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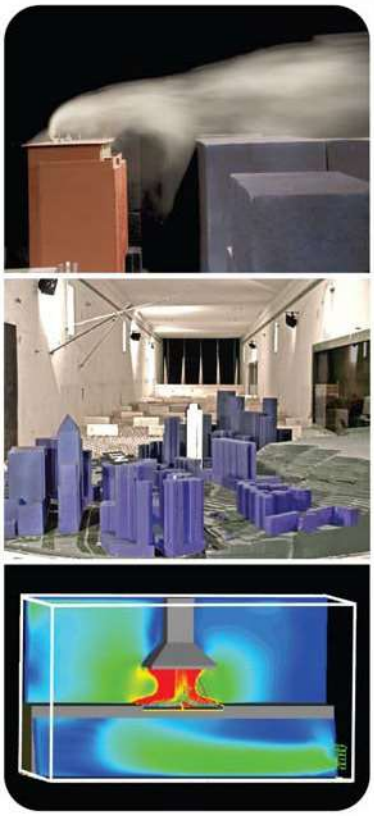
Final Report Revision 3



Wind Tunnel Tests Report for
Stage 2 State Significant
Development Application (SSDA 4):

SYDNEY INTERNATIONAL CONVENTION, EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP), THE HAYMARKET: NORTH WEST PLOT

Sydney, Australia

CPP Project 7094

24 May 2013

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EXECUTIVE SUMMARY

Cermak Peterka Petersen Pty. Ltd. has been engaged by Lend Lease to assess the proposed Haymarket Precinct of Sydney International Convention Centre, Exhibition and Entertainment Precinct (SICEEP) in terms of Wind Impact. This report supports a State Significant Development (SSD) Development Application (DA) submitted to the Minister for Planning and Infrastructure pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

The SICEEP Project will result in the lodgement of numerous SSD DAs for the various components of the redevelopment project. SSD DA wind reports have already been lodged for the PPP component of the SICEEP Project (comprising the convention centre, exhibition centre, entertainment facility and ancillary commercial premises and associated public domain upgrades), and the Stage 1 Concept Proposal for The Haymarket. Separate 'Stage 2' SSD DAs for the development of the South West Plot and the Western Plot (Darling Drive) and associated public domain works will be lodged concurrently with this application.

This report provides an assessment of the impact of the North West Plot on the amenity of the wind environment of the site by providing a Development Specific Wind Report for SSDA4. To achieve this, this report investigates wind impacts for the North West Plot development with an 'existing' surround configuration, as well as the whole SICEEP Preferred Masterplan including planned future precincts. Development Specific Wind Reports incorporating wind tunnel testing will be prepared separately for SSDA3, SSDA5 and SSDA 6 to meet the DGR requirements for Development Specific Wind Reports.

This report also makes reference to City of Sydney, (2004), "Central Sydney Development Control Plan 1996" and City of Sydney (2012), "Sydney Development Control Plan 2012, Section 3 General Provisions" as a best practice guideline.

A model of the full North West Plot project site, with replicas of surrounding buildings within a 570 m radius, was constructed at 1:400 scale and centred on a turntable in the wind tunnel. A wind tunnel study was conducted as part of the Development Specific assessment, and two configurations were tested: Configuration A, representing a case in which the North West Plot is modelled with the proposed PPP section of the SICEEP development in place, and with the proposed North West plot development as the only building on the Haymarket Precinct site, (Figure 7), and Configuration B in which the Haymarket Precinct is fully developed and with all future SICEEP precincts (Figure 8).

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 28 locations in each configuration for 16 wind directions each. These points were tested in the proposed configurations. 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.

A wind tunnel investigation of the pedestrian level wind environment around the proposed North West Plot development has been conducted. It is evident from the results of the investigation that conditions at ground level around the site are generally suitable for pedestrian standing or walking under Lawson, which is similar to conditions throughout much of Sydney. It is noted that no locations around the site met the more formal Lawson outdoor dining criterion. This also is typical in an urban environment in Sydney.

In Configuration A, Locations 8 and 14 at the north-west and south-east corners were windiest and at ground level and rated as suitable for pedestrian walking and able bodied patrons under Lawson.

Notwithstanding, Configuration A represents an unlikely final surrounding built environment. A more realistic representation of the final built environment was modelled in Configuration B, with Location 20.1 on Darling Drive having the highest wind intensity, rated as suitable for business walking and a distress rating for able bodied patrons only under Lawson.

It is expected that proposed mature street trees at this location will likely reduce wind conditions at this location to be below the distress level.

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D	Characteristic dimension (building height, width, etc.)
n	Mean velocity profile power law exponent
T_u	Turbulence intensity, U_{rms}/U
U	Local mean velocity
U_{ref}	Reference velocity at reference height z_{ref}
U_{pk}	Peak wind speed in pedestrian studies
U_{rms}	Root-mean-square of fluctuating velocity
z	Height above surface
ν	Kinematic viscosity of approach flow
$\sigma(\ )$	Standard deviation of $(\ ),=(\ )'_{rms}$
ρ	Density of approach flow
$(\ )_{max}$	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 often 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, 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 summarises 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(s)	
Configuration A	Proposed North West Plot with adjacent PPP development and existing surrounding buildings and landscape but with vacant surrounding Haymarket site, as shown in Figure 7. Pedestrian winds measured at 21 locations for 16 wind directions at 22.5° increments from 0° (north)
Configuration B	Proposed North West Plot and full Haymarket Precinct development with adjacent PPP precinct development and existing surrounding buildings and landscape beyond, as shown in Figure 8. Pedestrian winds measured at 28 locations for 16 wind directions at 22.5° increments from 0° (north)

2. CLIENT PROVIDED INFORMATION

2.1. Introduction

This report supports a State Significant Development (SSD) Development Application (DA) submitted to the Minister for Planning and Infrastructure pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

The Application (referred to as SSDA 4) follows the submission of a staged SSD DA (SSDA 2) submitted in March 2013 to the Department of Planning and Infrastructure that set out a Concept Proposal for a new mixed use residential neighbourhood at Darling Harbour known as 'The Haymarket'. The Haymarket forms part of the Sydney international convention, exhibition and entertainment precinct (SICEEP) Project, which will deliver Australia's global city with new world class convention, exhibition and entertainment facilities and support the NSW Government's goal to "make NSW number one again".

More specifically this subsequent DA seeks approval for a public car park (above ground) and commercial office building within the North West development plot of The Haymarket and associated public domain works. The DA has been prepared and structured to be consistent with the Concept Proposal DA.

2.2. Overview of Proposed Development

The proposal relates to a detailed ('Stage 2') DA for a commercial office and public car park development in the North West Plot of The Haymarket together with associated public domain works. The Haymarket Site is to be developed for a mix of residential and non-residential uses, including but not limited to residential buildings, commercial, retail, community and open space. The North West Plot is one of six development plots identified in the Concept Proposal DA.

Under the Concept Proposal, the North West Plot will accommodate active ground floor uses, a multi-storey above ground public car park and a commercial office building above. More specifically, this SSD DA seeks approval for the following components of the development:

- Staged demolition of existing site improvements, including the existing Sydney Entertainment Centre (SEC), Entertainment car park, and part of the pedestrian footbridge connected to the Entertainment car park;
- Associated tree removal and replanting;
- Construction and use of a mixed use commercial building comprising:
    - ground level retail/television studio uses/IQ Hub;
    - public car park (above ground);
    - ancillary parking (above ground); and
    - commercial office space.

- Provision of vehicle access to the development from realigned Exhibition Place;
- Public domain improvements, including:
    - provision (part) of a new north-south pedestrian connection (known as the Boulevard) eventually linking Quay Street to Darling Harbour;
    - provision (part) of a new east-west pedestrian laneway (known as Dickson's Lane) linking Darling Drive to the Boulevard;
- Extension and augmentation of physical infrastructure / utilities as required.

2.3. Background

On 21 March 2013 a critical step in realising the NSW Government's vision for the SICEEP Project was made, with the lodgement of the first two SSD DAs with the Department of Planning and Infrastructure. The key components of these proposals are outlined below.

Public Private Partnership SSD DA (SSD 12_5752)

The Public-Private Partnership (PPP) SSD DA (SSD 1) includes the core facilities of the SICEEP Project, comprising the new, integrated and world-class convention, exhibition and entertainment facilities along with ancillary commercial premises and public domain upgrades.

The Haymarket Concept Proposal (SSD 13_5878)

The Haymarket Concept Proposal SSD DA (SSDA 2) establishes the vision and planning and development framework which will be the basis for the consent authority to assess detailed development proposals within the Haymarket Site.

More specifically the Stage 1 Concept Proposal seeks approval for the following key components and development parameters:

- Staged demolition of existing site improvements, including the existing Sydney Entertainment Centre (SEC), Entertainment Centre Car Park, and part of the pedestrian footbridge connected to the Entertainment car park and associated tree removal;
- A network of streets, lanes, open space areas and through-site links generally as shown on the Public Domain Concept Proposal, to facilitate reintegration of the site into the wider urban context and connection with the broader SICEEP Site;
- Street layouts;
- Development plot sizes, development plot separation, building envelopes (maximum height in RLs), building separation, building depths, building alignments and a benchmark for natural ventilation and solar provision for the precinct;
- Land uses across the site, including residential and non-residential uses;
- A maximum total gross floor area (GFA) across The Haymarket Site of 197,236m2 for the mixed use development (excluding ancillary above ground car parking), comprising of:
    - A maximum of 49,545m2 non-residential GFA; and
    - A maximum of 147,691m2 residential GFA;
- Above ground parking including public car parking;

- Residential car parking rates to be utilised in the subsequent detailed (Stage 2) Development Applications, being:
    - Zero (0) spaces per studio apartment;
    - Maximum one (1) space per two (2) one bedroom apartments;
    - Maximum one (1) space per one bedroom + study apartment, plus one (1) additional space per five (5) apartments;
    - Maximum one (1) space per two bedroom apartment, plus one (1) additional space per five (5) apartments; and
    - Maximum two (2) spaces per 3+ bedroom apartment.
- Design Guidelines to guide future development and the public domain; and
- A remediation strategy.

This report has been prepared to support a detailed Stage 2 SSD DA for a mixed use commercial and public car park development and associated public domain works within The Haymarket (SSDA 4), consistent with the Concept Proposal SSD DA.

2.4. Site Description

The SICEEP Site is located within Darling Harbour. Darling Harbour is a 60 hectare waterfront precinct on the south-western edge of the Sydney Central Business District that provides a mix of functions including recreational, tourist, entertainment and business.

With an area of approximately 20 hectares, the SICEEP Site is generally bound by the Light Rail Line to the west, Harbourside shopping centre and Cockle Bay to the north, Darling Quarter, the Chinese Garden and Harbour Street to the east, and Hay Street to the south (refer to Figure 1).

The Haymarket Site is:

- located in the south of the SICEEP Site, within the northern portion of the suburb of Haymarket;
- bounded by the Powerhouse Museum to the west, the Pier Street overpass and Little Pier Street to the north, Harbour Street to the east, and Hay Street to the south; and
- irregular in shape and occupies an area of approximately 43,807m2.

Figure 1: Aerial Photograph of the SICEEP Site

The Concept Proposal DA provides for six (6) separate development plots across the Haymarket Site (refer to Figure 2):

1. North Plot;
2. North East Plot;
3. South East Plot;
4. South West Plot;
5. North West Plot; and
6. Western Plot (Darling Drive).

The Application Site area relates to the North West Plot and surrounds as detailed within the architectural and landscape plans submitted in support of the DA.

Figure 2: Concept Proposal Development Plots

2.5. Planning Approvals Strategy

The SICEEP Project will result in the lodgement of numerous SSD DAs for the various components of the redevelopment project. SSD DAs have already been lodged for the PPP component of the SICEEP Project (comprising the convention centre, exhibition centre, entertainment facility and ancillary commercial premises and associated public domain upgrades), and the Stage 1 Concept Proposal for The Haymarket. Separate 'Stage 2' SSD DAs for the development of the South West Plot and the Western Plot (Darling Drive) and associated public domain works will be lodged concurrently with this application. Future applications will be lodged for the Hotel complex, and the remaining development plots of The Haymarket Site.

3. 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 minimum model width 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 3. 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 4 and are explained more fully in Section 5.1.1.

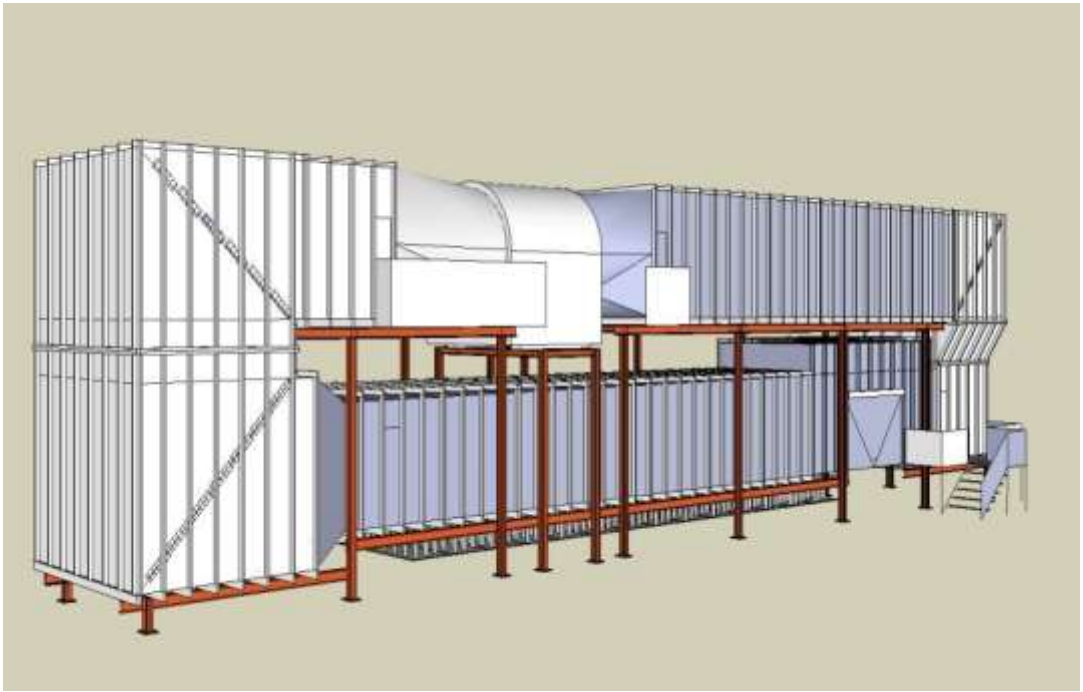


Figure 3: Schematic of the closed circuit wind tunnel

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, and was within wind tunnel blockage limitations. Significant variations in the building surface were formed into the model including all proposed awnings. The models were mounted on the turntable located near the downstream end of the wind tunnel test section, Figure 5. The turntable permitted rotation of the modelled area for examination of velocities from any approach wind direction. Additional photos of the testing are in Appendix 1.

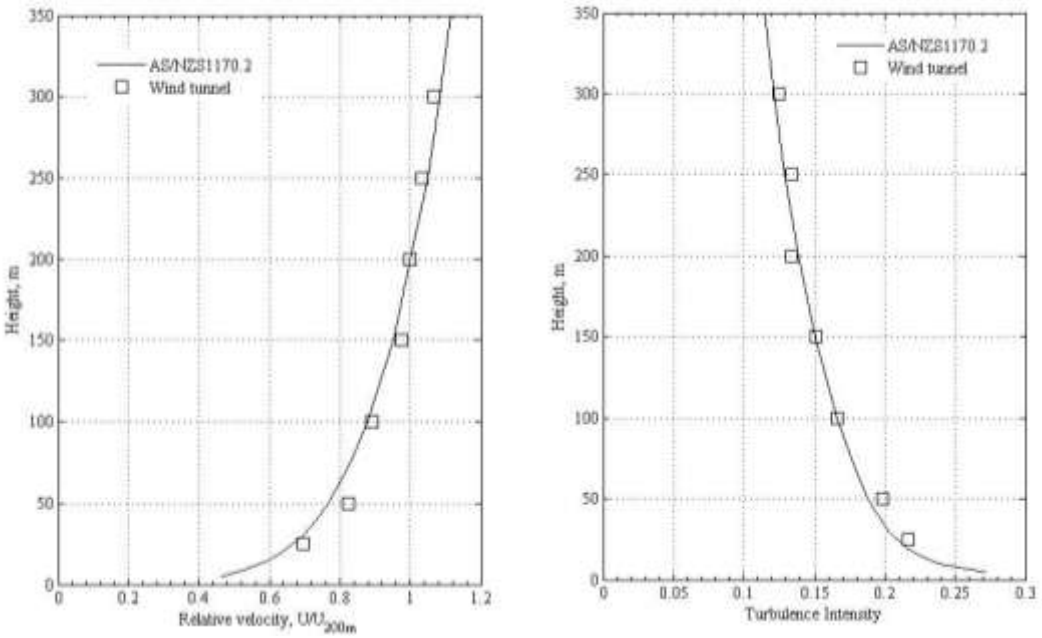


Figure 4: Mean velocity and turbulence profiles approaching the model

Figure 5: Photograph of Configuration A the CPP wind tunnel

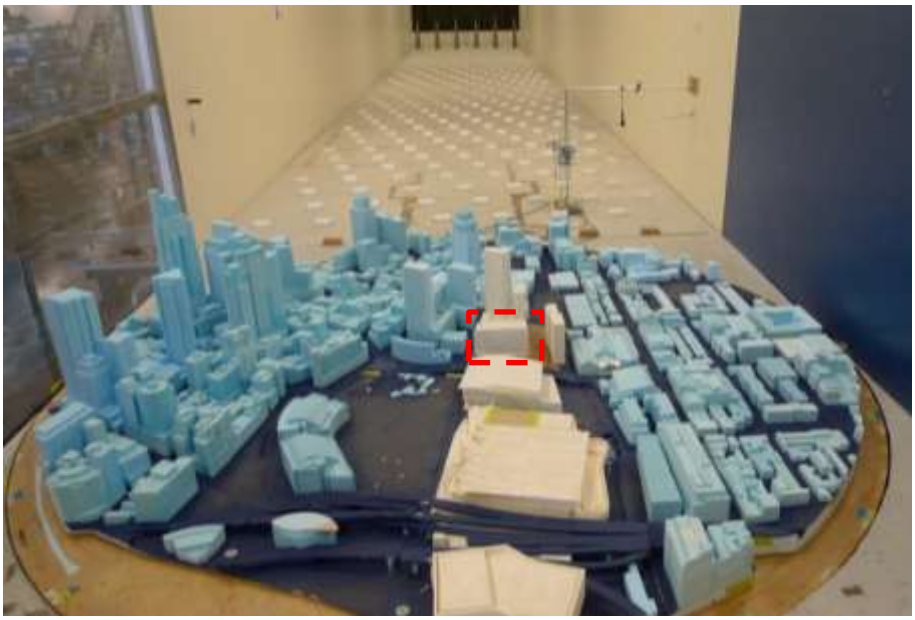


Figure 6: Photograph of Configuration B the CPP wind tunnel

4. 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 Lawson criteria also include a distress rating, for safety assessment, which is based on occasional (once or twice per year) wind speeds1. In both cases, the wind speed used is the larger of a mean or gust equivalent-mean (GEM) wind speed. 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. 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 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, but is meant to be interpreted as a comfort level criterion similar to the lower limit of the Lawson "Business Walking" rating, and is not a distress requirement.

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

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.

5. DATA ACQUISITION AND RESULTS

5.1. 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 5.1.2. 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)

5.1.1. Velocity Profiles

Mean velocity and turbulence intensity profiles for the boundary layer flow approaching the model are shown in Figure 4. Turbulence intensities are related to the local mean wind speed. These profiles have the form of Category 3 winds as defined in Standards Australia (2011) and are appropriate for the approach conditions.

5.1.2. Pedestrian Winds

The proposed development is located to the west of Sydney CBD to the south of Darling Harbour. The proposed North West plot development at the north of The Haymarket precinct consists of a single mid-rise building. The topography in the immediate vicinity is relatively flat, Figure 7 and Figure 8. For this report, wind speed measurements were recorded at 28 locations to evaluate pedestrian comfort around the project site, Figure 7, Figure 8 and Figure 10 to Figure 13. The locations were tested for the configurations described in Table 1. 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. These local wind speeds, U, were normalised by the tunnel reference velocity U_{ref}. Mean and turbulence statistics were calculated and used to calculate the normalised effective peak gust using $\frac{U_{pk}}{U_{ref}} = \frac{U + 3 \cdot U_{rms}}{U_{ref}}$.

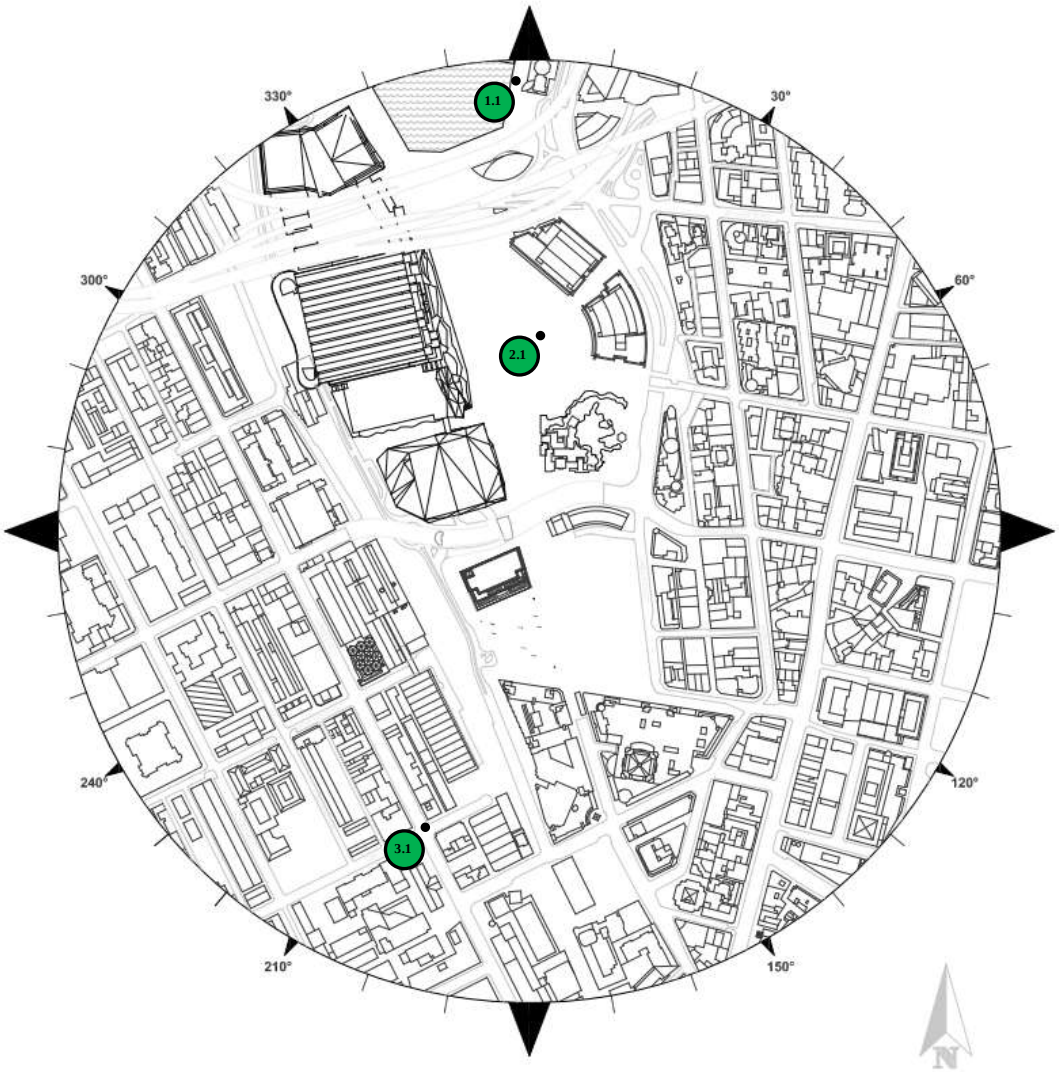


Figure 7: Extent of model for Configuration A

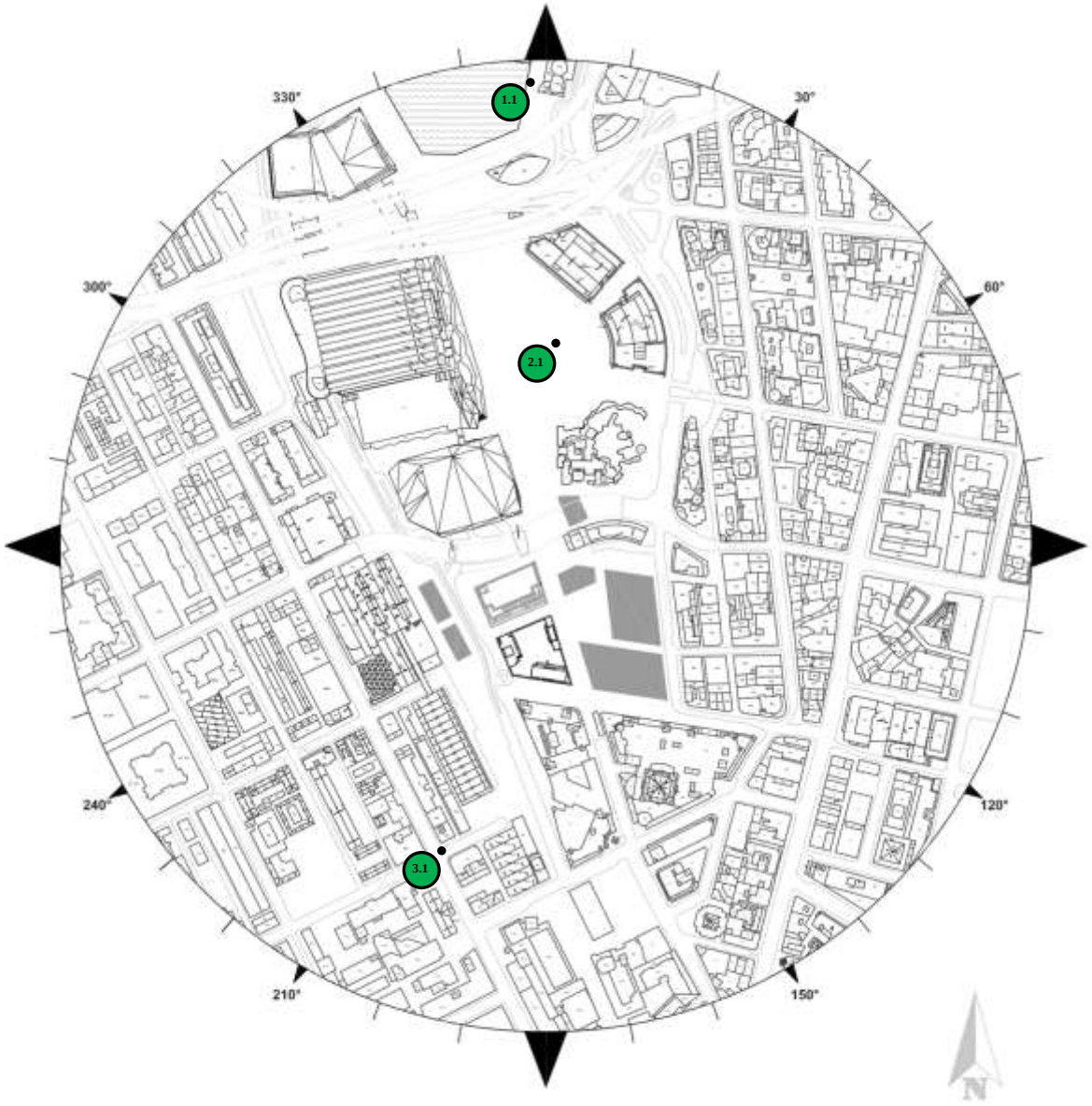


Figure 8: Extent of model for Configuration B

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 and Appendix 3 for Configurations A and B respectively. 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 1974 to 2008, Figure 9. 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 the city. From these data, directional criterion lines for the Lawson rating wind speeds have been calculated and included on the polar plots in Appendix 2 and Appendix 3; this gives additional information regarding directional sensitivity at each location.

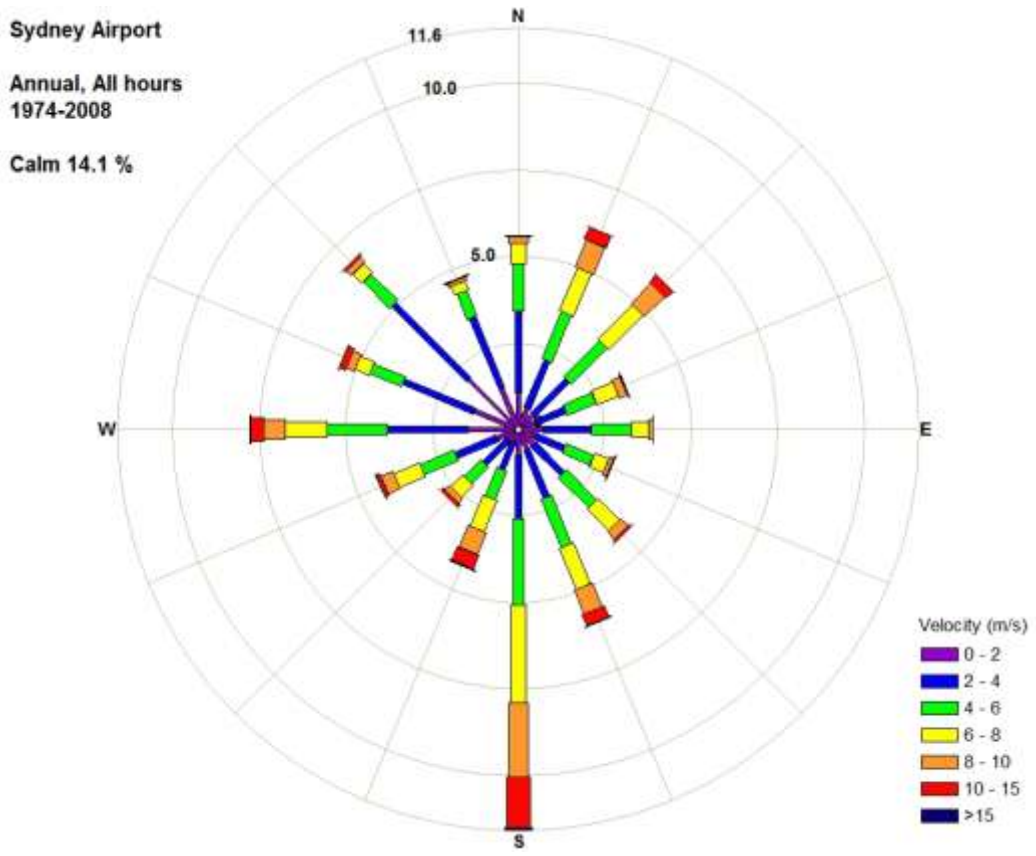


Figure 9: Wind rose of direction and speed for Sydney Airport

The criteria of Lawson consider the integration of the velocity measurements with local wind climate statistical data summarized in Figure 9 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 and Appendix 3 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 7 and Figure 10 to Figure 11 for each test location in Configuration A, and Figure 8 and Figure 12 to Figure 13 for similar locations in Configuration B. 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 6.

It should be noted that Sydney is relatively windy, with an average wind speed at 10 m reference height of approximately 4 m/s (8 kt, 14 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 wind speed at Sydney Airport to a typical pedestrian level in a generic urban environment of similar building massing to the SICEEP 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.

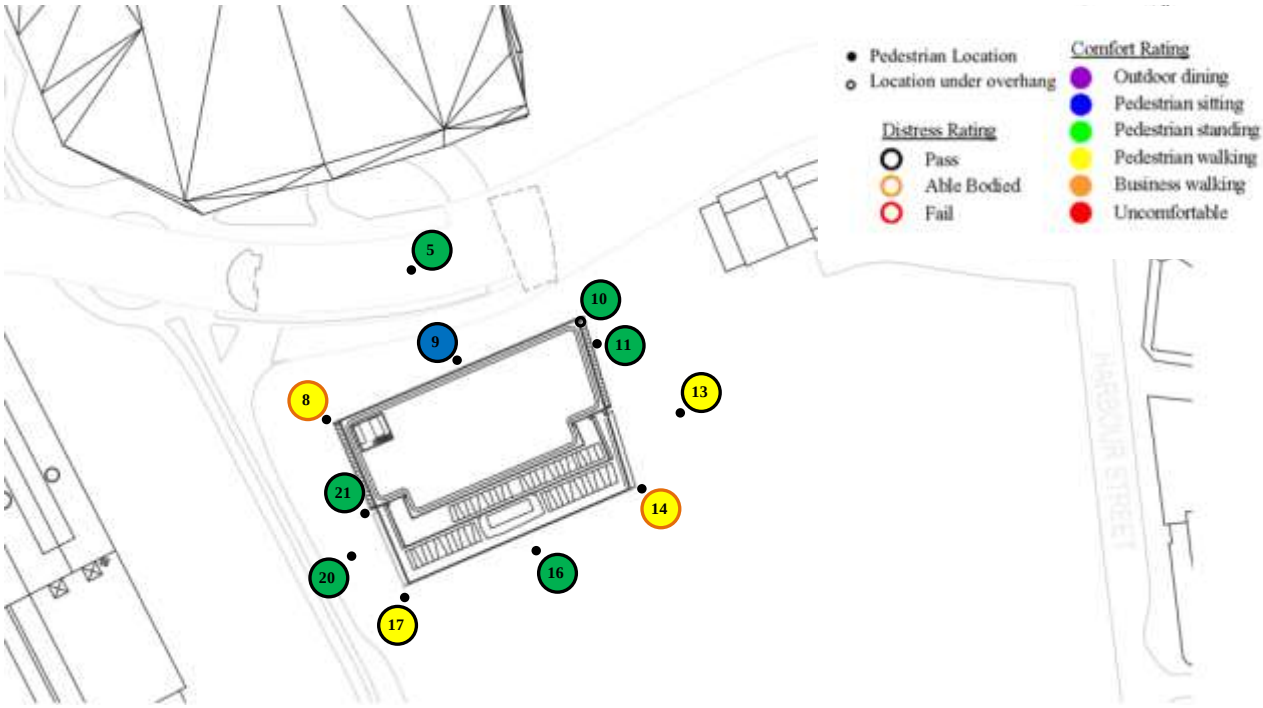


Figure 10: Pedestrian wind speed measurement locations with ratings for Configuration A – Street Level

Figure 11: Pedestrian wind speed measurement locations with ratings for Configuration A – Roof and Upper Level Terraces

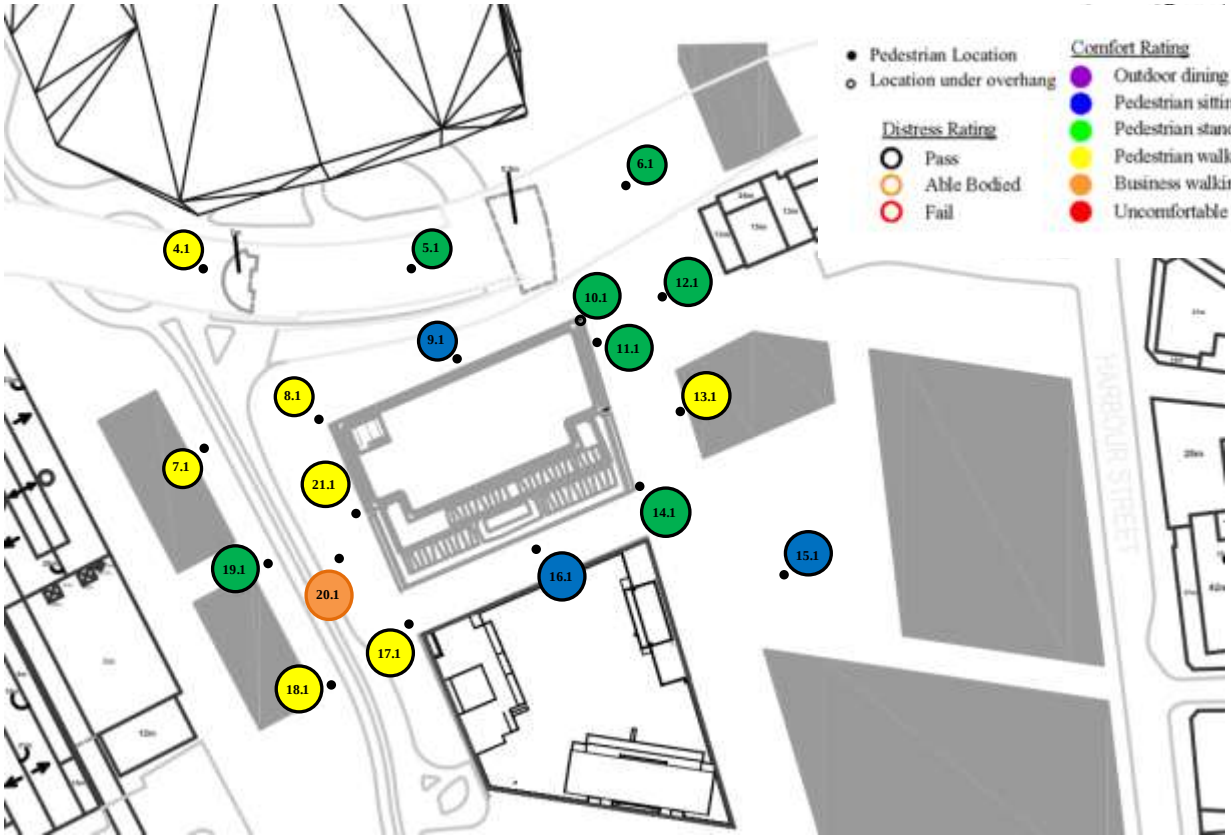


Figure 12: Pedestrian wind speed measurement locations with ratings for Configuration B – Street Level

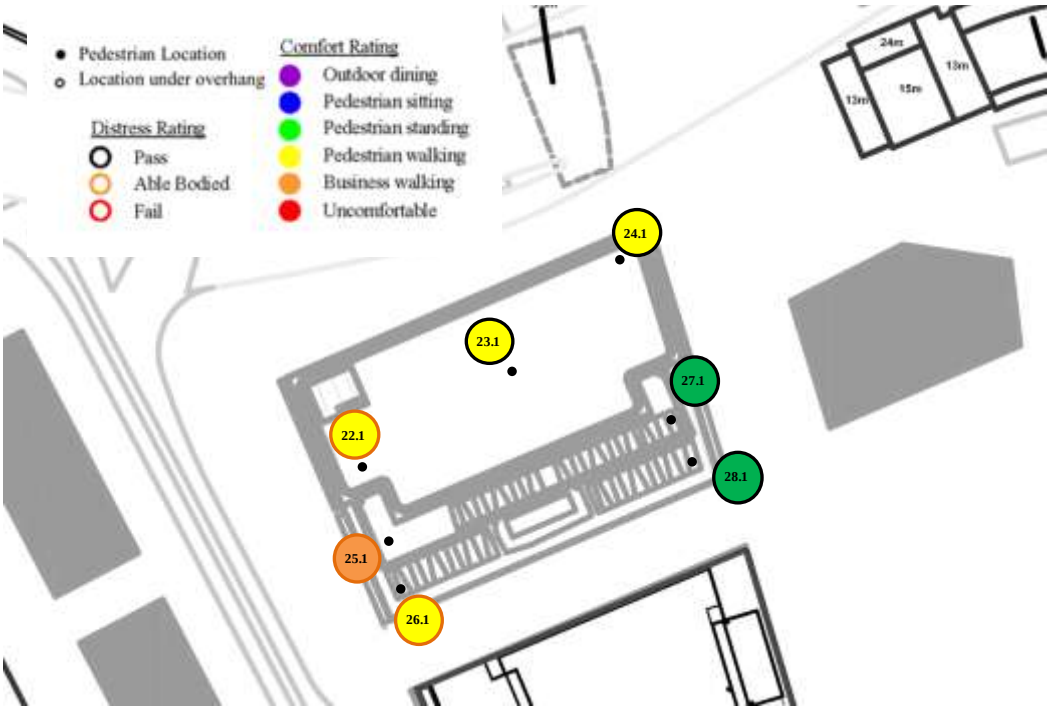


Figure 13: Pedestrian wind speed measurement locations with ratings for Configuration B – Roof and Upper Level Terraces

6. DISCUSSION

The wind climatology chart of Figure 9 indicates that the most frequent strong winds are from the south, and to a lesser extent, the west and north-east. 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 building geometry 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 and Appendix 3.

The primary conclusions of the pedestrian study can be understood by reviewing the colour coded images of Figure 10 to Figure 13, which depict the locations selected for investigation of pedestrian wind comfort around the site 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. Mitigation measures are likely to be required for red locations, as well as orange locations on main pedestrian thoroughfares, and may be necessary for other locations depending on the intended use of the space. Although wind 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 and Appendix 3. Note that testing was performed without planned trees, or other plantings to provide a worst case assessment; heavy streetscape planting typically reduces the wind speeds by less than 10%.

6.1. Configuration A Results

The Configuration A tests (Figure 7 and Figure 10 to Figure 11, and Appendix 2), were conducted with the proposed PPP section of the SICEEP development in place, and with the proposed North West plot development as the only building on the Haymarket Precinct site. Hence Configuration A represents an unlikely final surrounding built environment. Notwithstanding, this isolated case is used to determine the wind environment created by the proposed development, and would represent a baseline interim condition at the site in the event that the North West plot were to be constructed first. Note that remote Locations 1.1, 2.1 and 3.1 (Figure 7) were tested only in Configuration B, but are valid for Configuration A also; these locations, which are provided to show a general indication of conditions surrounding the site, are too distant to show significant influence from the proposed development

The proposed development consists of a mid-rise mixed use development, with car parking on the lower levels, and commercial space on the upper levels, with some terrace access on the southern side of some near-roof levels. It is slightly taller than the existing car parking structure, but smaller in plan. The proposed development has increased to wind approaching across the vacant Haymarket Precinct site to the east, and along Tumbalong Park to the north.

It is evident from Figure 10 that conditions at ground level around the site are generally suitable for pedestrian standing or walking under Lawson, which is similar to conditions throughout much of Sydney. It is noted that no locations around the site met the more formal Lawson outdoor dining criterion. This is typical in an urban environment in Sydney.

The windiest street level conditions around the site were at Locations 8 and 14, which are Located at the north-west corner and south-east corner, respectively. These locations were rated as suitable for pedestrian walking, and able bodied patrons only under Lawson. The windiest conditions at both of these locations occurred during winds from the south west quadrant. These winds will be diverted laterally around the building, and will accelerate around the corners of the building. Both locations only slightly exceed the general Lawson distress criterion. An appropriate planting scheme, particularly at the north-west and south-east corners and around the pedestrian space along the adjoining facades adjacent to these corners, can be used to provide local shelter and help improve conditions in these locations if desired.

The calmest conditions at street level observed adjacent to the proposed development were at Location 9, near the middle of the northern façade. This location, which is well sheltered from most directions by the proposed development, the adjacent elevated road deck, and other surrounding developments, was rated as suitable for casual pedestrian sitting activities under Lawson.

Location 10 is positioned in an undercroft section at the north-east corner of the development. This location is rated as suitable for Lawson pedestrian standing, and is suitable as an entry area.

Location 17 is situated at the southwest corner of the development adjacent to an entry area for cyclists, and is rated as suitable for Lawson pedestrian walking and passed the general distress criterion.

Conditions on the upper level spaces were windy. Locations 22, 23 and 24, positioned on the upper level roof were rated as suitable for Lawson business walking and Location 22 and Lawson pedestrian walking at Locations 23 and 24. Location 22 and 23 were rated for able bodied patrons only. Any areas of this roof intended for tenant use will likely require local screens to produce an amenable wind environment, although it is noted that this area is not a public space.

Locations 25 to 28 are positioned on the upper level terraces on the proposed development. These locations are rated as suitable for Lawson pedestrian walking or standing, with the fastest conditions due to winds from the south west quadrant. As a casual spill out area, patrons would soon learn to use these areas as conditions dictate. If frequent, or more formal usage (such as alfresco dining), is intended for these spaces local screening or dense planting is recommended to provide local shelter for patrons.

6.2. Configuration B Results

The Configuration B tests (Figure 8 and Figure 12 to Figure 13, and Appendix 3), were conducted with the proposed PPP section of the SICEEP development in place, and with the full Haymarket Precinct development in place.

Street level conditions immediately adjacent to proposed North West plot appear to be generally similar to or calmer than those observed for Configuration A. It is noted that no locations around the site met the more formal outdoor Lawson dining criterion. This is typical in an urban environment in Sydney. In the fully developed Configuration, Location 8.1 is still rated as suitable for pedestrian walking, however passes the general distress criterion.

Along the north façade of the proposed development, conditions were relatively calm, with location 9.1 rated under Lawson as suitable for casual pedestrian sitting. Conditions along the Boulevard (Location 10.1, 11.1, 13.1 and 14.1) were generally suitable for pedestrian standing or walking. Location 14.1 is noticeably calmer in Configuration B, and is rated as suitable for pedestrian standing under Lawson, and passes the Lawson distress criterion. Location 16.1 positioned between the proposed development and the adjacent South West plot development was quite calm, and rated as suitable for casual pedestrian sitting activities.

Conditions along Darling Drive were windier. The windy conditions at location 20.1 are primarily due to winds from a south to south-west direction being channelled between the West plot buildings on one side and the South West and proposed North West plot developments on the east side, and along Darling Drive. This location was rated as suitable for business walking and a distress rating suitable for able bodied patrons only under Lawson. Some downwash from W2 and the South West plots will also be contributing to the fast conditions and Location 20.1 (note without simulated street tree planting). This location is in a relatively central part of the Darling Drive, which is not intended for major pedestrian usage, hence wind comfort conditions will be less critical. It is currently proposed to include evergreen Crown Ash and Water Gum species lining Darling Drive and these will provide mild improvement in wind conditions once mature and likely reduce wind conditions at Location 20.1 to be marginally below the distress level.. Conditions along the balance of Darling Drive appear to be marginally calmer, with wind conditions that were suitable for pedestrian walking activities under Lawson and passing the Lawson distress criterion observed closer to the buildings.

Conditions on the roof and upper level terraces were similar for Configurations A and B, although Location 25.1 and 26.1 were windier in the fully developed Configuration. Location 25.1 was rated as suitable for business walking and able bodied patrons only under Lawson, and 26.1 rated as suitable for Lawson pedestrian walking and able bodied patrons only. Local screening is recommended for these two locations to provide calmer conditions for patrons. Location 22.1 is also rated as suitable for Lawson pedestrian walking and able bodied patrons only; if intended to be used by tenants and

patrons, screen is recommended to be used to improve in the vicinity of this location. In general, if frequent or more formal usage (such as alfresco dining) is intended for the roof or terrace spaces, local solid screening or dense shrub type planting is recommended to provide local shelter for patrons.

7. CONCLUSIONS

A wind tunnel investigation of the pedestrian level wind environment around the proposed North West Plot development has been conducted.

It is evident from the results of the investigation that conditions at ground level around the site are generally suitable for pedestrian standing or walking under the Lawson criteria, which is similar to conditions throughout much of Sydney. No locations around the site met the more formal Lawson outdoor dining criterion. This also is typical in an urban environment in Sydney.

In Configuration A, Locations 8 and 14 at the north-west and south-east corners were windiest and at ground level and rated as suitable for pedestrian walking and able bodied patrons under Lawson. Notwithstanding, Configuration A represents an unlikely final surrounding built environment. A more realistic representation of the final built environment was modelled in Configuration B, with Location 20.1 on Darling Drive having the highest wind intensity, rated as suitable for business walking and a distress rating for able bodied patrons only under Lawson. It is expected that proposed mature street trees at this location will likely reduce wind conditions at this location to be below the distress level.

8. 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.

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

City of Sydney (2010), "Draft Development Control Plan 2010, Part 2 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).

Architectural Drawings

Assessment of wind impacts in this report has been based upon development drawings prepared by Lend Lease April 2013.

Appendix 1: Additional Photographs of the CPP Wind Tunnel Model

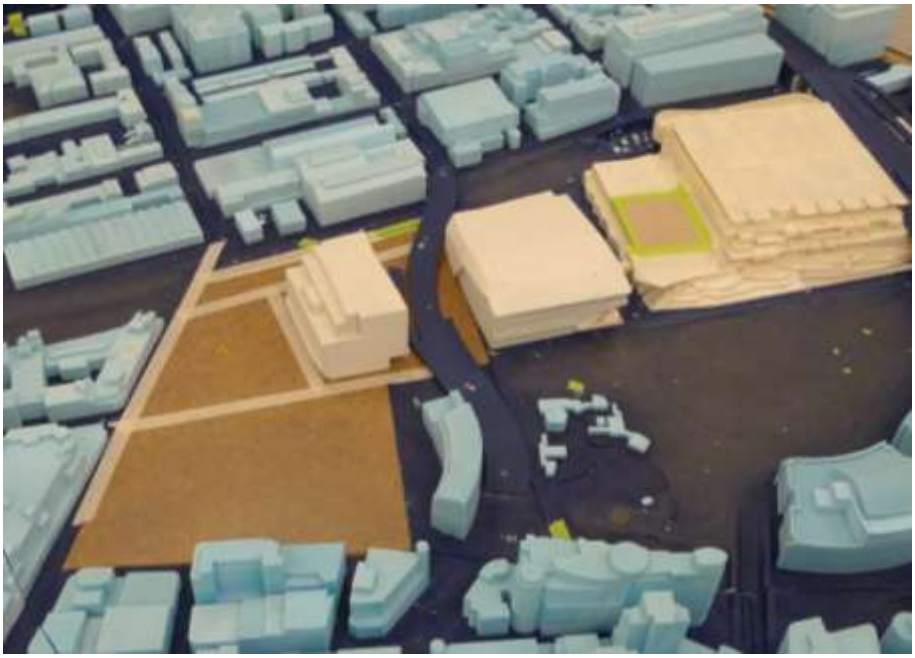
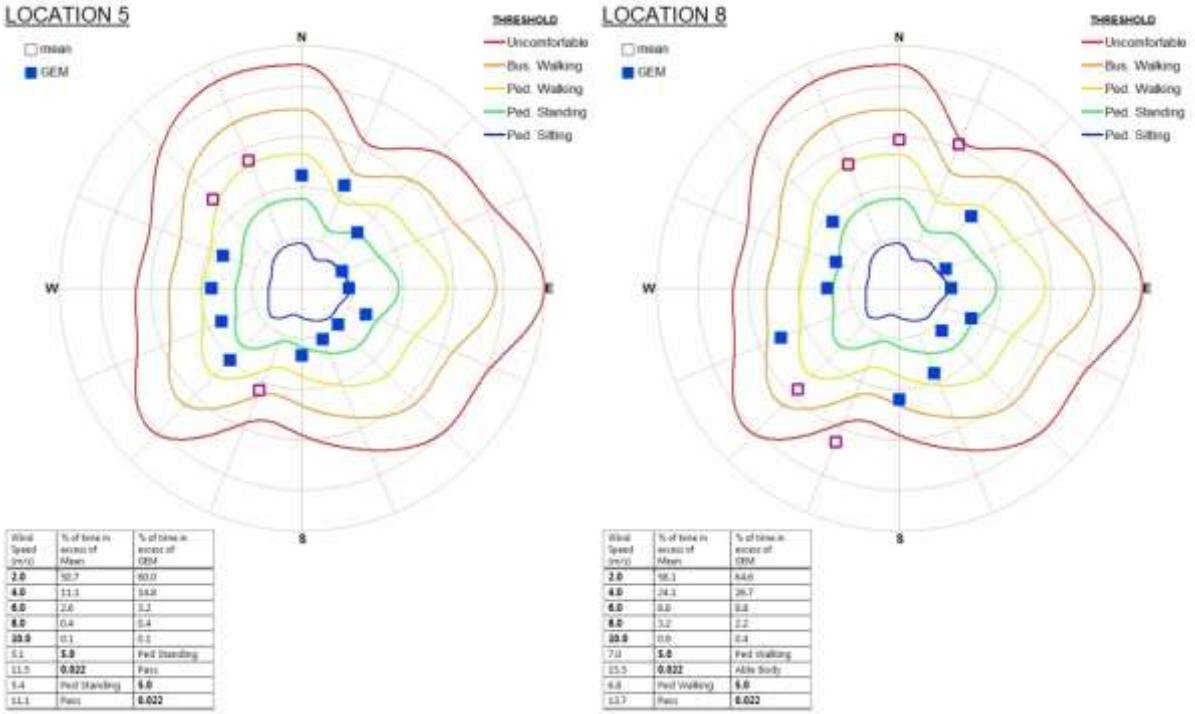


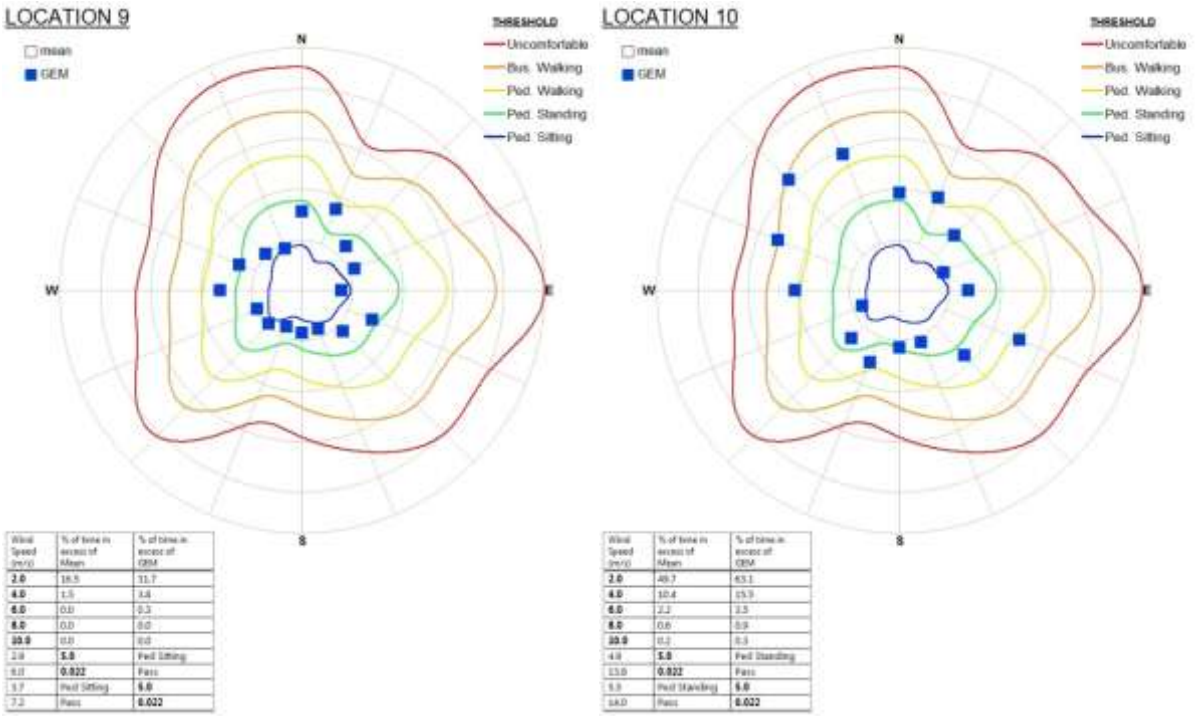
Figure 14: Configuration A

Figure 15: Configuration B

Appendix 2: Directional Wind Results for Configuration A



Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	50.7	60.0
4.0	11.1	14.8
6.0	2.6	3.2
8.0	0.4	0.4
10.0	0.1	0.1
5.1	**5.0**	Ped Standing
11.5	**0.022**	Pass
5.4	Ped Standing	**5.0**
11.1	Pass	**0.022**

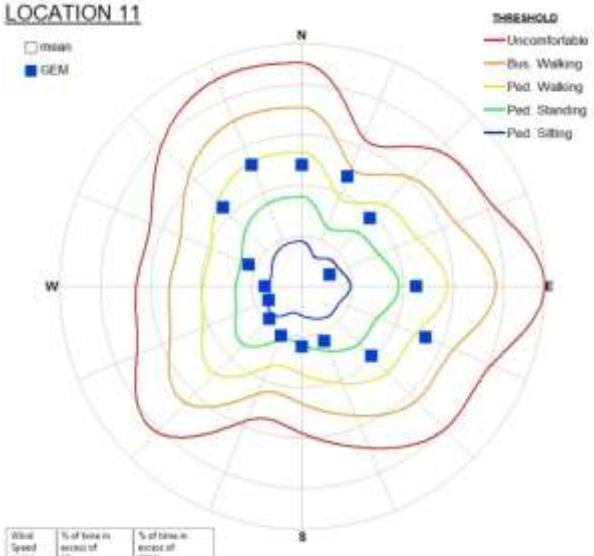


Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	58.1	64.6
4.0	24.1	26.7
6.0	8.8	8.8
8.0	3.2	2.2
10.0	0.9	0.4
7.0	**5.0**	Ped Walking
15.5	**0.022**	Able Body
6.8	Ped Walking	**5.0**
13.7	Pass	**0.022**

Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	16.5	11.7
4.0	1.5	3.4
6.0	0.0	0.3
8.0	0.0	0.0
10.0	0.0	0.0
2.9	**5.0**	Ped Sitting
9.0	**0.022**	Pass
3.7	Ped Sitting	**5.0**
7.2	Pass	**0.022**

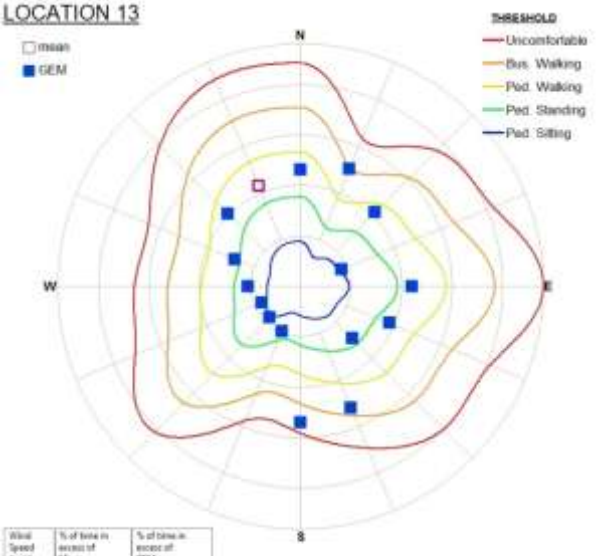
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	49.7	63.1
4.0	10.4	15.9
6.0	2.2	2.5
8.0	0.6	0.9
10.0	0.2	0.3
4.8	**5.0**	Ped Standing
13.0	**0.022**	Pass
5.0	Ped Standing	**5.0**
14.0	Pass	**0.022**

LOCATION 11



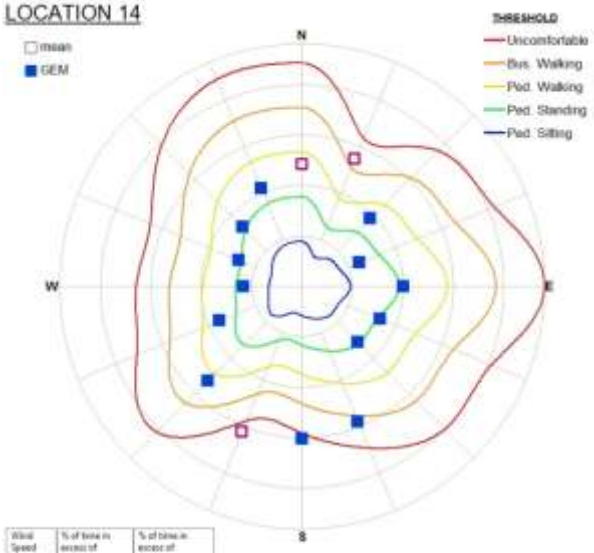
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	98.0	54.7
4.0	6.9	12.2
6.0	1.3	2.6
8.0	0.1	0.4
10.0	0.0	0.0
4.3	**5.0**	Ped Standing
6.8	**0.022**	Pass
9.1	Ped Standing	**5.0**
10.4	Pass	**0.022**

LOCATION 13



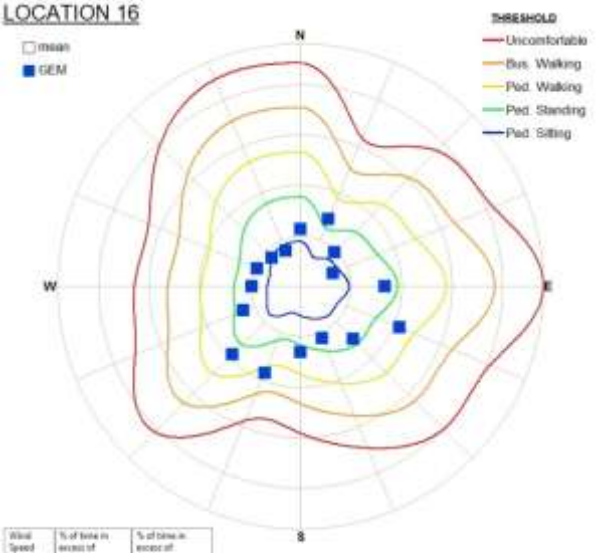
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	47.8	59.2
4.0	18.2	22.5
6.0	4.0	8.9
8.0	0.5	2.2
10.0	0.0	0.4
5.7	**5.0**	Ped Standing
10.3	**0.022**	Pass
6.8	Ped Walking	**5.0**
13.0	Pass	**0.022**

LOCATION 14



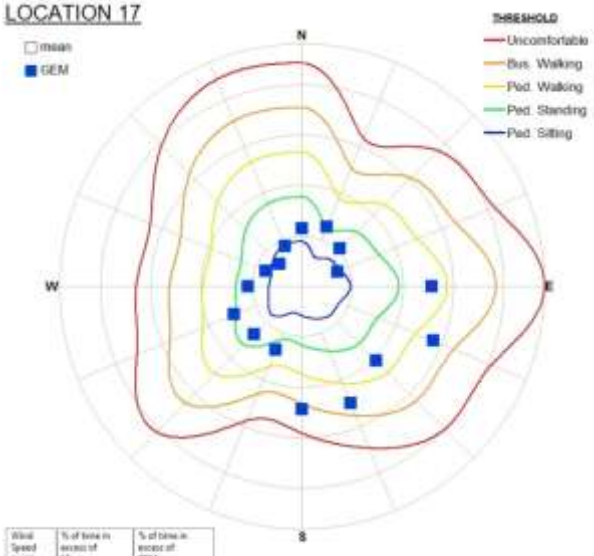
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	94.8	98.8
4.0	25.3	28.4
6.0	13.2	13.7
8.0	4.7	4.8
10.0	1.2	1.3
7.8	**5.0**	Ped Walking
15.3	**0.022**	Able Body
7.9	Ped Walking	**5.0**
15.3	Able Body	**0.022**

LOCATION 16



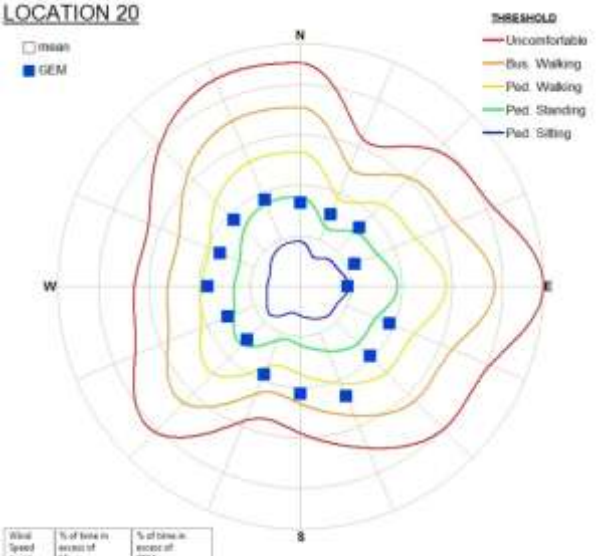
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	18.7	38.6
4.0	1.4	5.9
6.0	0.1	0.5
8.0	0.0	0.1
10.0	0.0	0.0
5.0	**5.0**	Ped Sitting
7.2	**0.022**	Pass
4.1	Ped Standing	**5.0**
4.7	Pass	**0.022**

LOCATION 17



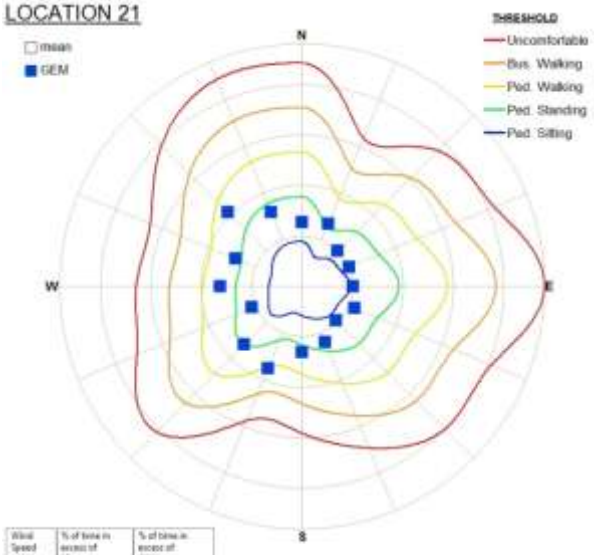
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	35.1	45.8
4.0	11.8	17.3
6.0	1.9	3.1
8.0	0.2	1.0
10.0	0.0	0.1
5.1	**5.0**	Ped Standing
9.0	**0.022**	Pass
6.0	Ped Walking	**5.0**
11.8	Pass	**0.022**

LOCATION 20



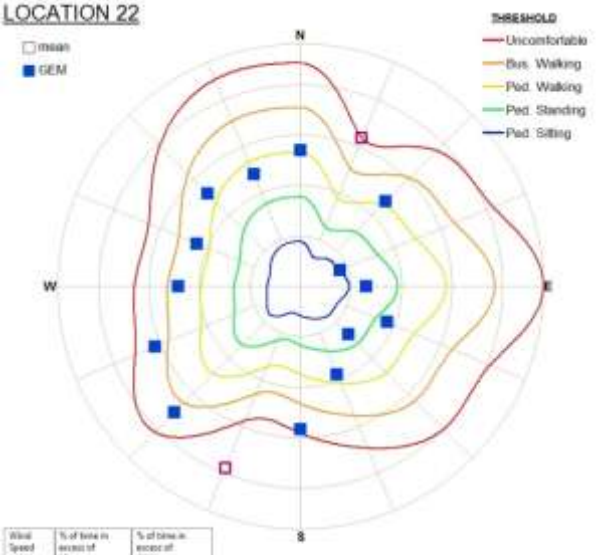
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	39.7	61.3
4.0	8.0	20.0
6.0	0.6	4.0
8.0	0.1	0.5
10.0	0.0	0.1
4.4	**5.0**	Ped Standing
8.0	**0.022**	Pass
5.7	Ped Standing	**5.0**
10.0	Pass	**0.022**

LOCATION 21



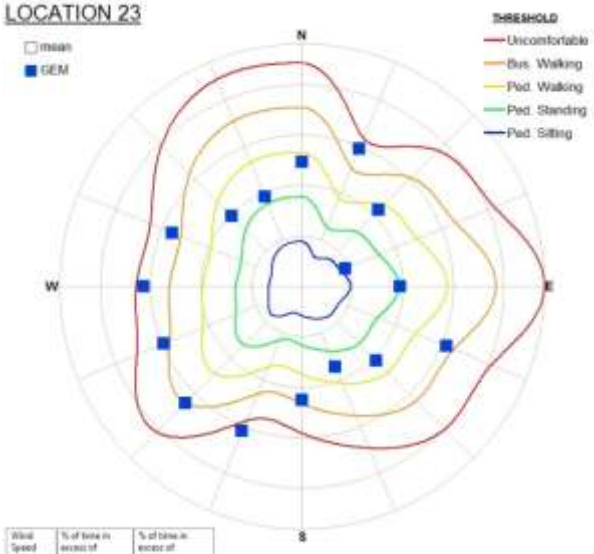
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	22.9	44.2
4.0	1.8	6.6
6.0	0.1	0.7
8.0	0.0	0.1
10.0	0.0	0.0
3.1	**5.0**	Ped Sitting
7.0	**0.022**	Pass
4.2	Ped Standing	**5.0**
9.4	Pass	**0.022**

LOCATION 22



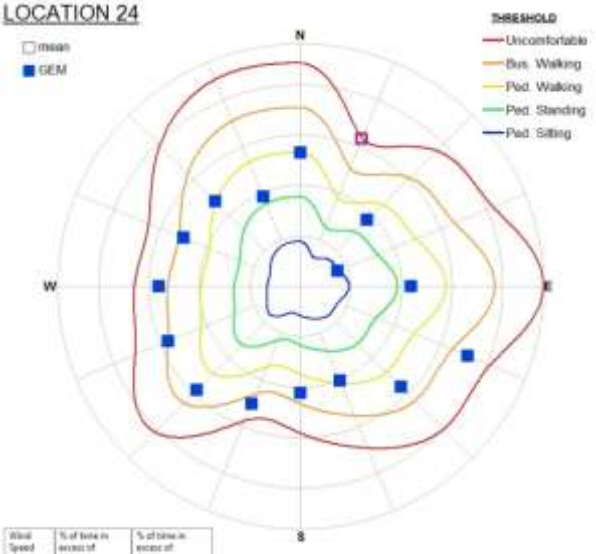
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	69.8	76.5
4.0	30.3	37.1
6.0	12.4	17.6
8.0	4.9	8.8
10.0	1.7	3.9
7.0	**5.0**	Ped Walking
10.3	**0.022**	Able Body
6.3	Bus. Walking	**5.0**
10.6	Able Body	**0.022**

LOCATION 23



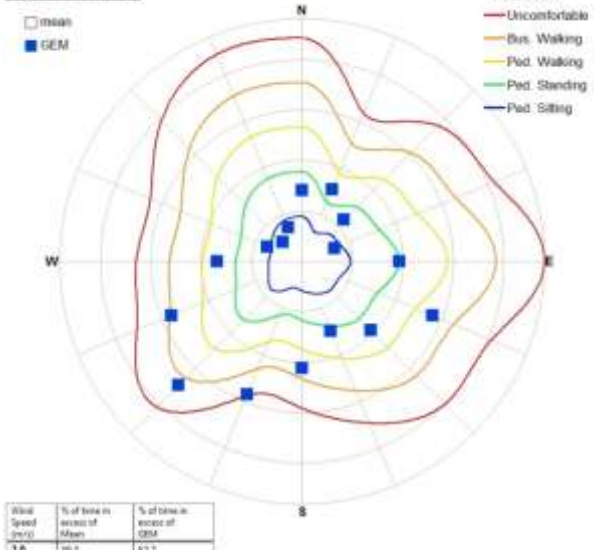
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	70.4	77.6
4.0	27.7	36.8
6.0	10.6	14.8
8.0	3.4	4.7
10.0	0.8	1.2
7.3	**5.0**	Ped Walking
14.2	**0.022**	Pass
7.8	Ped Walking	**5.0**
13.0	Able Body	**0.022**

LOCATION 24



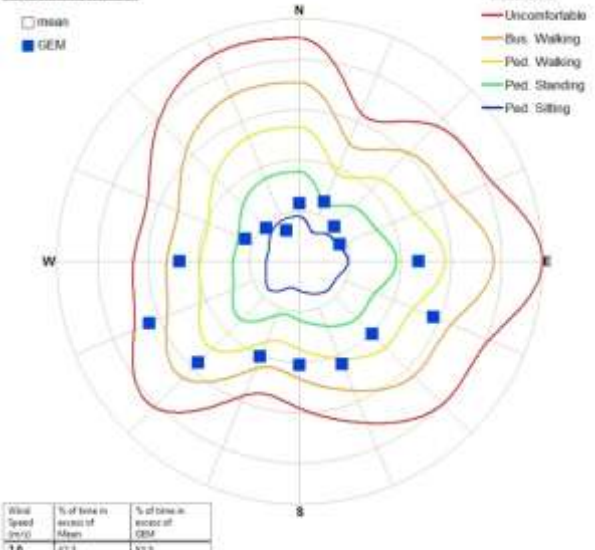
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	70.1	79.4
4.0	27.0	37.5
6.0	8.5	13.8
8.0	2.6	3.9
10.0	0.5	0.9
6.7	**5.0**	Ped Walking
12.7	**0.022**	Pass
7.9	Ped Walking	**5.0**
13.4	Pass	**0.022**

LOCATION 25



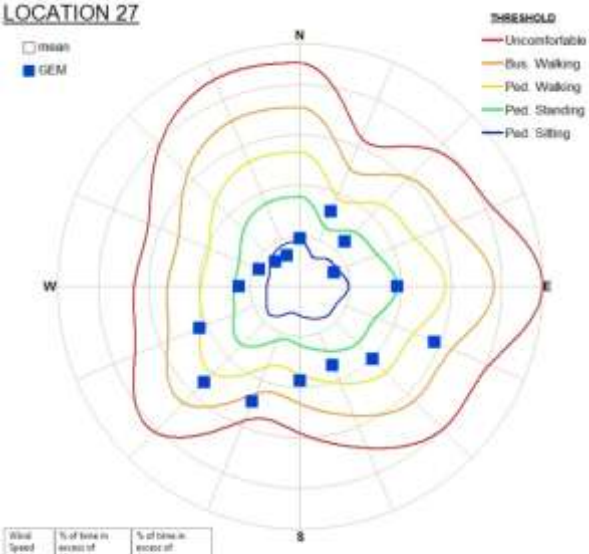
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	59.5	72.7
4.0	9.9	21.1
6.0	2.4	6.7
8.0	0.6	1.6
10.0	0.1	0.4
4.8	**5.0**	Ped Standing
12.0	**0.022**	Pass
6.4	Ped Walking	**5.0**
12.7	Pass	**0.022**

LOCATION 26



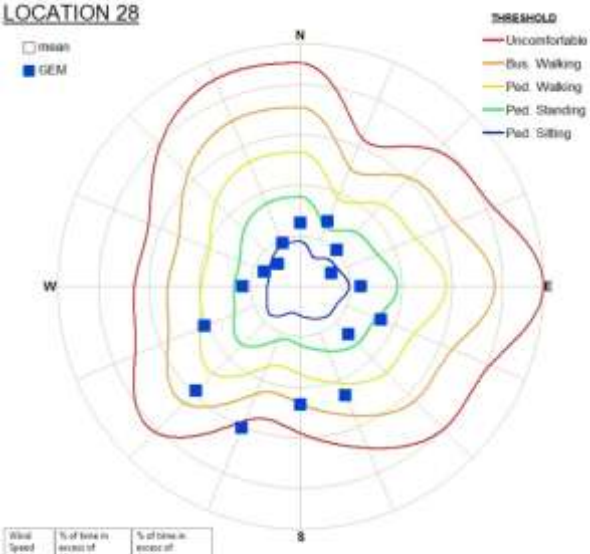
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	42.3	53.5
4.0	12.8	23.8
6.0	1.7	6.4
8.0	0.2	1.2
10.0	0.0	0.2
5.0	**5.0**	Ped Standing
8.7	**0.022**	Pass
6.3	Ped Walking	**5.0**
12.2	Pass	**0.022**

LOCATION 27



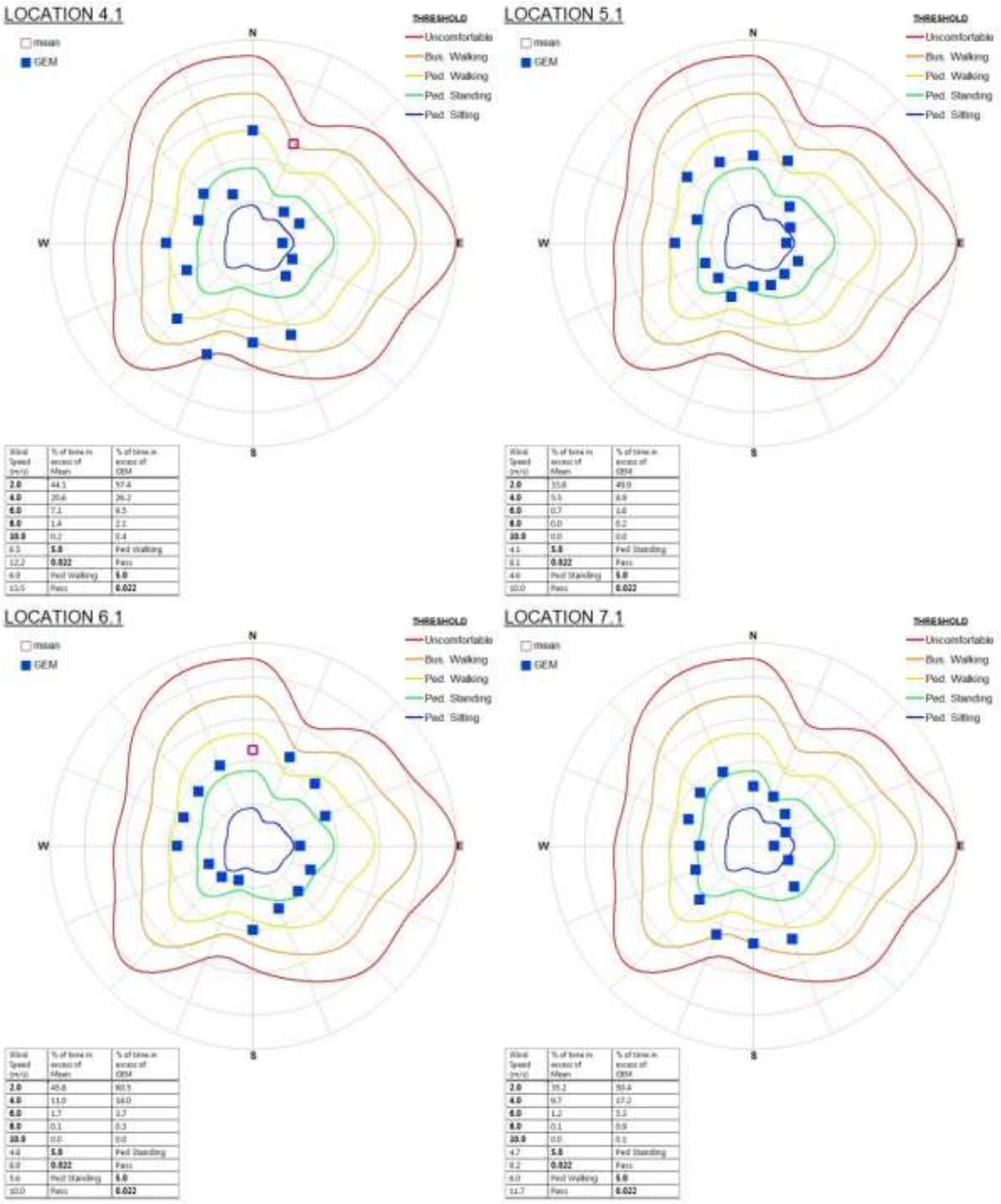
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	38.5	49.4
4.0	8.4	17.9
6.0	1.5	3.6
8.0	0.3	0.6
10.0	0.1	0.1
4.5	**5.0**	Ped Standing
10.9	**0.022**	Pass
5.6	Ped Standing	**5.0**
11.7	Pass	**0.022**

LOCATION 28

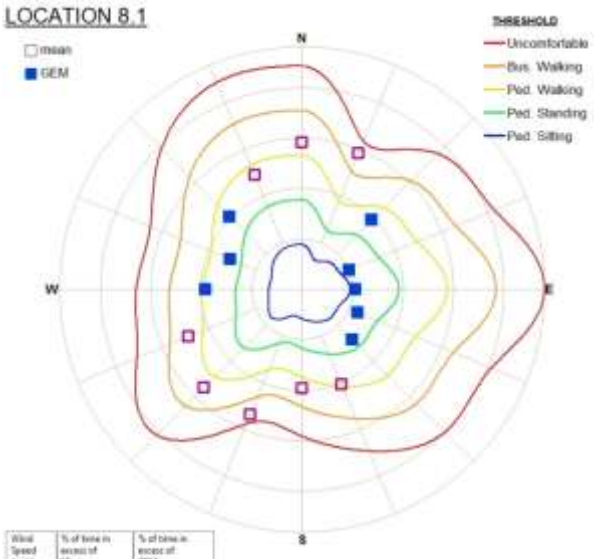


Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	31.8	45.3
4.0	12.6	19.2
6.0	3.2	7.1
8.0	0.6	1.9
10.0	0.1	0.3
5.2	**5.0**	Ped Standing
12.2	**0.022**	Pass
6.3	Ped Walking	**6.0**
14.1	Pass	**0.022**

Appendix 3: Directional Wind Results for Configuration B

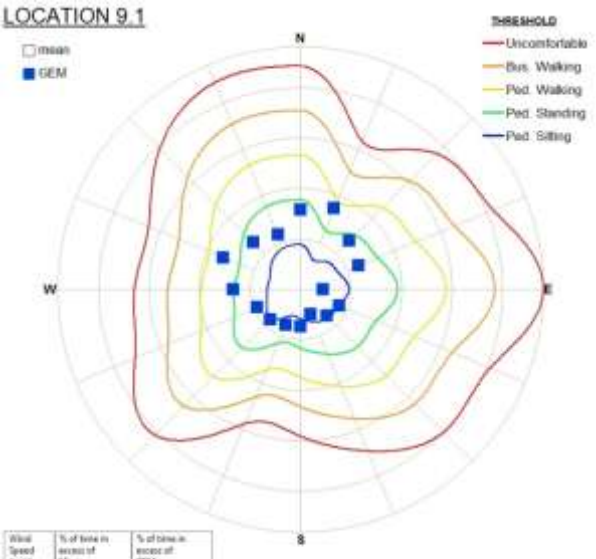


LOCATION 8.1



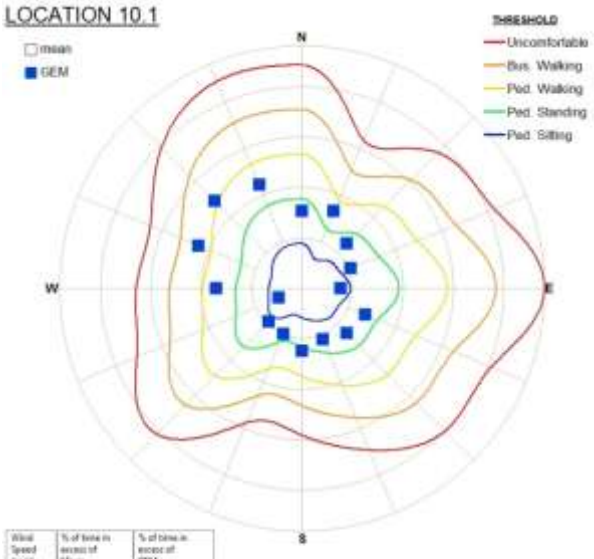
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	82.0	86.3
4.0	26.2	29.1
6.0	7.9	9.2
8.0	2.1	3.0
10.0	0.4	0.1
6.6	**5.0**	Ped Walking
12.0	**0.022**	Pass
6.0	Ped Standing	**5.0**
11.1	Pass	**0.022**

LOCATION 9.1



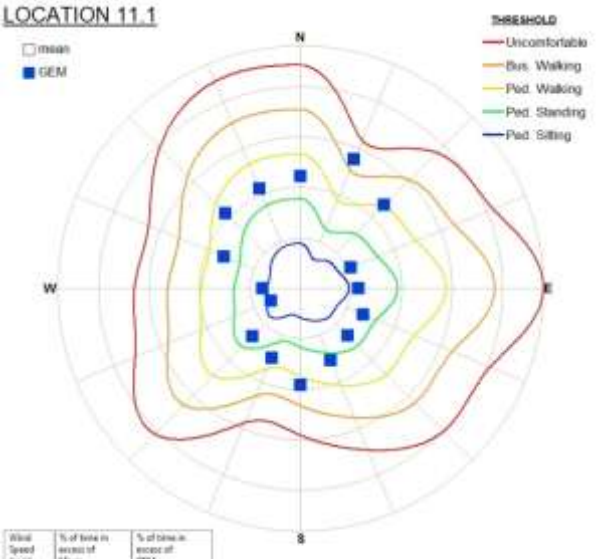
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	12.0	27.8
4.0	1.3	3.5
6.0	0.0	0.3
8.0	0.0	0.0
10.0	0.0	0.0
2.7	**5.0**	Ped Sitting
5.8	**0.022**	Pass
3.6	Ped Sitting	**5.0**
7.6	Pass	**0.022**

LOCATION 10.1



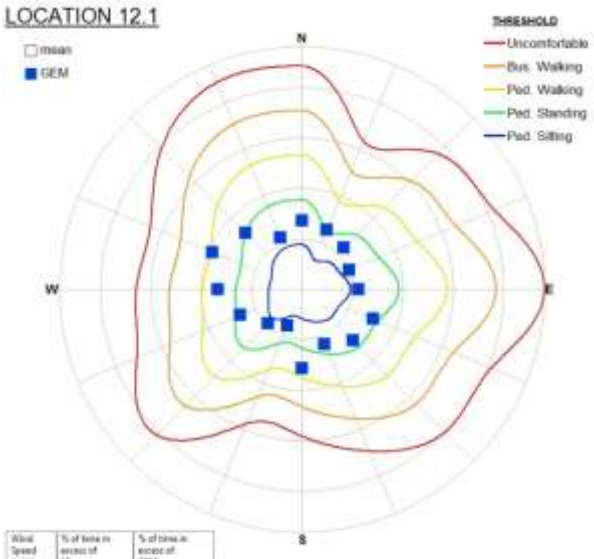
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	52.5	59.6
4.0	7.9	11.7
6.0	0.4	1.4
8.0	0.0	0.3
10.0	0.0	0.1
3.4	**5.0**	Ped Sitting
6.4	**0.022**	Pass
4.4	Ped Standing	**5.0**
11.1	Pass	**0.022**

LOCATION 11.1



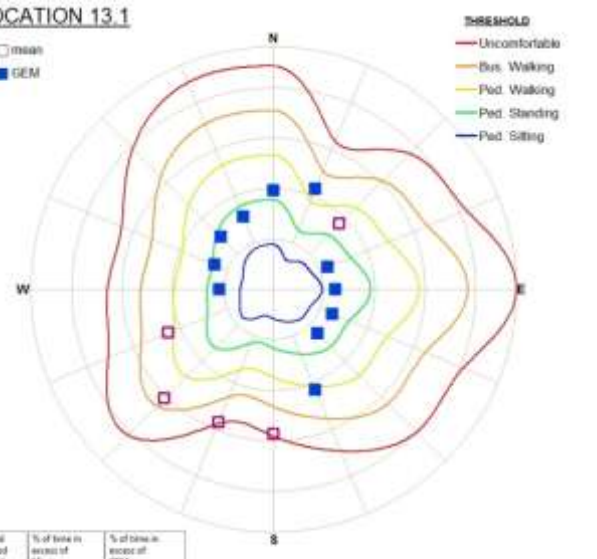
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	42.9	56.0
4.0	13.0	18.0
6.0	2.6	4.5
8.0	0.3	0.9
10.0	0.0	0.1
5.2	**5.0**	Ped Standing
8.6	**0.022**	Pass
5.8	Ped Standing	**5.0**
11.1	Pass	**0.022**

LOCATION 12.1



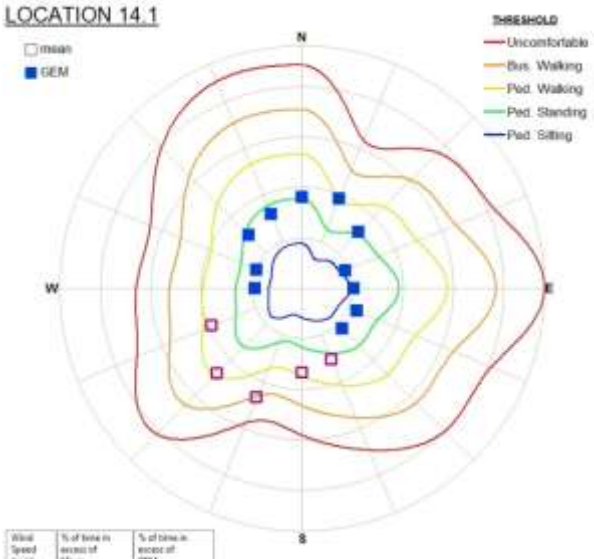
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	27.4	44.1
4.0	1.8	6.7
6.0	0.1	0.7
8.0	0.0	0.1
10.0	0.0	0.0
5.1	**5.0**	Ped Sitting
9.3	**0.022**	Pass
4.2	Ped Standing	**5.0**
6.9	Pass	**0.022**

LOCATION 13.1



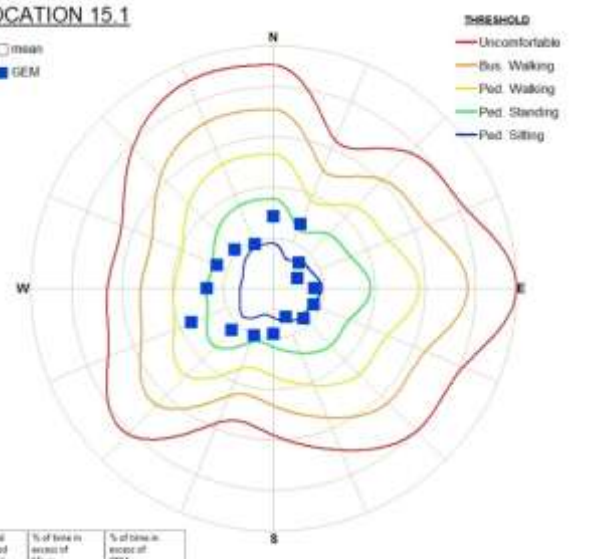
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	48.5	56.4
4.0	24.0	34.3
6.0	10.4	9.8
8.0	3.2	2.9
10.0	0.8	0.6
7.2	**5.0**	Ped Walking
14.4	**0.022**	Pass
7.1	Ped Walking	**5.0**
14.0	Pass	**0.022**

LOCATION 14.1



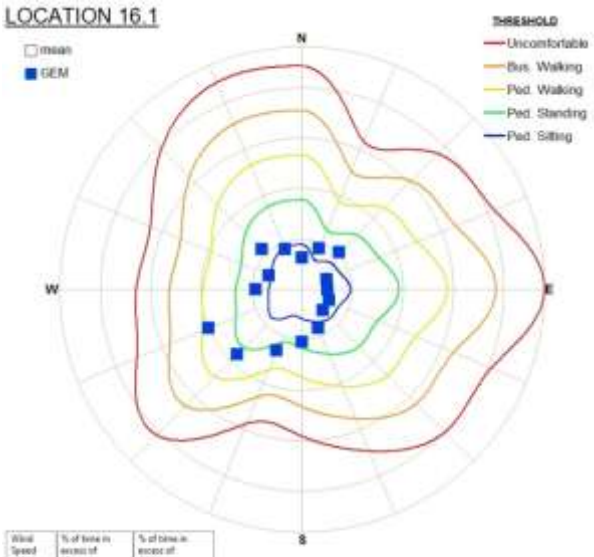
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	41.8	48.4
4.0	13.0	12.8
6.0	2.3	1.8
8.0	0.3	0.2
10.0	0.1	0.0
5.1	**5.0**	Ped Standing
11.1	**0.022**	Pass
5.0	Ped Standing	**5.0**
≥0.0	Pass	**0.022**

LOCATION 15.1



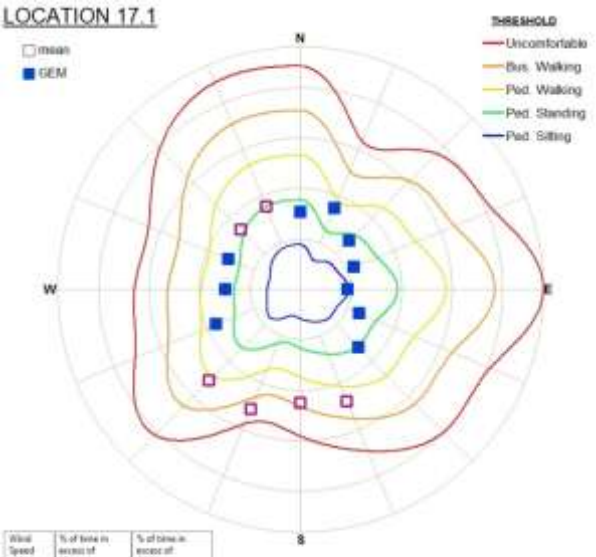
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	9.4	26.1
4.0	0.3	2.9
6.0	0.0	0.1
8.0	0.0	0.0
10.0	0.0	0.0
2.4	**5.0**	Ped Sitting
5.2	**0.022**	Pass
5.0	Ped Sitting	**5.0**
4.8	Pass	**0.022**

LOCATION 16.1



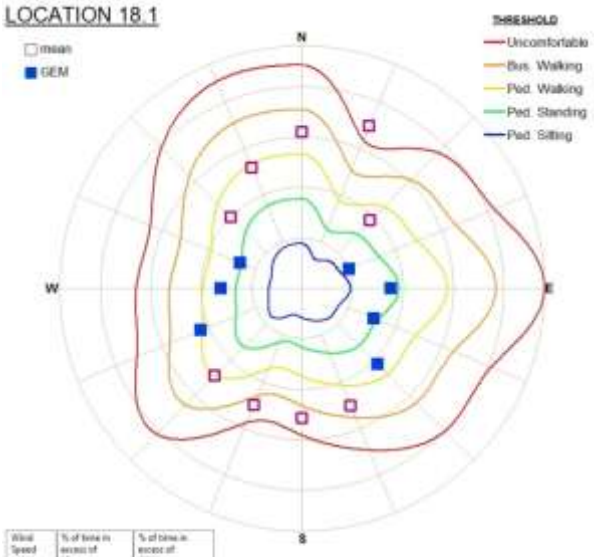
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	9.5	24.4
4.0	1.3	2.8
6.0	0.1	0.2
8.0	0.0	0.0
10.0	0.0	0.0
2.4	**5.0**	Ped Sitting
7.3	**0.022**	Pass
3.4	Ped Sitting	**5.0**
7.7	Pass	**0.022**

LOCATION 17.1



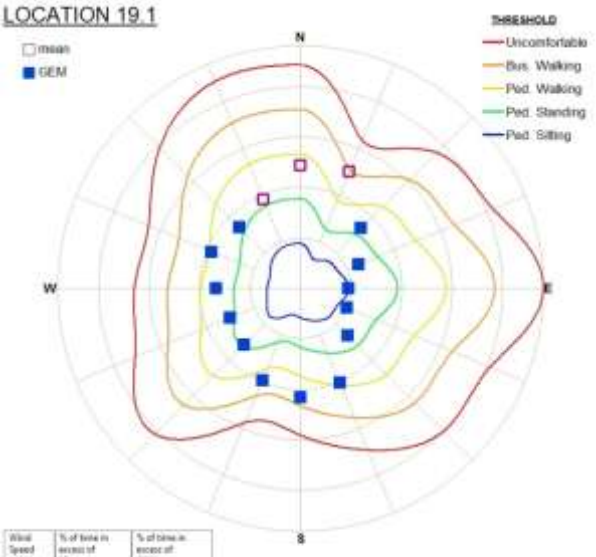
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	50.4	55.7
4.0	18.9	19.2
6.0	5.7	4.3
8.0	1.1	0.6
10.0	0.2	0.1
6.1	**5.0**	Ped Walking
12.3	**0.022**	Pass
5.8	Ped Standing	**6.0**
11.1	Pass	**0.022**

LOCATION 18.1



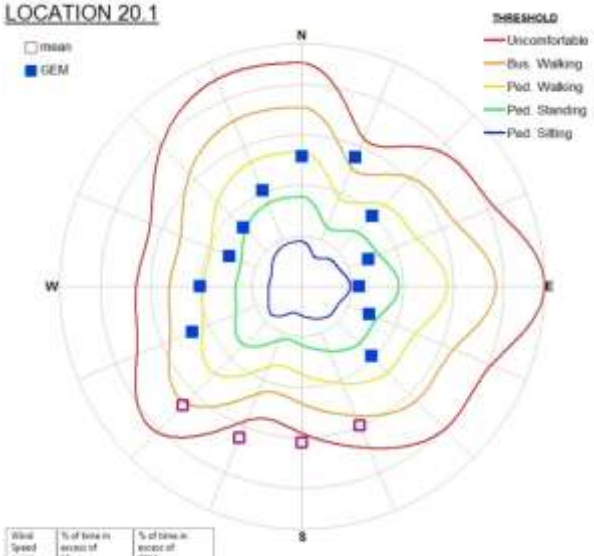
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	67.6	69.1
4.0	30.7	28.2
6.0	12.8	8.2
8.0	4.1	1.8
10.0	1.1	0.2
7.3	**5.0**	Ped Walking
14.0	**0.022**	Pass
6.7	Ped Walking	**6.0**
11.8	Pass	**0.022**

LOCATION 19.1



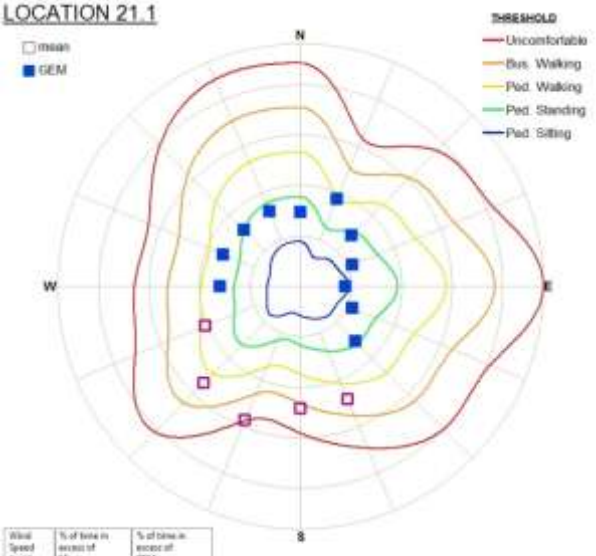
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	51.5	51.2
4.0	13.0	21.1
6.0	3.0	5.0
8.0	0.4	0.6
10.0	0.0	0.0
5.3	**5.0**	Ped Standing
8.0	**0.022**	Pass
6.0	Ped Standing	**6.0**
10.7	Pass	**0.022**

LOCATION 20.1



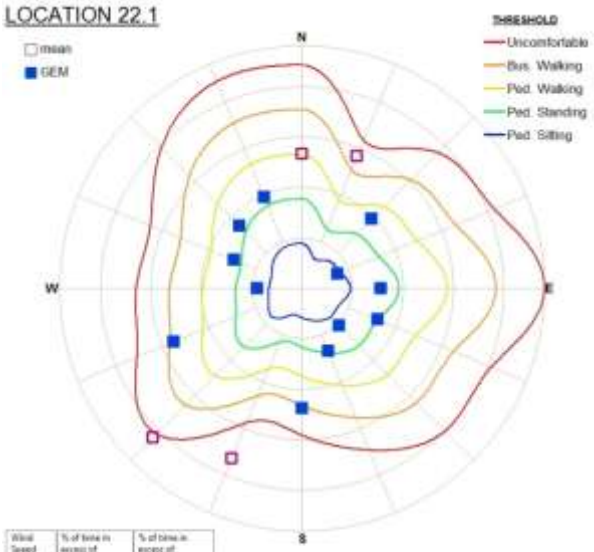
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	57.9	89.6
4.0	28.2	62.4
6.0	14.8	33.2
8.0	5.6	13.9
10.0	1.6	6.8
6.1	**5.0**	Bus Walking
16.1	**0.022**	Able Body
7.9	Ped Walking	**5.0**
14.4	Pass	**0.022**

LOCATION 21.1



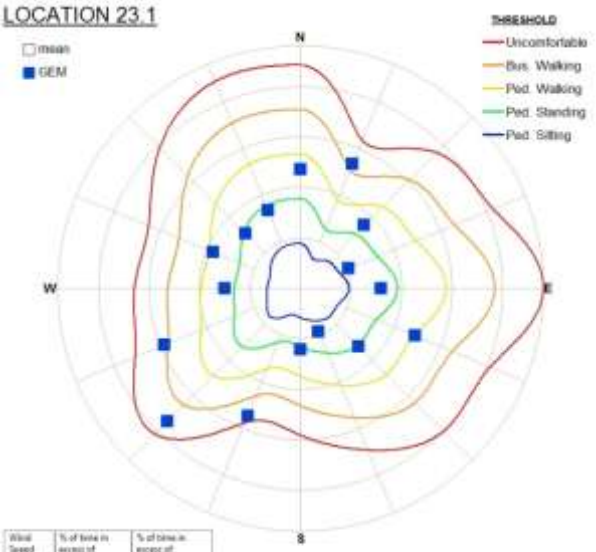
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	44.1	90.6
4.0	19.3	51.0
6.0	7.2	5.8
8.0	1.8	1.0
10.0	0.4	0.1
6.1	**5.0**	Ped Walking
13.6	**0.022**	Pass
6.1	Ped Walking	**5.0**
11.9	Pass	**0.022**

LOCATION 22.1



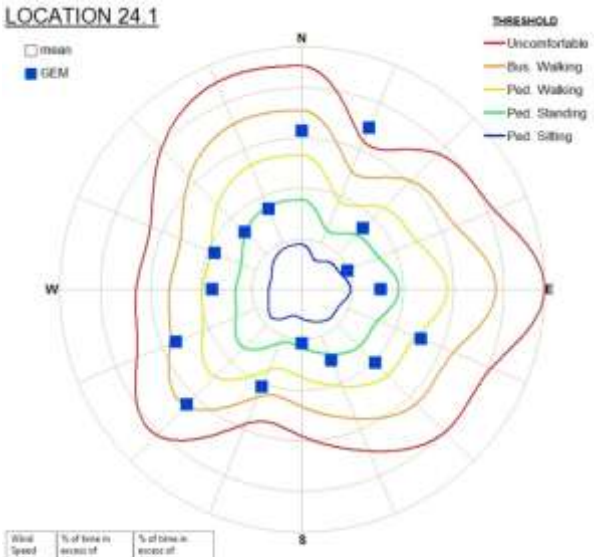
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	49.0	91.2
4.0	21.5	36.9
6.0	8.0	11.3
8.0	3.6	4.0
10.0	1.2	1.2
7.2	**5.0**	Ped Walking
17.3	**0.022**	Able Body
7.9	Ped Walking	**5.0**
17.1	Able Body	**0.022**

LOCATION 23.1



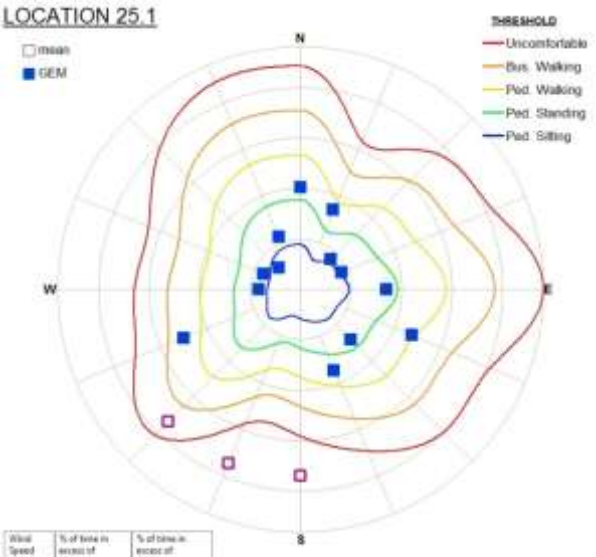
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	44.5	91.7
4.0	12.9	39.2
6.0	3.8	7.0
8.0	0.9	2.0
10.0	0.1	0.4
5.5	**5.0**	Ped Standing
13.0	**0.022**	Pass
6.6	Ped Walking	**5.0**
11.5	Pass	**0.022**

LOCATION 24.1



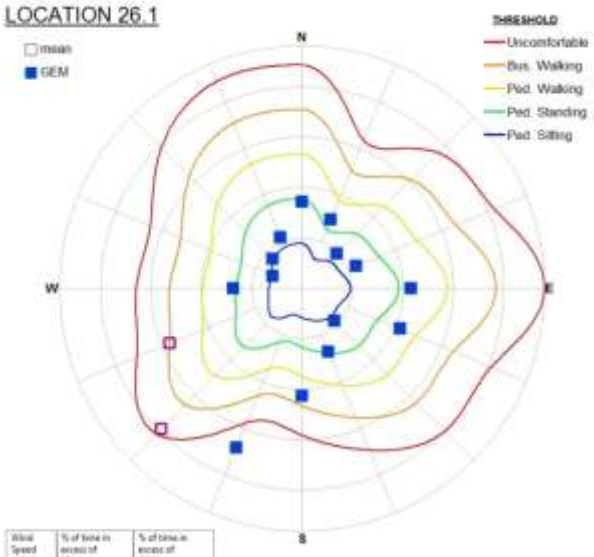
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	47.1	65.9
4.0	13.8	22.4
6.0	4.8	7.7
8.0	2.0	2.8
10.0	0.6	0.9
5.8	**5.0**	Ped Standing
12.9	**0.022**	Pass
6.7	Ped Walking	**5.0**
13.6	Pass	**0.022**

LOCATION 25.1



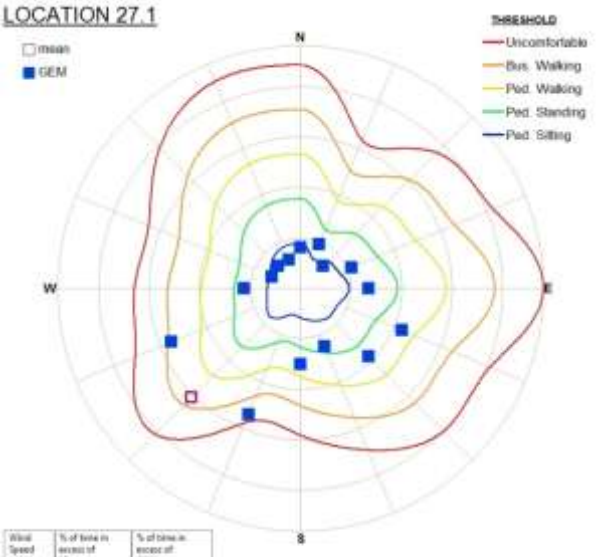
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	38.7	49.9
4.0	20.1	23.3
6.0	13.3	12.2
8.0	8.1	5.8
10.0	3.7	2.0
9.2	**5.0**	Bus Walking
18.7	**0.022**	Able Body
8.1	Bus Walking	**5.0**
16.4	Able Body	**0.022**

LOCATION 26.1



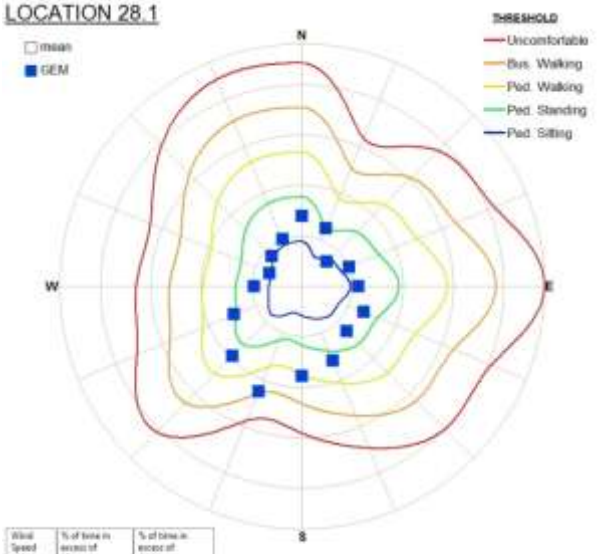
Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	38.1	49.7
4.0	12.0	19.2
6.0	5.1	7.1
8.0	2.0	2.4
10.0	0.7	0.8
5.8	**5.0**	Ped Standing
15.3	**0.022**	Able Body
6.6	Ped Walking	**5.0**
16.1	Able Body	**0.022**

LOCATION 27.1



Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	28.7	40.2
4.0	6.6	12.0
6.0	1.9	3.7
8.0	0.4	1.0
10.0	0.1	0.2
4.5	**5.0**	Ped Standing
11.1	**0.022**	Pass
5.4	Ped Standing	**5.0**
12.8	Pass	**0.022**

LOCATION 28.1



Wind Speed (m/s)	% of time in excess of Mean	% of time in excess of GEM
2.0	27.0	38.5
4.0	6.1	10.0
6.0	1.0	1.8
8.0	0.2	0.3
10.0	0.0	0.0
4.2	**5.0**	Ped Standing
10.0	**0.022**	Pass
4.8	Ped Standing	**5.0**
10.6	Pass	**0.022**