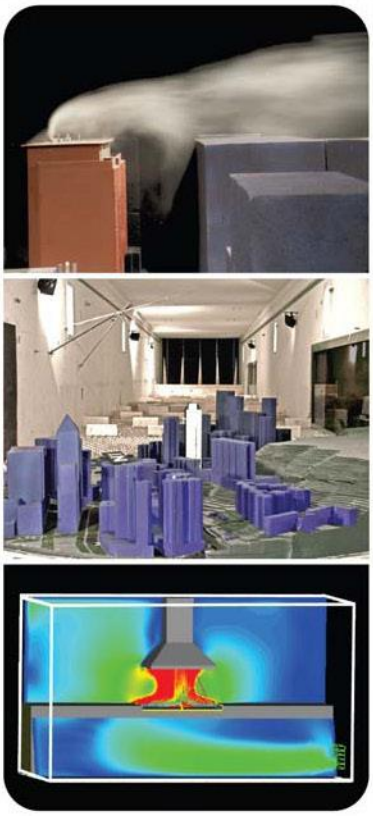
CERMAK
PETERKA
PETERSEN

WIND ENGINEERING AND AIR QUALITY CONSULTANTS

Final Report



Environmental Wind Tunnel Test Assessment:

ONE CENTRAL PARK BLOCK 11

Sydney, Australia

CPP Project 7702

August 2014

Prepared for:
Frasers Property
Suite 11, Lumiere Commerical
Level 12, 101 Bathurst Street
Sydney, NSW 2000

Prepared by:
Andrew Nguyen, Engineer
Graeme Wood, Director

CPP
Unit 2, 500 Princes Highway
St. Peters, NSW 2044, Australia
info-syd@cppwind.com
www.cppwind.com

EXECUTIVE SUMMARY

Cermak Peterka Petersen Pty. Ltd. has been engaged by Frasers Property to update measurements of the environmental wind conditions around the One Central Park Block 11, Sydney. A model of the One Central Park Block 11 development including replicas of surrounding buildings within a 570 m radius was constructed to a 1:400 scale and placed on a turntable in the wind tunnel.

The wind tunnel testing was performed in the natural boundary layer wind tunnel of Cermak Peterka Petersen Pty. Ltd., St. Peters. Measurements of winds likely to be experienced by pedestrians were made with a hot-film anemometer at 19 locations for 16 wind directions each. These points were tested in the proposed configuration. The measurements were combined with wind statistics to produce results of wind speed versus the percentage of time that wind speed is exceeded for each location. The wind conditions around the site were all acceptable for public walking from a comfort perspective and passed the distress criterion.

DOCUMENT VERIFICATION

Date	Revision	Prepared by	Checked by	Approved by
15/08/14	Initial release for review	AN	GSW	GSW

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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·s^{-1}
U_{ref}	Reference velocity at reference height z_{ref}, m·s^{-1}
U_{pk}	Peak wind speed in pedestrian studies, m·s^{-1}
U_{rms}	Root-mean-square of fluctuating velocity, m·s^{-1}
z	Height above surface, m
ν	Kinematic viscosity of approach flow, m^2·s^{-1}
$\sigma(\ )$	Standard deviation of $(\ ),=(\ )'_{rms}$
ρ	Density of approach flow, kg·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 in terms of wind impact is an important design parameter. Assessment of the acceptability of the pedestrian level wind environment is desirable during the project design phase so that modifications can be made and mitigation measures put in place 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, of estimating 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 a discussion of test results obtained. Table 1 summarizes the model configurations, test methods, and data acquisition parameters. All 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 scale	1:400
Surrounding model radius (full-scale)	570 m
Reference height (full-scale)	200 m
Approach Terrain Category	Terrain Category 3
Testing Configuration	
Geometry:	One Central Park development with existing surrounding buildings and landscape, as shown in Figure 4.
Pedestrian velocities:	Pedestrian winds measured at 19 locations for 16 wind directions in 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 dimensions 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, fence, 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 2and are explained more fully in Section 4.1.1.

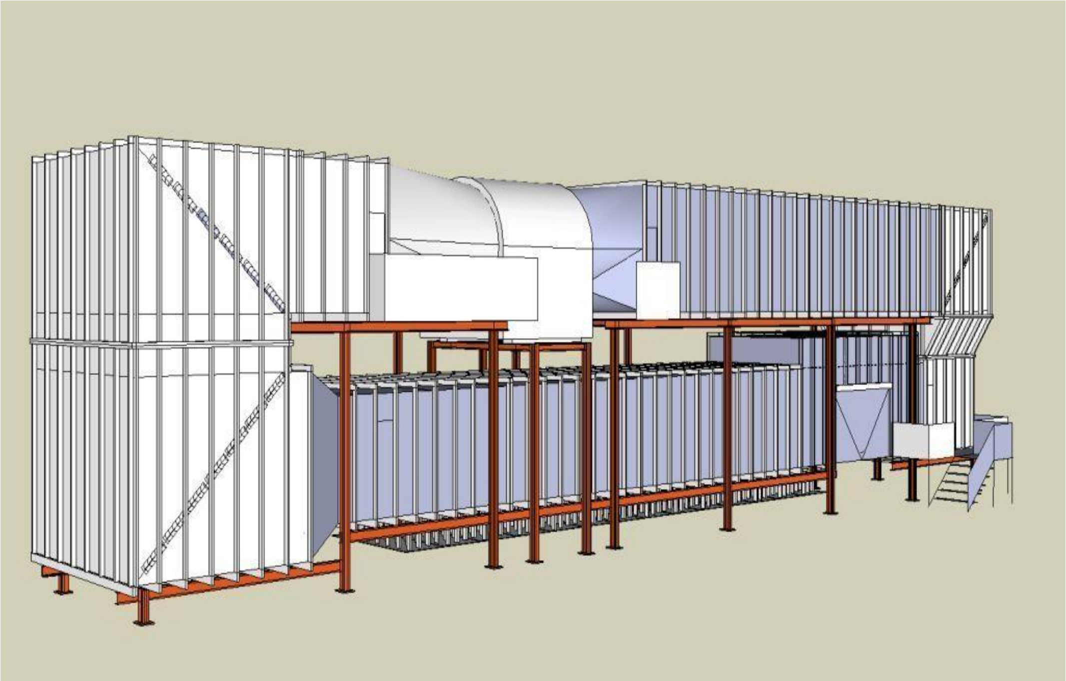


Figure 1: Schematic of the closed circuit wind tunnel

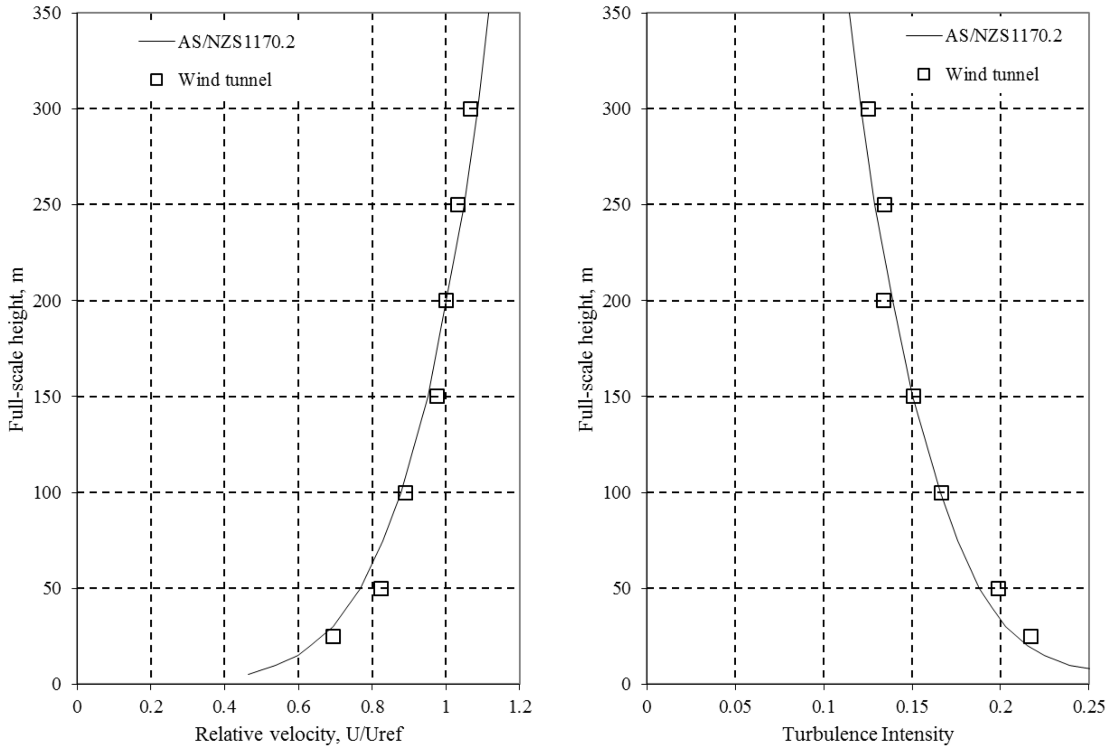


Figure 2: Mean velocity and turbulence profiles approaching the model

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, and was within wind tunnel blockage limitations. Significant variations in the building surface were formed into the model. A model of the development was fabricated based on the latest revision of the design drawings for the various buildings. The models were mounted on the turntable located near the downstream end of the wind tunnel test section, Figure 3. The turntable permitted rotation of the modelled are for examination of velocities from any approach wind direction. Additional photographs of the testing are in Appendix 1.

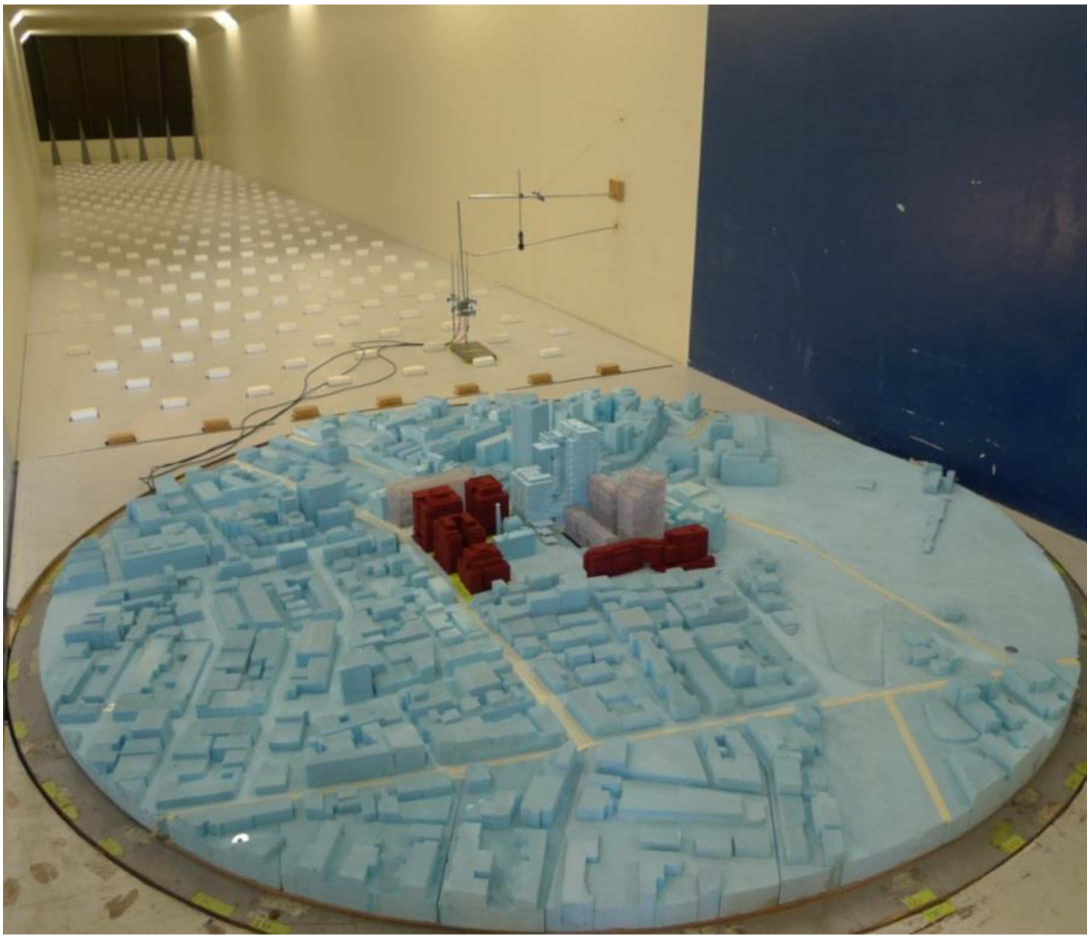


Figure 3: Proximity model in the CPP wind tunnel viewed from the south-west

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.

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. In both cases, the wind speed used is the larger of a mean or gust equivalent-mean (GEM) wind speed[1]. The GEM is defined as the peak gust wind speed divided by 1.85 for a typical turbulent environment; this is intended to account for locations where the gustiness is the dominant characteristic of the wind.

Table 2: Summary of Lawson criteria

Comfort (maximum of mean or gust equivalent mean (GEM$^{+\cdot}$) 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: $^{+\cdot}$ The gust equivalent mean (GEM) is the peak 3 s gust wind speed divided by 1.85.

Assessment using the Lawson criteria provides a similar classification as using the once per annum gust, which is the basis of the City of Sydney (2004) DCP, however provides information

[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.

regarding the serviceability wind climate. The current City of Sydney (2012) DCP specifies wind effects not to exceed 16 m/s as the area is not classified as an ‘active frontage’. From discussions with Council this is a once per annum gust wind speed similar to the 2004 DCP, and is similar to the Lawson pass distress limit.

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 of terrain category 3 winds as defined in Standards Australia (2011) and are considered appropriate for the approach conditions.

4.1.2. Pedestrian Winds

The proposed development is located to the south-south-west of Sydney CBD and to the south of Darling Harbour. The One Central Park development is surrounded by the UTS Broadway buildings and Tower to the north and mixed low-rise commercial and residential buildings in other directions, Figure 4. For this report, wind speed measurements were measured at 19 locations to evaluate pedestrian comfort around the project site, as shown in Figure 6 to Figure 9. Velocity measurements were made at the model scale equivalent of 1.5 to 2.1 m above the ground surface for 16 wind directions at 22.5° intervals. Locations were chosen to determine the degree of pedestrian comfort at the building corners where relatively severe conditions are frequently found, near building entrances, on adjacent pavements with heavy pedestrian traffic, in open plaza areas, and on proposed terraces.

The hot-film signal was sampled for a period corresponding to one hour in prototype. All velocity 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 the duration of gust on which the assessment criterion are based. These local wind speeds, U, were normalised by the tunnel reference velocity U_{ref}. Mean and turbulence statistics were calculated and used to determine the normalised effective peak gust using $\frac{U_{pk}}{U_{ref}} = \frac{U + 3 \cdot U_{rms}}{U_{ref}}$.

Figure 4: Extent of model for One Central Park development

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 velocity magnitude and the approach wind direction for which that velocity was measured. 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 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 2013, Figure 5.

This anemometer location is considered the most appropriate for analysis of the historic wind climate as the approach flow is flat and relatively consistent from all directions, and the immediate surrounds has not changed significantly through development over time compared with other anemometer locations in Sydney CBD. 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.

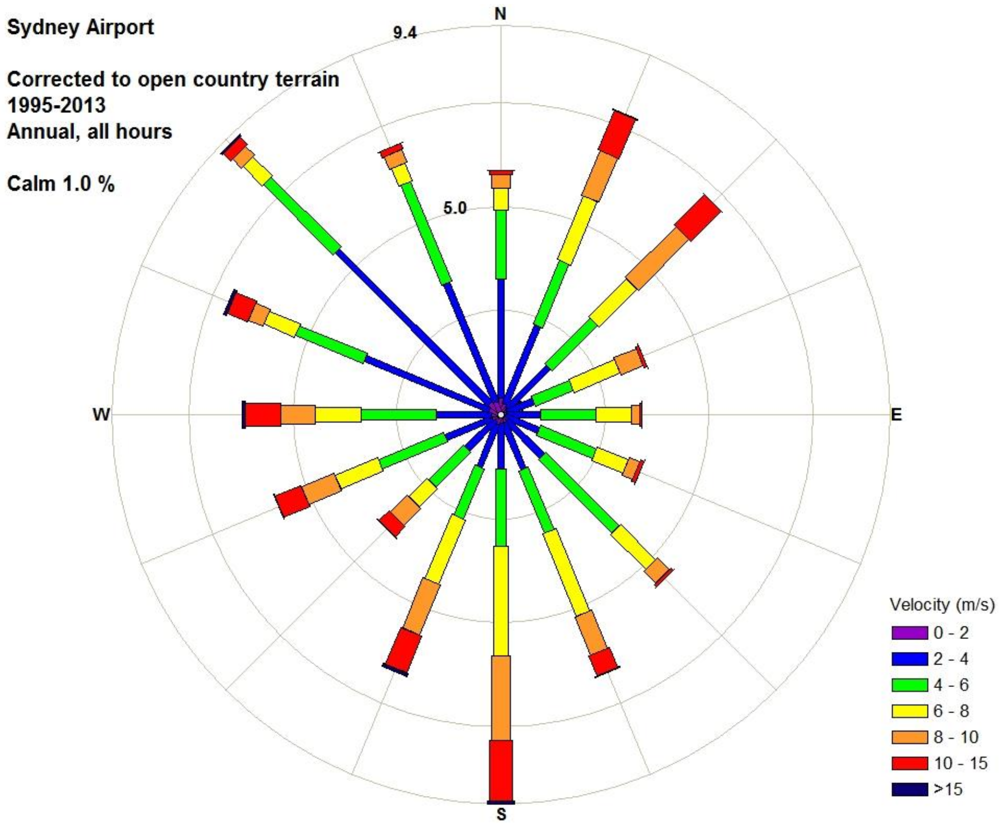


Figure 5: Wind rose of direction and speed for Sydney Airport

The criteria of Lawson consider the integration of the velocity measurements with local wind climate statistical data summarized in Figure 5 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.

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.

The tables in Appendix 2 additionally provide the wind speed exceeded 5% and 0.022% of the time for direct comparison with the Lawson 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 6 to Figure 9 for each test location. Because some pedestrian wind measurement positions are purposely chosen at sites where large velocities of small spatial extent may exist, the general wind environment about the structure may be less severe than one might infer from an analysis only of the plots. The implications of the results are discussed in Section 0. It should be noted that Sydney is relatively windy, with an average wind speed at 10 m reference height of approximately 5 m/s (10 kt, 18 kph) at Sydney Airport, and five percent of the time the mean wind speed is in excess of 9.5 m/s (18 kt, 34 kph). Converting the five percent of the time mean wind speed at Sydney Airport to a typical pedestrian level in a generic urban environment of similar building massing to the Block 11 development would result in about 6.0 m/s (12 kt, 22 kph). Comparing this with the comfort criteria of Table 2 suggests that the pre-existing locale would only just be acceptable for pedestrian walking prior to development; hence any recreational outdoor activity for any significant development of this site will likely require significant amelioration from prevailing Sydney wind directions.

5. DISCUSSION

The wind climatology chart of Figure 5 indicates that the most frequent strong winds are from the south, and to a lesser extent from the west and the north-east quadrants. The locations tested around the development site are susceptible to winds from different directions, depending on the relative location of the point tested to the geometry of the proposed development and surrounds. However, in general terms the winds from the west had the most pronounced effects on the local wind environment surrounding the development site.

The primary conclusions of the pedestrian study can be understood by reviewing the colour coded images, Figure 6 to Figure 9, which depict the locations selected for investigation of the pedestrian wind comfort along with the Lawson criteria rating for both comfort and distress. Note that testing was performed without planned trees, or other plantings to provide a worst case assessment; heavy landscape planting usually reduces the wind speeds by less than 10%. The central colour indicates the Lawson comfort rating for the location, and the colour of the outer ring indicates whether the location passes the Lawson distress criterion. Mitigation measures are likely to be required for orange and 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 directional wind plots in Appendix 2.

Wind conditions at Locations 1 to 6 along O’Connor Street are classified as satisfactory for pedestrian standing to the west, and pedestrian walking to the east, Figure 6. The windier locations to the east are governed by winds from the north quadrant accelerating around the south corners of Block 5C to the north of O’Connor Street.

Wind conditions at Location 7 to the north of the east wing are classified as suitable for pedestrian standing, Figure 6, towards to the pedestrian walking criterion. Similarly to Locations 1 to 6 the strong winds are from the north quadrant governed by Block 5C and will be horizontal. To improve the wind conditions at this location, vertical elements would be required such as dense trees or hedging to offer local protection.

Wind conditions at Locations 8 to 10 to the south of the west wing, Figure 6, are all classified as suitable for pedestrian standing with calmer conditions towards the middle of the block.

Wind conditions along Kensington Street to the east of the site are classified as suitable for pedestrian walking with calmer conditions in the centre of the block, Figure 6. The strong winds from these locations are from the east quadrant. Wind conditions along Wellington Street to the south of the heritage hotel, are classified as suitable for pedestrian sitting activities.

The main entries are well located away from the building corners to avoid a sudden change in wind speed. All locations at ground level pass the distress criterion.

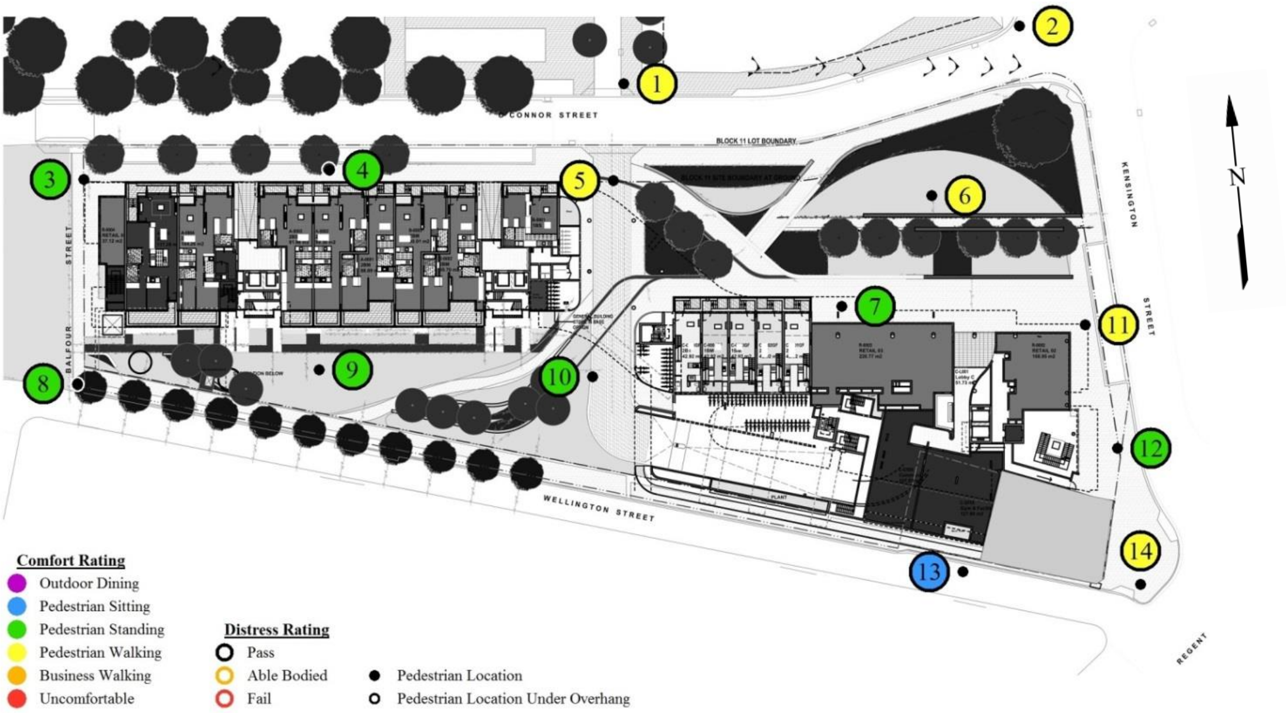


Figure 6: Pedestrian wind speed measurements locations at ground level

Wind conditions on the proposed Level 1 childcare centre, Figure 7, are classified as suitable for pedestrian standing. This would be considered suitable for the intended use of the space. Strong winds for this location are from the south-east and south-west quadrants. Wind conditions would be further improved with landscaping.

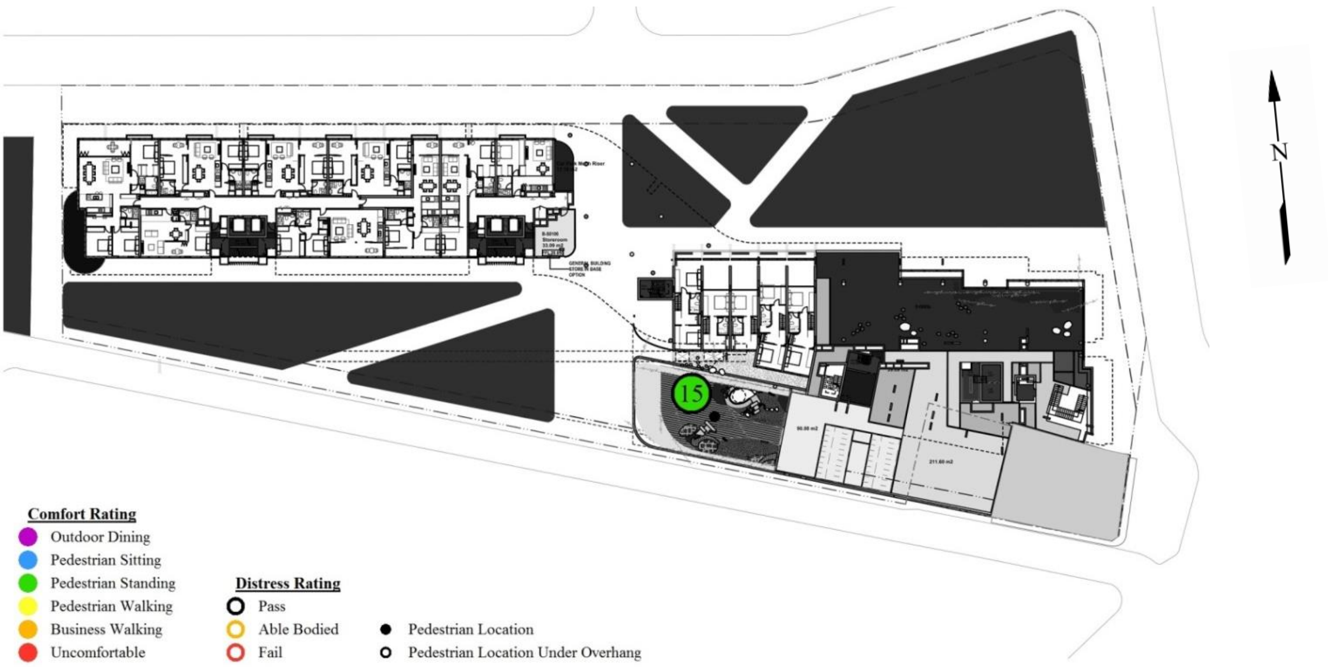


Figure 7: Pedestrian wind speed measurements locations at Level 1

Wind conditions on the proposed Level 9 terraces, Figure 8, are classified as suitable for pedestrian walking and would be useable for pedestrian dining for about 50% of the time, and sitting for café-style activities for about 70-75% of the time. These private-use areas will be frequented when environmental conditions are acceptable to the user. The critical incident wind directions are from the south-east and west quadrants and are local wind direction is expected to be horizontal at these locations. To ameliorate the local wind conditions, vertical barriers would be required; such as solid or porous barriers, dense planting.

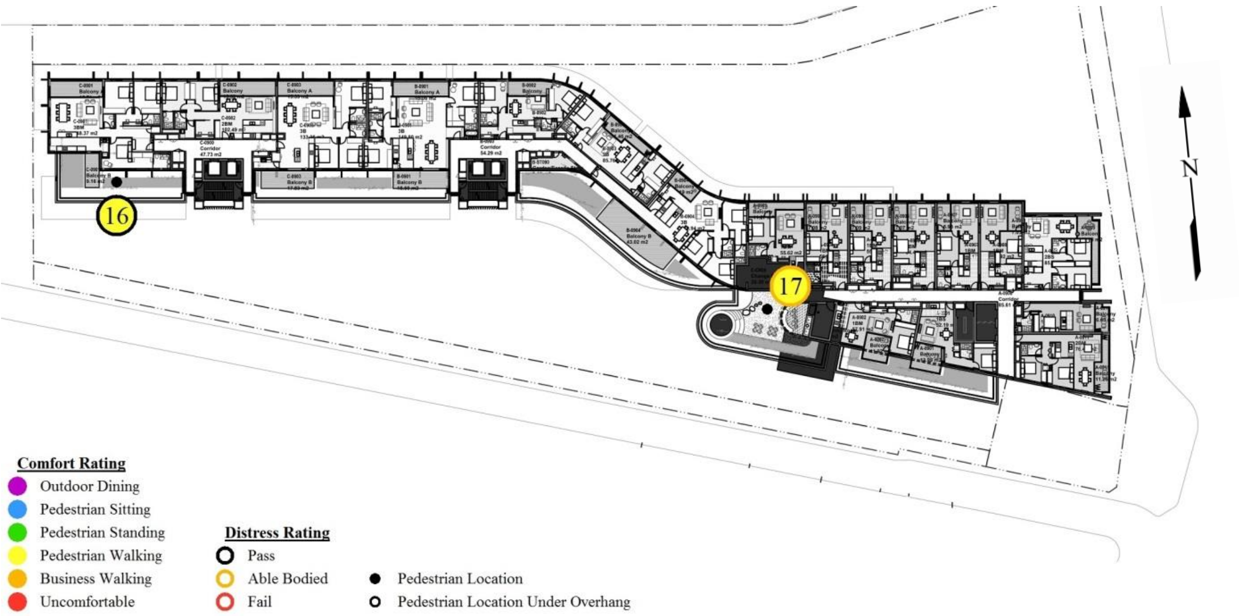


Figure 8: Pedestrian wind speed measurement locations at level 9

Wind conditions on the proposed rooftop terraces, Figure 9, are classified as suitable for pedestrian walking with Location 19 being marginally classified as business walking. These terraces would be useable for pedestrian dining for about 25-30% of the time, and sitting for café-style activities for about 60-70% of the time. These private-use areas will be frequented when environmental conditions are acceptable to the user. The roof is exposed to all wind directions and are local wind direction is expected to be horizontal at these locations. To ameliorate the local wind conditions, vertical barriers would be required; such as solid or porous barriers, dense planting.

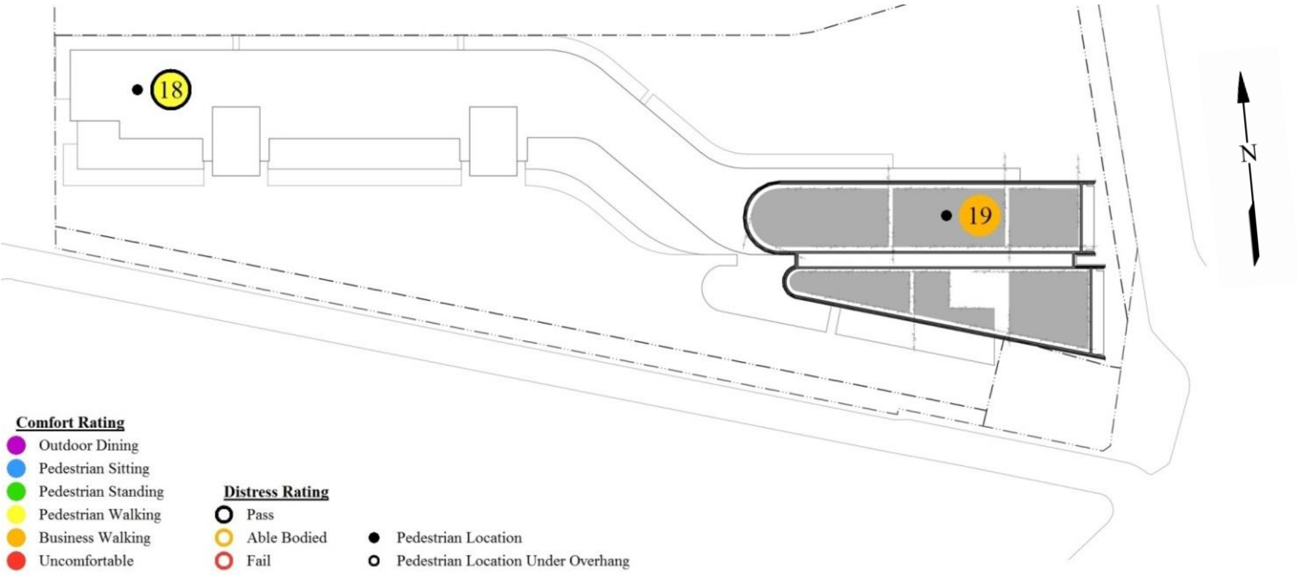


Figure 9: Pedestrian wind speed measurements locations on the roof

6. CONCLUSIONS

Cermak Peterka Petersen Pty. Ltd. has provided a quantitative assessment on the effects of the geometry for the One Central development on the local wind climate surrounding Block 11. The wind conditions at ground level are all satisfactory for pedestrian walking activities and pass the distress criterion. Wind conditions on the private upper level terraces are windier and will only be accessed when suitable environmental conditions exist.

7. REFERENCES

American Society of Civil Engineers (1999), *Wind Tunnel Model Studies of Buildings and Structures* (ASCE Manual of Practice Number 67).

American Society of Civil Engineers (2010), *Minimum Design Loads for Buildings and Other Structures* (ASCE 7–10).

Australasian Wind Engineering Society (2001), *Wind Engineering Studies of Buildings* (AWES-QAM-1-2001).

Cermak, J.E. (1971), “Laboratory Simulation of the Atmospheric Boundary Layer,” *AIAA Jl.*, Vol. 9, September.

Cermak, J.E. (1975), “Applications of Fluid Mechanics to Wind Engineering,” A Freeman Scholar Lecture, *ASME Journal of Fluids Engineering*, Vol. 97, No. 1, March.

Cermak, J.E. (1976), “Aerodynamics of Buildings,” *Annual Review of Fluid Mechanics*, Vol. 8, pp. 75 – 106.

Cermak Peterka Petersen (2009), “Wind Tunnel Tests for: Frasers Broadway Blocks 1, 4, and 8”.

City of Sydney, (2004), “Central Sydney Development Control Plan 1996”.

City of Sydney (2012), “Sydney Development Control Plan 2012, Section 3 General Provisions”.

King, C.V. (1914), “On the Convection of Heat From Small Cylinders in a Stream of Fluid,” *Philosophical Transactions of the Royal Society*, London, Vol. A214, p. 373.

Lawson, T.V. (1990), “The Determination of the Wind Environment of a Building Complex before Construction” Department of Aerospace Engineering, University of Bristol, *Report Number TVL 9025*.

Penwarden, A.D. (1973), "Acceptable wind speeds in towns", Building Science, Vol.8, pp. 259-267.

Standards Australia (2011), *Australian/New Zealand Standard, Structural Design Actions, Part 2: Wind Actions* (AS/NZS1170 Pt.2).

Appendix 1: Additional Photographs of the CPP Wind Tunnel Model

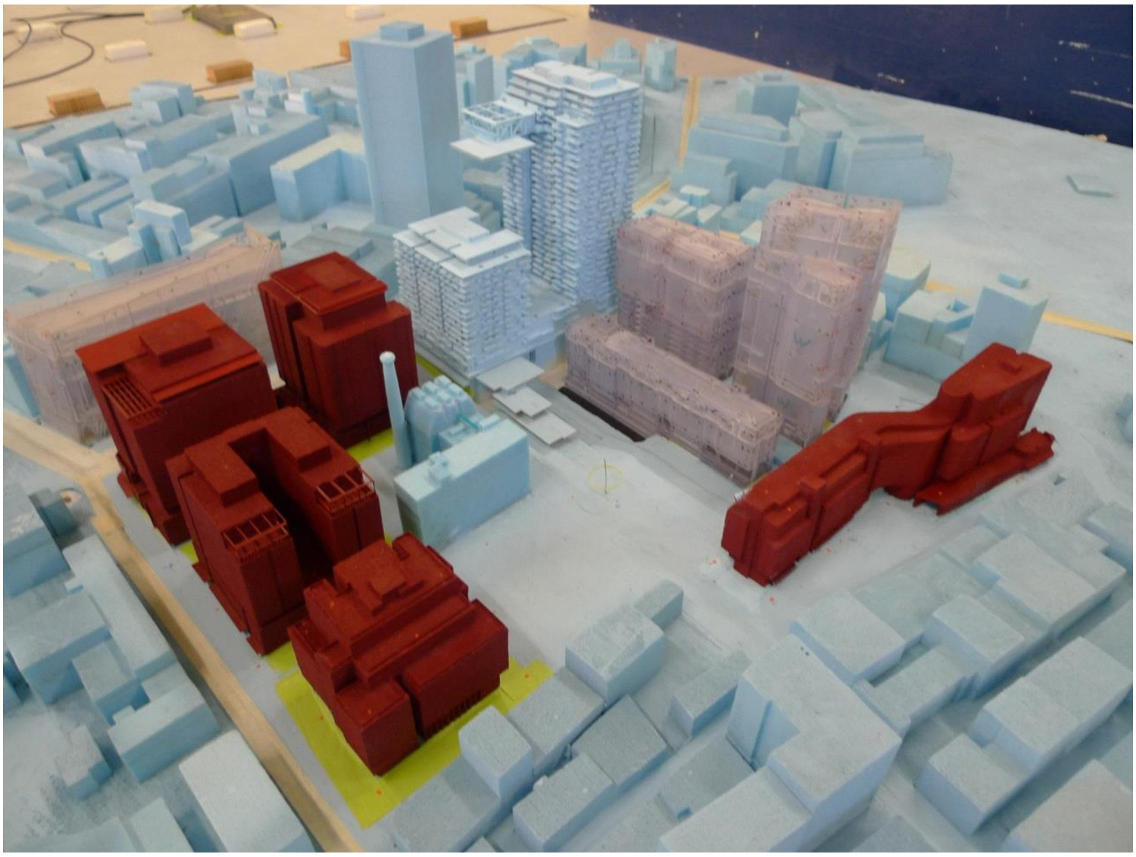


Figure 10: Bird’s eye view of the One Central Park development from the south-west

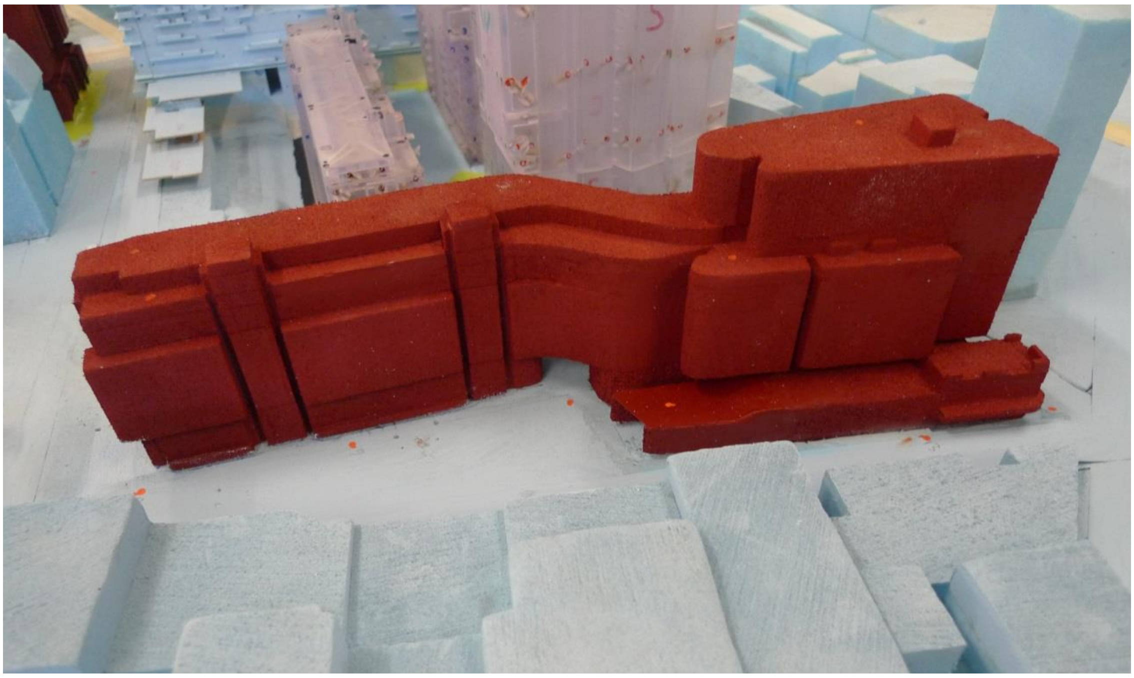
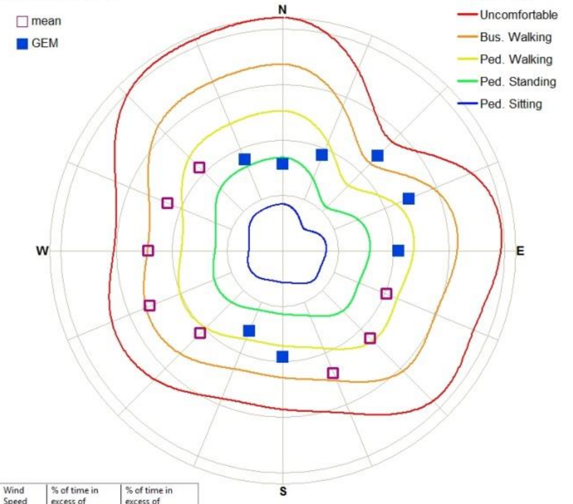


Figure 11: Close-up view of One Central Park Block 11 from the south

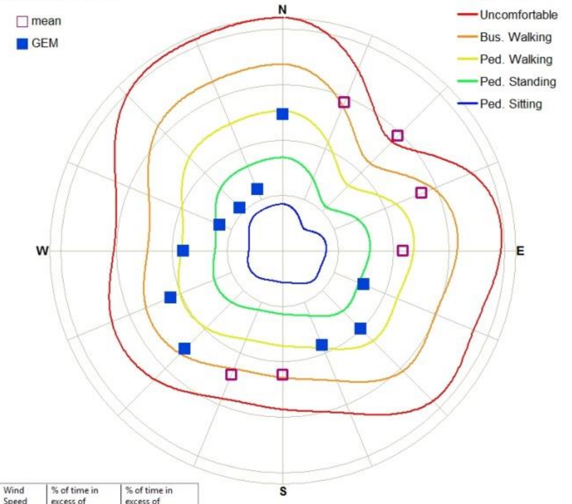
Appendix 2: Directional Wind Results

LOCATION 1



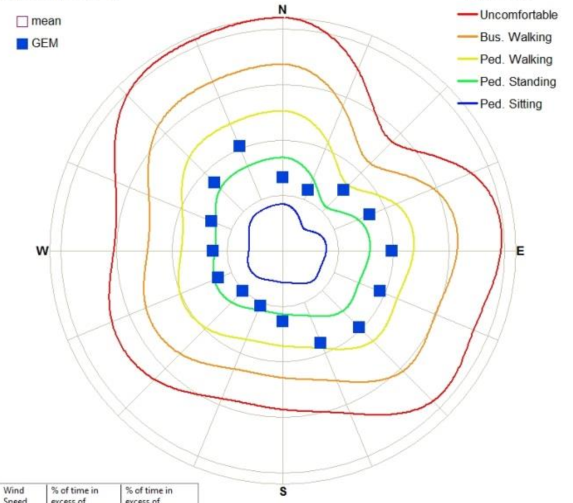
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	70.9	71.1
4.0	28.5	28.8
6.0	7.9	7.5
8.0	1.5	1.3
10.0	0.2	0.1
6.6	**5.0**	Ped Walking
11.9	**0.022**	Pass
6.4	Ped Walking	**5.0**
11.3	Pass	**0.022**

LOCATION 2



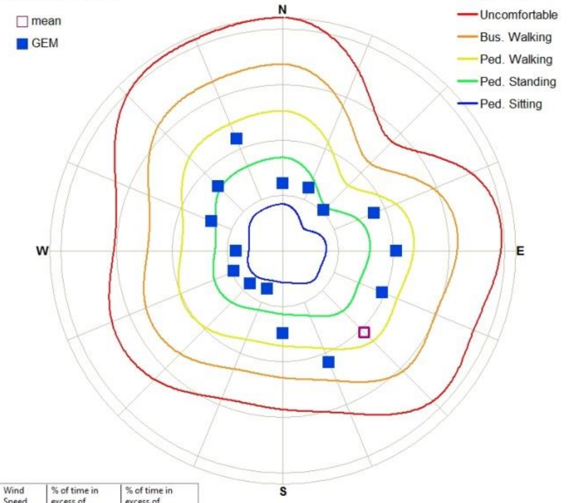
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	62.0	66.9
4.0	29.6	30.7
6.0	11.3	9.6
8.0	3.5	2.0
10.0	0.7	0.3
7.4	**5.0**	Ped Walking
13.3	**0.022**	Pass
6.9	Ped Walking	**5.0**
11.8	Pass	**0.022**

LOCATION 3



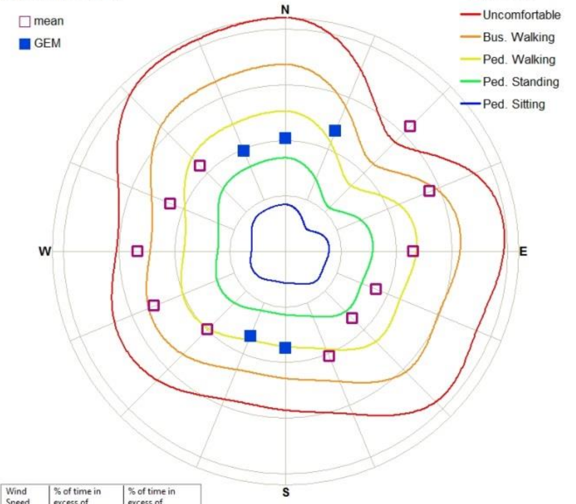
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	36.1	55.4
4.0	3.4	10.8
6.0	0.2	0.9
8.0	0.0	0.1
10.0	0.0	0.0
3.7	**5.0**	Ped Sitting
7.1	**0.022**	Pass
4.6	Ped Standing	**5.0**
8.7	Pass	**0.022**

LOCATION 4



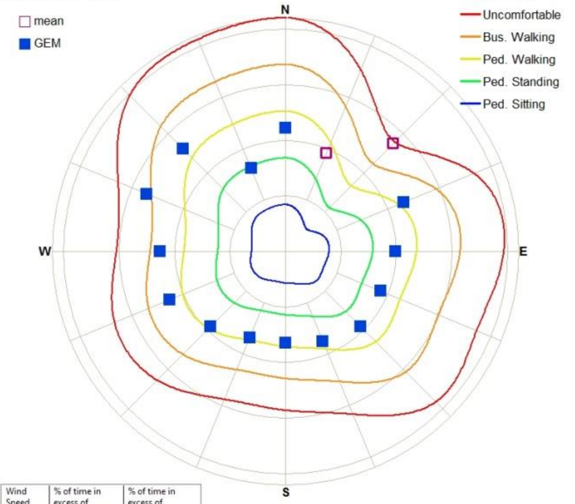
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	30.6	49.7
4.0	4.9	11.1
6.0	0.5	1.4
8.0	0.0	0.2
10.0	0.0	0.0
3.9	**5.0**	Ped Sitting
8.2	**0.022**	Pass
4.8	Ped Standing	**5.0**
9.6	Pass	**0.022**

LOCATION 5



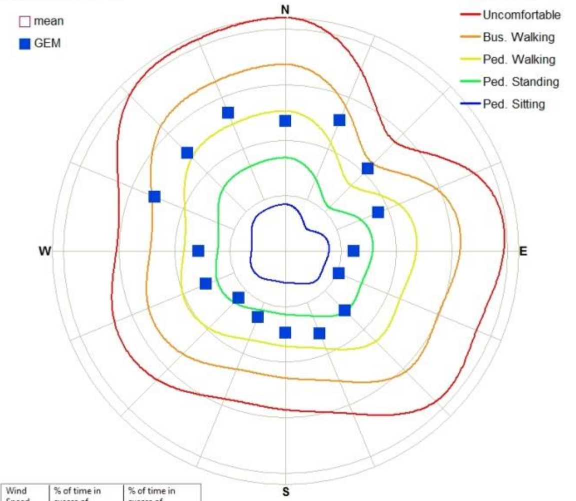
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	73.9	73.9
4.0	30.4	29.2
6.0	10.7	8.8
8.0	3.9	2.6
10.0	1.2	0.6
7.4	**5.0**	Ped Walking
14.5	**0.022**	Pass
6.8	Ped Walking	**5.0**
13.2	Pass	**0.022**

LOCATION 6



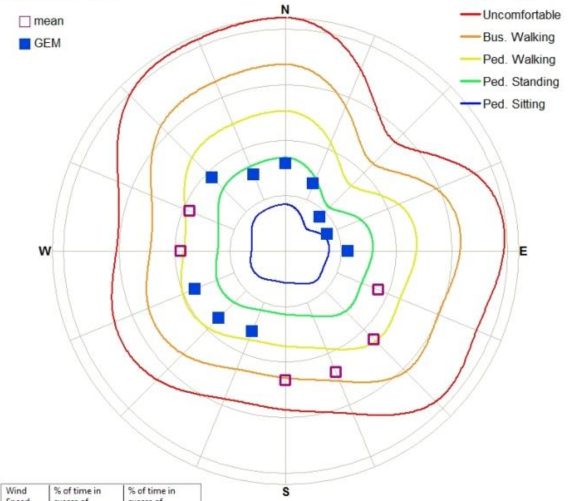
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	69.5	76.3
4.0	23.9	28.6
6.0	6.2	7.9
8.0	1.9	2.2
10.0	0.4	0.5
6.3	**5.0**	Ped Walking
12.4	**0.022**	Pass
6.7	Ped Walking	**5.0**
13.0	Pass	**0.022**

LOCATION 7



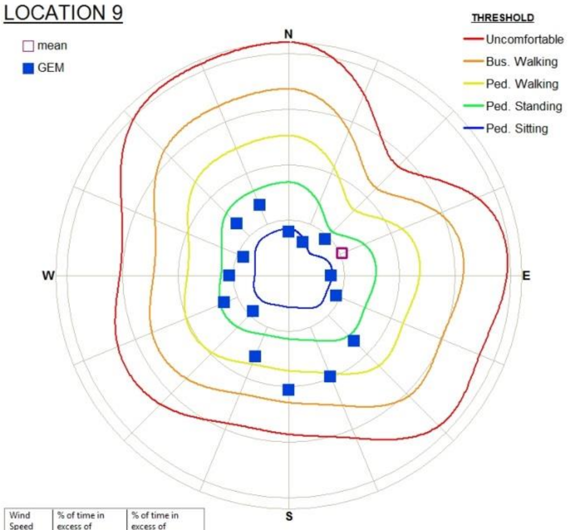
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	59.6	69.9
4.0	14.8	20.1
6.0	3.8	5.2
8.0	0.5	1.0
10.0	0.1	0.2
5.6	**5.0**	Ped Standing
10.9	**0.022**	Pass
6.0	Ped Standing	**5.0**
12.2	Pass	**0.022**

LOCATION 8



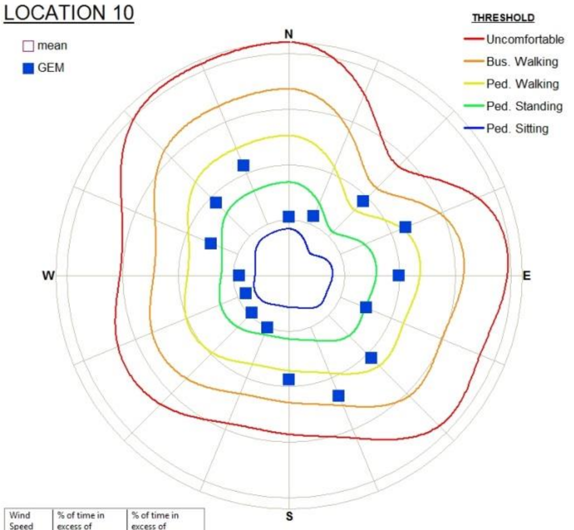
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	49.4	58.2
4.0	17.4	18.7
6.0	4.6	4.4
8.0	0.9	0.8
10.0	0.1	0.1
5.8	**5.0**	Ped Standing
11.4	**0.022**	Pass
5.8	Ped Standing	**5.0**
11.4	Pass	**0.022**

LOCATION 9



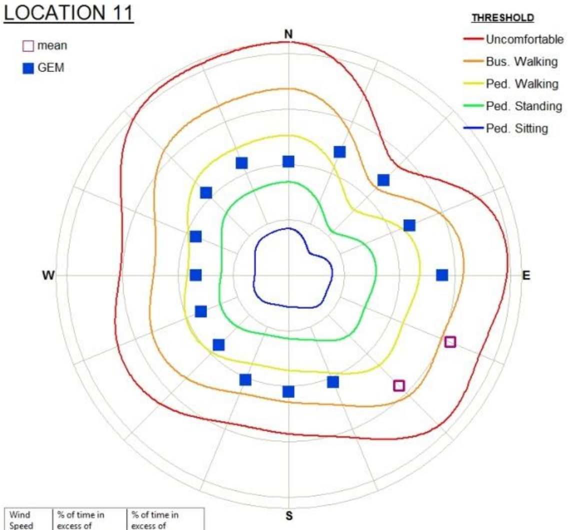
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	25.3	39.3
4.0	4.1	10.4
6.0	0.4	2.0
8.0	0.0	0.2
10.0	0.0	0.0
3.8	**5.0**	Ped Sitting
7.9	**0.022**	Pass
4.9	Ped Standing	**5.0**
10.0	Pass	**0.022**

LOCATION 10



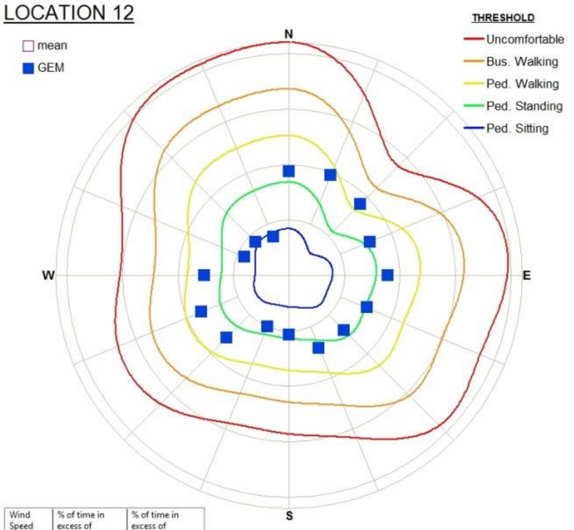
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	35.7	55.2
4.0	7.9	18.0
6.0	0.6	3.6
8.0	0.0	0.4
10.0	0.0	0.0
4.4	**5.0**	Ped Standing
8.1	**0.022**	Pass
5.6	Ped Standing	**5.0**
10.4	Pass	**0.022**

LOCATION 11



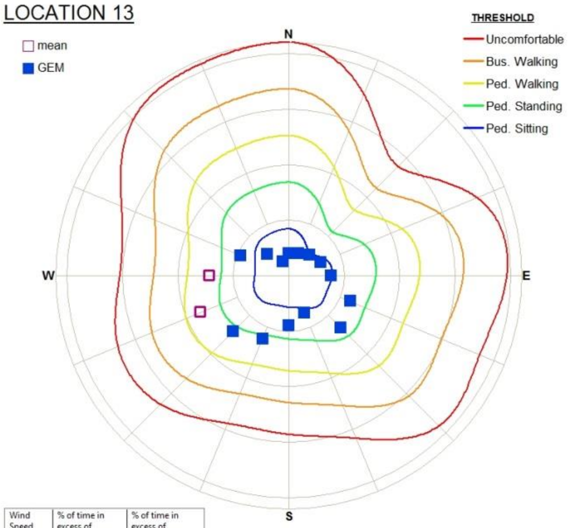
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	64.4	75.4
4.0	25.0	34.7
6.0	5.9	10.1
8.0	1.0	1.6
10.0	0.1	0.2
6.1	**5.0**	Ped Walking
11.3	**0.022**	Pass
6.8	Ped Walking	**5.0**
11.5	Pass	**0.022**

LOCATION 12



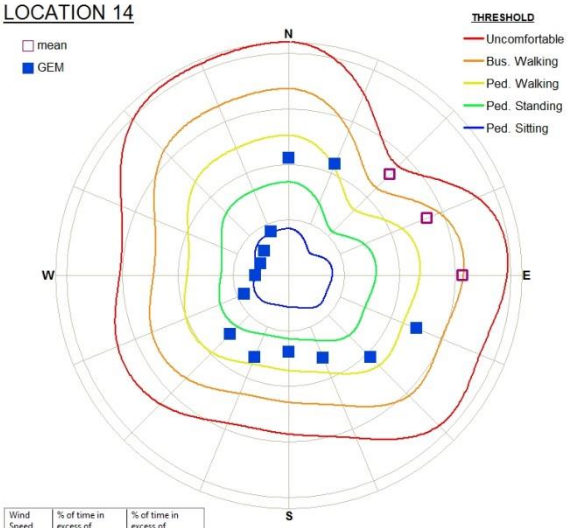
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	36.4	50.1
4.0	5.4	10.3
6.0	0.3	1.2
8.0	0.0	0.0
10.0	0.0	0.0
4.0	**5.0**	Ped Standing
7.4	**0.022**	Pass
4.8	Ped Standing	**5.0**
8.4	Pass	**0.022**

LOCATION 13



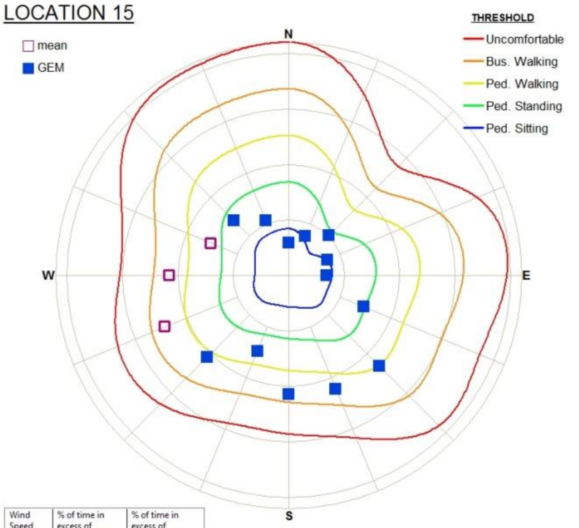
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	16.0	23.5
4.0	2.1	2.3
6.0	0.2	0.1
8.0	0.0	0.0
10.0	0.0	0.0
3.1	**5.0**	Ped Sitting
7.5	**0.022**	Pass
3.4	Ped Sitting	**5.0**
7.0	Pass	**0.022**

LOCATION 14



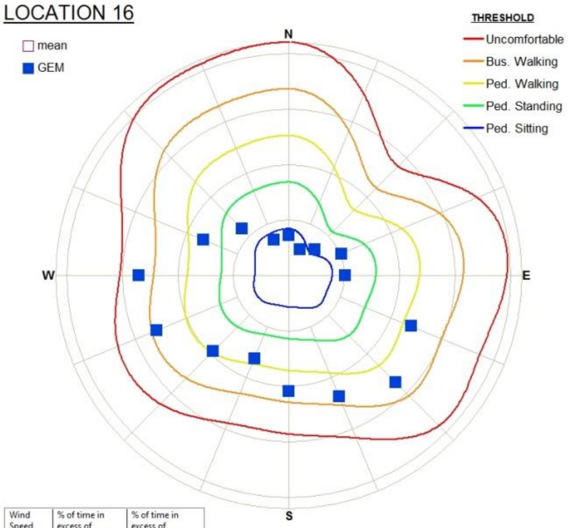
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	44.6	51.7
4.0	16.1	19.0
6.0	5.7	4.3
8.0	1.3	0.5
10.0	0.2	0.0
6.2	**5.0**	Ped Walking
11.8	**0.022**	Pass
5.8	Ped Standing	**5.0**
10.2	Pass	**0.022**

LOCATION 15



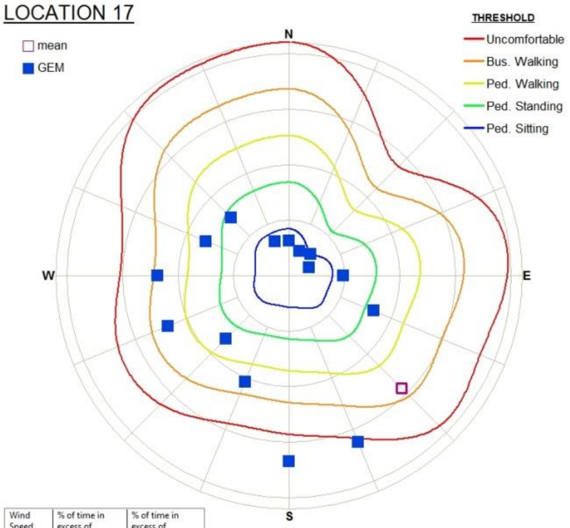
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	41.8	50.1
4.0	12.4	19.3
6.0	2.4	4.6
8.0	0.4	0.7
10.0	0.0	0.1
5.1	**5.0**	Ped Standing
10.6	**0.022**	Pass
5.8	Ped Standing	**5.0**
11.0	Pass	**0.022**

LOCATION 16



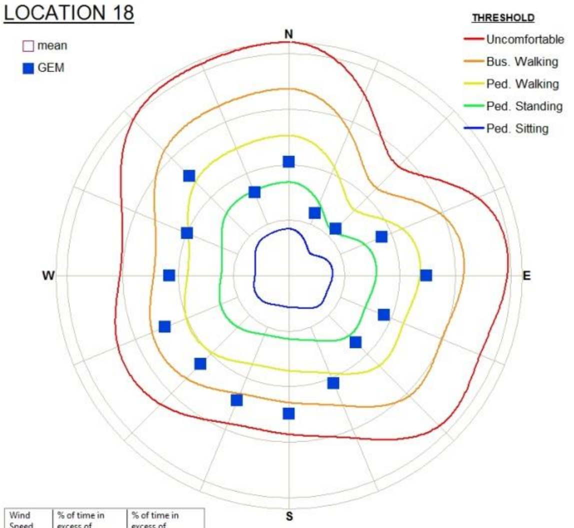
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	42.1	50.1
4.0	19.0	23.5
6.0	4.7	6.8
8.0	0.8	1.4
10.0	0.1	0.3
5.9	**5.0**	Ped Standing
11.2	**0.022**	Pass
6.3	Ped Walking	**5.0**
12.6	Pass	**0.022**

LOCATION 17



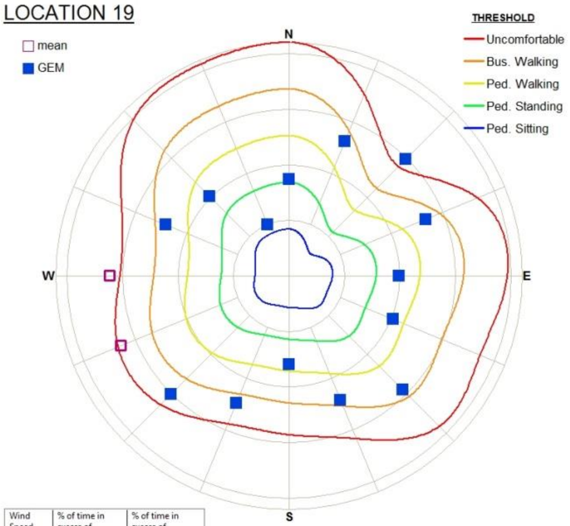
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	42.1	48.6
4.0	21.6	26.8
6.0	8.5	12.9
8.0	2.4	5.1
10.0	0.5	1.8
6.8	**5.0**	Ped Walking
13.5	**0.022**	Pass
7.9	Ped Walking	**5.0**
16.3	Able Body	**0.022**

LOCATION 18



Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	55.6	72.0
4.0	16.9	28.2
6.0	3.7	8.7
8.0	0.5	2.0
10.0	0.1	0.3
5.6	**5.0**	Ped Standing
10.7	**0.022**	Pass
6.7	Ped Walking	**5.0**
13.0	Pass	**0.022**

LOCATION 19



Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	65.1	75.8
4.0	28.8	39.2
6.0	10.8	16.1
8.0	3.2	5.4
10.0	0.8	1.4
7.2	**5.0**	Ped Walking
15.1	**0.022**	Able Body
8.1	Bus Walking	**5.0**
14.4	Pass	**0.022**