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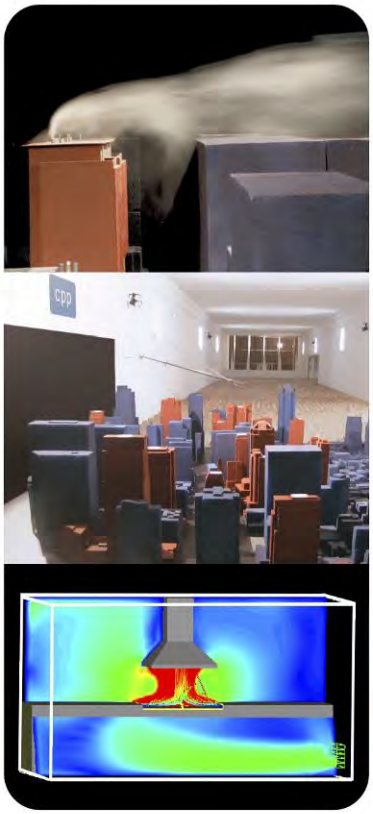
Final Report



Environmental Wind Tunnel Tests for:

SYDNEY 1
Sydney, NSW, Australia

CPP Project 8366
October 2016

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EXECUTIVE SUMMARY

A wind tunnel study of the proposed Sydney 1 development to be located in Sydney, NSW, Australia, was conducted to assess pedestrian wind comfort. A model of the project was fabricated to a 1:400 scale and centred on a turntable in the wind tunnel. Replicas of surrounding buildings within a 570 m radius were constructed and placed on the turntable.

The wind tunnel testing was performed in the natural boundary layer wind tunnel of Cermak Peterka Petersen Pty. Ltd., St. Peters. Approach boundary layers, representative of the environment surrounding the proposed development, were established in the test section of the wind tunnel. The approach wind flow had appropriate turbulence characteristics corresponding to a Suburban approach, as defined in Standards Australia (2011).

Measurements of winds likely to be experienced by pedestrians were made with a hot-film anemometer at 26 locations for 16 wind directions each. These points were tested around the development in the proposed configuration, focusing on access routes, doorways, and outdoor seating areas. The measurements were combined with site specific wind statistics to produce results of wind speed versus the percentage of time that wind speed is exceeded for each location. Selective locations were tested in the existing configuration for comparison.

The wind environment around the development was found to be generally suitable for pedestrian walking activities from a comfort perspective with reference to the Lawson criteria with individual locations rated as suitable for business walking only. Most locations passed the Lawson distress criteria except for a few locations exposed to prevailing winds from the north-east. The wind conditions on the ground plane were found to be similar to the existing conditions. The proposed buildings slightly redistribute the windy locations without deteriorating the general wind conditions around the site. Recommendations for wind amelioration are contained in the report.

DOCUMENT VERIFICATION

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LIST OF SYMBOLS

D	Characteristic dimension (building height, width, etc.), m
n	Mean velocity profile power law exponent
T_u	Turbulence intensity, U_{rms}/U
U	Local mean velocity, $m \cdot s^{-1}$
U_{ref}	Reference velocity at reference height z_{ref}, $m \cdot s^{-1}$
U_{pk}	Peak wind speed in pedestrian studies, $m \cdot s^{-1}$
U_{rms}	Root-mean-square of fluctuating velocity, $m \cdot s^{-1}$
z	Height above surface, m
ν	Kinematic viscosity of approach flow, $m^2 \cdot s^{-1}$
$\sigma( )$	Standard deviation of $( ), = ( )'_{rms}$
ρ	Density of approach flow, $kg \cdot m^{-3}$
$( )_{max}$	Maximum value during data record
$( )_{min}$	Minimum value during data record
$( )_{mean}$	Mean value during data record
$( )_{rms}$	Root mean square about the mean

1. INTRODUCTION

Pedestrian acceptability of footpaths, entrances, plazas, and terraces is an important design parameter of interest to the building owner and architect. Assessment of the acceptability of the pedestrian level wind environment is desirable during the project design phase so that modifications can be made, if necessary, to create wind conditions suitable for the intended use of the space.

Analytical methods such as computational fluid dynamics (CFD) are not capable, except in very simple geometries, to estimate wind pressures, frame loads, or windiness in pedestrian areas.

Techniques have been developed which permit boundary layer wind tunnel modelling of buildings to determine wind velocities in pedestrian areas. This report includes wind tunnel test procedures, test results, and discussion. Table 1 summarises the model configurations, test methods, and data acquisition parameters used. All the data collection was performed in accordance with Australasian Wind Engineering Society (2001), and American Society of Civil Engineers (1999, 2010).

Table 1: Configurations for data acquisition

General Information	
Model length scale	1:400
Surrounding model radius (full-scale)	570 m
Reference height (full-scale)	200 m AGL
Approach terrain category	Suburban approach, terrain category 3
Testing Configuration(s)	
Configuration A	Proposed Sydney 1 development with existing and approved surrounding buildings, as shown in Figure 3 and Figure 4. Pedestrian winds measured at 26 locations for 16 wind directions at 22.5° increments from 0° (north) Environmental winds measured at 3 locations for façade planting for 16 wind directions at 22.5° increments from 0° (north)
Configuration B	Existing 1 Alfred Street building (Goldfield House) with existing and approved surrounding buildings, as shown in Figure 5. Pedestrian winds measured at 6 locations for 16 wind directions at 22.5° increments from 0° (north)

2. THE WIND TUNNEL TEST

Modelling of the aerodynamic flow around a structure requires special consideration of flow conditions to obtain similitude between the model and the prototype. A detailed discussion of the similarity requirements and their wind tunnel implementation can be found in Cermak (1971, 1975, 1976). In general, the requirements are that the model and prototype be geometrically similar, that the approach mean velocity and turbulence characteristics at the model building site have a vertical profile shape similar to the full-scale flow, and that the Reynolds number for the model and prototype be equal. Due to modelling constraints the Reynolds number cannot be made equal and Australasian Wind Engineering Society Quality Assurance Manual (2001) suggests a minimum Reynolds number of 50,000, based on characteristic model dimension and wind velocity at the top of the model; in this study the modelled Reynolds number was over 50,000.

The wind tunnel test was performed in the boundary layer wind tunnel shown in Figure 1. The wind tunnel test section is 3.0 m wide, by 2.4 m high with a porous slatted roof for passive blockage correction. This wind tunnel has a 21 m long test section, the floor of which is covered with roughness elements, preceded by a vorticity generating fence and spires. The spires, barrier, and roughness elements were designed to provide a modelled atmospheric boundary layer approximately 1.2 m thick with a mean velocity and turbulence intensity profile similar to that expected to occur in the region approaching the modelled area. The approach wind characteristics used for the model test are shown in Figure 2, and are explained more fully in Section 4.1.1.

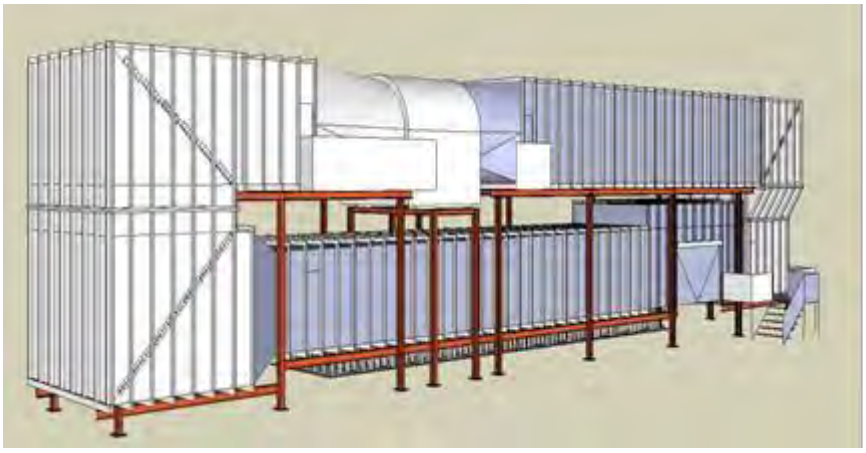

Figure 1: Schematic of the closed circuit wind tunnel

A model of the proposed development and surrounds to a radius of 570 m was constructed at a scale of 1:400, which was consistent with the modelled atmospheric flow, permitted a reasonable test model size with an adequate portion of the adjoining environment to be included in a proximity model, Figure 4 and Figure 5, and was within wind tunnel blockage limitations.

Significant variations in the building surface were formed into the model. The models were mounted on the turntable located near the downstream end of the wind tunnel test section. The turntable permitted rotation of the modelled area for examination of velocities from any approach wind direction. Additional photos of the testing are included in Appendix 1.

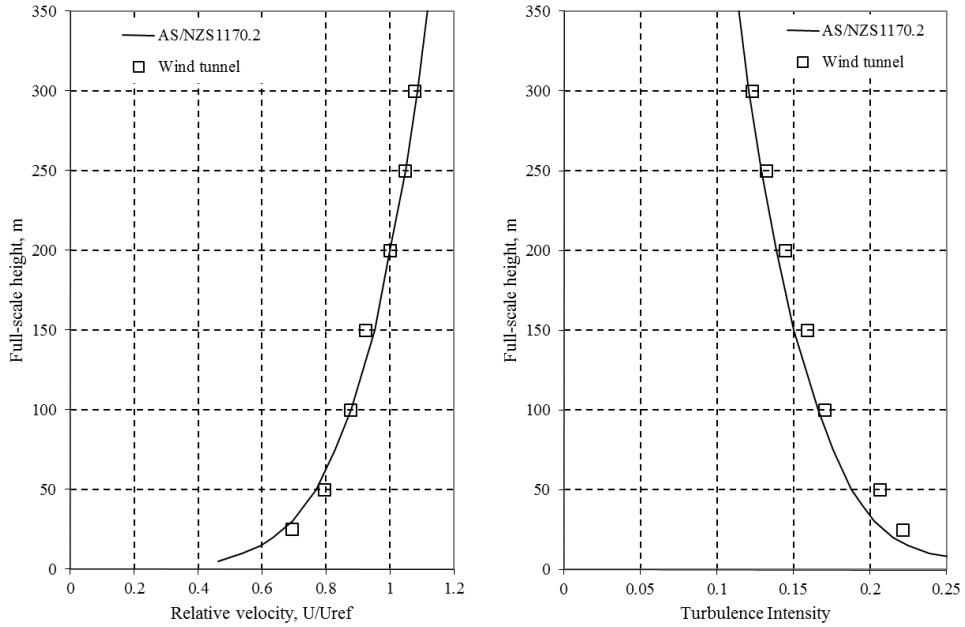

Figure 2: Mean velocity and turbulence profiles

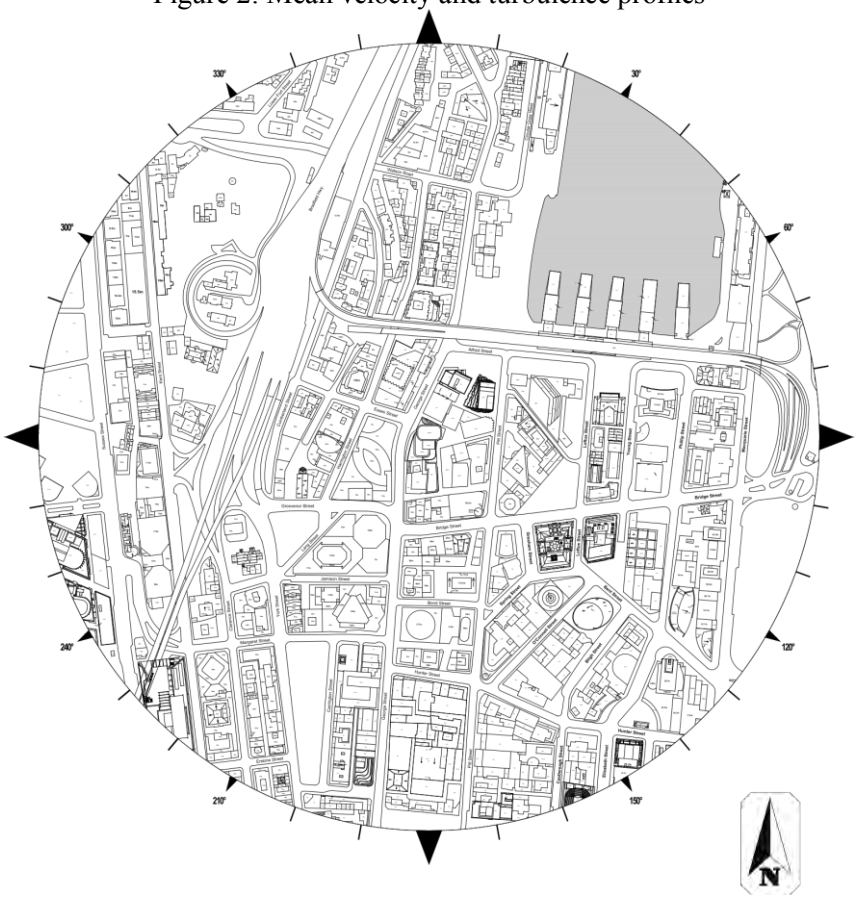

Figure 3: Project location and turntable layout – Configuration A

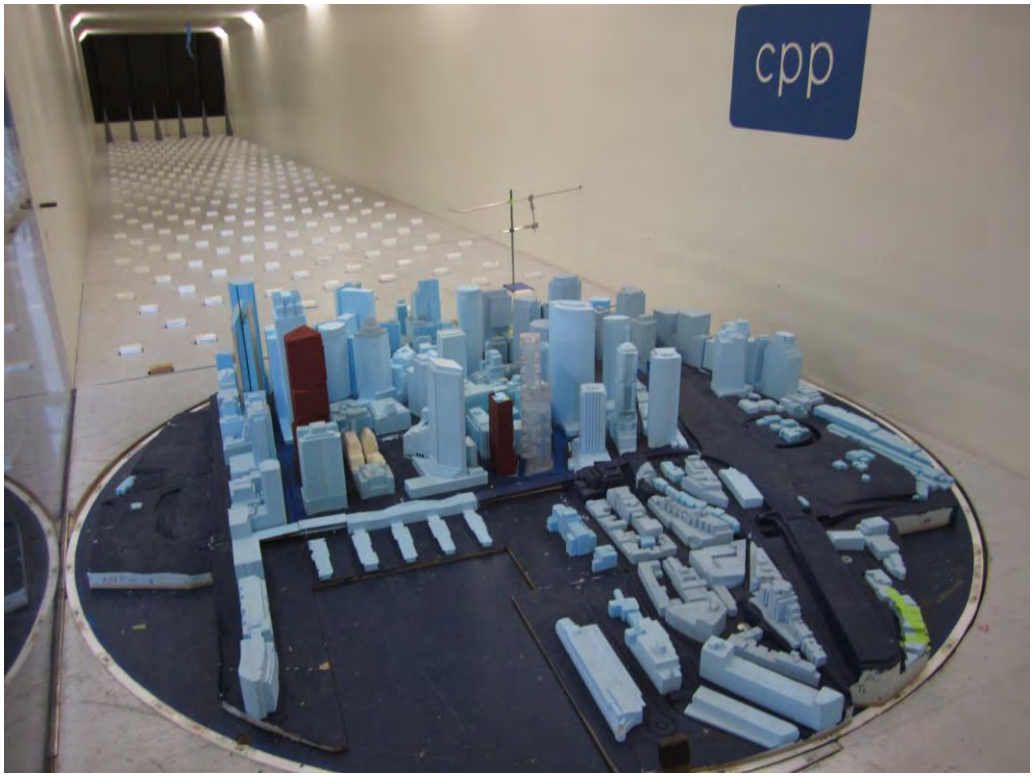

Figure 4: Proposed Sydney 1 model in the wind tunnel viewed from the north – Configuration A

Figure 5: Existing Goldfield House model in the wind tunnel viewed from the north – Configuration B

3. ENVIRONMENTAL WIND CRITERIA

Over the years, a number of researchers have added to the knowledge of wind effects on pedestrians by suggesting criteria for comfort and safety. Because pedestrians will tolerate higher wind speeds for a smaller period of time than for lower wind speeds, these criteria provide a means of evaluating the overall acceptability of a pedestrian location. Also, a location can be evaluated for its intended use, such as for an outdoor café or a footpath. One of the most widely accepted set of criteria was developed by Lawson (1990), which is described in Table 2.

The current City of Sydney (2012) DCP specifies wind effects not to exceed 16 m/s, and 10 m/s for active frontage, which would be applicable for this site. There are few street locations in Sydney that would meet this criterion without some level of shielding to improve the wind conditions. From discussions with Council this is a once per annum gust wind speed similar to the wind criteria in City of Sydney (2011) DCP, but is meant to be interpreted as a comfort level criterion to promote outdoor café style activities and is not intended to be used as a distress requirement. The once per annum gust wind speed criterion is based on the work of Melbourne (1978), and the 16 m/s level is classified as acceptable for pedestrian walking along a main accessway, and 10 m/s level is classified as generally acceptable for use for pedestrian sitting. This criterion gives the once per annum (actually 0.1% of the time) gust wind speed, and uses this as an estimator of the general conditions at a site, which may be more relevant. To combat this limitation, as well as the once per annum maximum gust wind speed, this study is based upon the criteria of Lawson (1990), which are described above. Assessment using the Lawson criteria provides a similar comfort classification as using the once per annum gust criteria, which is the basis of the City of Sydney (2012) DCP; however, it also provides significantly more information regarding the serviceability wind climate.

Lawson's criteria have categories for comfort, based on wind speeds exceeded five percent of the time, allowing planners to judge the usability of locations for various intended purposes ranging from "Business Walking" to "Pedestrian sitting". The level and severity of these comfort categories can vary based on individual preference, so calibration to the local wind environment is recommended when evaluating the Lawson ratings. The criteria also include a distress rating, for safety assessment, which is based on occasional (once or twice per year) wind speeds[1]. In both cases, the wind speed used the larger of a mean or gust equivalent-mean (GEM) wind speed. The GEM is defined as the peak gust

[1] The rating of "uncomfortable" in Table 2 is the word of the acceptance criteria author and may not apply directly to any particular project. High wind areas are certainly not uncomfortable all the time, just on windier days. The word uncomfortable, in our understanding, refers to acceptability of the site by pedestrians for typical pedestrian use; i.e., on the windiest days, pedestrians will not find the areas "acceptable" for walking and will tend to avoid such areas if possible. The distress rating fail indicates some unspecified potential for causing injury to a less stable individual who might be blown over. The likelihood of such events is not well described in the literature and is likely to be strongly affected by individual differences, presence of water, blowing dust or particulates, and other variables in addition to the wind speed.

wind speed divided by 1.85; this is intended to account for locations where the gustiness is the dominant characteristic of the wind. Assessment using the Lawson criteria provides a similar classification as using once per annum gust criteria, however provides significantly more information regarding the serviceability wind climate.

Table 2: Summary of Lawson criteria

Comfort (maximum of mean or gust equivalent mean ($GEM^{+,}$) wind speed exceeded 5% of the time)	
< 4 m/s	Pedestrian Sitting (considered to be of long duration)
4 - 6 m/s	Pedestrian Standing (or sitting for a short time or exposure)
6 - 8 m/s	Pedestrian Walking
8 - 10 m/s	Business Walking (objective walking from A to B or for cycling)
> 10 m/s	Uncomfortable
Distress (maximum of mean or GEM wind speed exceeded 0.022% of the time)	
<15 m/s	not to be exceeded more than two times per year (or one time per season) for general access area
<20 m/s	not to be exceeded more than two times per year (or one time per season) where only able bodied people would be expected; frail or cyclists would not be expected

Note: $^{+,}$ The gust equivalent mean (GEM) is the peak 3 s gust wind speed divided by 1.85.

4. DATA ACQUISITION AND RESULTS

4.1 Velocities

Velocity profile measurements were taken to verify that appropriate boundary layer flow approaching the site was established and to determine the likely pedestrian level wind climate around the test site. Pedestrian wind measurements and analysis are described in Section 4.1.2. All velocity measurements were made with hot-film anemometers, which were calibrated against a Pitot-static tube in the wind tunnel. The calibration data were described by a King's Law relationship (King, 1914)

4.1.1 Velocity Profiles

Mean velocity and turbulence intensity profiles for the boundary layer flow approaching the model are shown in Figure 2. Turbulence intensities are related to the local mean wind speed. These profiles have the form as defined in Standards Australia (2011) and are appropriate for the approach conditions.

4.1.2 Pedestrian Winds

The proposed development is located to the north of the Sydney CBD overlooking Circular Quay, Figure 3; on the block surrounded by George, Alfred, Pitt, and Dalley Streets. The development is surrounded by the high-rise buildings of the Sydney CBD with the Sydney Harbour and Circular Quay to the north. The site is consequently exposed to prevailing winds from the north.

For this report wind speed measurements were recorded at 26 locations to evaluate pedestrian comfort in and around the project site, Figure 7 to Figure 15. All points tested were for the configurations described in Table 1. Wind speed measurements were made at the model scale equivalent of 1.5 to 2.1 m above the surface for 16 wind directions at 22.5° intervals. Locations were chosen to determine the degree of pedestrian comfort on adjacent pavements with pedestrian traffic including near building corners where relatively severe conditions are frequently found, near building entrances, and on site outdoor recreational areas.

The hot-film signal was sampled for a period corresponding to one hour in prototype. All wind speed data were digitally filtered to obtain the two to three second running mean wind speed at each point; this is the minimum size of a gust affecting a pedestrian and is the basis for the various acceptability criteria.

These local wind speeds, U, were normalised by the tunnel reference velocity U_{ref}. Mean and turbulence statistics were measured and used to calculate the normalised effective peak gust using:

$$\frac{U_{pk}}{U_{ref}} = \frac{U + 3 \cdot U_{rms}}{U_{ref}} .$$

The mean and gust equivalent mean velocities relative to the free stream wind tunnel reference velocity at a full-scale elevation of 200 m are plotted in polar form in Appendix 2. The graphs show wind speed ratio and the approach wind direction for which that measurement was taken. The polar plots aid in visualisation of the effects of the nearby structures or topography, the relative significance of various wind azimuths, and whether the mean or gust wind speed is of greater importance.

To enable a quantitative assessment of the wind environment, the wind tunnel data were combined with wind frequency and direction information measured by the Bureau of Meteorology at a standard height of 10 m at Sydney Airport from 1995 to 2015, Figure 6.

From these data, directional criterion lines for the Lawson rating wind speeds have been calculated and included on the polar plots in Appendix 2; this gives additional information regarding directional sensitivity at each location.

The criteria of Lawson consider the integration of the velocity measurements with local wind climate statistical data summarized in Figure 6 to rate each location. From the cumulative wind speed distributions for each location, the percentage of time each of the Lawson comfort rating wind speeds are exceeded are presented in tabular form under the polar plots in Appendix 2. In addition to the rating wind speeds, the percentage of time that 2 m/s is exceeded is also reported. This has been provided as it has been found that the limiting wind speed for long-term stationary activities such as fine outdoor dining should be about 2 to 2.5 m/s rather than 4 m/s.

Interpretation of these wind levels can be aided by the description of the effects of wind of various magnitudes on people. The earliest quantitative description of wind effects was established by Sir Francis Beaufort in 1806, for use at sea; the Beaufort scale is reproduced in Table 3 including qualitative descriptions of wind effects.

The tables in Appendix 2 additionally provide the wind speed exceeded 5% and 0.022% of the time for direct comparison with the Lawson comfort and distress criteria and the associated Lawson ratings for both mean and GEM wind speeds. A colour coded summary assessment of pedestrian comfort and safety with respect to the Lawson criteria is presented in Figure 7 to Figure 15, for each test location. The implications of the results are discussed in Section 5.

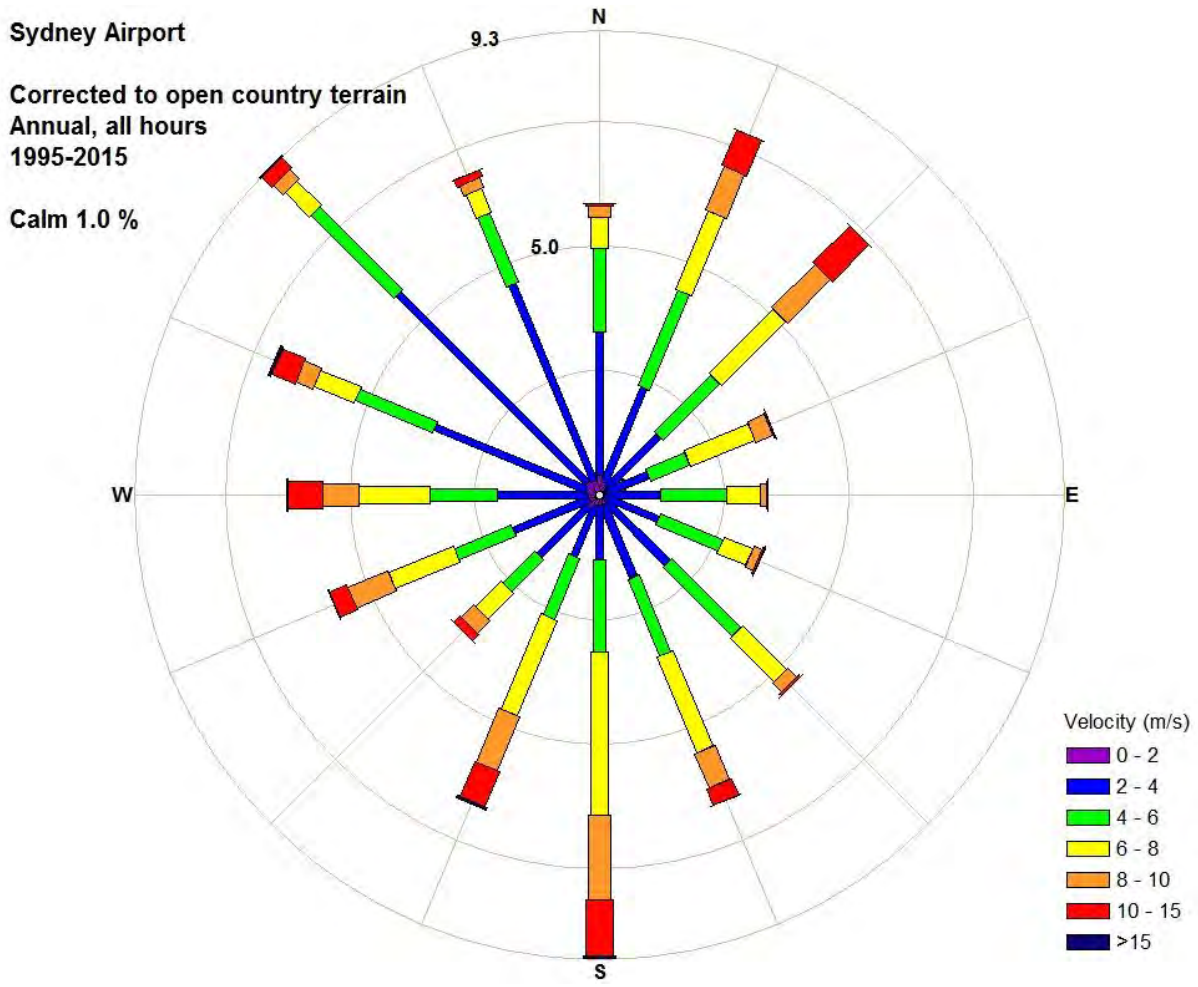

Figure 6: Wind rose of direction and speed for Sydney Airport

Table 3: Summary of wind effects on people, Penwarden (1973)

Description	Beaufort Number	Speed (m/s)	Effects
Calm, light air	0, 1	0–2	Calm, no noticeable wind.
Light breeze	2	2–3	Wind felt on face.
Gentle breeze	3	3–5	Wind extends light flag. Hair is disturbed. Clothing flaps
Moderate breeze	4	5–8	Raises dust, dry soil, and loose paper. Hair disarranged.
Fresh breeze	5	8–11	Force of wind felt on body. Drifting snow becomes airborne. Limit of agreeable wind on land.
Strong breeze	6	11–14	Umbrellas used with difficulty. Hair blown straight. Difficult to walk steadily. Wind noise on ears unpleasant. Windborne snow above head height (blizzard).
Near gale	7	14–17	Inconvenience felt when walking.
Gale	8	17–21	Generally impedes progress. Great difficulty with balance in gusts.
Strong gale	9	21–24	People blown over by gusts.

5. DISCUSSION

The wind climatology chart of Figure 6 indicates that the most frequent strong winds are from the south quadrant and to a lesser extent the west and north-east quadrant. The locations tested around the development site are susceptible to winds from the different directions, depending on the relative location of the point tested to the geometry of the proposed development and surrounds. The influence of wind direction on the suitability of a location for an intended purpose can be ascertained from the graphs in Appendix 2.

A summary of the target criteria based on the intended use of the space for the pedestrian level measurement locations and the wind tunnel results including the Lawson comfort and safety ratings is provided in Table 4.

The primary conclusions of the pedestrian study can be understood by reviewing the colour coded images of Figure 7 to Figure 15, which depict the locations selected for investigation of pedestrian wind comfort along with the Lawson criteria rating for both comfort and distress. The central colour indicates the comfort rating for the location, and the colour of the outer ring indicates whether the location passes the distress criterion.

Note that testing was performed without planned trees, or other plantings to provide a worst case assessment; heavy landscape planting typically reduces the wind speeds by less than 10%. Mitigation measures are likely to be required for red locations, and may be necessary for other locations depending on the intended use of the space. Although conditions may be classified acceptable there may be certain wind directions that cause regular strong events, these can be determined by an inspection of the plots in Appendix 2.

The wind conditions in the locations remote to the site are presented in Figure 7. Wind conditions at Locations 1 to 3 are classified as suitable for pedestrian walking, standing, and sitting, respectively. These surrounding locations give a general indication of the surrounding wind climate and can be used for comparison to the wind environment in and around the development.

In the surrounding area of the proposed development the wind conditions at pedestrian level are generally classified as suitable for pedestrian standing and walking under Lawson, Figure 8. Test location 6 exceeds the walking comfort criterion and is classified as suitable for business walking.

The test locations along George Street, Locations 4 to 7, experience strong street level winds especially for winds from the north-east quadrant. For these directions a combination of downwash off

the proposed development and channelling along George Street impacts these locations. Channelling winds also impact these locations for winds from the south-west quadrant.

Table 4: Summary of target criteria and wind tunnel results

Location	Target		Wind Tunnel Results			Notes
	Comfort rating	5% exceedance wind speed /m/s	Lawson comfort rating	5% exceedance wind speed /m/s	Lawson safety rating	
1	Ped. Walking	8	Ped. Walking	7.1	pass	
2	Ped. Walking	8	Ped. Sitting	3.9	pass	
3	Ped. Walking	8	Ped. Standing	4.3	pass	
4	Ped. Walking	8	Ped. Walking	7.8	able bodied	slightly exceeding existing conditions in 4.1, better than existing conditions in nearby locations 5.1 and 6.1
5	Ped. Walking	8	Ped. Walking	6.2	pass	
6	Ped. Walking	8	Business Walking	9.4	able bodied	slightly better than exisiting conditions in 6.1
7	Ped. Walking	8	Ped. Walking	6.7	pass	
8	Ped. Walking	8	Ped. Standing	4.6	pass	
9	Ped. Walking	8	Ped. Standing	4.1	pass	
10	Ped. Walking	8	Ped. Standing	5.9	pass	
11	Ped. Walking	8	Ped. Walking	6.2	pass	
12	Ped. Sitting	4	Ped. Sitting	3.0	pass	
13	Ped. Walking	8	Ped. Standing	4.7	pass	
14	Ped. Sitting	4	Ped. Walking	7.3	pass	local screening required to achieve sitting criterion
15	Ped. Sitting	4	Ped. Standing	5.1	pass	local screening required to achieve sitting criterion
16	Ped. Walking	8	Ped. Walking	6.3	pass	
17	Ped. Walking	8	Business Walking	9.3	able bodied	significant screening required on northern side of area between Tower A and Tower B
18	Ped. Walking	8	Ped. Standing	4.1	pass	
19	Ped. Sitting	4	Ped. Standing	5.2	pass	screening on western side of balcony can improve conditions
20	Ped. Sitting	4	Ped. Sitting	3.3	pass	
21	Ped. Sitting	4	Ped. Sitting	4.0	pass	
22	Ped. Walking	8	Ped. Walking	8.0	pass	
23	Ped. Sitting	4	Ped. Sitting	3.4	pass	
24	Ped. Sitting	4	Outdoor Dining	1.8	pass	
25	Ped. Sitting	4	Ped. Sitting	2.3	pass	
26	Ped. Sitting	4	Ped. Sitting	2.8	pass	

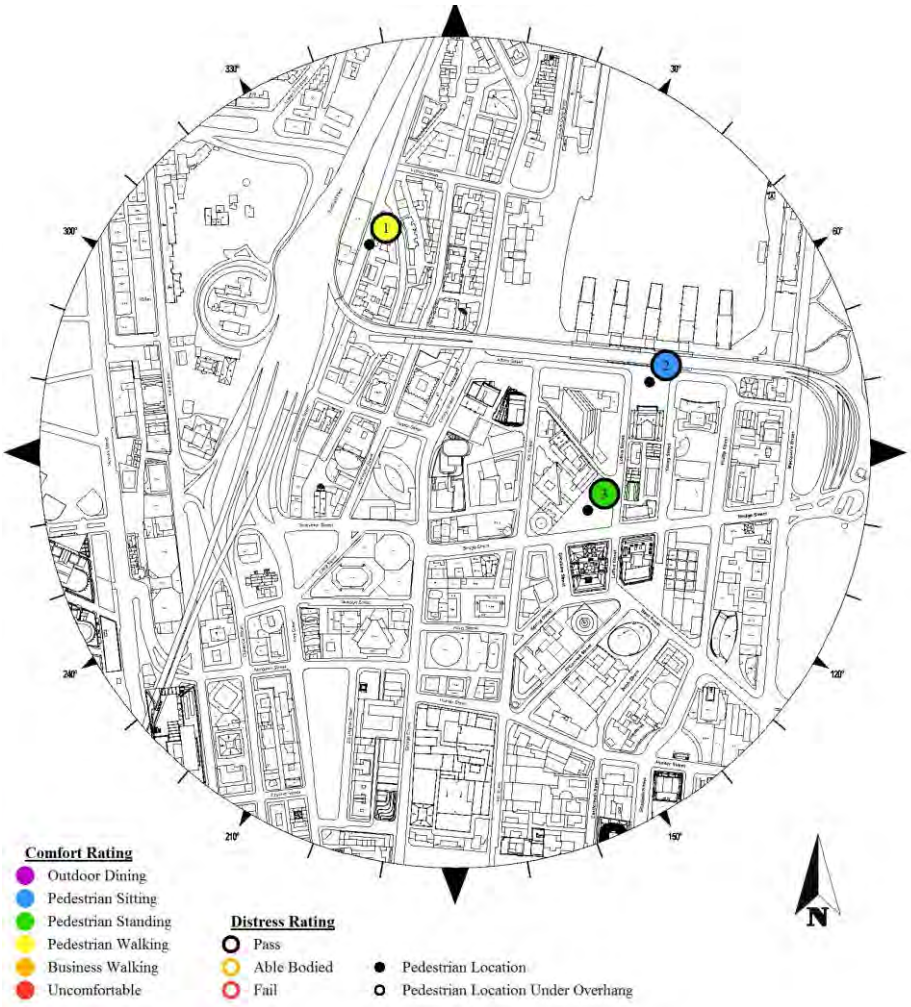

Figure 7: Pedestrian wind speed measurement locations with comfort/distress ratings – Configuration A Remote locations

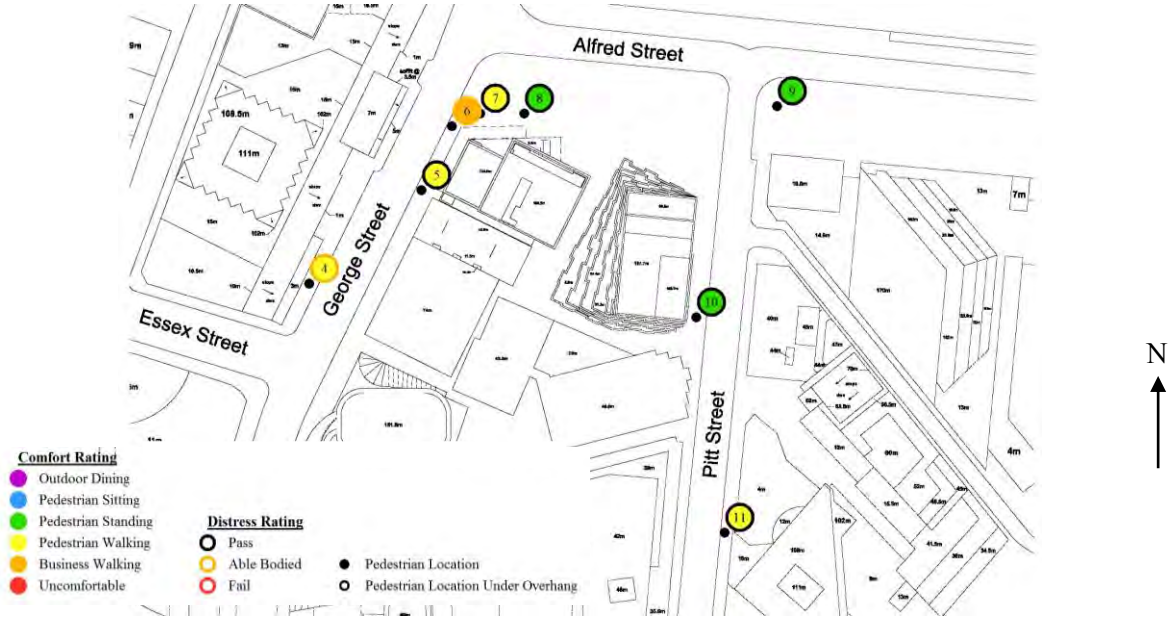

Figure 8: Pedestrian wind speed measurement locations with comfort/distress ratings – Configuration A surrounding locations

Test Locations 8 and 9 on the northern side of the proposed development, and Location 10 to the east of Tower B, experience calmer conditions and are rated as suitable for standing activities. Location 11 further south on Pitt Street was found to meet the pedestrian walking criteria, as it is experiences windy conditions for channelled winds from the north-east quadrant; similar to the locations on George Street.

From a safety perspective, all locations pass the Lawson safety criterion, with the exception of Locations 4 and 6 along George Street, which achieve a safety rating as suitable for able bodied pedestrians.

In comparing the pedestrian level wind conditions in the proposed configuration with those in the existing configuration, it is found that the conditions are generally similar and slightly improved in individual locations, Figure 9. In this exposed location, the change in massing and geometry of the buildings is essentially rearranging the overall flow pattern into George and Pitt Streets for winds from the north.

In the existing configuration, the test locations along George and Pitt Street are rated as suitable for pedestrian walking and business walking from a comfort perspective under Lawson. Location 4.1 shows slightly improved wind conditions than Location 4 in the proposed configuration, as it marginally passes the Lawson distress criterion. Locations 5.1 and 10.1, however, show worse wind conditions in the existing configuration than they do with the proposed buildings; with both locations only achieving an able bodied distress classification, and pedestrian walking rather than pedestrian standing for comfort. Locations 6.1, 9.1, and 11.1 were found to have similar classifications in the existing and proposed configuration. Location 11.1 marginally exceeds the distress criterion and is rated as suitable for able bodied pedestrians.

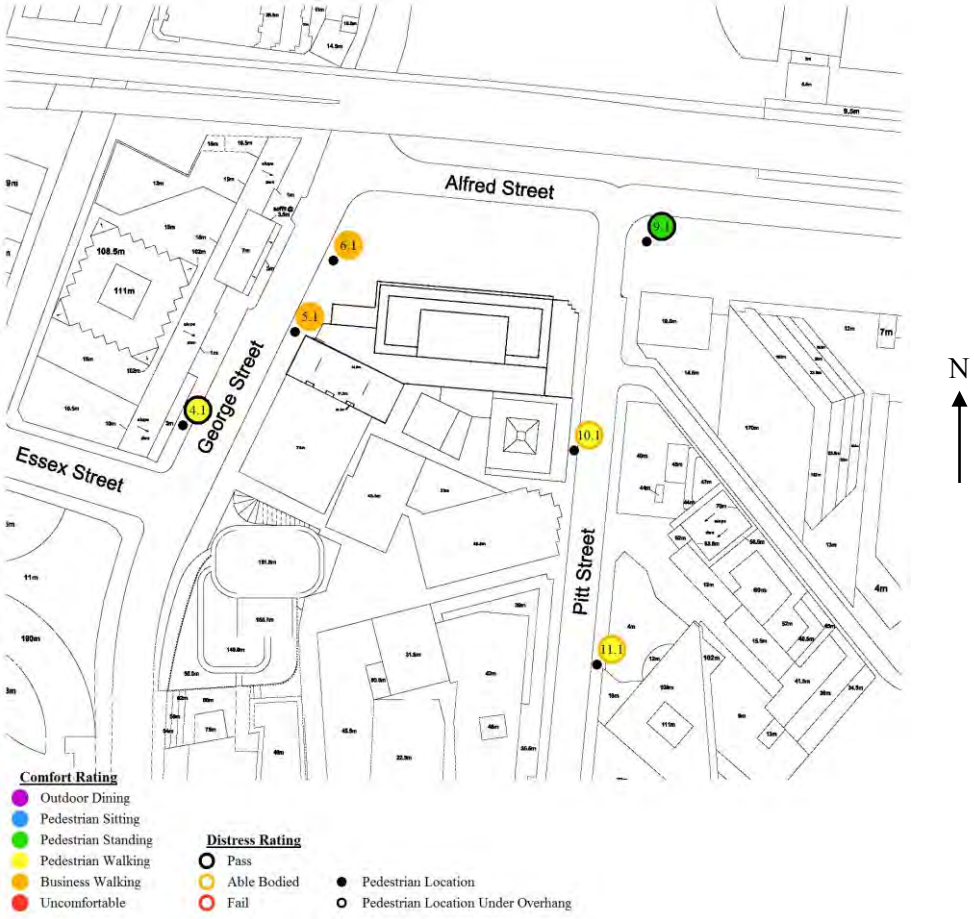

Figure 9: Pedestrian wind speed measurement locations with comfort/distress ratings – Configuration B surrounding locations

The test locations close to the proposed towers achieve Lawson comfort ratings from pedestrian seating to business walking, Figure 10. Some locations will require local wind mitigation measures to be suitable for the intended purpose.

The proposed seating area to the north of Tower A around Location 12 is classified as suitable for pedestrian sitting, while the planned seating area north of Tower B only achieves pedestrian standing and walking ratings at Locations 14 and 15. These areas are exposed for winds from the north quadrant that pass through the seating areas before channelling down Pitt Street and between Tower A and Tower B, and would need local vertical screening to meet the intended use of the space and be suitable as café style pedestrian seating areas.

The thoroughfare between Tower A and Tower B is rated as suitable for pedestrian standing at either end of the link at Locations 13 and 18, Figure 10. However, a strong pressure driven flow for winds from the north-east, leads to high mean wind speeds in the area directly between the towers. Location 17 is rated as suitable for business walking and exceeds the Lawson safety criterion with an able bodied rating. From flow visualisation, winds from the north-east are channelled between the two

towers and disperse over the top of the low-rise building at 176 George Street and these conditions would be expected to occur for about half the length of the laneway.

It is highlighted that the wind conditions at this location are not significantly altered by the proposed design of the towers when compared with the currently approved Stage 1 design. The minor reduction in the distance between Tower A and Tower B is not expected to cause a notable difference of the wind conditions in this thoroughfare. It is expected that the inclusion of the proposed Lend Lease Circular Quay tower to the south of the site together with the open plaza at 182 George Street will provide a slight improvement of the wind conditions at this location. It is reiterated that this exposed section of the city is already windy and changing the building massing on the city fringe, will redistribute the flows down the various north-south streets.

The area in front of the main entrance to the hotel in Tower B under the awning on the eastern side is rated as suitable for pedestrian walking in Location 16, which is considered suitable for the intended purpose. Strong winds from the north-east quadrant channelling down Pitt Street cause windy conditions in this area.

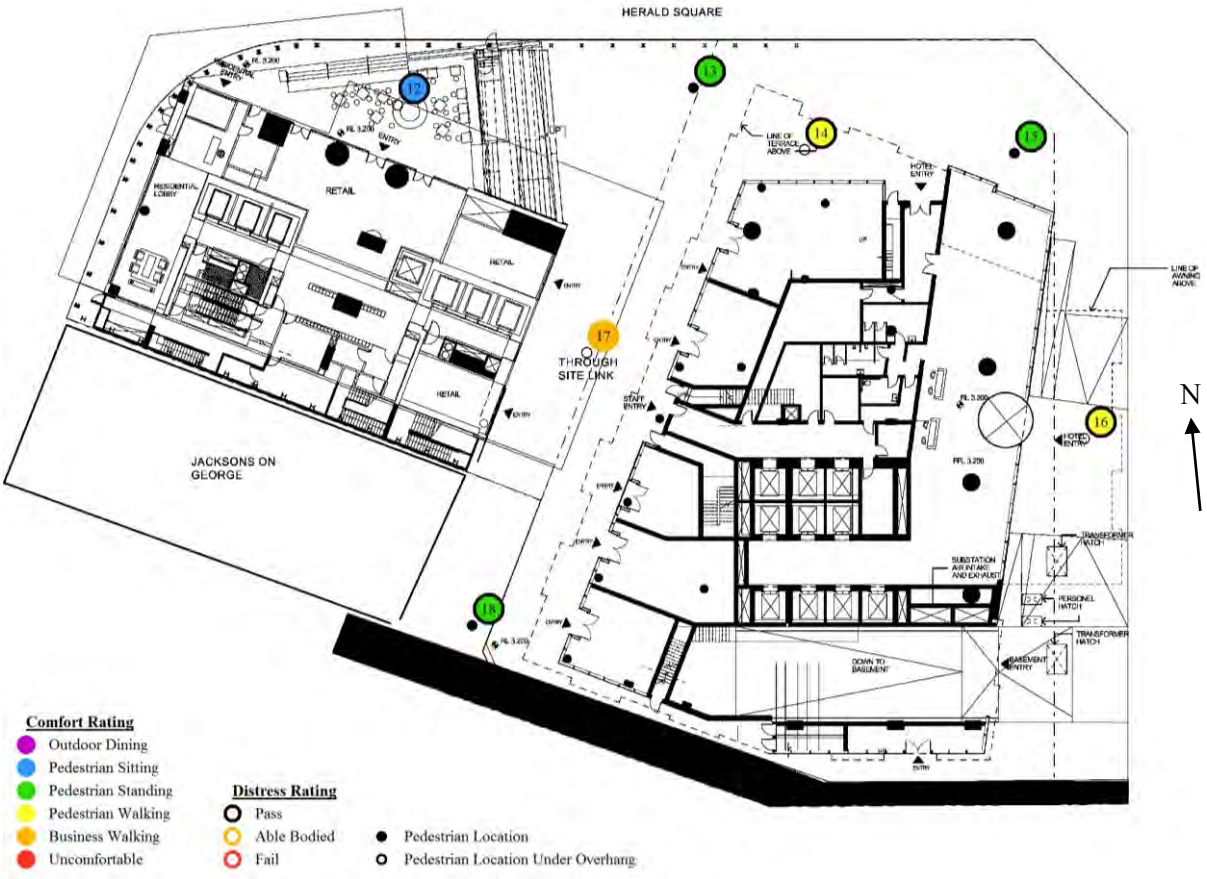

Figure 10: Pedestrian wind speed measurement locations with comfort/distress ratings – Configuration A close locations

The wind conditions at Location 19, on the Level 36 balcony of Tower A, are rated as suitable for pedestrian standing and pass the distress criterion, Figure 11. Winds from the north-west quadrant and to a lesser extent from the north-east quadrant cause windy conditions on the balcony. The wind conditions on this balcony are generally better than most balconies at this height in the Sydney CBD with wind speeds below 2 m/s for comfortable outdoor sitting conditions at Location 19 for 62% of the time. If required by the residents, increasing the height of the balustrade to approximately 2 m on the western side of the balcony could be considered, but this would only improve the wind conditions in the vicinity of the screen. It should be noted that the wind conditions closer to the building walls than the test location are expected to be calmer than at the test location, while the conditions closer to the balustrade will generally be windier. The owner would quickly determine how to best use the external balcony space for their intended use.

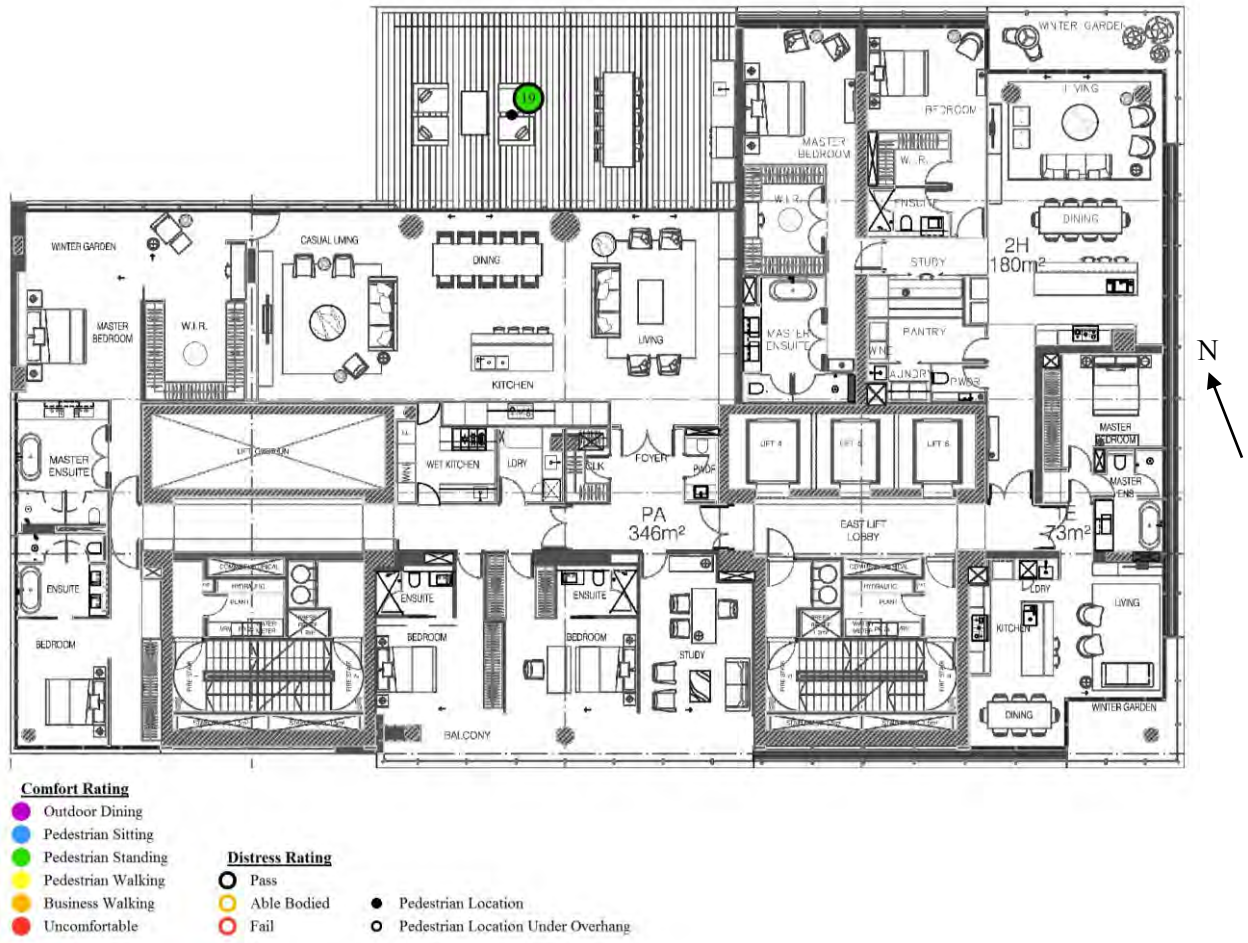

Figure 11: Pedestrian wind speed measurement locations with comfort/distress ratings – Configuration A Tower A Level 36

Wind conditions on the Level 39 terrace of Tower A were found to be suitable for pedestrian sitting under Lawson at Locations 20 and 21, Figure 12, which is considered exceptionally good for an open terrace at this height in the Sydney CBD. The awning covering the terrace, as well as the balustrade,

protect the eastern part of the terrace and provide for relatively calm conditions at this height on the building. Further away from the building west façade in the landscaped area around Location 22, wind conditions were rated as suitable for pedestrian walking and exceed the Lawson safety criterion with an able bodied rating. From inspection of the polar plot in Appendix 2, these wind conditions are expected to occur over the western half of the terrace, however increasing the height of the balustrade would only improve conditions in the immediate vicinity of the balustrade. The main outdoor sitting areas on this terrace are on the eastern side, and it is recommended that residents keep furniture items on this part of the terrace.

Figure 12: Pedestrian wind speed measurement locations with comfort/distress ratings – Configuration A Tower A Level 39

Location 23 on the rooftop terrace is rated as suitable for pedestrian sitting, Figure 13. The terrace is well protected by full height façade balustrade to the north, east, and west. All test locations on terraces and balconies in Figure 11 to Figure 14 except Location 22 pass the distress criterion.

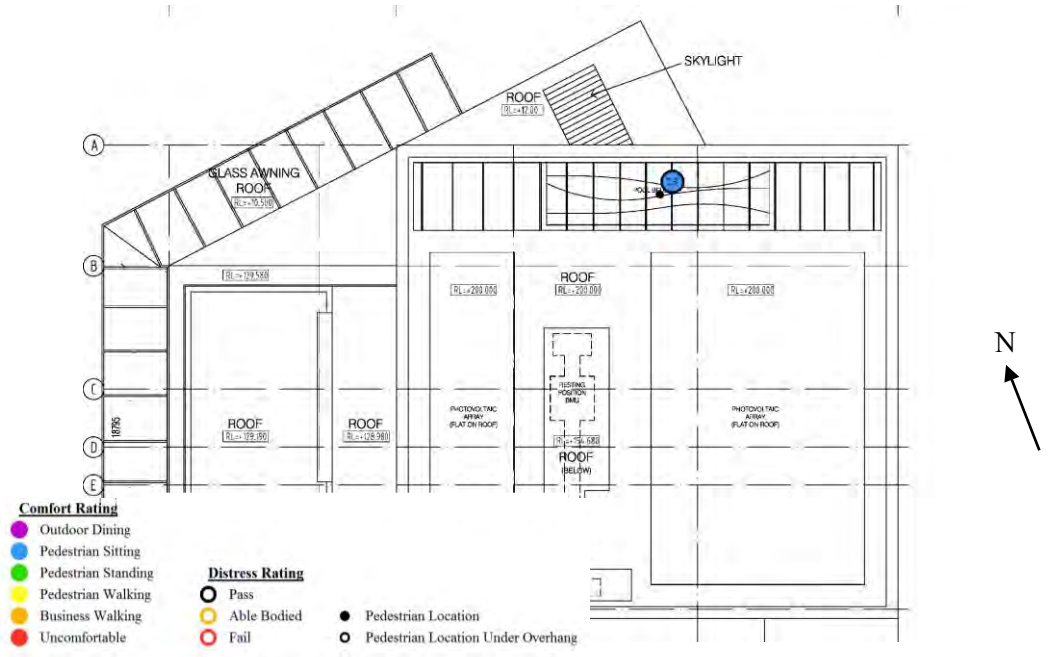

Figure 13: Pedestrian wind speed measurement locations with comfort/distress ratings – Configuration A Tower A Roof

Tower B has an open accessible terrace at roof level and an open bar terrace a level below on the northern side of the tower, Figure 14. The façade around both terraces reaches up to roof height and hence provides considerable shielding against strong winds for the terrace locations. The top level terrace is rated as suitable for pedestrian sitting; Location 26 was tested covered by an awning, and Location 25 was not covered. With the awning extending over the entire roof level terrace, the wind conditions in Location 25 are likely to be slightly improved. The open sky bar terrace on the level below, Location 24, is rated as suitable for outdoor dining. All locations pass the distress criterion.

Figure 14: Pedestrian wind speed measurement locations with comfort/distress ratings – Configuration A Tower B Roof

Measurements were taken at three locations around Tower B to assess the wind conditions for planting. From previous testing with a landscape architect in the wind tunnel, a suitable plant criterion would be between pedestrian standing and walking depending on the species. Test Location 27 on the roof of Tower B, was found to be subjected to high wind speeds from the north-east and south quadrants. The detailed results for this location in Appendix 2 show that the wind speeds in this location exceed 9.1 m/s at 5% of the time and the once per annum wind speed was found to be 21 m/s. Wind conditions here exceed the plant criterion established on a previous project and any plants in this location will need to be extremely resistant to high wind speeds.

Planting is proposed on the lower façade Tower B; shown in dark grey in Figure 15. Measurements were taken at two representative locations that are expected to be among the most exposed locations intended for façade planning, Locations 28 and 29. Both locations are classified as pedestrian walking under Lawson with a 5% exceedance wind speed of 6.6 m/s and 7.1 m/s, respectively. The wind conditions along these facades are not as extreme as in the intended planting areas on the roof, but would still require wind resistant planting based on previous studies.

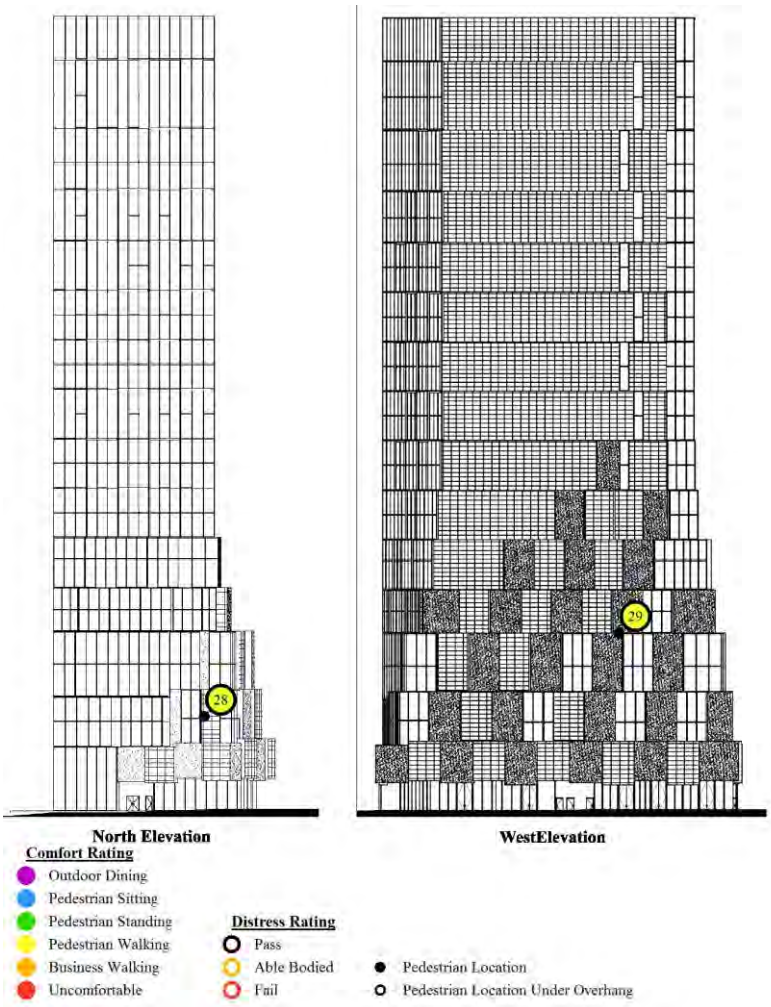

Figure 15: Pedestrian wind speed measurement locations with comfort/distress ratings – Tower B Green Façade Locations

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Appendix 1: Additional photographs of the CPP wind tunnel model

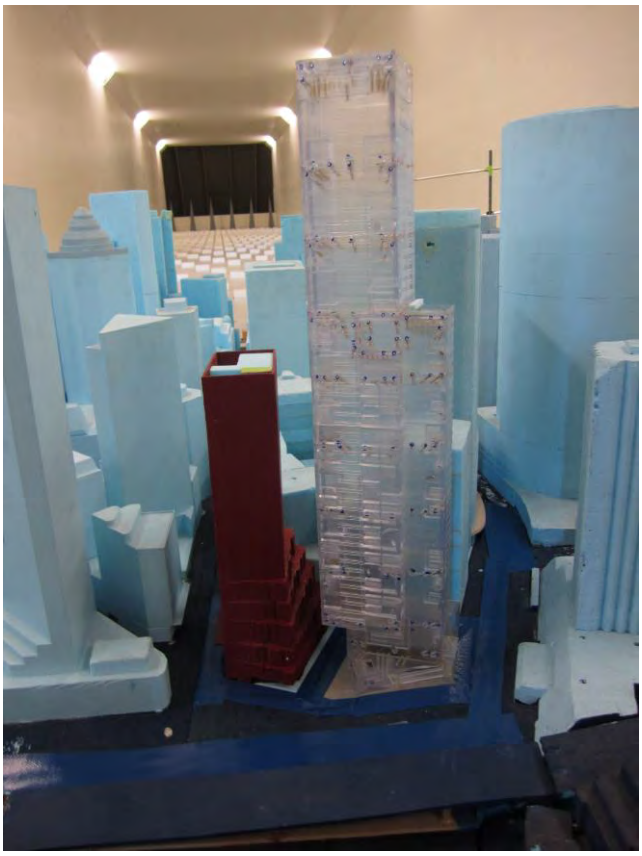
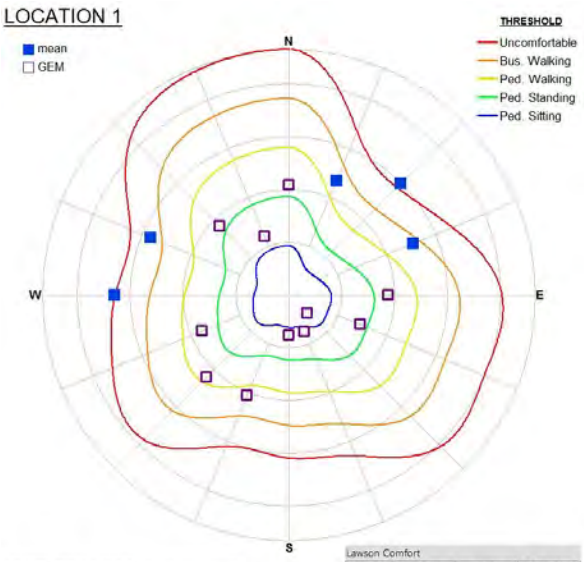


Figure 16: Proposed Sydney 1 development model viewed from the north

Figure 17: Existing 1 Alfred Street (Goldfield House) model viewed from the north

Appendix 2: Directional Wind Results

LOCATION 1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	46.53	53.27	54.79
4	19.97	20.71	23.05
6	9.06	6.22	9.62
8	3.19	1.45	3.26
10	0.98	0.24	0.99

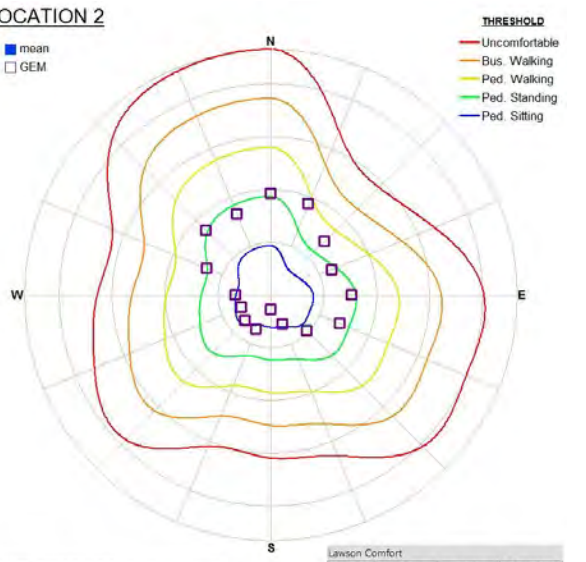
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	7.1	6.2	7.1
Rating	Ped Walking	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	14.2	12.2	14.2
Rating	Pass	Pass	Pass

LOCATION 2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	17.36	28.89	28.89
4	1.92	4.86	4.86
6	0.06	0.39	0.39
8	0.00	0.01	0.01
10	0.00	0.00	0.00

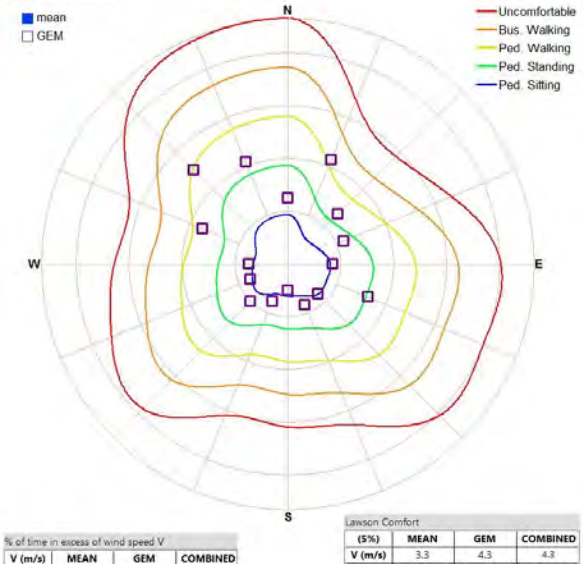
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.1	3.9	3.9
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.4	7.7	7.7
Rating	Pass	Pass	Pass

LOCATION 3



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	21.45	34.68	34.68
4	2.58	6.68	6.68
6	0.39	1.40	1.40
8	0.11	0.21	0.21
10	0.03	0.04	0.04

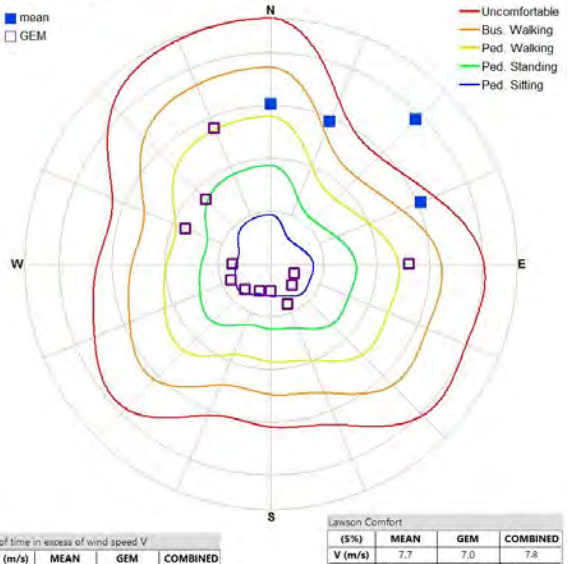
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.3	4.3	4.3
Rating	Ped Sitting	Ped Standing	Ped Standing

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.2	11.0	11.0
Rating	Pass	Pass	Pass

LOCATION 4



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	34.94	39.82	40.33
4	17.88	17.74	19.08
6	9.60	8.51	10.00
8	4.63	3.16	4.74
10	1.98	1.08	2.00

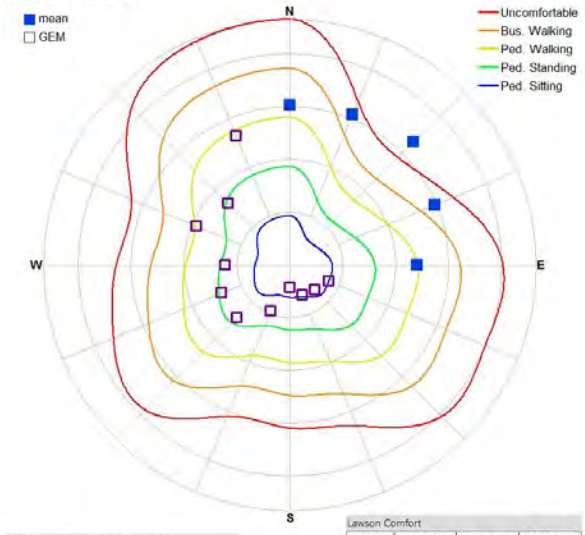
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	7.7	7.0	7.8
Rating	Ped Walking	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	16.8	14.4	16.8
Rating	Able Body	Pass	Able Body

LOCATION 4.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	41.93	45.92	47.60
4	17.99	15.90	19.03
6	9.20	5.99	9.40
8	3.76	1.53	3.82
10	1.24	0.19	1.25

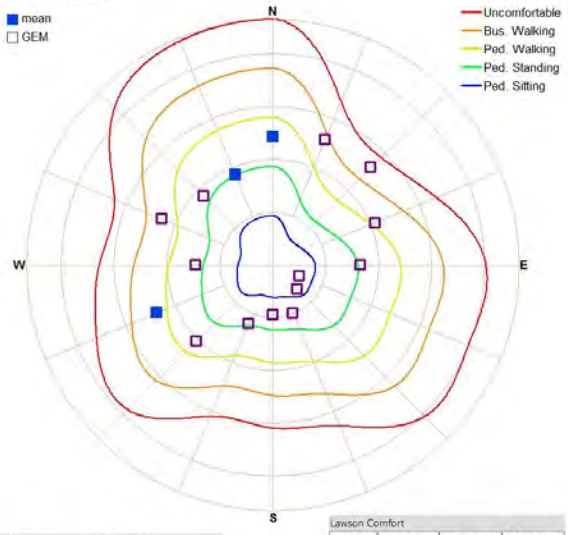
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	7.4	6.2	7.4
Rating	Ped Walking	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	14.3	11.6	14.4
Rating	Pass	Pass	Pass

LOCATION 5



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	46.53	53.12	54.11
4	14.15	17.19	17.93
6	4.08	5.59	5.85
8	0.62	1.45	1.50
10	0.03	0.17	0.18

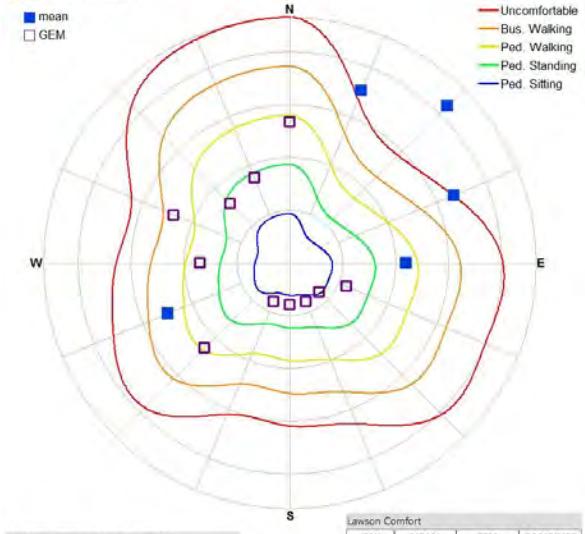
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.6	6.1	6.2
Rating	Ped Standing	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.2	11.5	11.5
Rating	Pass	Pass	Pass

LOCATION 5.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	48.20	51.14	51.69
4	21.70	21.58	23.59
6	11.79	9.69	12.19
8	6.47	3.84	6.60
10	3.17	1.17	3.21

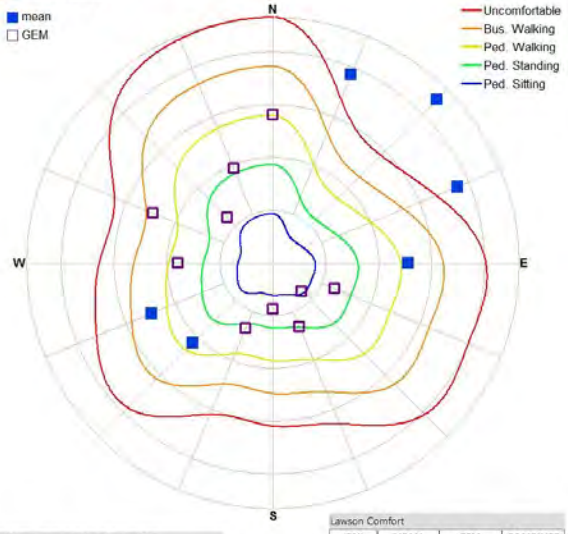
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	8.7	7.4	8.7
Rating	Bus Walking	Ped Walking	Bus Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	18.2	14.0	18.2
Rating	Able Body	Pass	Able Body

LOCATION 6



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	47.14	58.50	59.20
4	22.65	22.68	25.96
6	12.63	9.77	13.37
8	7.62	3.80	7.86
10	4.06	1.15	4.13

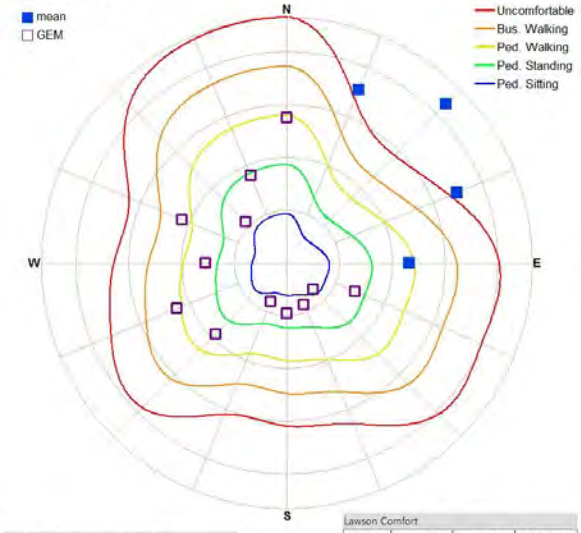
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	9.3	7.4	9.4
Rating	Bus Walking	Ped Walking	Bus Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	19.0	14.0	19.0
Rating	Able Body	Pass	Able Body

LOCATION 6.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	37.89	50.78	51.20
4	19.45	20.61	22.45
6	11.02	9.63	11.78
8	6.50	4.01	6.67
10	3.33	1.33	3.35

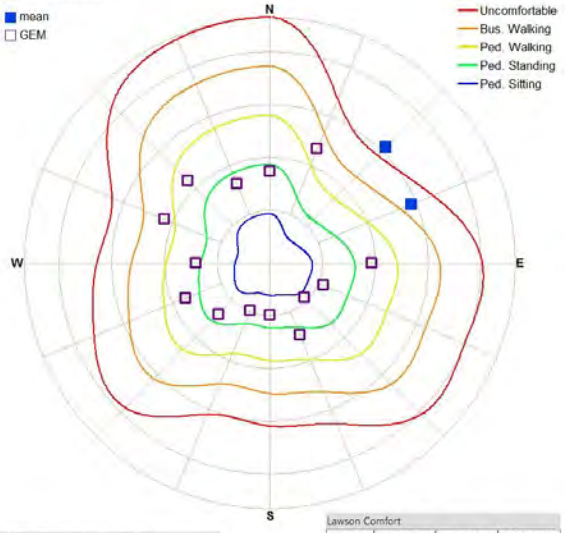
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	8.8	7.4	8.8
Rating	Bus Walking	Ped Walking	Bus Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	18.5	14.4	18.5
Rating	Able Body	Pass	Able Body

LOCATION 7



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	32.47	54.64	55.00
4	12.73	15.65	16.62
6	6.38	5.53	7.35
8	2.23	1.29	2.45
10	0.67	0.14	0.70

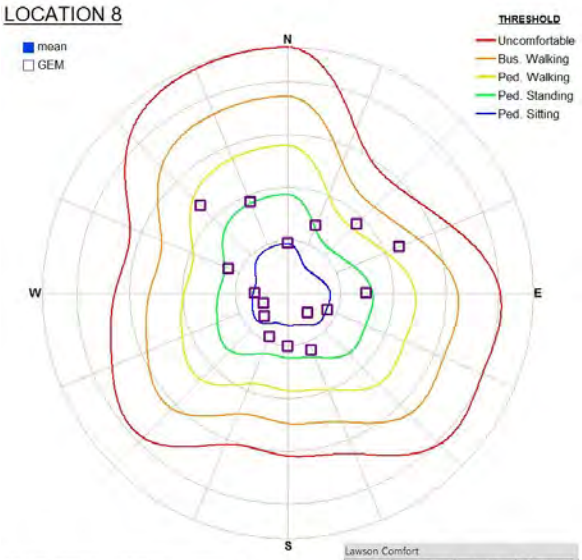
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	6.4	6.1	6.7
Rating	Ped Walking	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	13.4	11.3	13.5
Rating	Pass	Pass	Pass

LOCATION 8



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	24.70	36.41	36.41
4	5.44	7.73	7.73
6	0.90	1.47	1.47
8	0.08	0.14	0.14
10	0.01	0.03	0.03

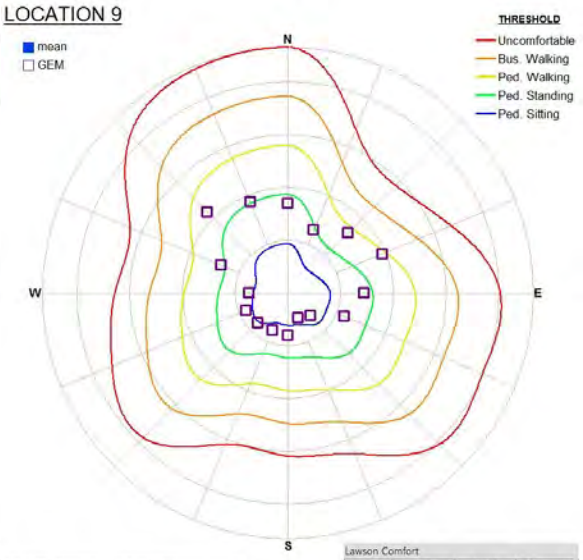
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.1	4.6	4.6
Rating	Ped Standing	Ped Standing	Ped Standing

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.6	10.2	10.2
Rating	Pass	Pass	Pass

LOCATION 9



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	20.59	32.44	32.44
4	3.09	5.95	5.95
6	0.23	0.69	0.69
8	0.04	0.07	0.07
10	0.00	0.01	0.01

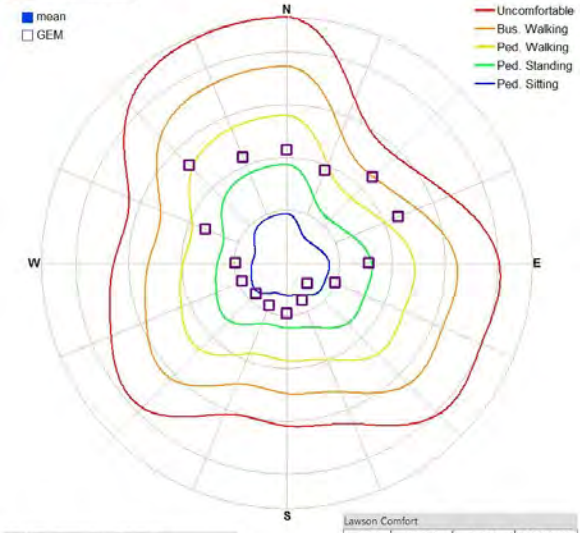
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.5	4.1	4.1
Rating	Ped Sitting	Ped Standing	Ped Standing

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	8.5	9.4	9.4
Rating	Pass	Pass	Pass

LOCATION 9.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	29.34	44.88	44.88
4	8.62	11.78	11.78
6	2.08	3.28	3.28
8	0.26	0.61	0.61
10	0.02	0.08	0.08

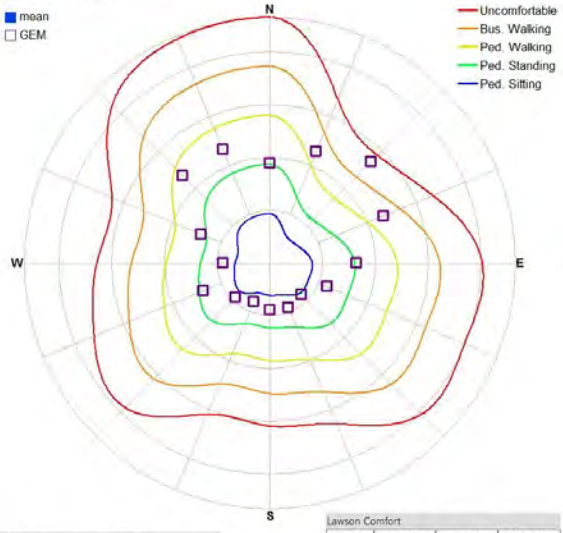
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.8	5.4	5.4
Rating	Ped Standing	Ped Standing	Ped Standing

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.0	11.4	11.4
Rating	Pass	Pass	Pass

LOCATION 10



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	32.55	46.57	46.57
4	9.59	13.26	13.26
6	3.10	4.91	4.91
8	0.76	1.35	1.35
10	0.09	0.23	0.23

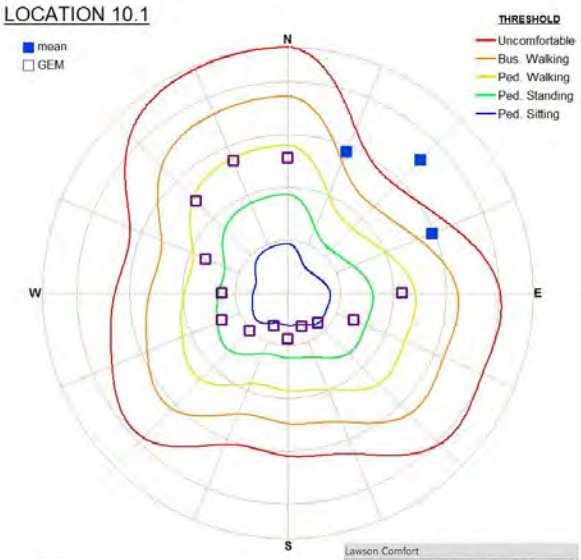
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.2	5.9	5.9
Rating	Ped Standing	Ped Standing	Ped Standing

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.0	11.9	11.9
Rating	Pass	Pass	Pass

LOCATION 10.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	39.13	51.69	52.05
4	16.06	17.49	18.50
6	8.61	7.92	9.12
8	3.89	2.61	4.04
10	1.46	0.62	1.50

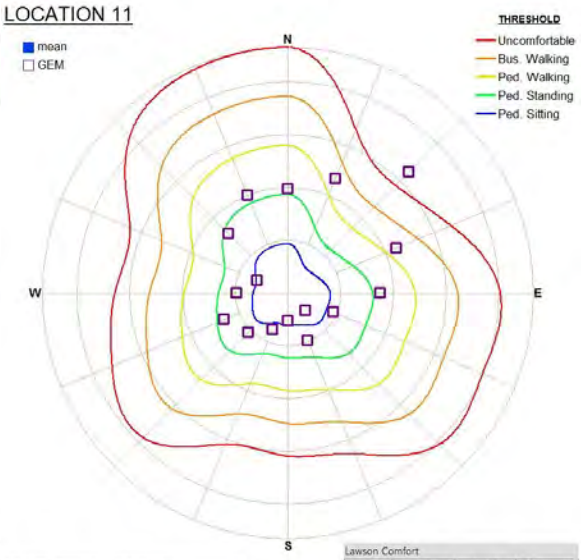
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	7.4	6.8	7.5
Rating	Ped Walking	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	15.4	13.3	15.4
Rating	Able Body	Pass	Able Body

LOCATION 11



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	23.95	37.10	37.10
4	8.85	12.55	12.55
6	4.07	5.60	5.60
8	1.95	2.24	2.24
10	0.76	0.90	0.90

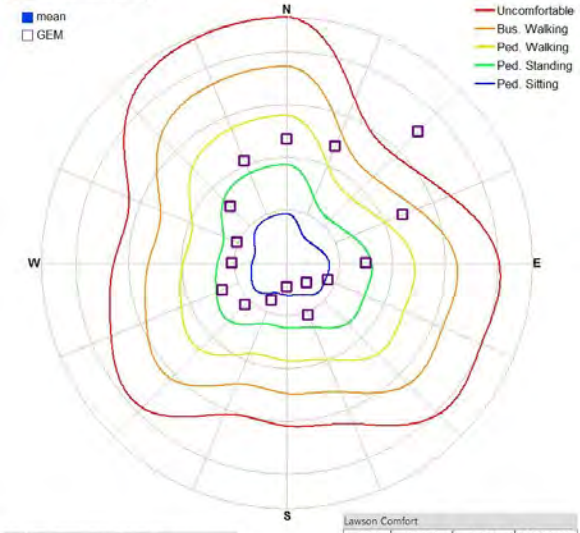
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.3	6.2	6.2
Rating	Ped Standing	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	13.7	14.0	14.0
Rating	Pass	Pass	Pass

LOCATION 11.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	20.56	39.83	39.83
4	7.13	13.45	13.45
6	3.48	6.35	6.35
8	1.51	2.86	2.86
10	0.45	1.30	1.30

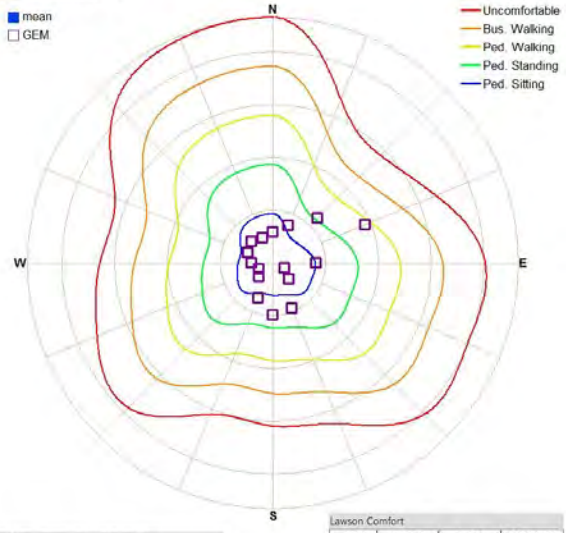
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.7	6.5	6.5
Rating	Ped Standing	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	12.8	15.2	15.2
Rating	Pass	Able Body	Able Body

LOCATION 12



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	5.81	15.40	15.40
4	0.03	2.01	2.01
6	0.00	0.09	0.09
8	0.00	0.00	0.00
10	0.00	0.00	0.00

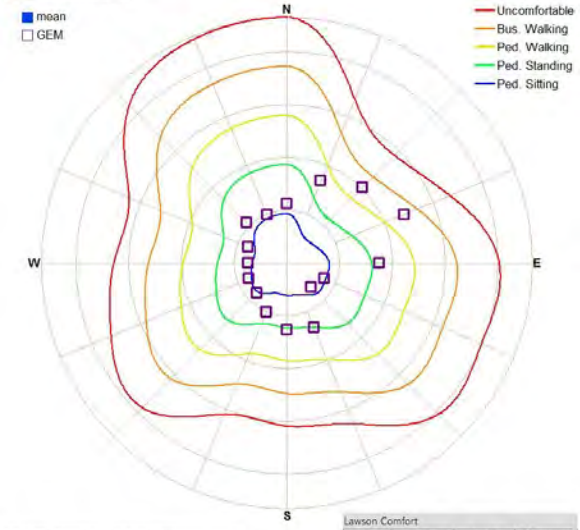
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.1	3.0	3.0
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	4.1	6.5	6.5
Rating	Pass	Pass	Pass

LOCATION 13



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	24.78	34.70	34.70
4	5.69	8.47	8.47
6	0.93	1.81	1.81
8	0.03	0.11	0.11
10	0.00	0.00	0.00

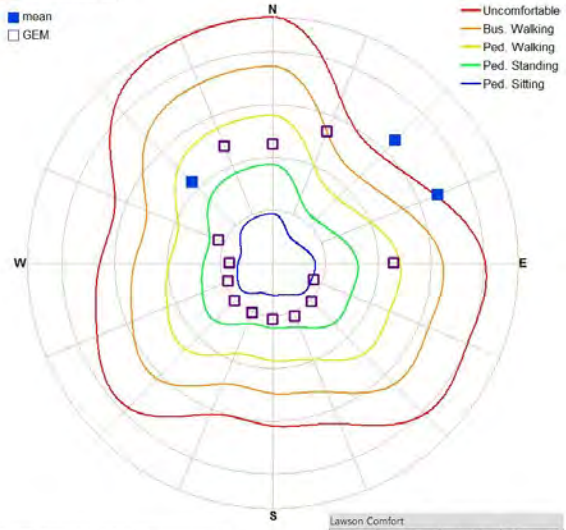
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.1	4.7	4.7
Rating	Ped Standing	Ped Standing	Ped Standing

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	8.2	9.0	9.0
Rating	Pass	Pass	Pass

LOCATION 14



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	39.93	50.89	51.07
4	13.99	16.26	16.45
6	7.82	8.15	8.37
8	3.30	3.25	3.55
10	1.21	1.02	1.23

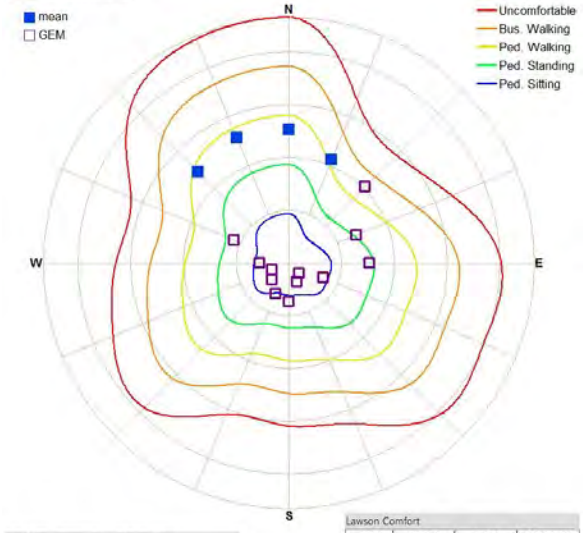
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	7.1	7.1	7.3
Rating	Ped Walking	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	14.3	13.9	14.3
Rating	Pass	Pass	Pass

LOCATION 15



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	31.97	34.21	36.90
4	8.79	9.14	10.09
6	1.92	2.29	2.59
8	0.25	0.21	0.33
10	0.05	0.02	0.05

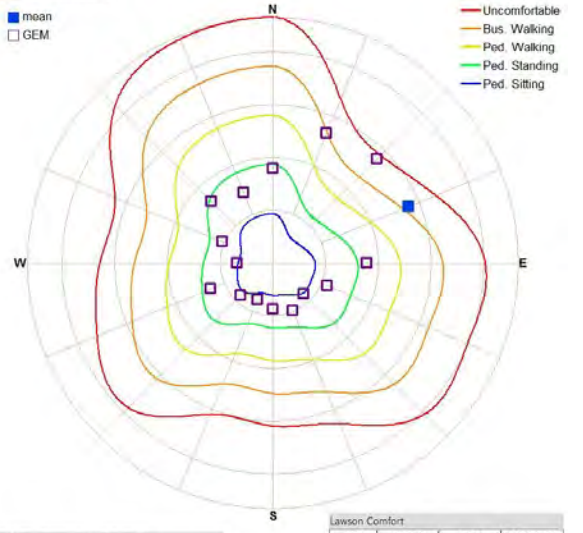
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.8	4.8	5.1
Rating	Ped Standing	Ped Standing	Ped Standing

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.7	9.7	10.7
Rating	Pass	Pass	Pass

LOCATION 16



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	24.23	38.05	38.08
4	9.95	12.65	12.74
6	4.70	5.87	6.09
8	1.46	1.83	1.90
10	0.24	0.29	0.29

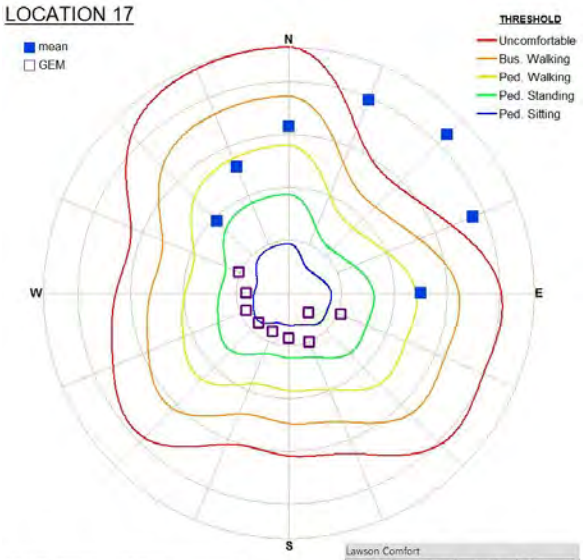
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.8	6.3	6.3
Rating	Ped Standing	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	12.0	12.1	12.2
Rating	Pass	Pass	Pass

LOCATION 17



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	40.55	43.90	46.25
4	20.39	16.46	20.53
6	12.32	8.63	12.32
8	7.64	3.48	7.64
10	4.01	1.01	4.01

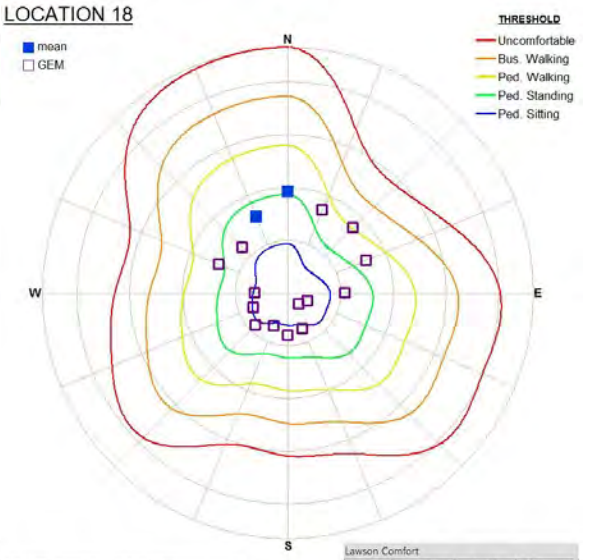
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	9.3	7.2	9.3
Rating	Bus Walking	Ped Walking	Bus Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	18.4	13.8	18.4
Rating	Able Body	Pass	Able Body

LOCATION 18



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	19.84	26.28	26.31
4	3.58	5.88	5.94
6	0.16	0.55	0.56
8	0.00	0.01	0.01
10	0.00	0.00	0.00

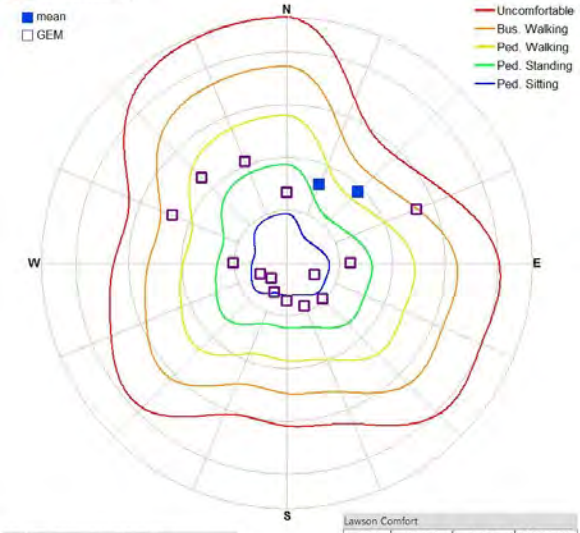
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.7	4.1	4.1
Rating	Ped Sitting	Ped Standing	Ped Standing

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.8	7.7	7.7
Rating	Pass	Pass	Pass

LOCATION 19



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	26.89	37.00	37.72
4	8.46	9.27	10.31
6	1.71	2.57	2.96
8	0.13	0.50	0.52
10	0.02	0.07	0.07

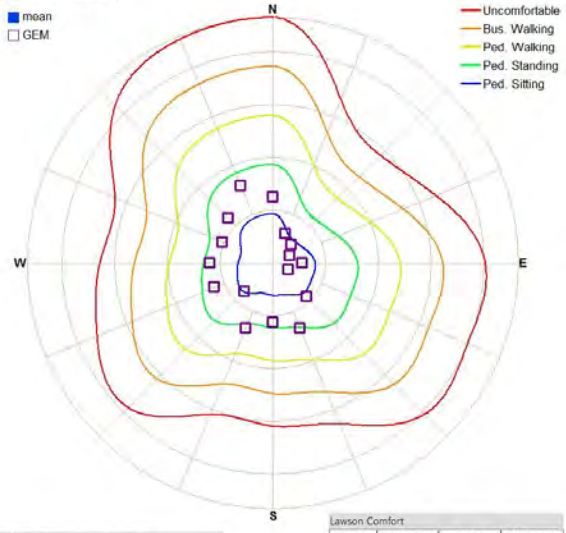
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.7	5.0	5.2
Rating	Ped Standing	Ped Standing	Ped Standing

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.6	10.9	10.9
Rating	Pass	Pass	Pass

LOCATION 20



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	10.10	25.04	25.04
4	0.24	1.70	1.70
6	0.01	0.06	0.06
8	0.00	0.00	0.00
10	0.00	0.00	0.00

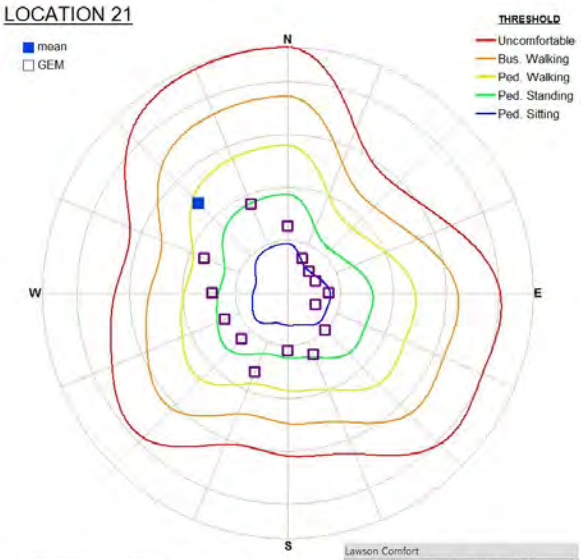
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.4	3.3	3.3
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	5.5	6.4	6.4
Rating	Pass	Pass	Pass

LOCATION 21



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	19.80	35.30	36.35
4	2.08	4.71	5.01
6	0.43	0.66	0.76
8	0.12	0.08	0.13
10	0.03	0.01	0.03

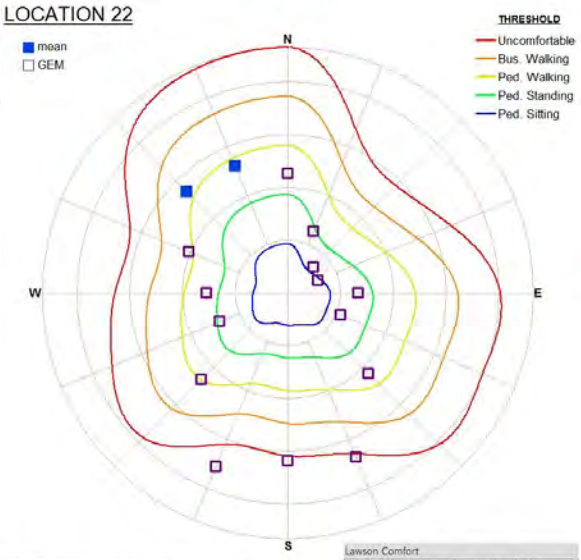
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.0	3.9	4.0
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.4	9.3	10.4
Rating	Pass	Pass	Pass

LOCATION 22



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	51.07	62.74	63.52
4	18.86	25.68	26.08
6	6.44	13.08	13.28
8	1.69	5.06	5.17
10	0.30	1.71	1.74

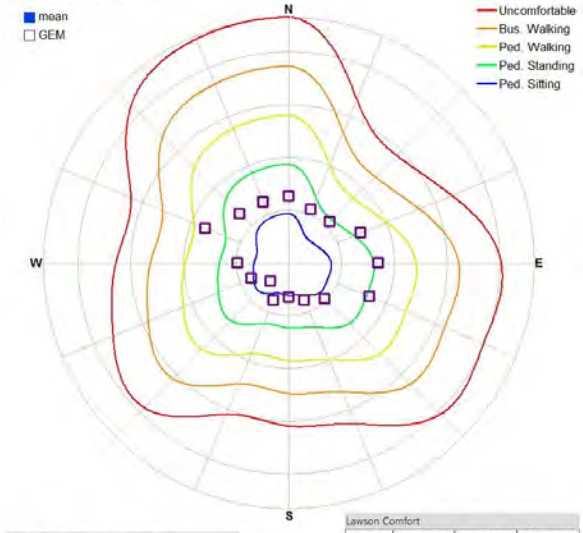
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	6.4	7.9	8.0
Rating	Ped Walking	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	12.9	16.3	16.3
Rating	Pass	Able Body	Able Body

LOCATION 23



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	10.06	25.80	25.80
4	0.55	2.21	2.21
6	0.03	0.22	0.22
8	0.00	0.01	0.01
10	0.00	0.00	0.00

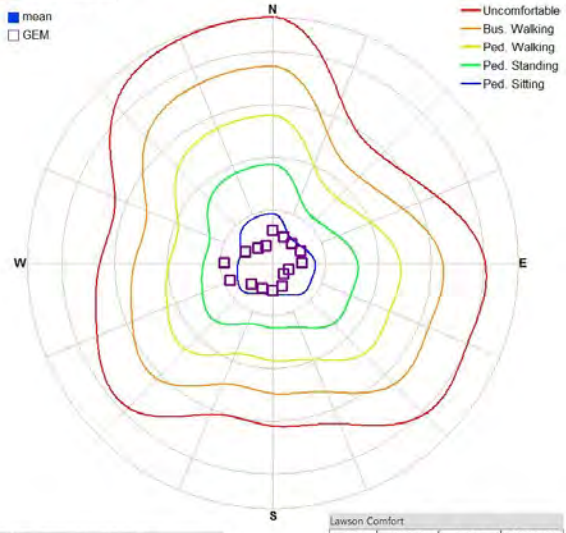
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.5	3.4	3.4
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.1	7.7	7.7
Rating	Pass	Pass	Pass

LOCATION 24



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	0.03	2.61	2.61
4	0.00	0.02	0.02
6	0.00	0.00	0.00
8	0.00	0.00	0.00
10	0.00	0.00	0.00

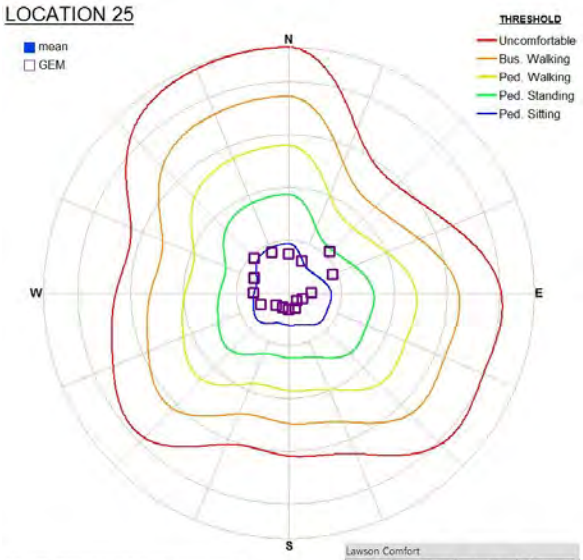
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	1.1	1.8	1.8
Rating	Outdoor Dining	Outdoor Dining	Outdoor Dining

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	2.0	3.9	3.9
Rating	Pass	Pass	Pass

LOCATION 25



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	5.37	7.38	7.38
4	0.02	0.25	0.25
6	0.00	0.00	0.00
8	0.00	0.00	0.00
10	0.00	0.00	0.00

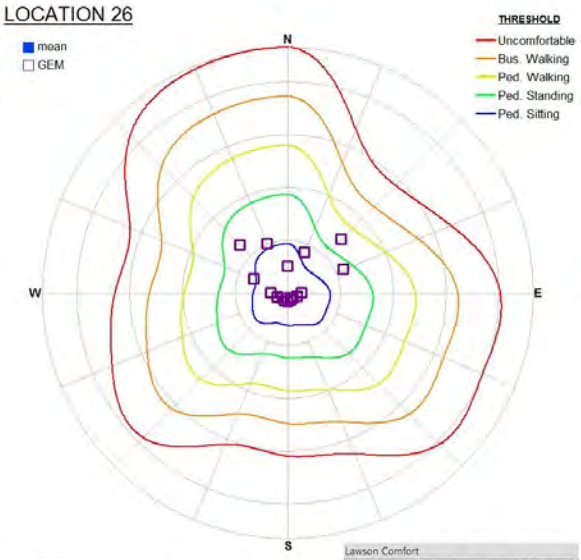
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	1.7	2.3	2.3
Rating	Outdoor Dining	Ped Sitting	Ped Sitting

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	3.9	4.8	4.8
Rating	Pass	Pass	Pass

LOCATION 26



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	5.35	10.90	10.90
4	0.43	1.60	1.60
6	0.00	0.05	0.05
8	0.00	0.00	0.00
10	0.00	0.00	0.00

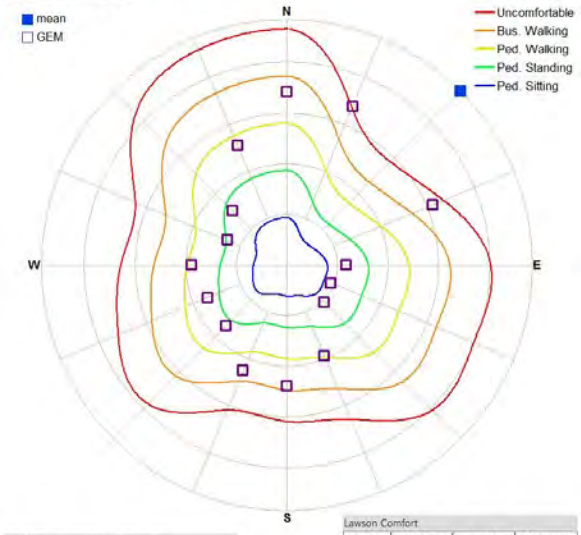
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.0	2.8	2.8
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	5.1	6.3	6.3
Rating	Pass	Pass	Pass

LOCATION 27



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	52.91	65.16	65.17
4	21.85	32.63	32.71
6	9.19	14.65	14.81
8	5.05	7.05	7.24
10	3.40	3.67	3.96

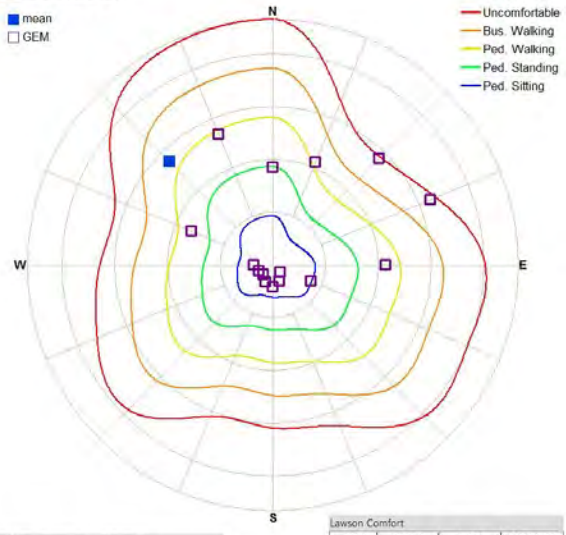
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	7.8	8.9	9.1
Rating	Ped Walking	Bus Walking	Bus Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	21.0	20.1	21.0
Rating	Fail	Fail	Fail

LOCATION 28



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	29.07	38.30	38.37
4	10.14	15.09	15.12
6	4.54	6.90	6.92
8	1.30	2.37	2.39
10	0.17	0.55	0.56

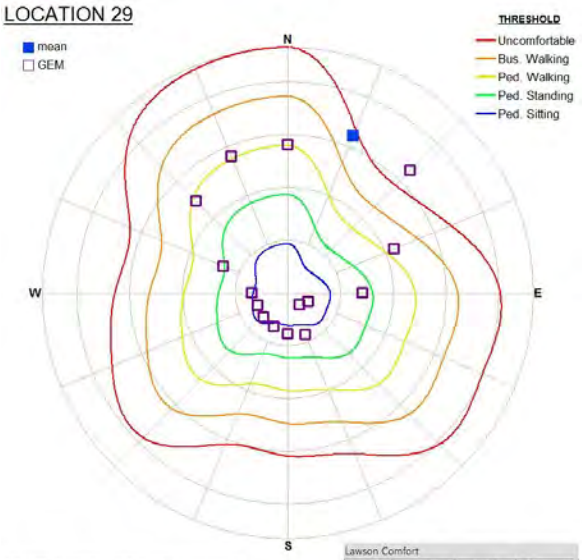
Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.7	6.6	6.6
Rating	Ped Standing	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	12.2	13.0	13.1
Rating	Pass	Pass	Pass

LOCATION 29



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	32.09	42.90	42.93
4	13.10	16.80	16.88
6	6.61	7.99	8.08
8	2.91	3.63	3.71
10	0.80	1.27	1.31

Lawson Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	6.6	7.1	7.1
Rating	Ped Walking	Ped Walking	Ped Walking

Lawson Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	13.2	14.3	14.3
Rating	Pass	Pass	Pass