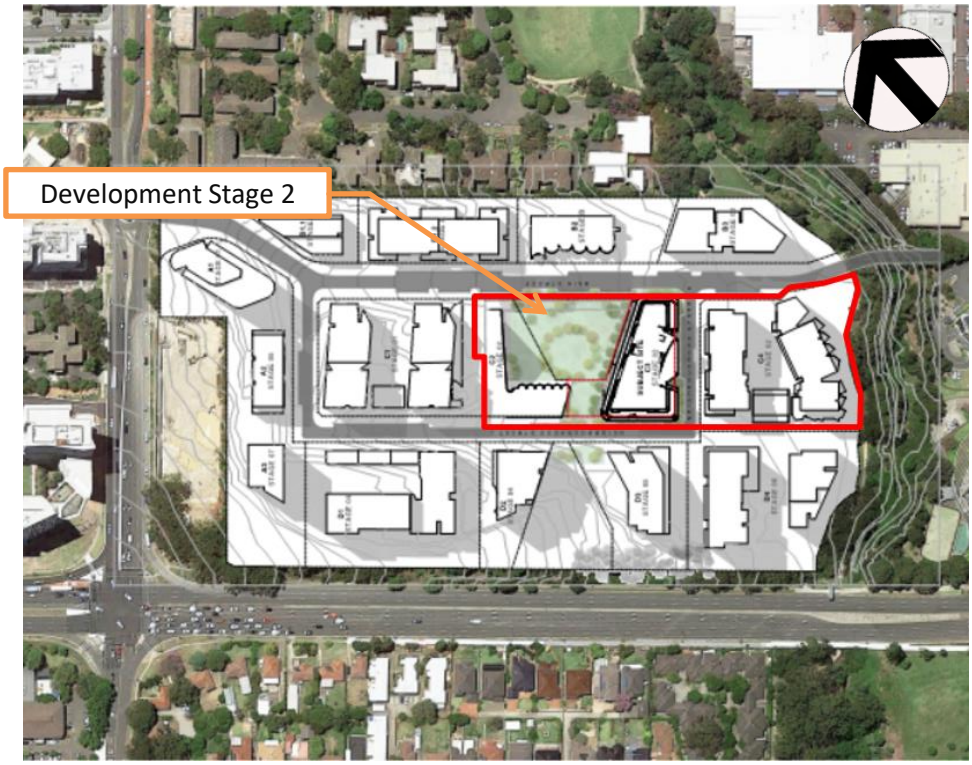
Within the context of the Ivanhoe Site, Site 2 will comprise development across Subject Sites C2, C3 and C4. The Stage 2 development site is bounded by Main Street to the north with Sites B2 and B3 across the street, Neighbourhood Street to the south and to the east of Site C3, Site C1 to the west, and existing bushland with Shrimptons Creek to the east. Across the Neighbourhood Street to south are Sites D2, D3 and D4. - Refer to **Figure 1**.

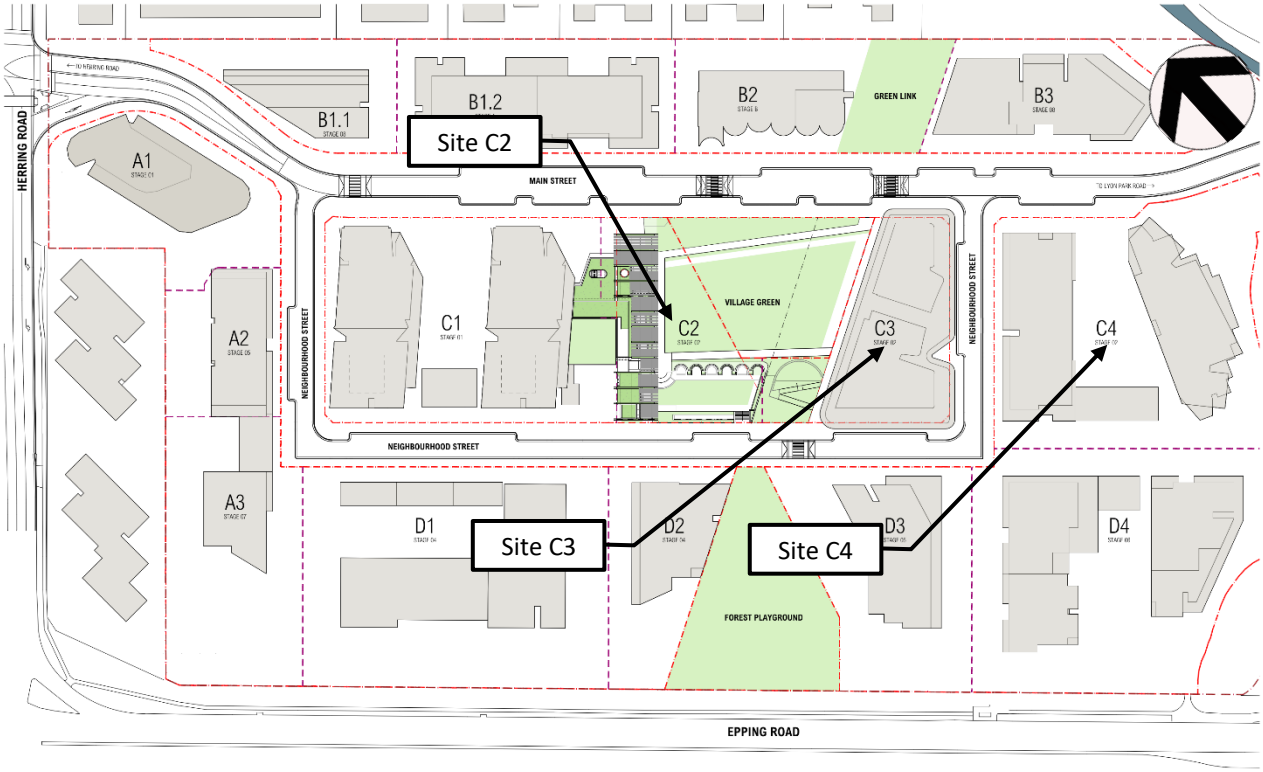
Figure 1 Aerial View of Development Site

Image: Courtesy NearMap December 2021

Figure 2 shows the context of the proposed Stage 2 sites C2, C3, and C4 within the overall site.

Figure 2 Context of the Proposed Stage 2 sites C2, C3, and C4 Within the Overall Site





1.2 Description of the Proposed Development

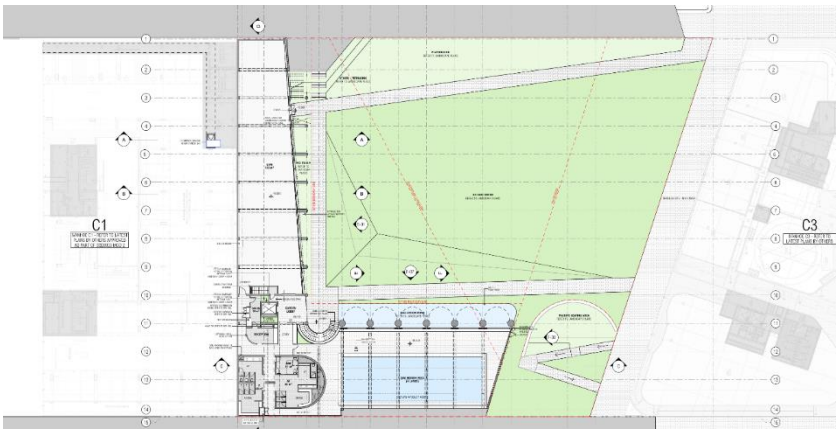
The proposed report will focus on sites C2, C3 and C4 of the planned development. From the plans provided, the proposed development contains the following:

- Site C2:
  - Three (3) storey community building with pool, gym and café adjacent to the Village Green, a new public park.
- Site C3:
  - Basement car parking
  - Ground level with building lobbies, supermarket, retail tenancies and loading dock;
  - Level 1 podium with residential apartments and rooftop garden;
  - Level 2-4 podium with residential apartments;
  - Level 5-14 with residential apartments;
  - Forest rooms on levels 5-7 and 10-12;
  - Level 15 with residential apartments, communal conference room, communal outdoor area and garden; and
  - Level 16 residential apartments.
- Site C4:
  - Consists of 3 buildings; namely C4-Social (16 storey), C4-Market (23 storey), and C4-Townhouses (3 storey)
  - Basement car parking;
  - Ground level with building lobbies, residential apartments, communal outdoor area and central courtyard;
  - Building C4-Social and C4-Market: Level 1-16 with residential apartments;
  - Building C4-Social: Level 17 roof with outdoor area and mechanical plants and PV panels.
  - Building C4-Market: Level 18 with residential apartments and sky garden;
  - Building C4-Market: Level 19-23 with residential apartments; and
  - Building C4-Market: Level 24 roof with mechanical plants and PV panels.

Representative floor plans are shown in **Figure 3**.

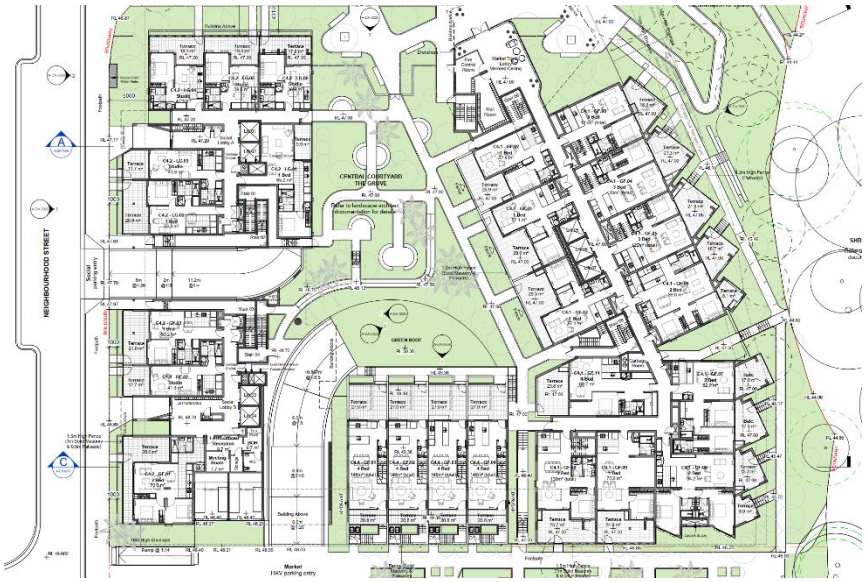
Figure 3 Architectural Views of the Proposed Development

Building C2: Lower Ground Plan



Building C3: Level 9 (Typical)

Building C4: Ground Plan



1.3 Surrounds

In terms of the surrounding buildings:

- There are a number of future proposed developments within the overall Ivanhoe site that are surrounding the Stage 2 development sites, as shown in **Figure 2**.
- Immediately to the northeast of the overall site are existing low to mid-rise residential buildings.
- Immediately to the southeast of the overall site are two existing mid-rise commercial buildings; similarly, immediately to the northwest are two existing residential high-rise towers with almost identical built-form.
- Further to the northwest clockwise around to the southeast are a mix of low to mid-rise residential/commercial buildings.
- To the west anti-clockwise through to the south-southeast, are low-rise residential dwellings.
- The terrain is undulating in the surrounding built environment, with no particularly significant topographical variations (ie hills, escarpments, etc) influencing local wind speeds.

Figure 4 Surrounding Built Environment

Image: Courtesy NearMap December 2021

2 SYDNEY'S WIND CLIMATE

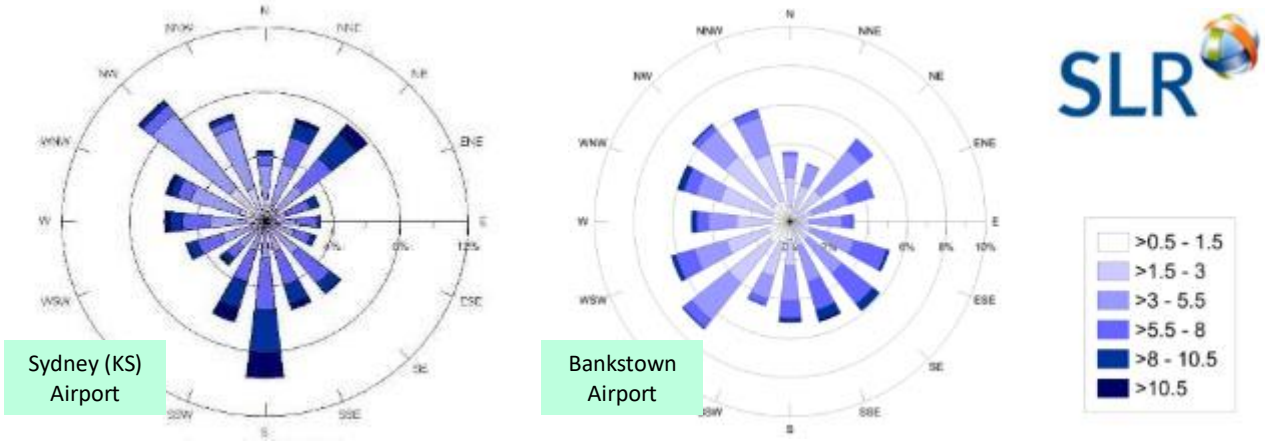
The data of interest in this study are the mean hourly wind speeds and largest gusts experienced throughout the year (especially higher, less frequent winds), how these winds vary with azimuth, and the seasonal break-up of winds into the primary Sydney Region wind seasons.

2.1 Annual and Seasonal Variations

Key characteristics of Sydney's Regional Wind Climate are illustrated in two representative wind roses shown in **Figure 5**, taken from Bureau of Meteorology (BoM) data recorded during the period 1999-2017 at Sydney (Kingsford Smith) Airport and Bankstown Airport. A review of the associated seasonal wind roses (refer **Appendix A**) shows that Sydney is affected by two primary wind seasons with relatively 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. Both northeast winds (as sea breezes) 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 5 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 overall Ivanhoe site is currently surrounded by low-rise residential dwellings to the west anti-clockwise around to the south-southeast, and a mix of low to mid-rise residential/commercial buildings further to the northwest clockwise around to the southeast.
- The overall Ivanhoe site will therefore receive only modest wind shielding from most of the wind directions with increased sheltering (especially at lower levels) from northwest and southeast direction.

- There are however a number of future proposed developments within the overall Ivanhoe site that are surrounding the Stage 2 development sites, as shown in **Figure 2**. These future developments are expected to provide relatively significant shielding, especially from north anticlockwise through to the south.

2.3 Design Wind Speeds

SLR has carried out a detailed study of Sydney Basin wind speeds using continuous records of wind speed and direction measured at the Bureau of Meteorology's (BoM) Sydney weather stations. The above analysis is described in detail in …

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

In particular, SLR has determined statistical wind information for locations not situated in close proximity (ie within say approximately a kilometre) of BoM weather stations. Particular emphasis was given to weather stations with a "clean" surrounding exposure, ie stations such as Sydney (Kingsford Smith) Airport and Bankstown Airport, which are relatively free of immediately surrounding obstacles such as buildings, vegetation, trees, etc, which would otherwise distort the winds seen by the weather station anemometer.

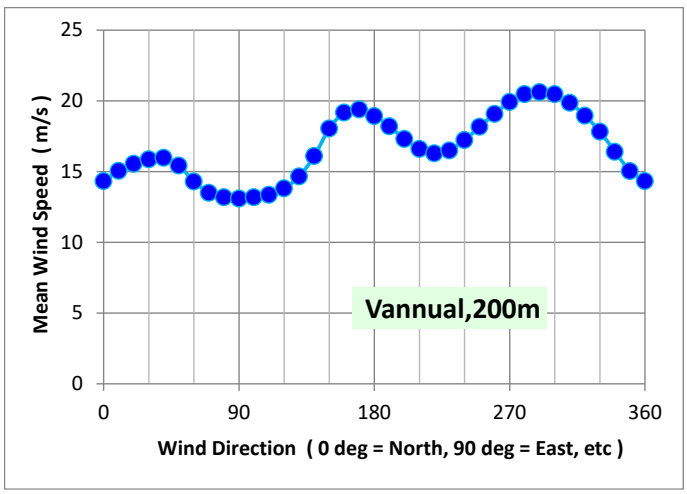
For Macquarie Park, SLR has determined that local upper level winds reflective of the weather systems experienced at the site have characteristics in between Bankstown Airport and Sydney (KS) Airport, given the site's distance (15 km) inland from the coast compared to Bankstown Airport (25 km) and Sydney (KS) Airport (5 km).

Accordingly, the adopted Macquarie Park wind model has slightly lower strength characteristics from the northeast and south compared to Sydney (Kingsford Smith) Airport and correspondingly higher strengths from the southeast and southwest/northwest relative to Sydney (KS) Airport.

2.4 Reference Height Annual Mean 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 6** and have been based on the adopted Macquarie Park wind model as described above. The winds shown have a once-per-year exceedance probability.

Figure 6 Reference Height (200 m) Annual Recurrence Mean Wind Speed at Project Site



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 several decades.

3.1 Comfort and Safety Criteria

The criteria used in the evaluation of pedestrian level winds surrounding the proposed development are:

- **COMFORT:** the "Lawson (2001)" criteria which couple the probability of exceeding winds at given statistical levels with wind speed magnitudes and associated impacts originally related to the Beaufort Wind Speed Land Scale – refer **Table 1**; and
- **SAFETY:** the Melbourne (1978) criteria, based on the exceedance of annual peak gust wind speeds.

Table 1 Beaufort Wind Speed – LAND Scale

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

"COMFORT" Criteria

As noted above, in relation to comfort, the Lawson (2001) criteria used in this report make use of the same Beaufort wind speed ranges to characterise issues of interest in terms of both pedestrian comfort and safety.

- The **Lawson (2001) Comfort** criteria relate a range of typical pedestrian activities such as purpose-walking, strolling, sitting, etc, to the local "GEM" wind speed which is exceeded on average 5% of the time, on an annual return period basis – refer **Table 2**.
- The "GEM" (Gust Equivalent Mean) wind speed used in the criteria is the maximum of the local mean wind speed or the local gust speed divided by 1.85.

Table 2 Lawson Wind Acceptability Criteria – COMFORT

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

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

"SAFETY" Criteria

The safety acceptability criteria used in this report, currently referenced by many Australian Local Government Development Control Plans, are the so-called **Melbourne (1978)** criteria, summarised in **Table 3**.

Table 3 Melbourne (1978) Wind Acceptability Criteria - SAFETY

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

3.2 Significance Criteria - Comfort

The significance criteria used by SLR in the assessment of "Comfort-related" wind effects at measurement locations surrounding the site are based on comparing the wind-tunnel predicted conditions at any particular location with the target usage at the same location (eg sitting, strolling, leisure walking, etc) as defined by the Lawson (2001) Comfort Criteria.

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

The chosen significance criteria are shown **Table 4**.

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

Table 4 Significance Criteria Related to Lawson Acceptability Criteria

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

3.3 Comments on the Application of the Acceptability Criteria

Approach for Areas Where Existing Wind Conditions Already Exceed Criteria

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

In such instances, a new development should:

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

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

The probabilistic way in which the Comfort Criteria are defined indicates that the relevant activity may be unsuitable at a particular location for about 5% of the time (say around 18 days per year). For the rest of the time, the relevant activity may be suitable (given that winds will be lower than the prescribed acceptability level). Moreover, it is noted that the recommended limiting values for comfort-related wind conditions were generally derived from subjective assessments of wind acceptability. These have been found to vary considerably with the height, strength, age, etc, of the pedestrian concerned.

Accordingly, some latitude can be applied to the Comfort Criteria in particular taking into account the extent of windy conditions, eg some relaxation of the criteria may be acceptable for small areas under investigation which are used infrequently.

The safety criteria shown in **Table 3** reflect the potential for stronger winds to cause a loss of balance and even possible wind knock-down, especially for frail pedestrians. The criteria are accordingly significantly more stringent.

Mitigation Using Landscaping

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

In particular, the AWES Guideline notes the following:

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

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

4 WIND TUNNEL TEST METHODOLOGY

4.1 Simulation of Natural Wind

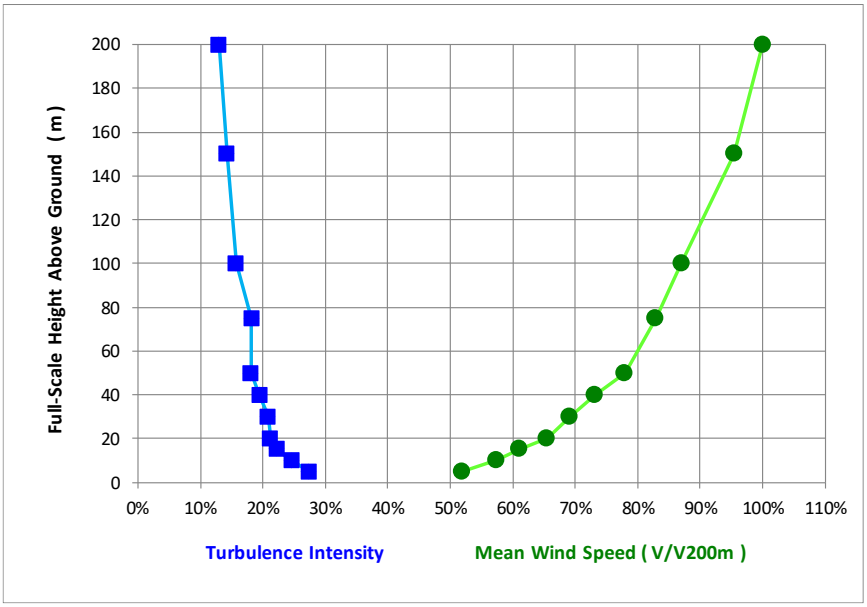
Similarity requirements between the wind tunnel model and prototype (ie full-scale) need to be fulfilled so that similitude in the flow conditions is satisfied. Usually all requirements cannot be satisfied, and compromises need to be made. In this type of wind tunnel test, it is possible to waive strict adherence to the full range of similarity parameters, eg the need to take into account buoyancy effects which are not relevant under strong wind conditions.

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 7**.

Figure 7 Wind Tunnel Test Profiles for Mean Wind and Turbulence Intensity



4.2 Proposed Development Model and Proximity Model

Development Model

A 1:400 scale model of the proposed development was built for the testing – refer **Figure 8**.

Figure 8 1:400 Scale Model of the Proposed Development

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 9**.

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

- Scenario 1 – **"Baseline"** Existing built environment
- Scenario 2 – **"Proposed"** "Baseline" + Proposed Development
- Scenario 3 – **"Mitigation"** "Proposed" + recommended wind mitigation treatments

Figure 9 1:400 Scale Proximity Model in Wind Tunnel

"Baseline" Scenario (Existing)

View from South-Southeast

"Proposed" Scenario

View from South

"Mitigation" Scenario

View from South

4.3 Data Processing

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

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

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

The sampling time for each measurement is 60 seconds.

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

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

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

The measured wind speeds are transformed using the directional wind speed information derived from the local wind climate to yield ground level wind speeds as a function of annual return period and directional mean reference wind speed - refer **Figure 6**. The measured 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 Project Site. The results are computed on a probabilistic basis, enabling calculation of wind events which will occur at the probability levels relevant to the Lawson Comfort Criteria, ie 5% exceedance level on an annual basis, and the peak annual wind speed relevant to the Melbourne 23 m/s Safety Criterion, using the local Project Site statistical wind distribution.

4.4 Test Method – Sensor Locations

In the wind tunnel testing, Irwin wind sensors were positioned at the locations shown in **Figure 10.** 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.

- Locations 1-32 (excluding 2 and 5) were positioned at Ground Level locations within and surrounding the site.
- Locations 2, 5, and 33-37 were positioned at elevated locations on upper levels.
- Note: Locations 2, 5, and 33-37 were only present (and hence measured) for "Proposed", and "Mitigation" test scenarios as these were located on upper levels.

Figure 10 Sensor Locations

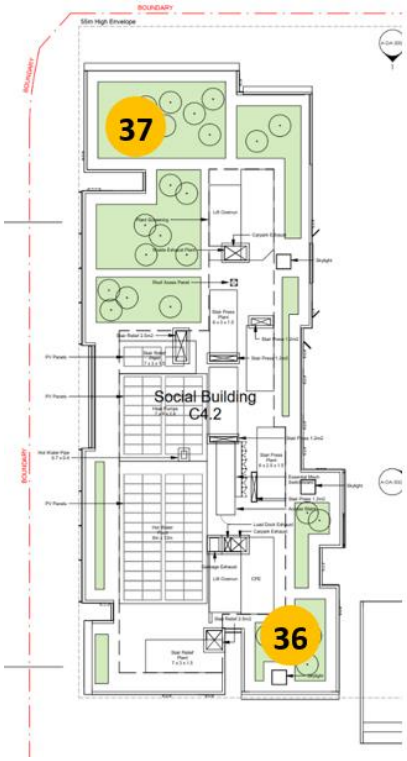
Ground Level Sensor Locations

Building C3: Level 11

Building C3: Level 10

Building C3: Level 15

Building C4 Social – Roof Plan



4.5 Sample Test Result

An example of the test results and interpretation of these results is shown in **Figure 11**, illustrating the peak annual mean and representative gust wind speeds at:

Sensor: **Location 14**
Location: The southern corner of Building C4-Social.

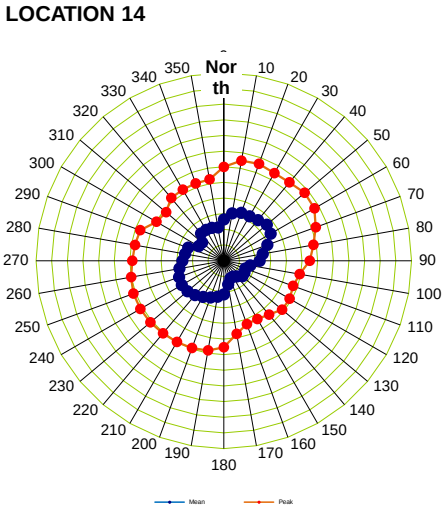
The polar diagram shows the output of the wind tunnel test results in terms of the ratio of local ground level wind speeds to the 200 m height reference mean wind speed:

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

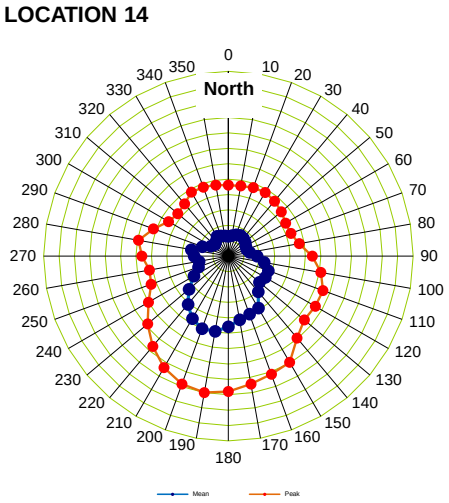
The polar diagram circumferential markings show the above ratios in "0.1" intervals.

Figure 11 Sample Polar Plot Test Result – Location 14 – Scenarios 1 and 2

Scenario 1 – "Baseline" (Existing Built Environment)



Scenario 2 – "Proposed" ("Baseline" + Proposed Development)



Scenario 1 - "Baseline" Scenario

- Location 14 receives minimal shielding from most of the wind directions due to the relatively open nature of the surroundings with low to mid-rise buildings to the northeast, and low-rise residential dwellings to the west and southwest. As a result, existing winds at this location are higher from the northeast, west, and southwest.

Scenario 2 - "Proposed" Scenario

- With the addition of the proposed development, winds at Location 14 see a noticeable decrease in winds from northeast wind direction, due to the shielding provided by the proposed development itself. Additionally, with the addition of the proposed development, winds increase at Location 14 from the southerly quadrant, due to the side-streaming and funnelling of the winds along the southwestern façade of the C4 Social and C4 Townhouses buildings.

5 TEST RESULTS

5.1 Lawson (2001) and Melbourne (1978) Calculation Methodology

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

- The wind tunnel test data yield ratios of the local ground level wind speed (mean and peak gust) to the reference height (200 m full-scale) mean wind speed (refer **Figure 6**) in the wind tunnel;
- The local Project Site wind speed and wind direction probability distribution is then used to calculate the probability of occurrence of the "GEM" wind speeds at an annual exceedance level of 5% to compare to the Lawson (2001) Comfort Criteria and the peak annual gust to compare to the Melbourne (1978) 23 m/s Safety Criterion.

5.2 Wind Tunnel Test Data - "Baseline" and "Proposed" Scenarios

Appendices B, C, and D shows the relevant wind tunnel test result polar plots for all locations for "Baseline", "Proposed", and "Mitigation" Scenarios respectively.

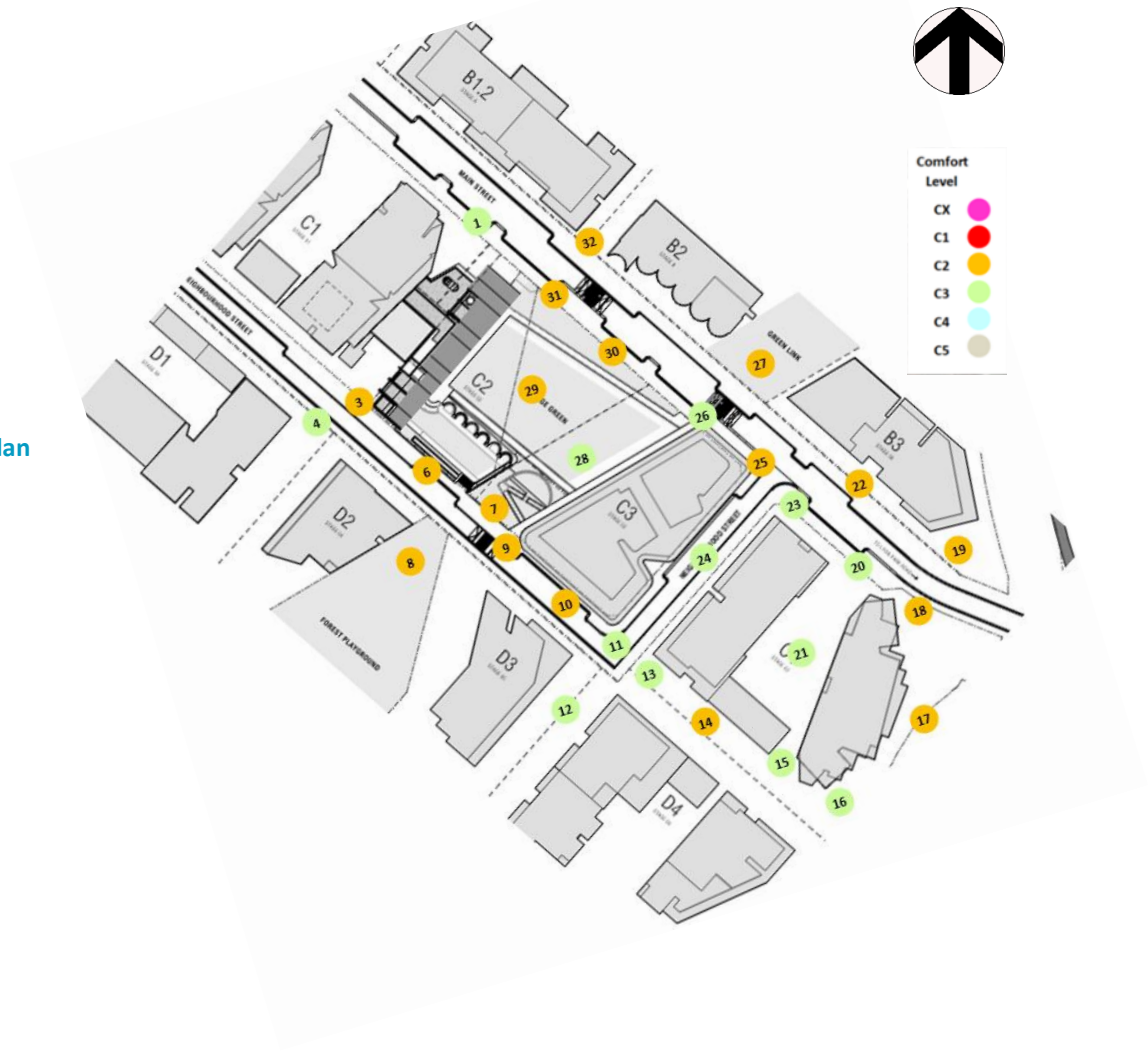
It should be noted that no existing or future planned landscaping was incorporated in the above scenarios. This is done to provide a clear insight as to the approach angles resulting in potential adverse wind conditions and the magnitude of such adverse conditions, which in turn can then be used to develop effective additional horizontal and vertical windbreak mitigation options – refer also **Section 6**.

5.3 Predicted Lawson Comfort Criteria Levels – "Baseline" and "Proposed" Scenarios

The results of the combination of wind tunnel test results (local ground level wind speed ratios) with the wind speed and wind direction probability distribution (5% annual exceedance level) derived for the site compared to the Lawson Comfort criteria are shown in **Figure 12**.

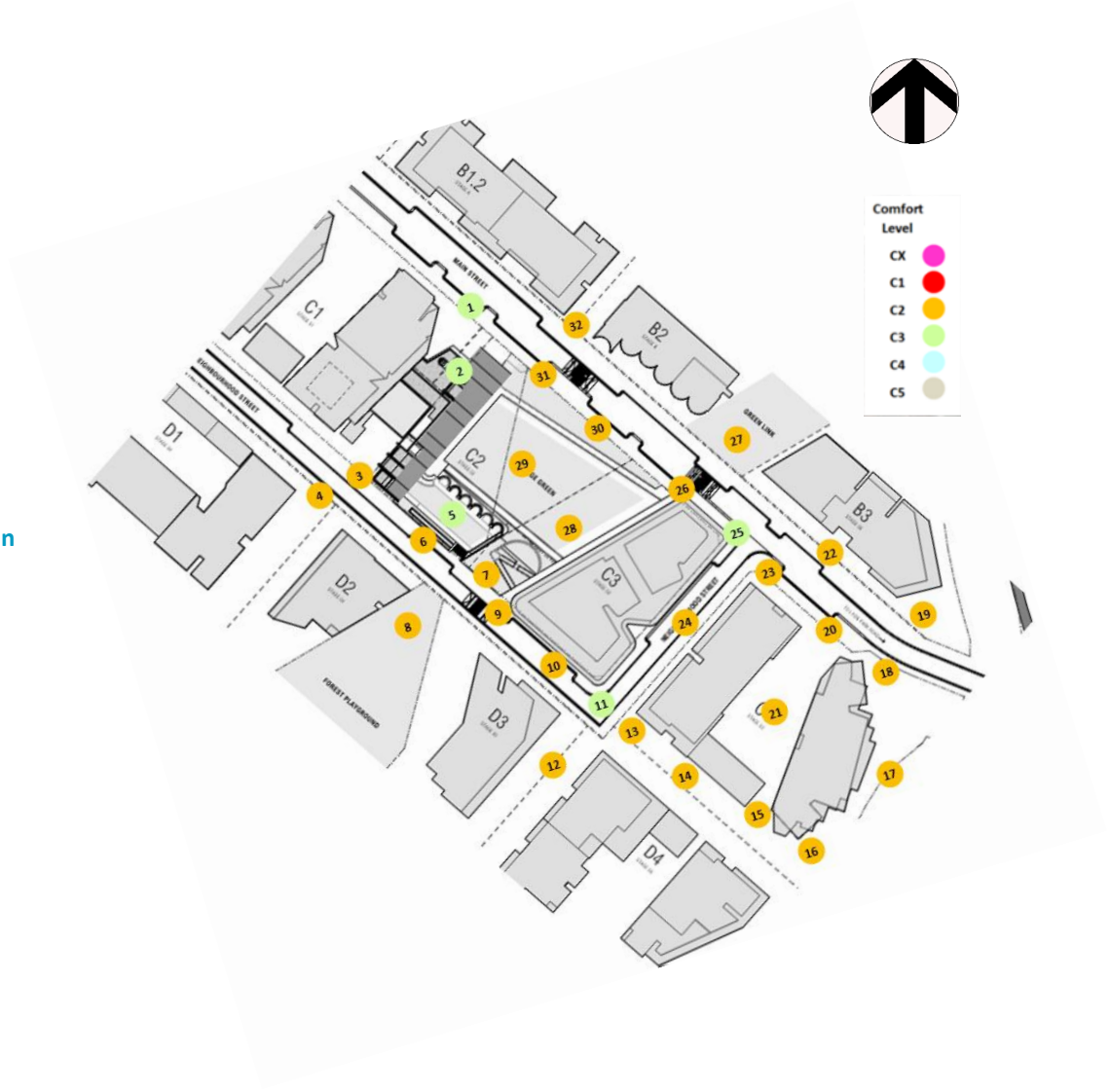
Figure 12 Predicted Lawson Comfort Levels - "Baseline" and "Proposed" Scenarios

Baseline Scenario: Ground Plan



(Fig.12 cont'd)

Proposed Scenario: Ground Plan



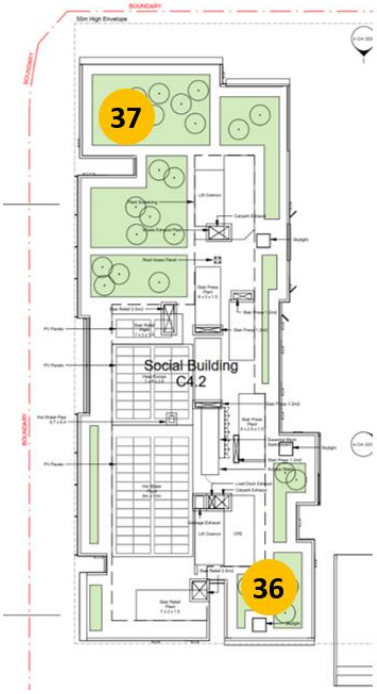
Proposed Scenario: Building C3 - Level 11

(Fig.12 cont'd)

Proposed Scenario: Building C3 - Level 10

Proposed Scenario: Building C3 - Level 15

Proposed Scenario: Building C4 Social – Roof Plan



5.4 Predicted Melbourne (1978) Safety Criteria Levels

The results of the combination of wind tunnel test results (local ground level wind speed ratios) with the wind speed and wind direction probability distribution (peak annual gust) relevant to safety yielded the following results:

- In the "Baseline" scenario, the peak annual gust at ALL locations within and around the site are below the 23 m/s criterion level; and
- In the "Proposed" scenario, the peak annual gust at ALL locations within and around the site are below the 23 m/s criterion level; and

5.5 Impact of the Proposed Development on Existing Wind Conditions

"PROPOSED" Scenario Compared to the "BASELINE" Scenario

- In the "Proposed" scenario, the majority of the locations will experience minimal to no change in local wind speed with the addition of the proposed development (and hence no change to the Lawson Comfort Level).
- Out of the remaining locations (12):

  11 locations are predicted to increase their local wind speed by one Lawson Comfort Criteria level, going from a "C3" level to a "C2" level;

  The other 1 location is predicted to decrease its local wind speed by one Lawson Comfort Criteria level, going from a "C2" level to a "C3" level.

5.6 Impact of the Proposed Development Relative to Target Comfort Wind Criteria

The wind-tunnel predicted "Proposed" Lawson (2001) Comfort levels are compared to the Target Comfort levels for areas surrounding and within the proposed development in **Table 5**.

It is noted that none of the landscaping proposed for the development was included in the "Baseline" and "Proposed" built environment scenarios. Testing in their absence assists in confirming areas where wind mitigation may be needed and more importantly, using the polar plot information shown in **Appendices B** and **C**, revealing the wind directions of most concern, further assisting the decision making in relation to placement of specific landscaping elements.

"Proposed" Built Environment Scenario

- Lawson Comfort Levels range from "C2" (suitable for leisure walking/strolling) to "C3" (suitable for standing);
- The "C2" locations are: 3, 4, 6-10, 12-24, 26-32, 36, and 37;
- The remaining locations are "C3": 1, 2, 5, 11, 25, 33, 34, 35;
- There are NO areas with the potential to experience winds which exceed the 23 m/s Safety Criterion.

Table 5 Assessment of Impacts of the Proposed Development – Proposed Scenario Results

Location	Wind Tunnel Predicted Comfort Level – "Proposed"	Target Comfort Level	"Proposed" Impact (refer Table 4) Relative to Target Comfort Level
1	C3	C1/C2	Favourable Moderate / Favourable Minor
2	C3	C4	Unfavourable Minor
3	C2	C1/C2	Favourable Minor / Negligible
4	C2	C1/C2	Favourable Minor / Negligible
5	C3	C3	Negligible
6	C2	C1/C2	Favourable Minor / Negligible
7	C2	C1/C2	Favourable Minor / Negligible
8	C2	C1/C2	Favourable Minor / Negligible
9	C2	C1/C2	Favourable Minor / Negligible
10	C2	C1/C2	Favourable Minor / Negligible
11	C3	C1/C2	Favourable Moderate / Favourable Minor
12	C2	C1/C2	Favourable Minor / Negligible
13	C2	C1/C2	Favourable Minor / Negligible
14	C2	C1/C2	Favourable Minor / Negligible
15	C2	C1/C2	Favourable Minor / Negligible
16	C2	C1/C2	Favourable Minor / Negligible
17	C2	C1/C2	Favourable Minor / Negligible
18	C2	C1/C2	Favourable Minor / Negligible
19	C2	C1/C2	Favourable Minor / Negligible
20	C2	C1/C2	Favourable Minor / Negligible
21	C2	C4	Unfavourable Moderate
22	C2	C1/C2	Favourable Minor / Negligible
23	C2	C1/C2	Favourable Minor / Negligible
24	C2	C1/C2	Favourable Minor / Negligible
25	C3	C1/C2	Favourable Moderate / Favourable Minor
26	C2	C1/C2	Favourable Minor / Negligible
27	C2	C1/C2	Favourable Minor / Negligible
28	C2	C3	Unfavourable Minor
29	C2	C3	Unfavourable Minor
30	C2	C1/C2	Favourable Minor / Negligible
31	C2	C1/C2	Favourable Minor / Negligible
32	C2	C1/C2	Favourable Minor / Negligible
33	C3	C3	Negligible
34	C3	C3	Negligible
35	C3	C4	Unfavourable Minor

Location	Wind Tunnel Predicted Comfort Level – "Proposed"	Target Comfort Level	"Proposed" Impact (refer Table 4) Relative to Target Comfort Level
36	C2	C3	Unfavourable Minor
37	C2	C3	Unfavourable Minor

Note 1 All Unfavourable impacts are deemed "significant" and require consideration of wind mitigation

Note 2 Locations 2, 5, and 33-37 were not present in "Baseline" scenario.

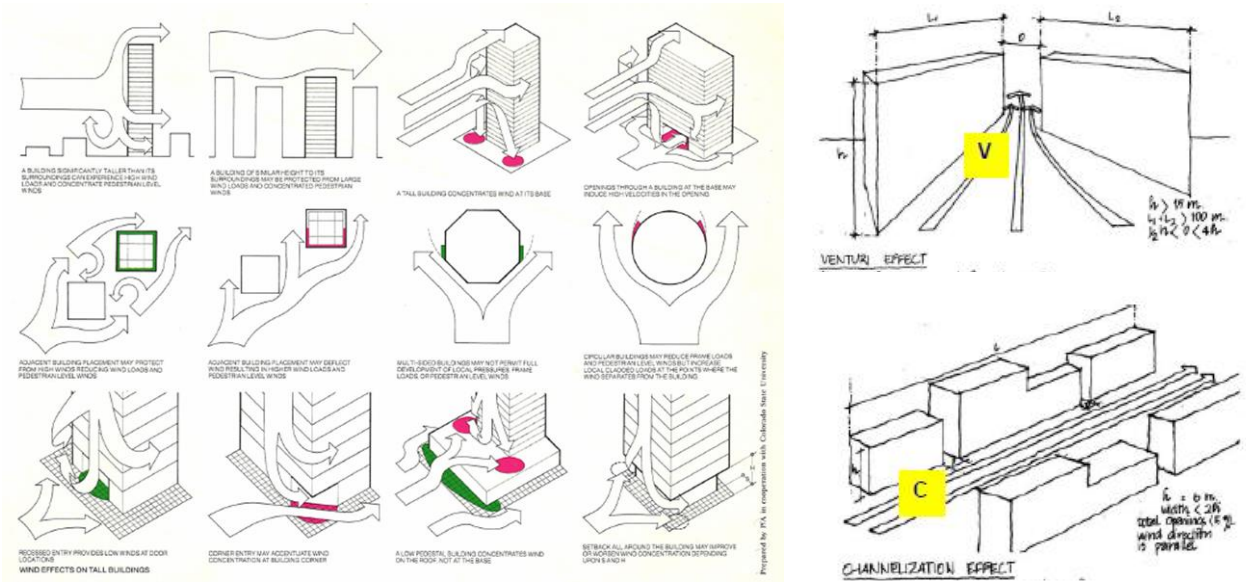
Note 3 All locations were present in the "Proposed", and "Mitigation" scenarios.

It will be recalled (refer **Section 3.2**) that all locations where the significance impact is "Unfavourable" leads to consideration of mitigation treatments (also taking into account the existing "Baseline" conditions).

6 WIND MITIGATION OPTIONS

Figure 13 shows some common wind impact flow patterns surrounding a new building development.

Figure 13 Common Built Environment Windflow Patterns



On the basis of the above, wind mitigation options generally fall into two categories:

- Windbreaks designed to mitigate **vertical or oblique** winds (eg downwash winds); and
- Windbreaks designed to mitigate **horizontal** winds (eg channelling/funnelling winds).

6.1 Windbreaks Suited to Mitigating Vertical/Oblique Winds

Wind mitigation options suited to ameliorating vertical/oblique wind conditions include:

- Horizontal (or near horizontal) Canopies, Awnings and Pergolas (solid or of moderate porosity) which are able to deflect winds approaching from above and redirect the wind away from ground level areas below.

6.2 Windbreaks Suited to Mitigating Horizontal Winds

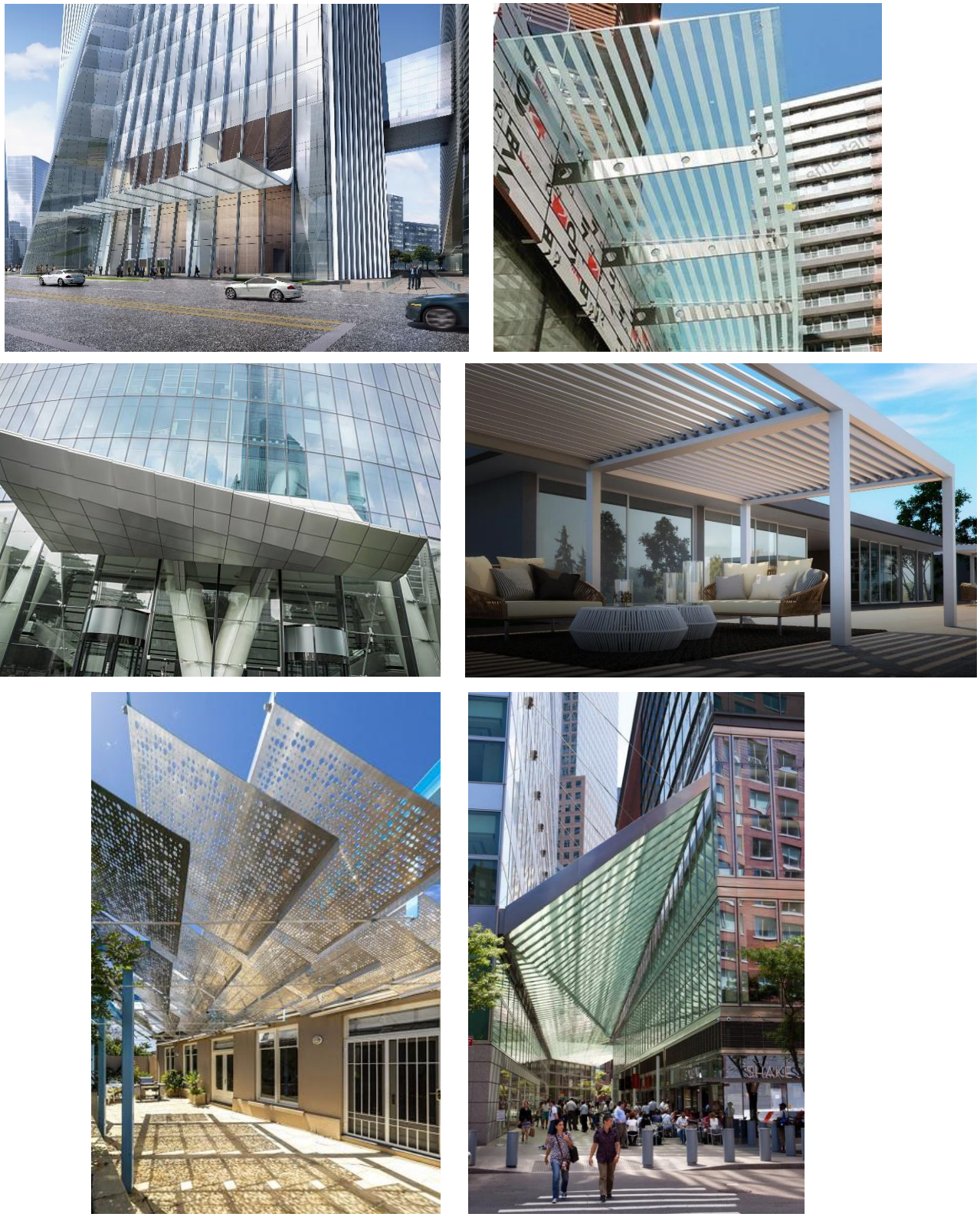
Wind mitigation options suited to ameliorating horizontal wind conditions include:

- Landscaping: trees, shrubs, vegetation, etc; and
- Sculptural screening (solid or of moderate porosity) – which can also be combined with landscaping.

6.3 Horizontal Windbreak Examples

Figure 14 shows typical examples of horizontal windbreak options typically found in urban built environments – they can be solid or porous, purely horizontal or with a slope aimed at deflecting oblique windflow.

Figure 14 Horizontal Windbreak Options

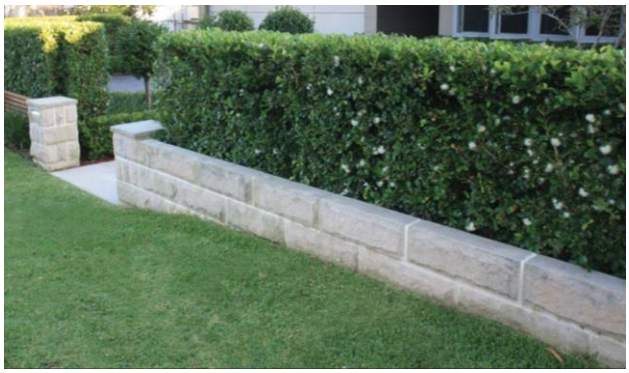


6.4 Vertical Windbreak Examples

Figure 15 shows examples of vertical windbreak options found in urban built environments – they can be solid or porous, involve landscaping (full or partial), timber, glazing, etc, and can provide a wide range of utilitarian functions beyond their wind mitigation capability (eg seating, advertising, etc).

Figure 15 Vertical Windbreak Options

Landscaping



Solid

Multi-Function

Combination

7 MITIGATION AND TREATMENT RECOMMENDATIONS

Sections 5 and 6 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 are:

- The outdoor seating and dining area at the northern end of Building C2;
- The area at the central courtyard "The Grove" of Building C4;
- The central part of the "Village Green" area between Building C2 and C3;
- The area towards the northern end of rooftop at Level 17 of C4 Social tower.

7.1 Already Planned Wind Amelioration Treatments

The following features, all of which would have a significant ameliorating impact on local wind conditions, are either existing or have already been planned for the proposed development:

- The existing and significant landscaping along Epping Road – refer **Figure 16-A**;
- The existing and significant landscaping located within the adjacent bushland, along the south-eastern perimeter of the site boundary – refer **Figure 16-B**; and
- The proposed landscaping within and around the site at Ground Level locations – refer **Figure 16-C**.
- The proposed landscaping within various upper-level open areas such as rooftops, forest rooms, or outdoor communal spaces.

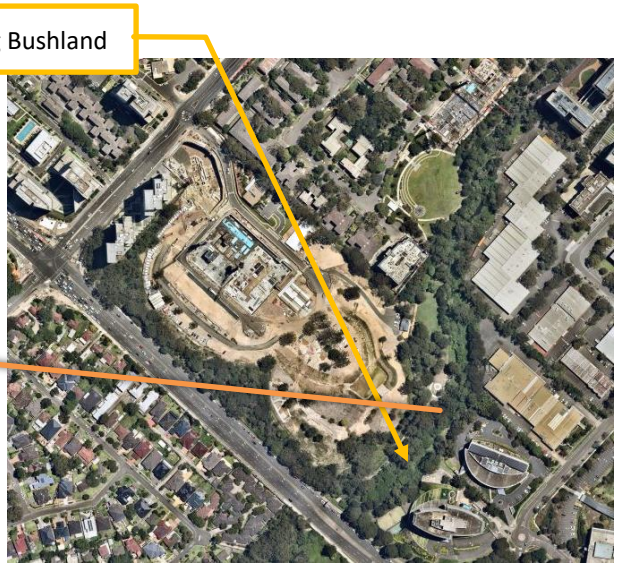
It is recommended to retain all proposed landscaping within and around the development. The proposed landscaping is recommended to be evergreen and densely foliated to maintain its effectiveness throughout the year.

Figure 16 Existing Landscaping and Already Planned Wind Mitigation

A - Existing and significant landscaping along Epping Road

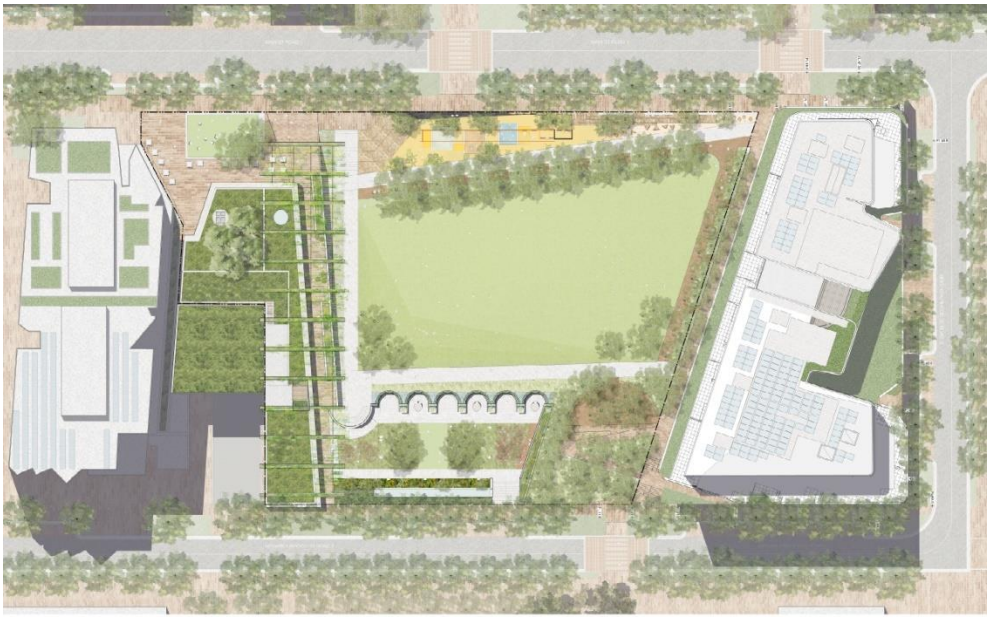
(Fig.16 cont'd)

B – Existing and significant landscaping located within the adjacent bushland



C – Proposed landscaping within and around the site

Site C2 and C3:



Site C4:


STAGE 2 FUTURE DEVELOPMENT LOT
MAIN STREET
NEIGHBOURHOOD GARDEN
SHRIMPTON'S COMMUNAL OPEN SPACE
THE GROVE
SHRIMPTONS CREEK
NEIGHBOURHOOD STREET
MEWS

7.2 Additional Wind Mitigation Recommendations

Based on the Lawson Comfort and Safety levels identifies through the wind tunnel testing for the "Baseline" and "Proposed" scenarios, additional wind mitigation is proposed for the following locations:

Building C2 Ground Level Area

- It is recommended to include horizontal protection (eg pergola, shade-cloth, canopies, operable louvered roof, etc) to protect the areas at the northern end of Building C2 that are intended to be used for longer duration activities such as sitting/outdoor dining – refer Figure 17
- It is recommended to include localised vegetation or planting within the central part of the "Village Green" area between Building C2 and C3 – refer **Figure 17**.

Building C4 Ground Level Area

- It is recommended to include horizontal protection (eg pergola, shade-cloth, canopies, operable louvered roof, etc) to protect the areas of the central courtyard "The Grove" of Building C4 that are intended to be used for longer duration activities such as sitting/outdoor dining – refer **Figure 18**.

Building C4 Social Rooftop Area (Level 17)

- It is recommended to include at least 1.8m high perimeter screening around the northern end of the rooftop at Level 17 – refer **Figure 19**.

Figure 17 Building C2 Ground Level Area

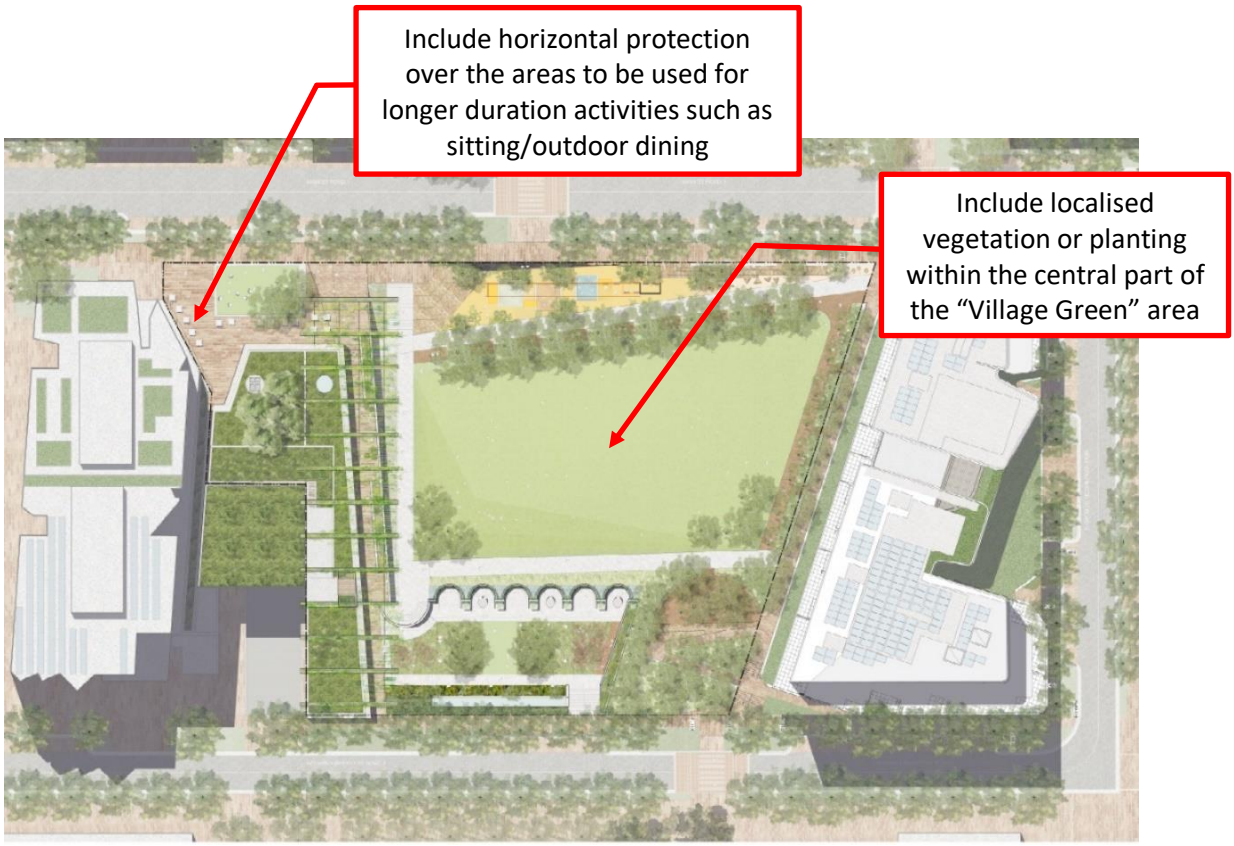
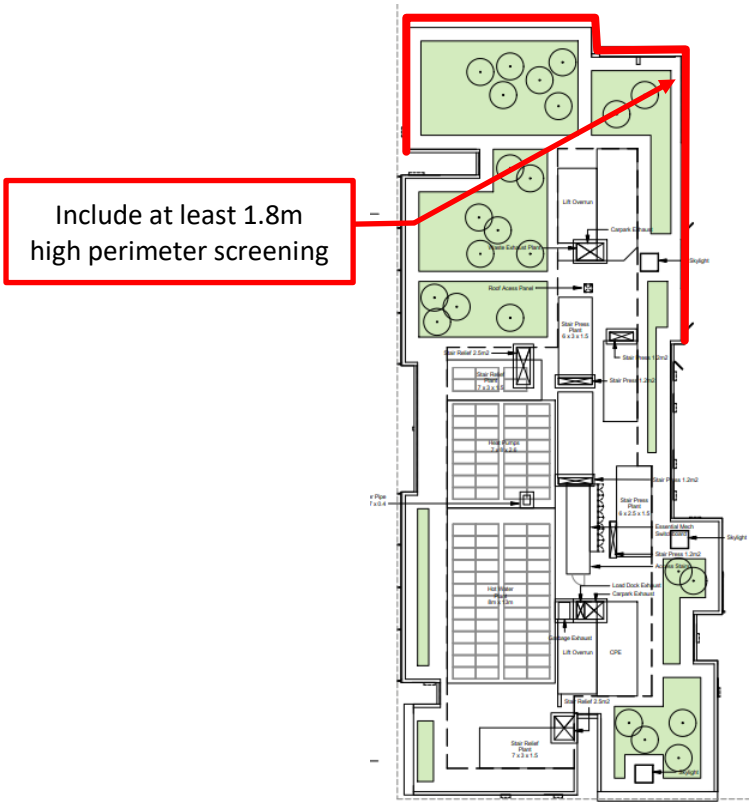


Figure 18 Building C4 Ground Level Area

Figure 19 Building C4 Social Rooftop Area (Level 17)



7.3 Additional Wind Tunnel Testing – "Mitigation" Scenario

The proposed windbreak treatments along with already proposed windbreak treatments not included in the "Proposed" round of testing) were assessed by carrying out a further round of testing – 0° to 360°, all sensor locations – with either "generic" vertical or horizontal treatments at relevant locations.

- This testing has been termed the **"Mitigation"** 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**. The "Mitigation" scenario testing is shown in **Figure 20**.

Figure 20 Treatments implemented onto Ground Level areas

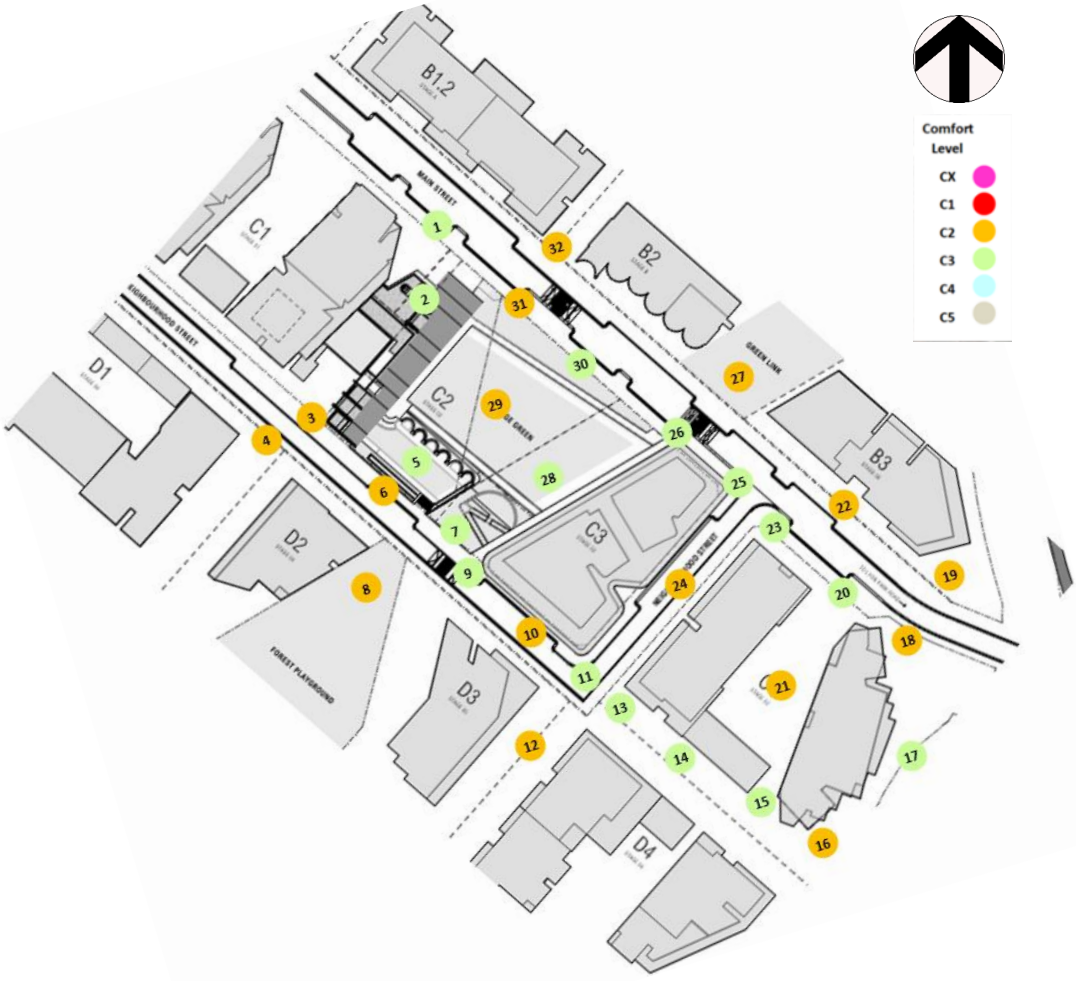
View from south-southwest

"Mitigation" Outcome – Predicted Lawson Comfort Levels

The results of the combination of wind tunnel test results (local ground level wind speed ratios) with the wind speed and wind direction probability distribution (5% annual exceedance level) derived for the site compared to the Lawson Comfort criteria for the "Mitigation" scenario are shown in **Figure 21**.

Figure 21 Predicted Lawson Comfort Levels – "Mitigation" Scenario

Mitigation Scenario - Ground Level Areas



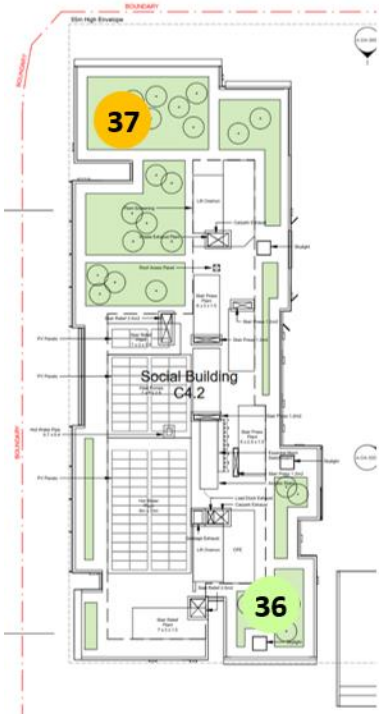
Mitigation Scenario: Building C3 - Level 11

(Fig.19 cont'd)

Mitigation Scenario: Building C3 - Level 10

Mitigation Scenario: Building C3 - Level 15

Mitigation Scenario: Building C4 Social – Roof Plan



Discussion of Results – Overall

A comparison of the wind tunnel test results for the "Proposed" and "Mitigation" scenarios shows locations either experience minimal change or improve with the inclusion of the already proposed and recommended mitigations.

Discussion of Results

- Location 2 – This area receives stronger winds from the east potentially funnelling between the future proposed buildings located to the northeast of Building C2. Although some planting/vegetation and landscaping is already proposed within this area, it is not expected to be effective to mitigate the adverse effect of vertical/oblique winds. Therefore, it is recommended to include horizontal protection (eg pergola, shade-cloth, canopies, operable louvered roof, etc) to protect the areas at the northern end of Building C2 that are intended to be used for longer duration activities such as sitting/outdoor dining.
- Location 21 – This area receives stronger winds from the east and the west potentially funnelling between the proposed C4 Social and C4 Market towers. Although some planting/vegetation and landscaping is already proposed within this area, it is not expected to be effective to mitigate the adverse effect of vertical/oblique winds. Therefore, it is recommended to include horizontal protection (eg pergola, shade-cloth, canopies, operable louvered roof, etc) to protect the areas of the central courtyard "The Grove" of Building C4 that are intended to be used for longer duration activities such as sitting/outdoor dining.
- Location 29 – The central part of the "Village Green" area between Building C2 and C3 is affected by the easterly and north-westerly winds. There is already proposed landscaping around the perimeter of this "Village Green" area; however, the central part of this "Village Green" area is relatively open. It is therefore recommended to include localised vegetation or planting within the central part of the "Village Green" area between Building C2 and C3. These additional localised trees along with the already proposed significant landscaping around the perimeter is expected to lower winds at this location by at least one Lawson Comfort Level.
- Location 37 – Easterly and north-easterly winds are expected to accelerate around the northern corner of C4 Market tower and adversely affect the rooftop area of C4 Social tower at Level 17. It is therefore recommended to include at least 1.8m high perimeter screening around the northern end of the rooftop at Level 17 of C4 Social tower. This perimeter screen is expected to deflect the winds away, hence mitigating the adverse effect of the easterly and north-easterly corner accelerated winds.

Results Summary

All of the areas identified within the "Proposed" scenario as requiring consideration of windbreak treatment can successfully be addressed through a combination of:

- Vertical screening, eg vertical screens, landscaping, etc; and
- Horizontal windbreak elements, eg awnings, etc.

7.4 Residual Effects and Overall Summary

The following summarises the results of the wind tunnel testing for the proposed development:

- The "Proposed" test results led to the identification of several areas where wind mitigation was indicated.
- The "Mitigation" test results showed that once the already proposed and additional recommended windbreak treatments are included to the development, all ground level locations within and surrounding the proposed development are expected to achieve the target Lawson Comfort Criteria and Melbourne Safety Criterion established for the project.

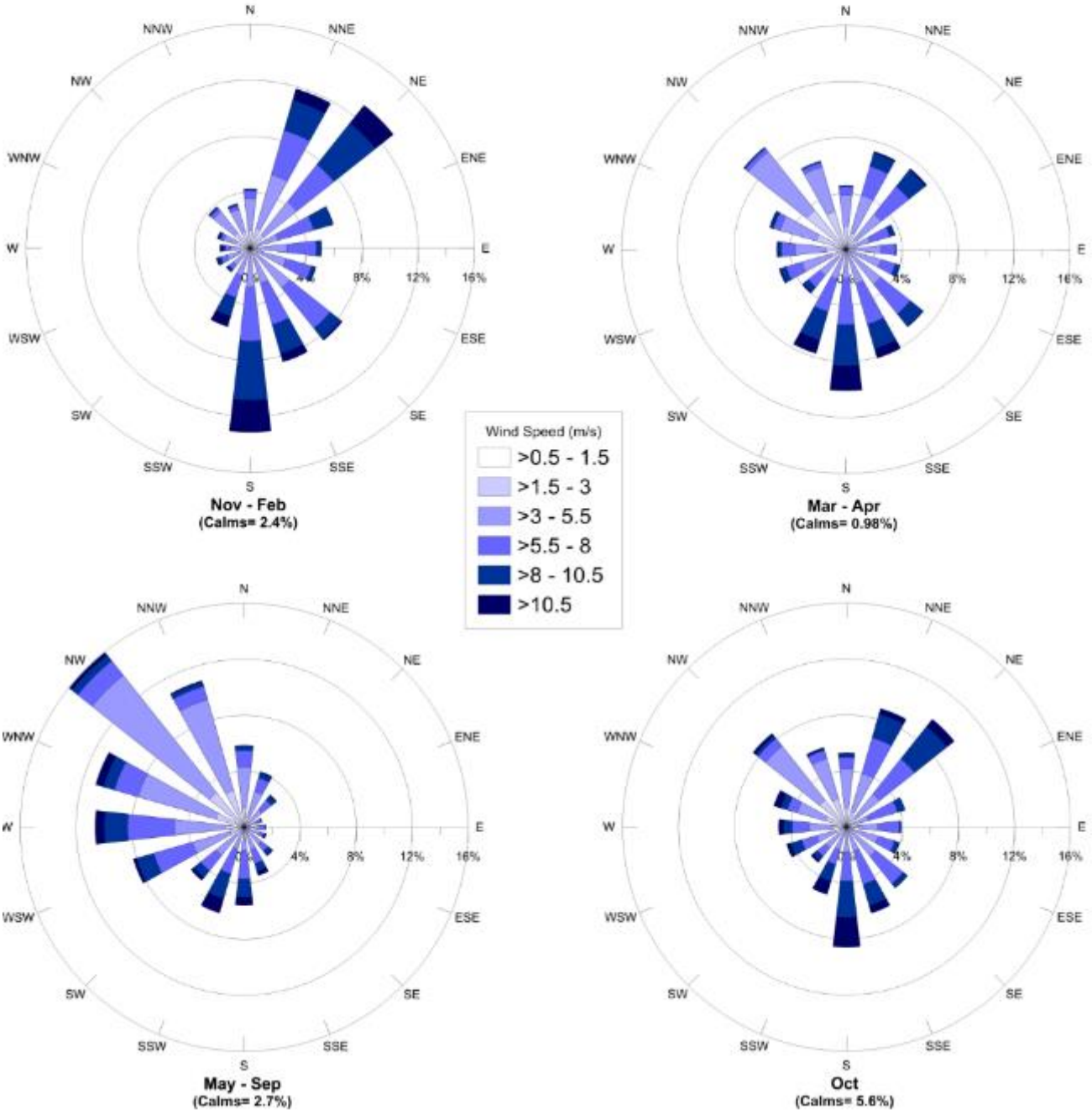
On the basis of all of the above, the overall effect of the proposed development on the local wind microclimate, with the wind mitigation treatments recommended, is predicted to be "not significant" (refer **Section 3.2**).

Accordingly, the proposed development should satisfy the nominated Wind Acceptability criteria for the project.

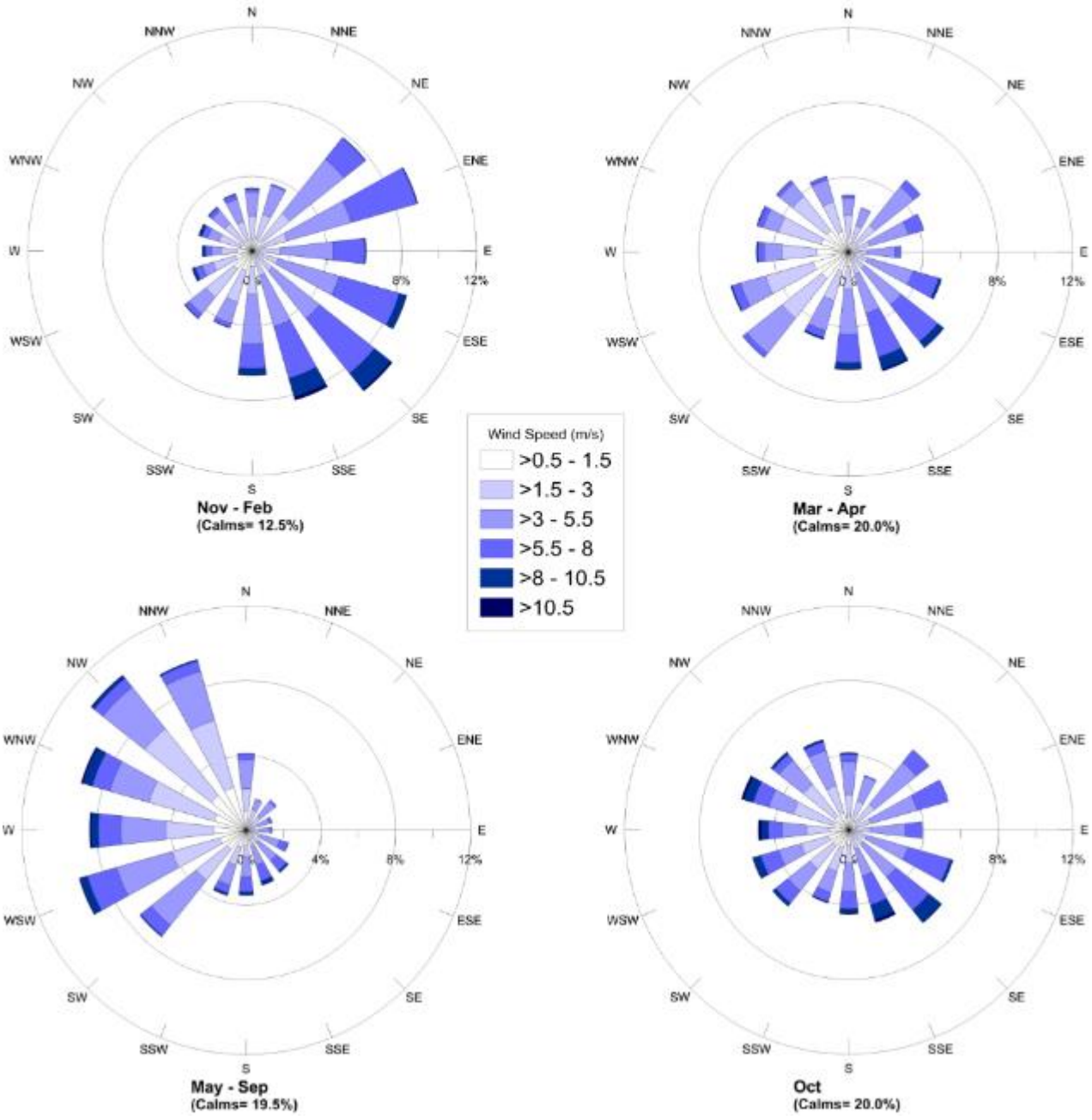
APPENDIX A

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

Sydney Airport AWS
(Observations)
1999-2017
600.09300



Bankstown Airport AWS
(Observations)
1999-2017
600.09300



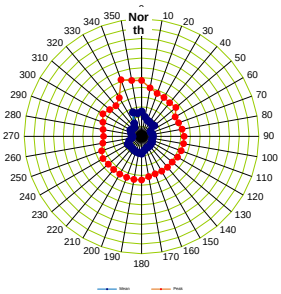
APPENDIX B

Wind Tunnel Test Data (Polar Plots) – **BASELINE** Scenario

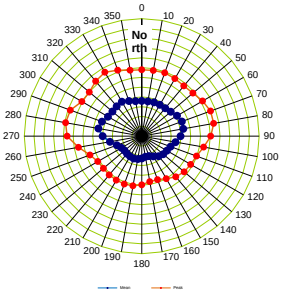
The polar diagram plots show the local (ground level) mean and peak gust wind speed as a ratio of the mean reference wind speed (at a full-scale height of 200 m).

The polar diagram circumferential lines representing gradations in 0.1 intervals, ie 10% ratios.

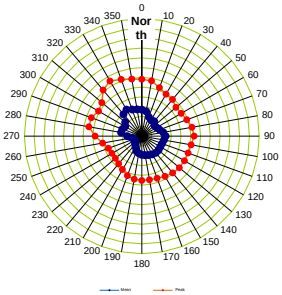
LOCATION 1



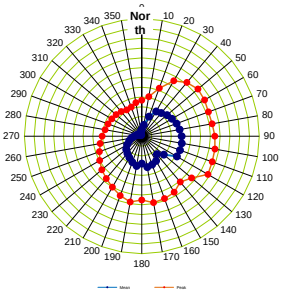
LOCATION 3



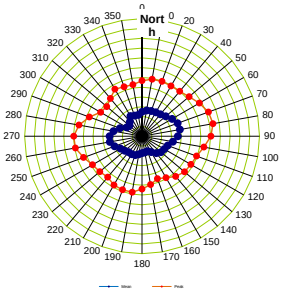
LOCATION 4



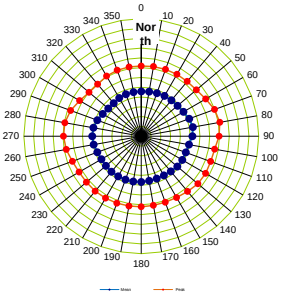
LOCATION 6



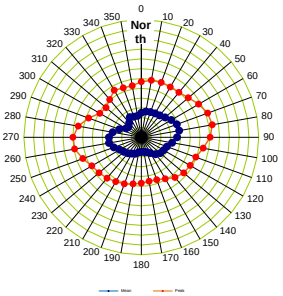
LOCATION 7



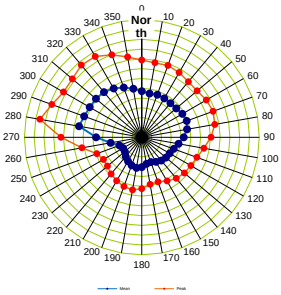
LOCATION 8



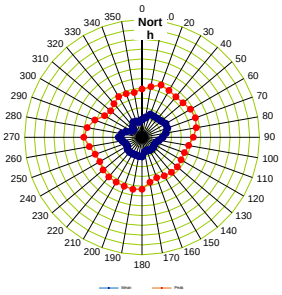
LOCATION 9



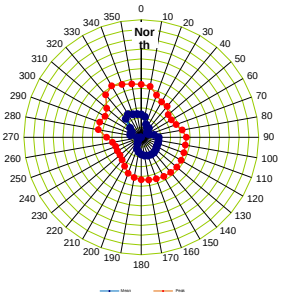
LOCATION 10



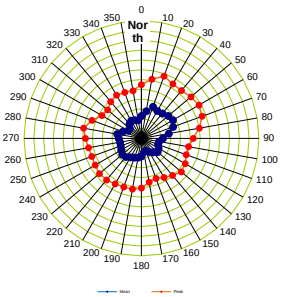
LOCATION 11



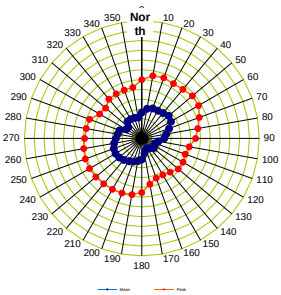
LOCATION 12



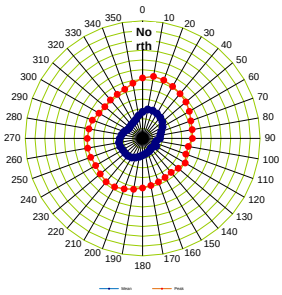
LOCATION 13



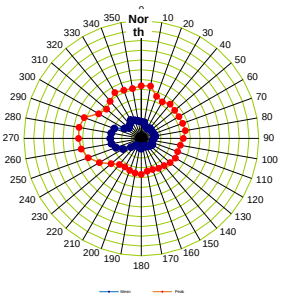
LOCATION 14



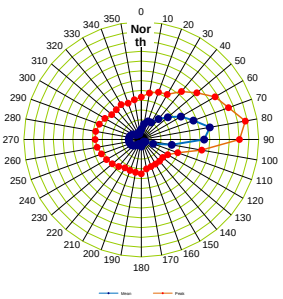
LOCATION 15



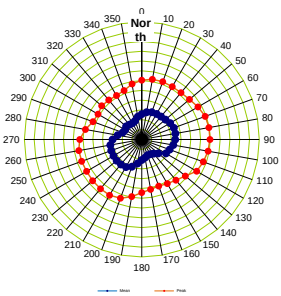
LOCATION 16



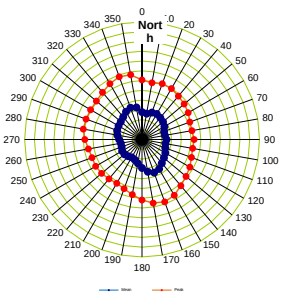
LOCATION 17



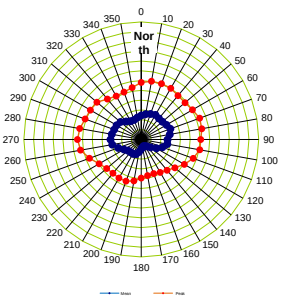
LOCATION 18



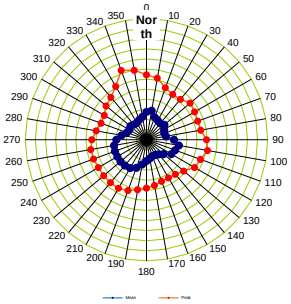
LOCATION 19



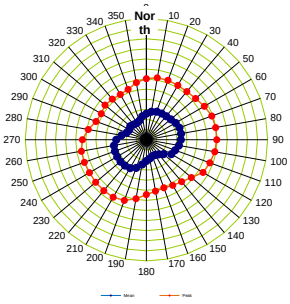
LOCATION 20



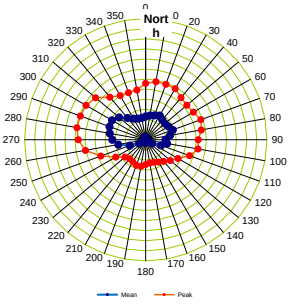
LOCATION 21



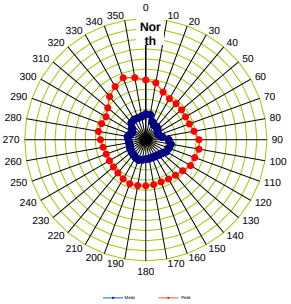
LOCATION 22



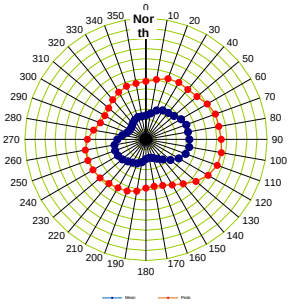
LOCATION 23



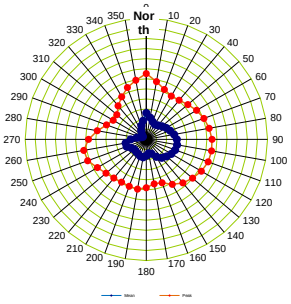
LOCATION 24



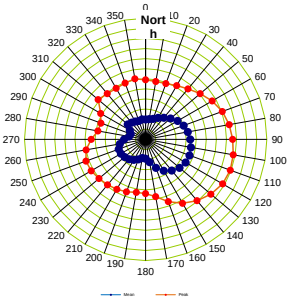
LOCATION 25



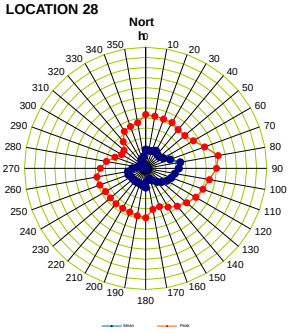
LOCATION 26



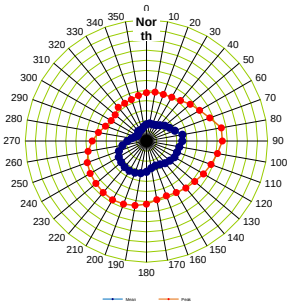
LOCATION 27



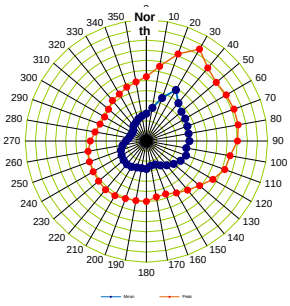
LOCATION 28



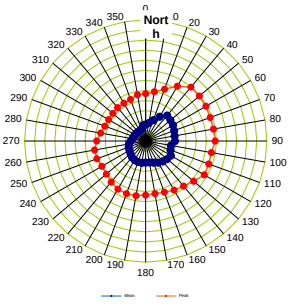
LOCATION 29



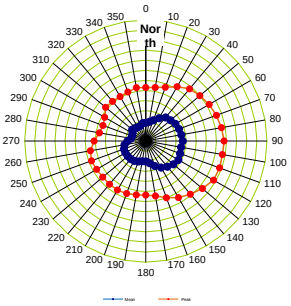
LOCATION 30



LOCATION 31



LOCATION 32



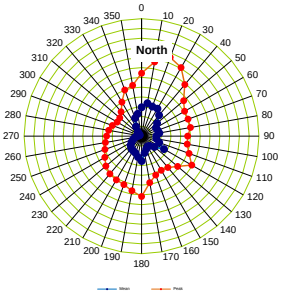
APPENDIX C

Wind Tunnel Test Data (Polar Plots) – **PROPOSED** Scenario

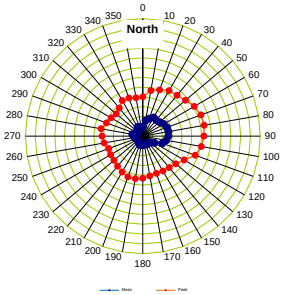
The polar diagram plots show the local (ground level) mean and peak gust wind speed as a ratio of the mean reference wind speed (at a full-scale height of 200 m).

The polar diagram circumferential lines representing gradations in 0.1 intervals, ie 10% ratios.

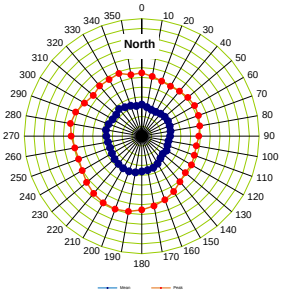
LOCATION 1



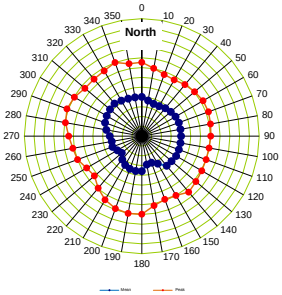
LOCATION 2



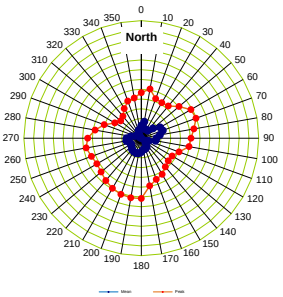
LOCATION 3



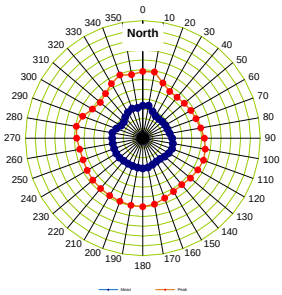
LOCATION 4



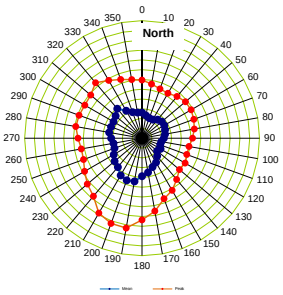
LOCATION 5



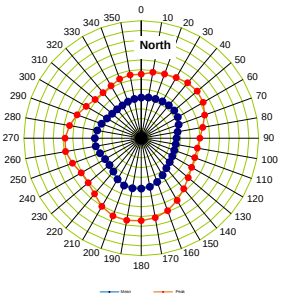
LOCATION 6



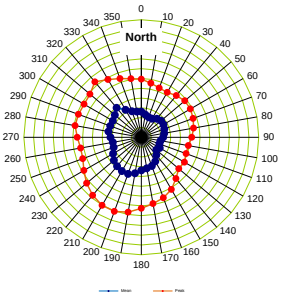
LOCATION 7



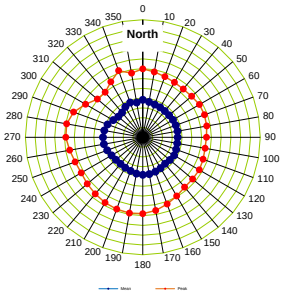
LOCATION 8



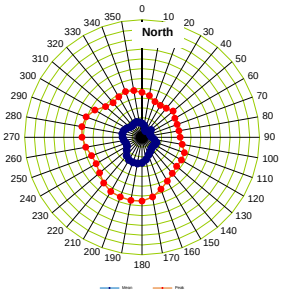
LOCATION 9



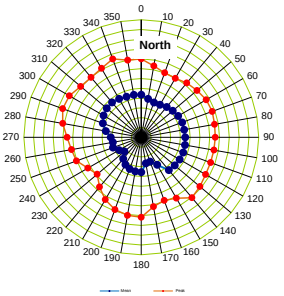
LOCATION 10



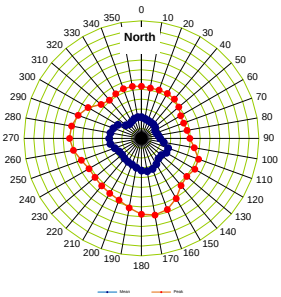
LOCATION 11



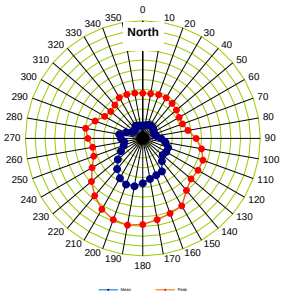
LOCATION 12



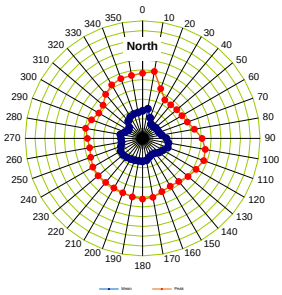
LOCATION 13



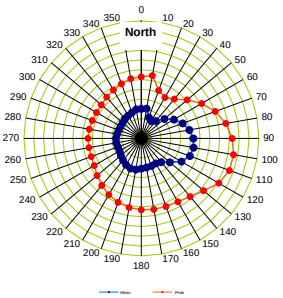
LOCATION 14



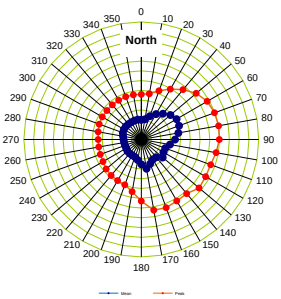
LOCATION 15



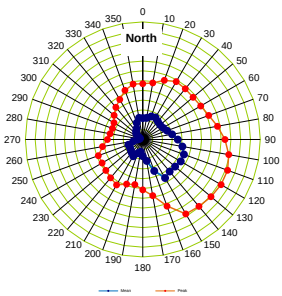
LOCATION 16



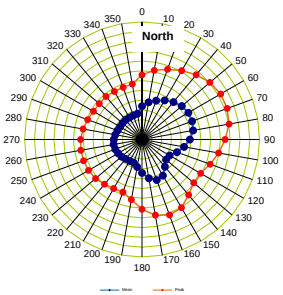
LOCATION 17



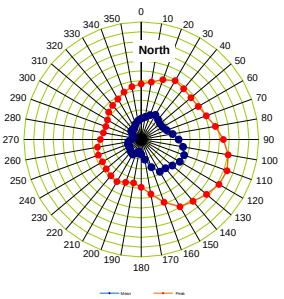
LOCATION 18



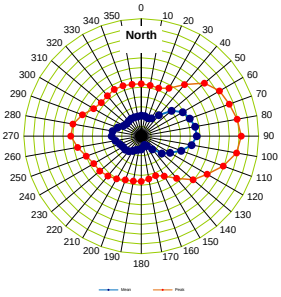
LOCATION 19



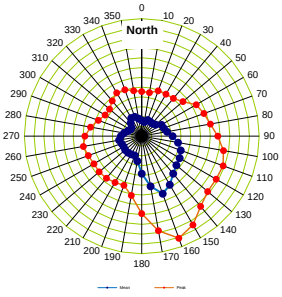
LOCATION 20



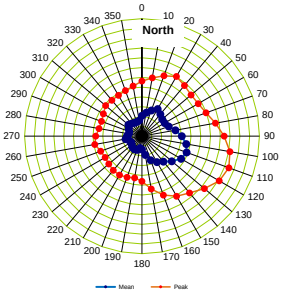
LOCATION 21



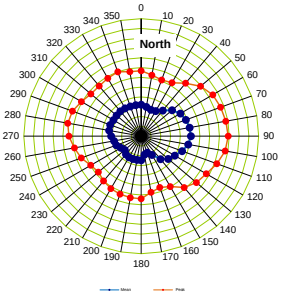
LOCATION 22



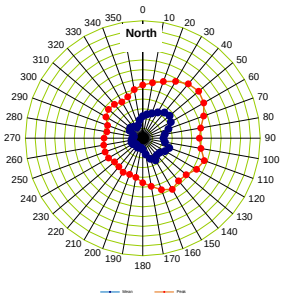
LOCATION 23



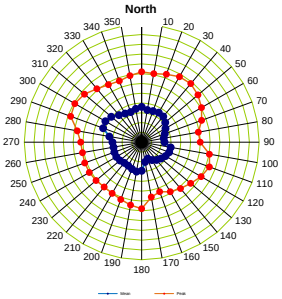
LOCATION 24



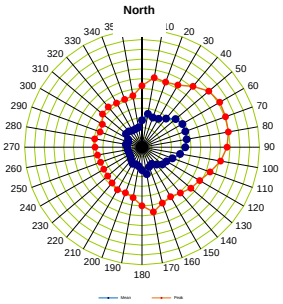
LOCATION 25



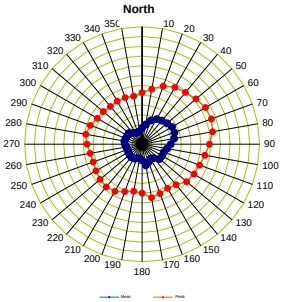
LOCATION 26



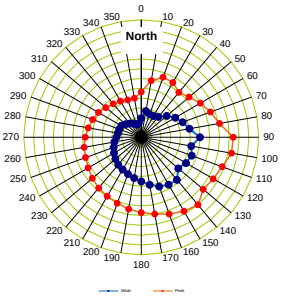
LOCATION 27



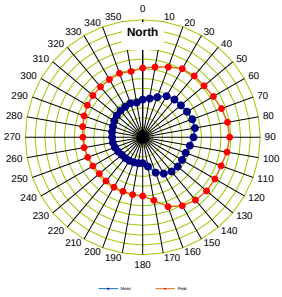
LOCATION 28



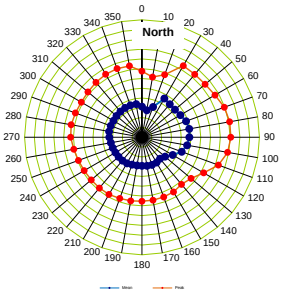
LOCATION 29



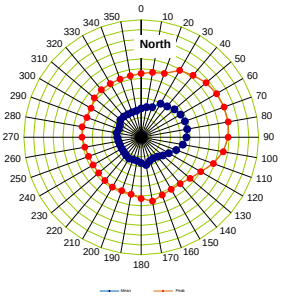
LOCATION 30



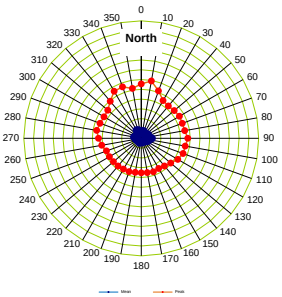
LOCATION 31



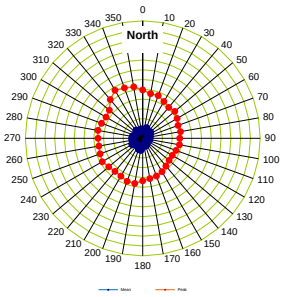
LOCATION 32



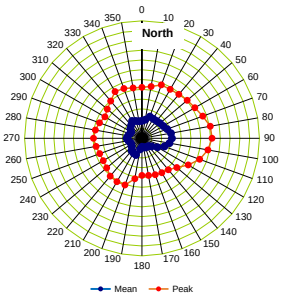
LOCATION 33



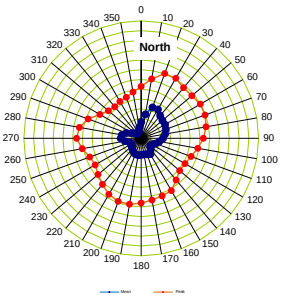
LOCATION 34



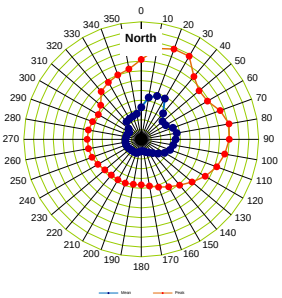
LOCATION 35



LOCATION 36



LOCATION 37



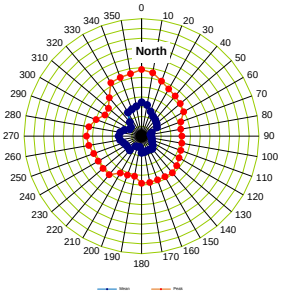
APPENDIX D

Wind Tunnel Test Data (Polar Plots) – **MITIGATION** Scenario

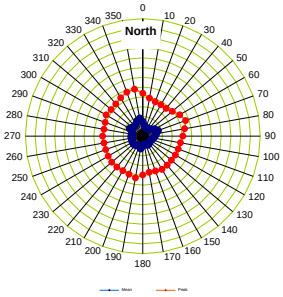
The polar diagram plots show the local (ground level) mean and peak gust wind speed as a ratio of the mean reference wind speed (at a full-scale height of 200 m).

The polar diagram circumferential lines representing gradations in 0.1 intervals, ie 10% ratios.

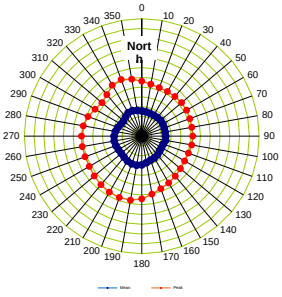
LOCATION 1



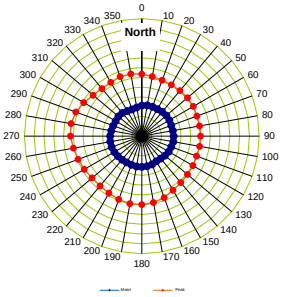
LOCATION 2



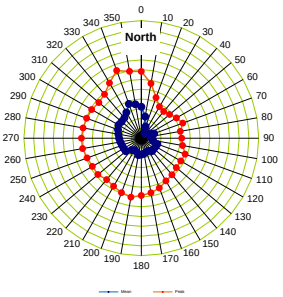
LOCATION 3



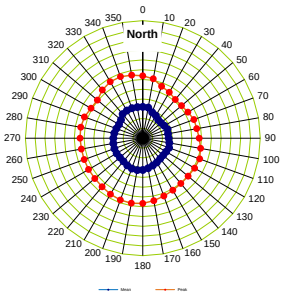
LOCATION 4



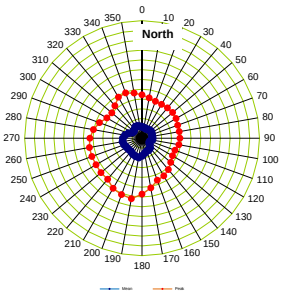
LOCATION 5



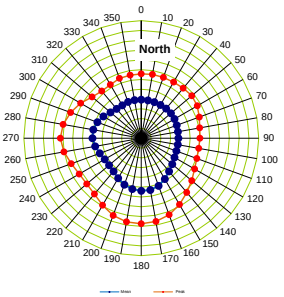
LOCATION 6



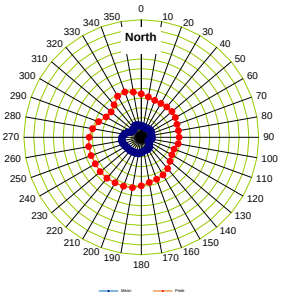
LOCATION 7



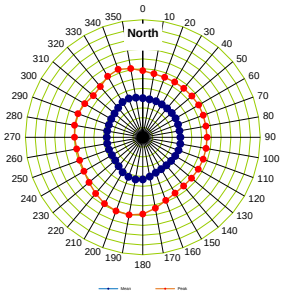
LOCATION 8



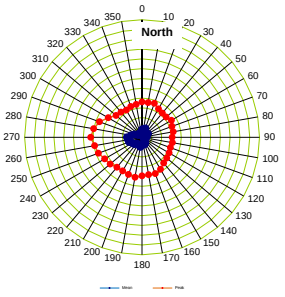
LOCATION 9



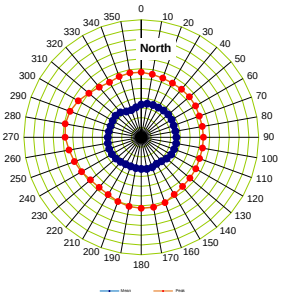
LOCATION 10



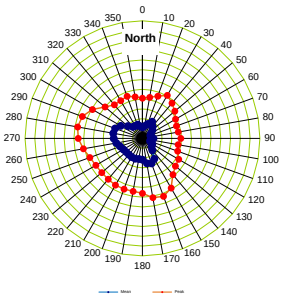
LOCATION 11



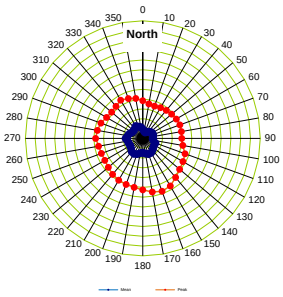
LOCATION 12



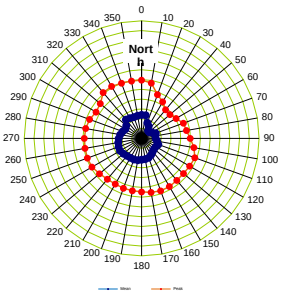
LOCATION 13



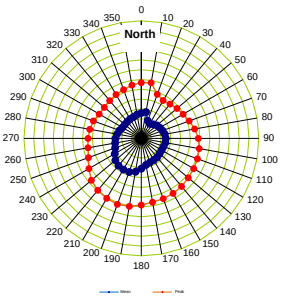
LOCATION 14



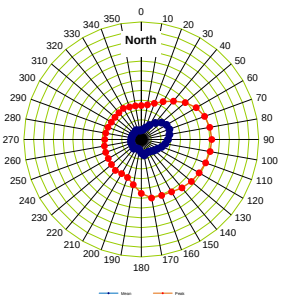
LOCATION 15



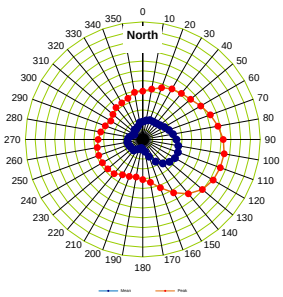
LOCATION 16



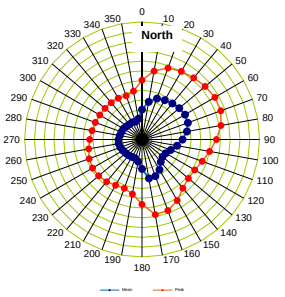
LOCATION 17



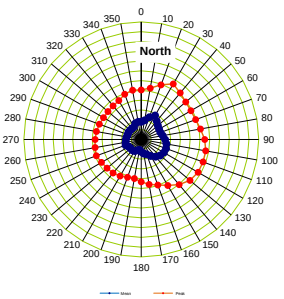
LOCATION 18



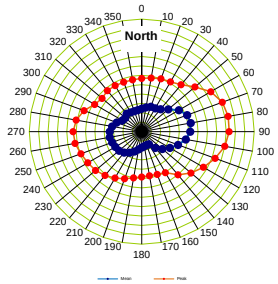
LOCATION 19



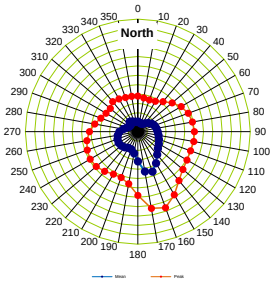
LOCATION 20



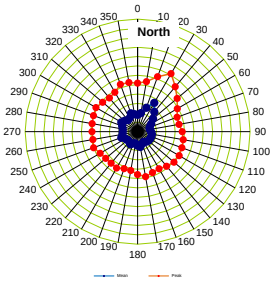
LOCATION 21



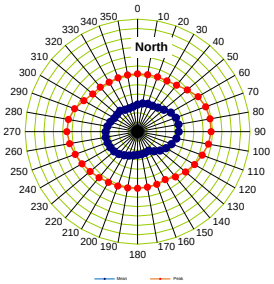
LOCATION 22



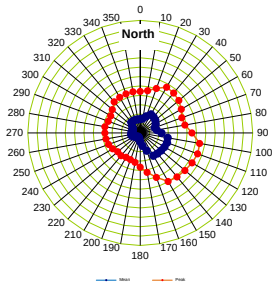
LOCATION 23



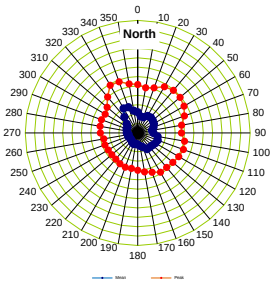
LOCATION 24



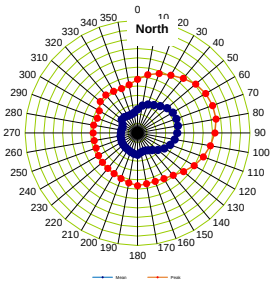
LOCATION 25



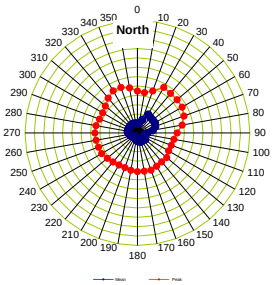
LOCATION 26



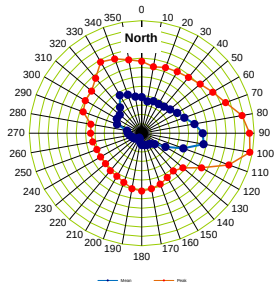
LOCATION 27



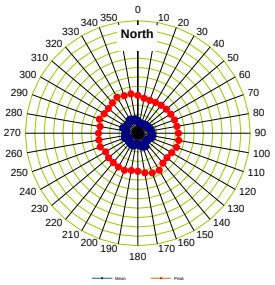
LOCATION 28



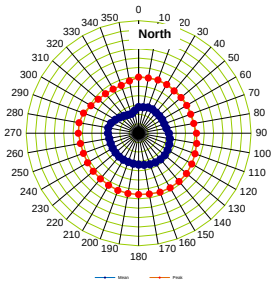
LOCATION 29



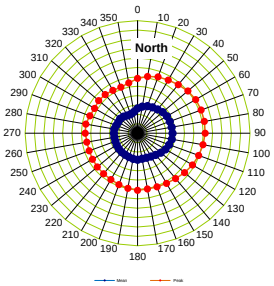
LOCATION 30



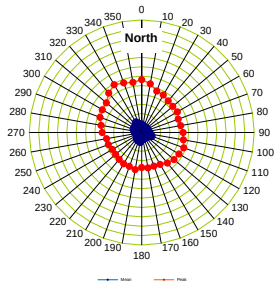
LOCATION 31



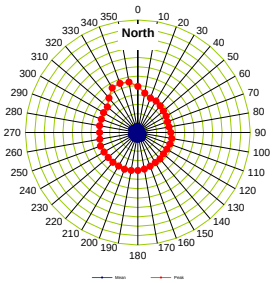
LOCATION 32



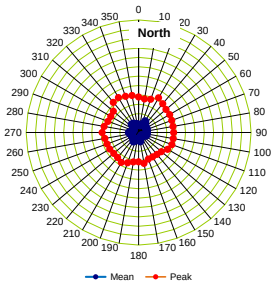
LOCATION 33



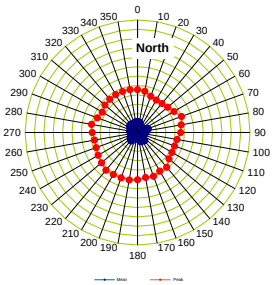
LOCATION 34



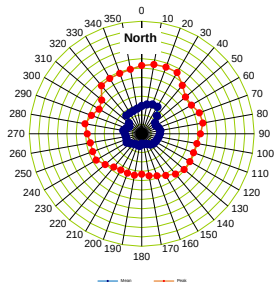
LOCATION 35



LOCATION 36



LOCATION 37



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

SYDNEY
2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
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
6/A Cambridge Street
Richmond, Nelson 7020
New Zealand
T: +64 274 898 628