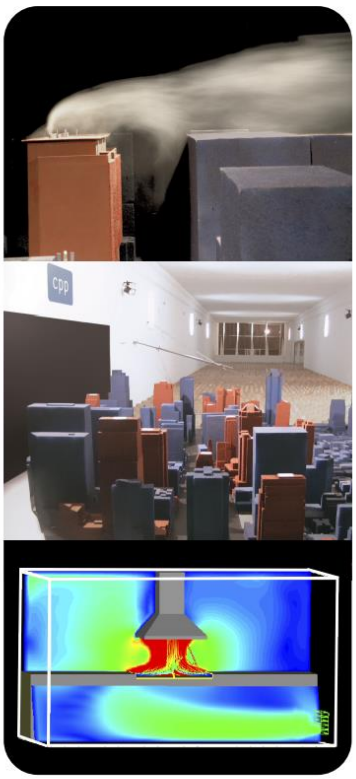
CERMAK
PETERKA
PETERSEN

WIND ENGINEERING AND AIR QUALITY CONSULTANTS

Final Report

CSWSMP-MAC-SMA-UD-REP-000380



Wind Tunnel Test for:

SYDNEY METRO MARTIN PLACE INTEGRATED STATION DEVELOPMENT

NORTH SITE

Sydney, Australia

Prepared for:

Macquarie Corporate Holdings Pty Ltd

Level 6, 50 Martin Place

Sydney

NSW 2000

Prepared by:

Tom Evans, Project Engineer

Joe Paetzold, Engineering Manager

CPP Project 9973
August 2018

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

EXECUTIVE SUMMARY

A wind tunnel study of the proposed Sydney Metro Martin Place Integrated Station Development, to be located in Sydney, was conducted to assess pedestrian wind comfort at ground level. A massing model of the envelope of the project was fabricated to a 1:400 length scale and centred on a turntable in the wind tunnel. Replicas of surrounding buildings within a 570 m radius were constructed and placed on the turntable. The testing was conducted in a configuration with the maximum proposed building envelope and with the detailed tower design. The results are compared with the wind conditions in the existing configuration on the site.

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

Measurements of winds likely to be experienced by pedestrians were made with a hot-film anemometer at 19 locations for 16 wind directions each. These points were tested around the development in the proposed configurations, focusing on access routes, doorways, and outdoor seating areas. The measurements were combined with site specific wind statistics to produce results of wind speed versus the percentage of time that wind speed is exceeded for each location. All locations were also tested in the existing configuration for comparison. Testing was conducted for both the North and South Site with this report focussing on the relevant locations for the North Site only. Additional locations on the podium terraces were tested for the detailed tower shape.

The wind environment around the development in the final proposed configuration was found to be generally suitable for pedestrian sitting and standing activities from a comfort perspective with reference to the Lawson criteria. All locations passed the Lawson distress criteria. The tested wind conditions on the ground plane were found to be similar to the existing conditions with individual locations slightly improving in the comfort rating with the proposed buildings. Some areas to the immediate north and east of the maximum envelope of the proposed building are affected by increased downwash off the northern façade, but still satisfy the required comfort and safety criteria. For the detailed design of the tower the increased downwash was not observed and the pedestrian wind comfort rating was found to be similar or better than in the existing configuration.

DOCUMENT VERIFICATION

Date	Revision	Prepared by	Checked by	Approved by
06/08/2018	Initial release	JP	TXE	JP
23/08/2018	Final report	JP		JP

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_{stdev}/U
U	Local mean velocity (m/s)
U_{ref}	Reference velocity at reference height z_{ref} (m/s)
U_{pk}	Peak wind speed in pedestrian studies (m/s)
U_{stdev}	Standard deviation of fluctuating velocity (m/s)
z	Height above surface (m)
ν	Kinematic viscosity of approach flow (m^2/s)
$\sigma(\ )$	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
$(\ )_{stdev}$	Standard deviation

1. CLIENT PROVIDED PROJECT BACKGROUND

1.1 Introduction

This report supports a State Significant Development (SSD) Development Application (DA) (SSD DA) submitted to the Minister for Planning (Minister) pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on behalf of Macquarie Corporate Holdings Pty Limited (Macquarie), who is seeking to create a world class transport and employment precinct at Martin Place, Sydney.

The SSD DA seeks approval for the detailed design and construction of the **North Site** Over Station Development (OSD), located above and integrated with Metro Martin Place station (part of the NSW Government's approved Sydney Metro project). The northern entrance to Metro Martin Place station will front Hunter Street, Elizabeth Street and Castlereagh Street, with the North Site OSD situated above.

This application follows the approval granted by the Minister for a Concept Proposal (otherwise known as a Stage 1 SSD DA) for two OSD commercial towers above the northern and southern entrances of Metro Martin Place station (SSD 17_8351). The approved Concept Proposal establishes building envelopes, land uses, Gross Floor Areas (GFA) and Design Guidelines with which the detailed design (otherwise known as a Stage 2 SSD DA) must be consistent.

This application does not seek approval for elements of the Metro Martin Place Precinct (the Precinct) which relate to the Sydney Metro City and Southwest project, which is subject to a separate Critical State Significant Infrastructure (CSSI) approval. These include:

- Demolition of buildings on the North Site and South Site;
- Construction of rail infrastructure, including station platforms and concourse areas;
- Ground level public domain works; and
- Station related elements in the podium of the North Tower.

However, this application does seek approval for OSD areas in the approved Metro Martin Place station structure, above and below ground level, which are classified as SSD as they relate principally to the OSD. These components are within the Sydney Metro CSSI approved station building that will contain some OSD elements not already approved by the CSSI Approval. Those elements include the end of trip facilities, office entries, office space and retail areas, along with other office/retail plant and back of house requirements that are associated with the proposed OSD and not the rail infrastructure.

This report presents the results of wind tunnel testing of the pedestrian level wind environment around the proposed development as reported for the Stage 1 DA configurations in CPP (2017 & 2018).

1.2 Context

The New South Wales (NSW) Government is implementing Sydney's Rail Future (Transport for NSW, 2012), a plan to transform and modernise Sydney's rail network so that it can grow with the city's population and meet the needs of customers in the future.

Sydney Metro is a new standalone rail network identified in Sydney's Rail Future. The Sydney Metro network consists of Sydney Metro Northwest (Stage 1) and Sydney Metro City and Southwest (Stage 2).

Stage 2 of Sydney Metro entails the construction and operation of a new metro rail line from Chatswood, under Sydney Harbour through Sydney's CBD to Sydenham and onto Bankstown through the conversion of the existing line to metro standards. The project also involves the delivery of seven (7) new metro stations, including Martin Place.

This step-change piece of public transport infrastructure once complete will have the capacity for 30 trains an hour (one every two minutes) through the CBD in each direction catering for an extra 100,000 customers per hour across the Sydney CBD rail lines.

On 9 January 2017 the Minister approved the Stage 2 (Chatswood to Sydenham) Sydney Metro application lodged by Transport for NSW (TfNSW) as a Critical State Significant Infrastructure (CSSI) project (reference SSI 15_7400). Work is well underway under this approval, including demolition of buildings at Martin Place.

The OSD development is subject to separate applications to be lodged under the relevant provisions of the EP&A Act. One approval is being sought for the North Site – this application – and one for the South Site via a separate application.

1.3 Site Description

The Metro Martin Place Precinct relates to the following properties (refer to Figure 1):

- 50 Martin Place, 9 – 19 Elizabeth Street, 8 – 12 Castlereagh Street, 5 Elizabeth Street, 7 Elizabeth Street, and 55 Hunter Street (North Site);
- 39 – 49 Martin Place (South Site); and
- Martin Place (that part bound by Elizabeth Street and Castlereagh Street).

This application relates **only to the North Site**, being the city block bounded by Hunter Street, Castlereagh Street, Elizabeth Street, and Martin Place (refer to Figure 1).

The South Site (39 – 49 Martin Place) is the subject of a separate Stage 2 SSD DA.

Figure 1: Aerial photo of the North and South Site (Nearmap and JBA, 2018)

1.4 Background

Sydney Metro Stage 2 Approval (SSI 15_7400)

The Sydney Metro CSSI Approval approves the demolition of existing buildings at Martin Place, excavation and construction of the new station (above and below ground) along with construction of below and above ground structural and other components of the future OSD, although the fit-out and use of such areas are the subject of separate development approval processes.

On 22 March 2018, the Minister approved Modification 3 to the Sydney Metro CSSI Approval. This enabled the inclusion of Macquarie-owned land at 50 Martin Place and 9-19 Elizabeth Street within Metro Martin Place station, and other associated changes (including retention of the opening to the existing MLC pedestrian link).

Concept Proposal (SSD 17_8351)

On 22 March 2018, the Minister approved a Concept Proposal (SSD 17_8351) relating to Metro Martin Place Precinct. The Concept Proposal establishes the planning and development framework through which to assess the detailed Stage 2 SSD DAs.

Specifically, the Concept Proposal encompassed:

- Building envelopes for OSD towers on the North Site and South Site comprising:
  - 40+ storey building on the North Site (see Figure 2)
  - 28+ storey building on the South Site.
  - Concept details to integrate the North Site with the existing and retained 50 Martin Place building (the former Government Savings Bank of NSW)
- Predominantly commercial land uses on both sites, comprising office, business and retail premises
- A maximum total GFA of 125,437m^2 across both sites
- Design Guidelines to guide the built form and design of the future development.
- A framework for achieving design excellence.
- Strategies for utilities and services provision, managing drainage and flooding, and achieving ecological sustainable development.
- Conceptual OSD areas in the approved Martin Place Metro Station structure, above and below ground level. [1]

Planning Proposal (PP_2017_SYDNE_007_00) – Amendment to Sydney LEP 2012

The Planning Proposal (PP_2017_SYDNE_007_00) sought to amend the development standards applying to the Metro Martin Place Precinct through the inclusion of a site-specific provision in the Sydney Local Environmental Plan (LEP) 2012. This site-specific provision reduced the portion of the **South Site** that was subject to a 55 metre height limit from 25 metres from the boundary to Martin Place, to 8 metres, and applies the Hyde Park North Sun Access Plane to the remainder of the South Site, forming the height limit of the tower. It also permits a revised FSR of 22:1 on the South Site and 18.5:1 on the North Site. These amendments were gazetted within Sydney LEP 2012 (Amendment No. 46) on 8 June 2018 and reflect the new planning controls applying to the Precinct.

[1] *Refers to those components within the Metro CSSI approved station envelope that will contain some OSD elements not approved in the CSSI consent. Those elements include the end of trip facilities, office entries, office space and retail areas, along with other office/retail plant and back of house requirements that are associated with the proposed OSD and not the rail infrastructure.*

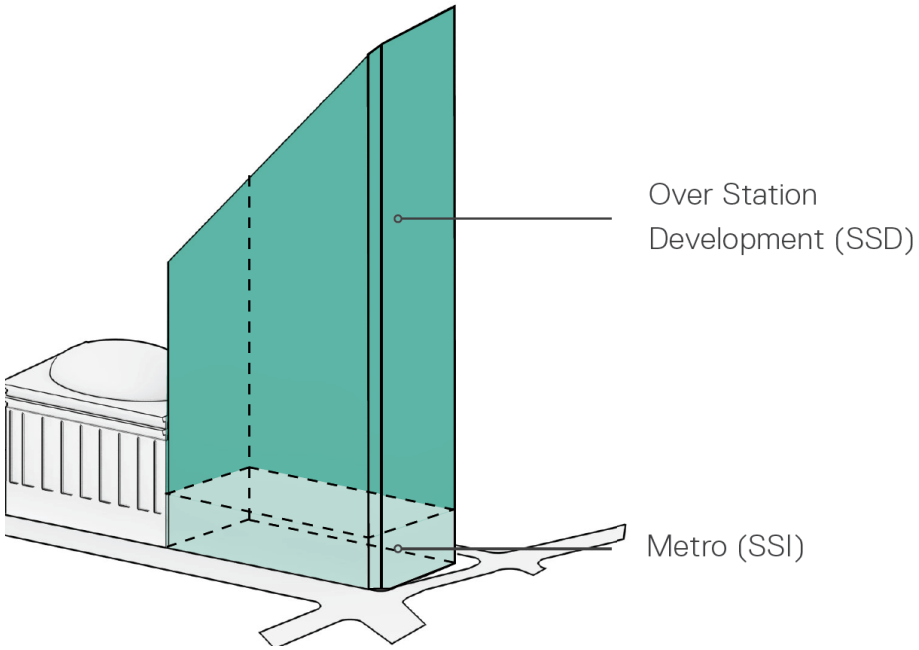


Figure 2: North Site Approved OSD Building Envelope (JBA, 2018)

1.5 Overview of the Proposed Development

The subject application seeks approval for the detailed design, construction and operation of the North Tower. The proposal has been designed as a fully integrated station and OSD project that intends to be built and delivered as one development, in-time for the opening of Sydney Metro City and Southwest in 2024. This application seeks consent for the following:

- The design, construction and operation of a new 39 storey commercial OSD tower (plus rooftop plant) within the approved building envelope for the North Site, including office space and retail tenancies.
- Physical connections between the OSD podium and the existing 50 Martin Place building, to enable the use of the North Site as one integrated building.
- Vehicle loading areas within the basement levels.
- Extension and augmentation of physical infrastructure / utilities as required.
- Detailed design and delivery of 'interface areas' within both the approved station and Concept Proposal envelope that contain OSD-exclusive elements, such as end of trip facilities, office entries, office space and retail areas not associated with the rail infrastructure.

1.6 Planning Approvals Strategy

The *State Environmental Planning Policy (State and Regional Development) 2011* (SEPP SRD) identifies development which is declared to be State Significant. Under Schedule 1 and Clause 19(2) of SEPP SRD, development within a railway corridor or associated with railway infrastructure that has a capital investment value of more than $30 million and involves commercial premises is declared to be State Significant Development (SSD) for the purposes of the EP&A Act.

The proposed development (involving commercial development that is both located within a rail corridor and associated with rail infrastructure) is therefore SSD.

Pursuant to Section 4.22 of the EP&A Act a Concept DA may be made setting out concept proposals for the development of a site (including setting out detailed proposals for the first stage of development), and for which detailed proposals for the site are to be the subject of subsequent DAs. This SSD DA represents a detailed proposal and follows the approval of a Concept Proposal on the site under Section 4.22 of the EP&A Act.

Submitted separately to this SSD DA is a SSD DA for the South Site (Stage 2 South Site SSD DA). A Stage 1 Amending SSD DA to the Concept Proposal (Stage 1 Amending DA) has also been submitted that has the effect of aligning the approved South Site envelope with the new planning controls established for the South Site (achieved through the site specific amendment to the Sydney LEP 2012).

Figure 3 below is a diagrammatic representation of the suite of key planning applications undertaken or proposed by Macquarie and their relationship to the subject application (the subject of this report).

The Department of Planning and Environment have provided Secretary's Environmental Assessment Requirements (SEARs) to the applicant for the preparation of an Environmental Impact Statement for the proposed development. This report has been prepared having regard to the SEARs as relevant.

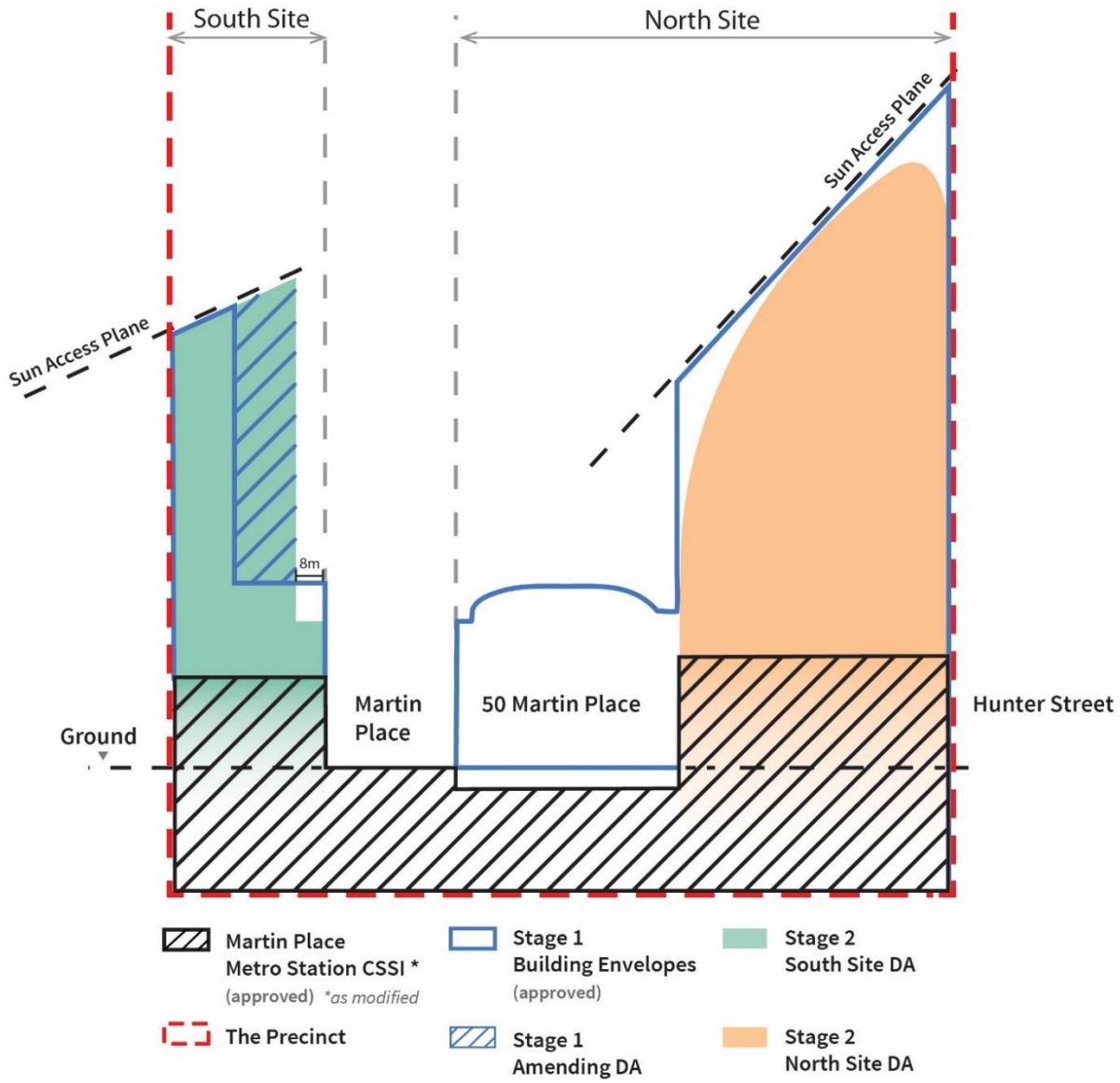


Figure 3: Relationship of key planning applications to the Stage 2 North Site DA (this application) (JBA, 2018)

2. INTRODUCTION

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

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

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

Table 1: Configurations for data acquisition

General Information	
Model length scale	1:400
Surrounding model radius (full-scale)	570 m
Reference height (full-scale)	200 m above ground level
Approach Terrain Category	Suburban approach, Terrain Category 3
Test Configuration Specifications	
Configuration A: Existing (Locations denoted XX)	Existing development with surrounding buildings and landscape, as shown in Figure 6 and Figure 7. Pedestrian winds measured at 19 locations for 16 wind directions at 22.5° increments from 0° (north)
Configuration B: Proposed, maximum envelope (Locations denoted XX.1)	Maximum envelope of the proposed Sydney Metro Martin Place Integrated Station Development, as shown in Figure 10. Pedestrian winds measured at 19 locations.
Configuration C: Proposed, detailed tower shape (Locations denoted XX.2)	Detailed tower shape of the proposed Sydney Metro Martin Place Integrated Station Development, as shown in Figure 8, Figure 9, and Figure 11. Pedestrian winds measured at 19 ground level locations and 4 locations on the podium terraces.

3. THE WIND TUNNEL TEST

Modelling of the aerodynamic flow around structures 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 representative 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 4. The wind tunnel test section is 3.0 m wide, by 2.4 m high with a porous slatted roof for passive blockage correction. This wind tunnel has a 21 m long test section, the floor of which is covered with roughness elements, preceded by a vorticity generating fence and spires. The spires, barrier, and roughness elements were designed to provide a modelled atmospheric boundary layer approximately 1.2 m thick with a mean velocity and turbulence intensity profile similar to that expected to occur in the region approaching the modelled area. The approach wind characteristics used for the model test are shown in Figure 5 and are explained more fully in Section 5.1.1.

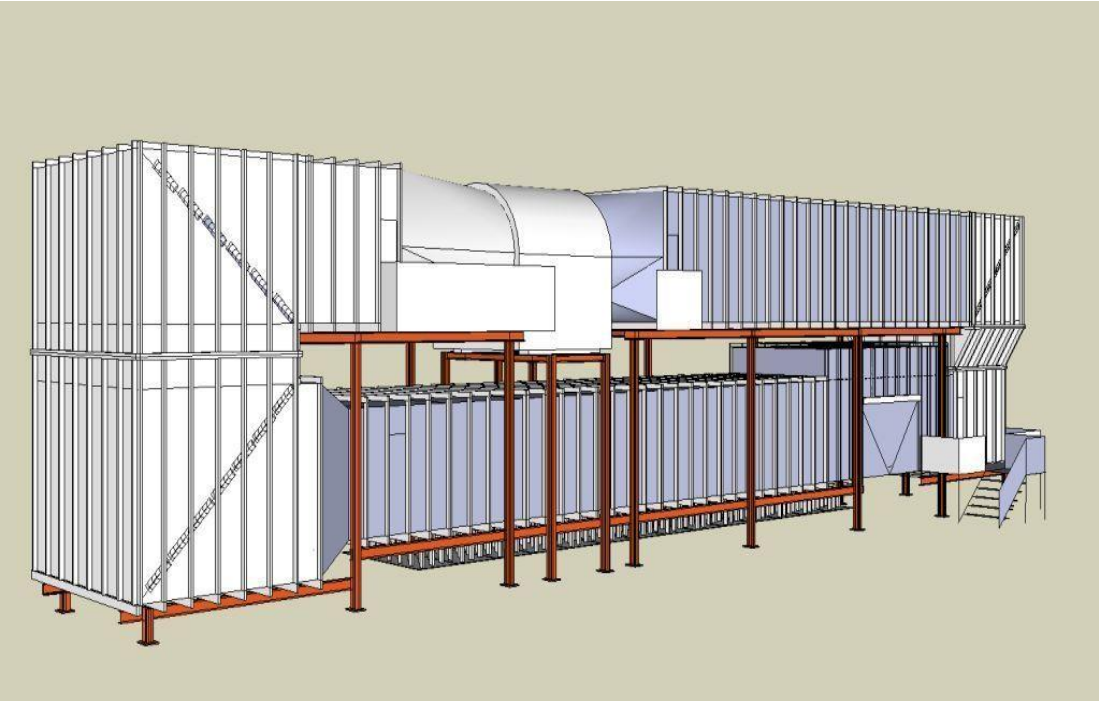


Figure 4: Schematic of the closed circuit wind tunnel

A massing model of the proposed development and surrounds to a radius of 570 m was constructed at a length scale of 1:400, which was consistent with the modelled atmospheric flow, and permitted a reasonable test model size with an adequate portion of the adjoining environment to be included in a proximity model that was within wind tunnel blockage limitations. The model was mounted on the turntable located near the downstream end of the wind tunnel test section, Figure 7. The turntable permitted rotation of the modelled area for examination of velocities from any approach wind direction.

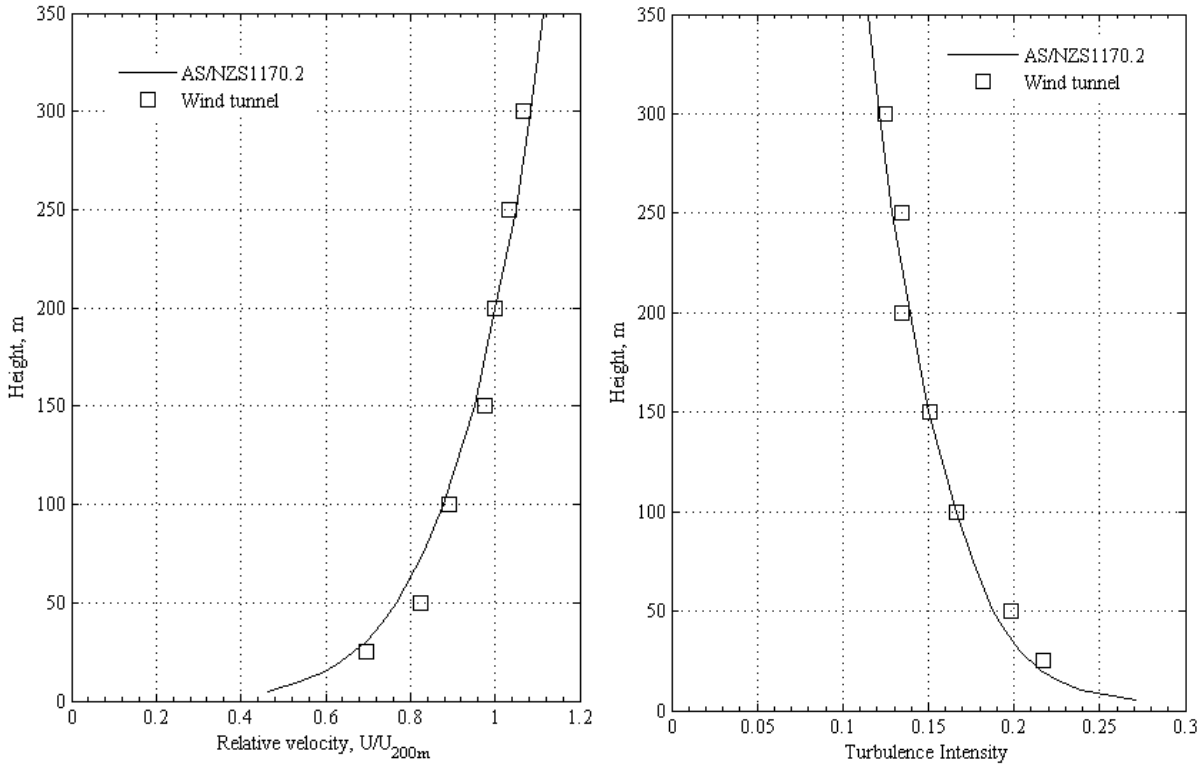


Figure 5: Mean velocity and turbulence profiles approaching the model, terrain category 3

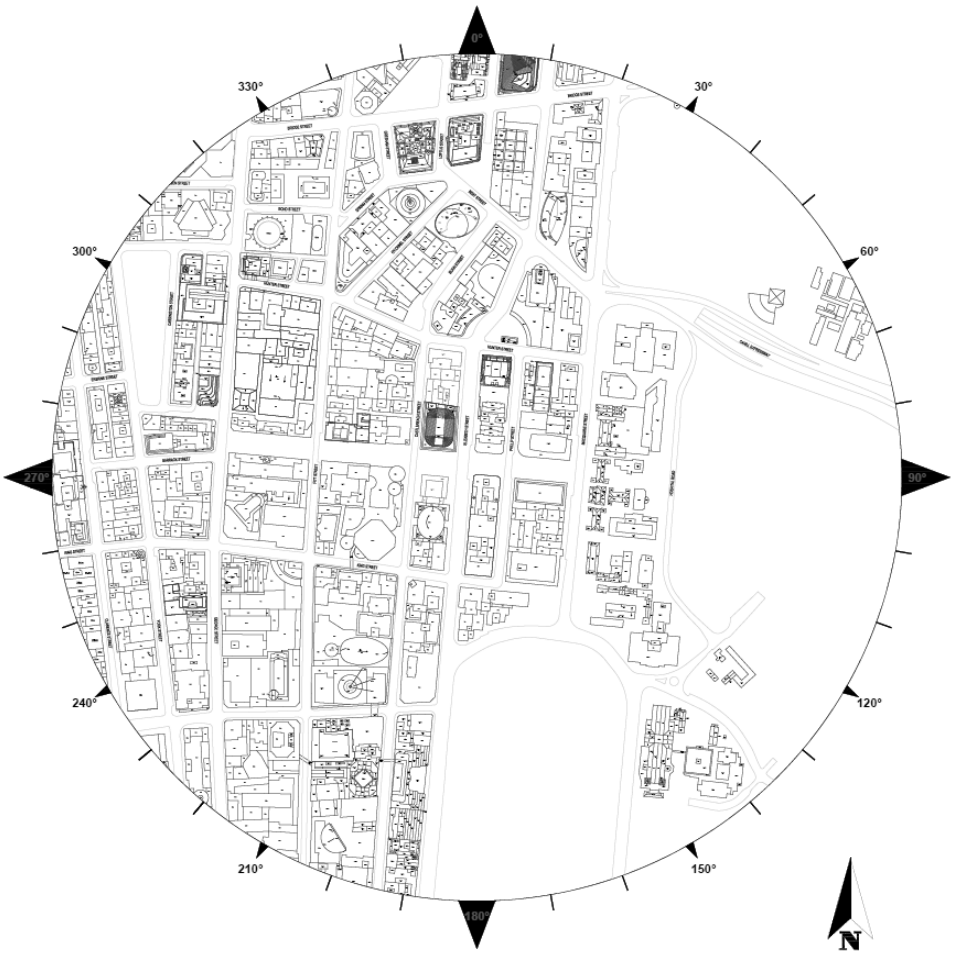


Figure 6: Turntable layout with existing buildings

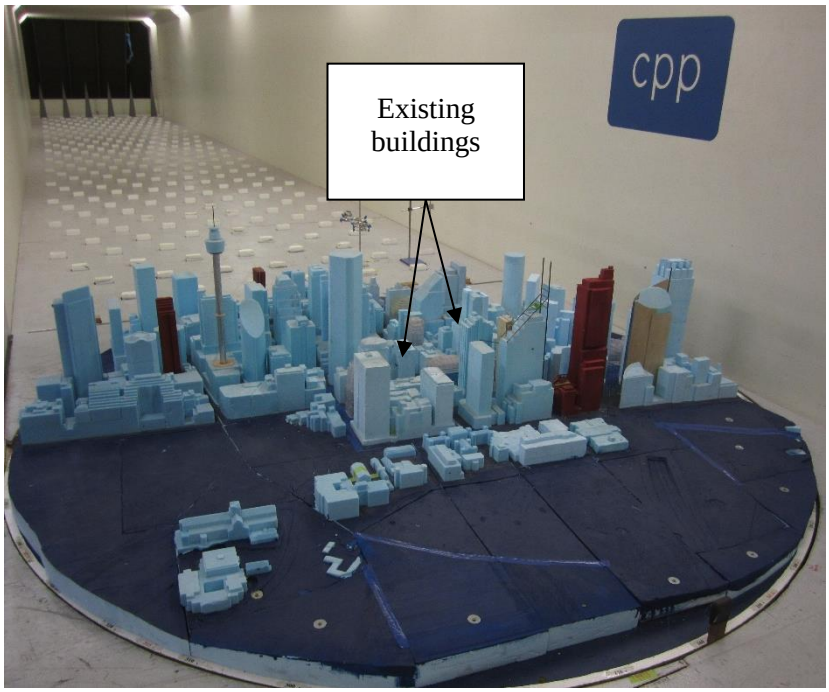


Figure 7: Photograph of the existing configuration model in the CPP wind tunnel viewed from the east

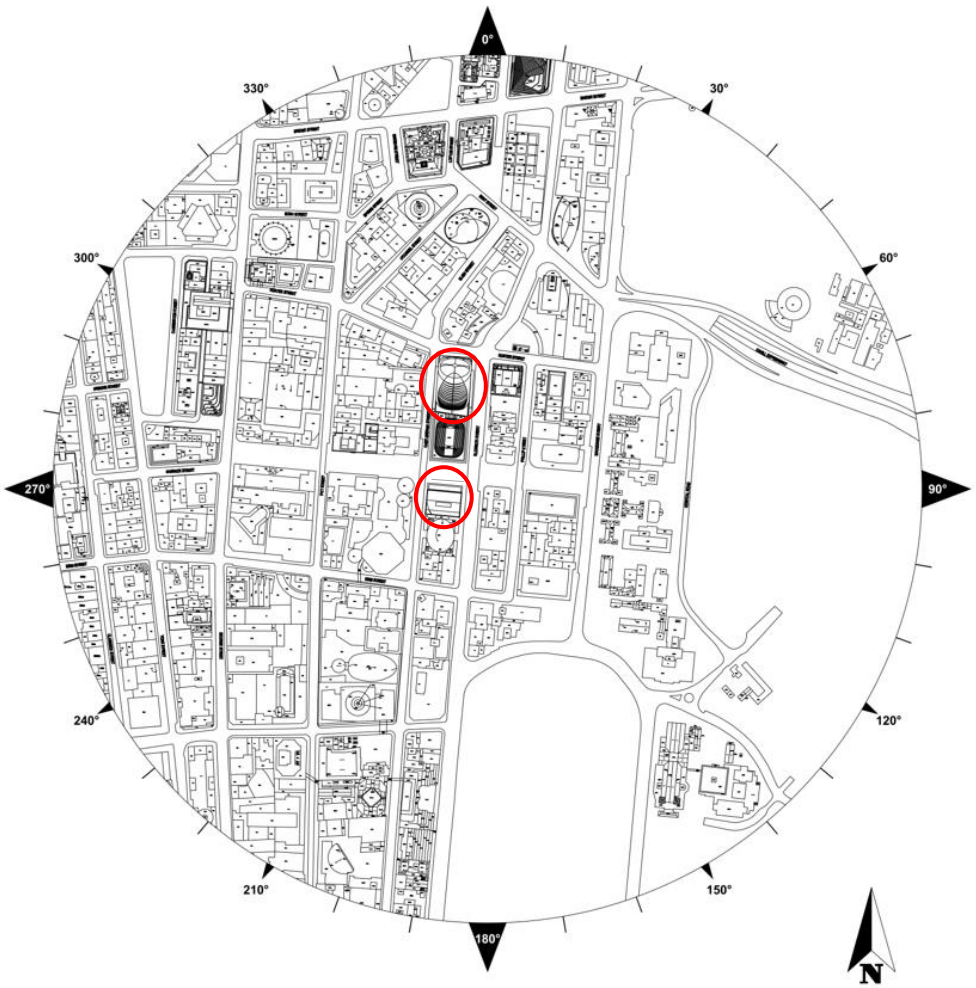


Figure 8: Turntable layout with proposed buildings

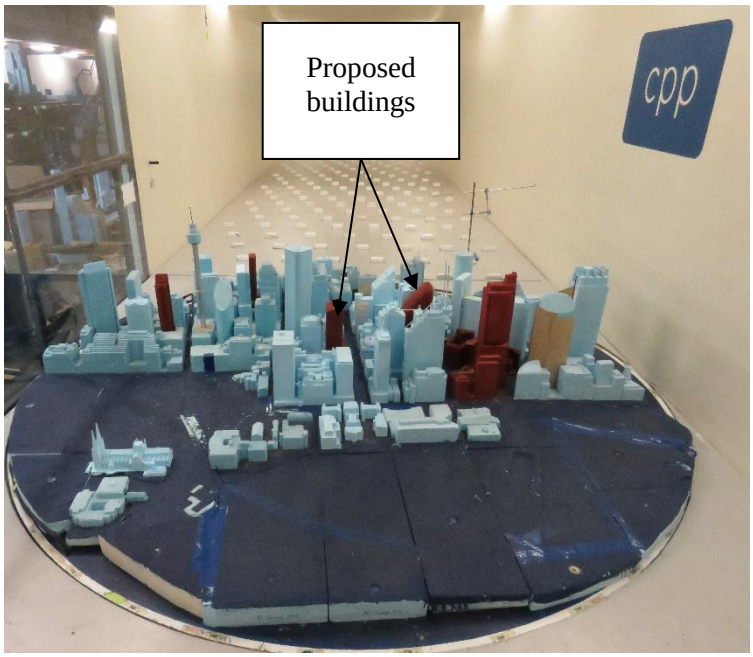


Figure 9: Photograph of the proposed configuration model in the CPP wind tunnel viewed from the east

Figure 10: Close-up photograph of the wind tunnel model for Configuration B viewed from the north-east

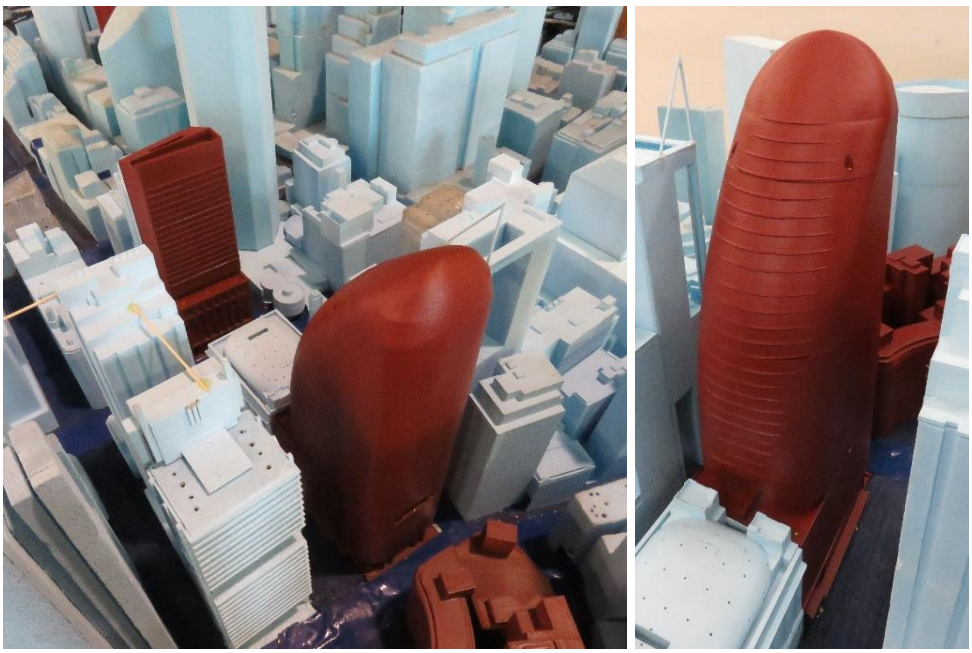


Figure 11: Close-up photograph of the wind tunnel model for Configuration C viewed from the north-east for both towers (L), and the north tower only viewed from the south-east (R)

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. A location can further 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.

Table 2: The Lawson comfort criteria

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

Note: [+] The gust equivalent mean (GEM) is the peak 3 s gust wind speed divided by 1.85.

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[2]. The GEM is defined as the peak gust wind speed divided by 1.85; this is intended to account for locations where the gustiness is the dominant characteristic of the wind. Assessment using the Lawson criteria provides a similar classification as using the once per annum gust, which was the basis of the City of Sydney (2011) DCP, however provides additional information regarding the serviceability wind climate. The current City of Sydney (2012) DCP specifies wind effects not to exceed 16 m/s, and 10 m/s for 'active frontages'. The draft amendments of the DCP require a wind speed of 8 m/s not to be exceeded for more than 5% of the time

[2] 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.

between 6 am and 10 pm, aligning with the pedestrian walking criterion by Lawson. The safety criterion of the draft amendments requires an annual maximum peak 0.5 second gust wind speed not to be exceeded, which aligns with the Lawson criterion of a GEM wind speed of 15 m/s for a 3 second gust. In the vicinity of the Sydney Metro Martin Place Integrated Station Development Martin Place, Hunter Street, and parts of Castlereagh Street are classified as active frontages, while Elizabeth Street is not. There are few locations in Sydney that would meet the current DCP criteria without shielding to improve the wind conditions. From discussions with Council the current DCP criterion wind speed is a once per annum gust wind speed similar to the 2004 DCP, but is meant to be interpreted as a comfort level criterion to promote outdoor café style activities and is not a distress requirement.

The once per annum gust wind speed criterion is based on the work of Melbourne (1978), and the 16 m/s level is classified as acceptable for pedestrian walking along a main accessway, and 10 m/s level is classified as generally acceptable for use for pedestrian sitting. This criterion gives the once per annum (actually 0.1% of the time) gust wind speed, and uses this as an estimator of the general wind conditions at a site. To combat this limitation, this study is based upon the criteria of Lawson (1990), which are described above. Assessment using the Lawson criteria provides a similar comfort classification as using the once per annum gust criteria, which is the basis of the City of Sydney (2012) DCP; however, it also provides significantly more information regarding the serviceability wind climate. The Lawson criteria align with the draft amendments of the City of Sydney DCP.

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 5. Turbulence intensities are related to the local mean wind speed. These profiles have the form as derived from Standards Australia (2011) and are appropriate for the approach conditions.

5.1.2 Pedestrian Winds

The proposed development is situated in the Sydney CBD between Castlereagh and Elizabeth Streets with the proposed towers being located north and south of the existing 50 Martin Place building, Figure 13. The site is surrounded by high-rise buildings of the Sydney CBD. The site is in the centre of the CBD and consequently receives some shielding from all wind directions.

Wind speed measurements for the North Site were recorded at 19 locations to evaluate pedestrian comfort in and around the project site, Figure 13 to Figure 15. These locations were tested in a full envelope configuration of the proposed development and a configuration with the detailed tower shape of both towers, as well as in the existing building configuration for comparative purposes. Additional locations on the podium terraces were tested for the detailed tower shape. Wind speed measurements were made at the model scale equivalent of 1.5 to 2.1 m above the surface for 16 wind directions at 22.5° intervals. Locations were chosen to determine pedestrian comfort at the building corners where relatively severe conditions are frequently found, near building entrances, on adjacent pavements with heavy pedestrian traffic.

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

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

The mean and gust equivalent mean velocities relative to the free stream wind tunnel reference velocity at a full-scale elevation of 200 m are plotted in polar form in Appendix 1. 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 wind speed is of greater importance.

To enable a quantitative assessment of the wind environment, the wind tunnel data were combined with wind frequency and direction information measured by the Bureau of Meteorology (BoM) at a standard height of 10 m at Sydney Airport from 1995 to 2015, Figure 12. From these data, directional criterion lines for the Lawson rating wind speeds have been calculated and included on the polar plots in Appendix 1; this gives additional information regarding directional sensitivity at each location.

The criteria of Lawson consider the integration of the velocity measurements with local wind climate statistical data summarized in Figure 12 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 1. In addition to the rating wind speeds, the percentage of time that 2 m/s is exceeded is also reported. This has been provided as it has been found that the limiting wind speed for long-term stationary activities such as fine outdoor dining should be about 2 to 2.5 m/s rather than 4 m/s.

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

The tables in Appendix 1 additionally provide the wind speed exceeded 5% and 0.022% of the time for direct comparison with the Lawson comfort and distress criteria and the associated Lawson ratings for both mean and GEM wind speeds. A colour coded summary assessment of pedestrian comfort and safety with respect to the Lawson criteria is presented in Figure 13 to Figure 16 for each test location. The implications of the results are discussed in Section 6.

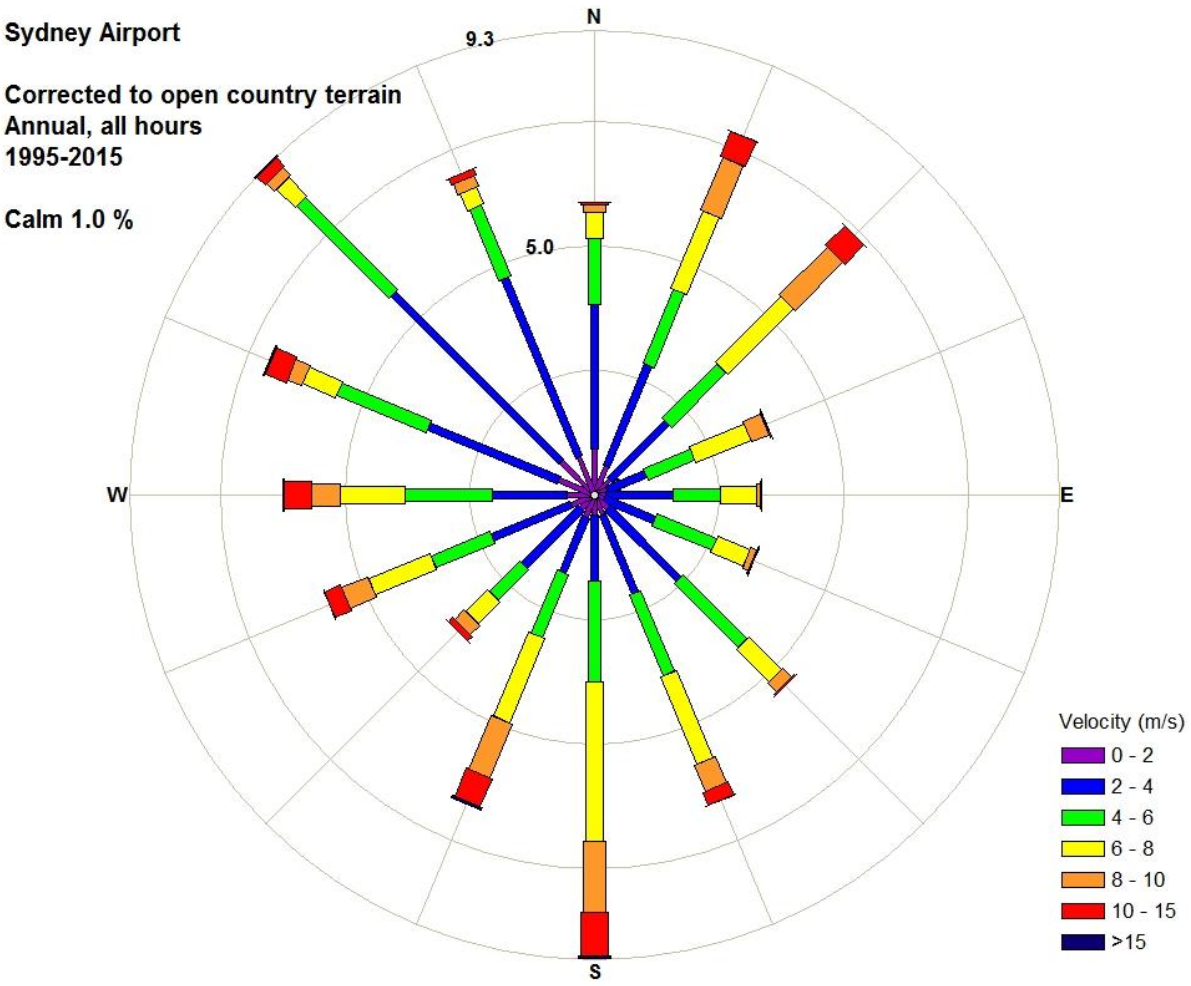


Figure 12: Wind rose of direction and speed for Sydney Airport

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

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

6. DISCUSSION

The wind climatology chart of Figure 12 indicates that the most frequent strong winds are from the south, and to a lesser extent, the west and north-east. The development is located in a central area of the city leading to some shielding effects from all wind directions. The topography and surrounding building layout relative to the prevailing strong wind directions influence the local wind flow in and around the development. Individual locations around the development are more susceptible to winds from different directions, depending on the relative location of the point tested to the geometry of the surrounding buildings. The influence of wind direction on the suitability of a location for an intended purpose can be ascertained from the polar plots in Appendix 1.

A high-level summary of the wind tunnel results including the Lawson comfort and safety ratings is provided in Table 4. The target criteria are based on the intended use of the space for each pedestrian level measurement location. It is evident that all ground plane locations meet the intended use of the space from a comfort perspective and pass the safety criterion.

More detailed conclusions of the pedestrian study can be understood by reviewing the colour coded images in Figure 13 to Figure 16, which present the locations selected for investigation of pedestrian wind comfort in and 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.

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%. Although conditions may be classified as acceptable there may be certain wind directions that cause regular strong events, these can be determined by an inspection of the plots in Appendix 1.

Table 4: Summary of target criteria and wind tunnel results

Description / Location		Target	Wind Tunnel Results								
			Existing Configuration			Full Envelope (8m setback to Martin Place)			Proposed Configuration		
		Comfort rating, 5% exceedance wind speed (m/s)	Comfort rating, 5% exceedance wind speed (m/s)	Meets target Y/N	Safety rating, 0.022% exceedance wind speed (m/s)	Comfort rating, 5% exceedance wind speed (m/s)	Meets target Y/N	Safety rating, 0.022% exceedance wind speed (m/s)	Comfort rating, 5% exceedance wind speed (m/s)	Meets target Y/N	Safety rating, 0.022% exceedance wind speed (m/s)
Ground Plane	1	>6 to 8	3.7	Y	7.1	4.2	Y	8.3	3.5	Y	7.3
	2	>6 to 8	4.1	Y	8.0	4.0	Y	7.4	3.8	Y	6.8
	3	>6 to 8	4.8	Y	9.2	4.8	Y	10.2	3.7	Y	8.3
	4	>6 to 8	5.8	Y	11.8	6.3	Y	12.6	4.3	Y	7.9
	5	>6 to 8	4.8	Y	9.2	6.8	Y	13.0	4.5	Y	9.3
	6	>6 to 8	5.0	Y	10.7	4.4	Y	10.3	4.4	Y	10.2
	7	>6 to 8	6.2	Y	12.1	5.9	Y	12.2	5.6	Y	10.7
	8	>6 to 8	3.2	Y	6.3	4.0	Y	7.4	2.9	Y	5.4
	9	>6 to 8	2.2	Y	4.3	3.7	Y	7.7	3.1	Y	6.3
	10	>6 to 8	3.8	Y	7.5	4.0	Y	8.1	3.5	Y	7.1
	11	>6 to 8	2.5	Y	5.1	2.4	Y	4.9	1.9	Y	4.1
	12	>6 to 8	5.8	Y	10.6	6.0	Y	11.6	5.6	Y	10.9
	13	>6 to 8	4.0	Y	8.1	5.5	Y	11.1	4.2	Y	8.5
	14	>6 to 8	6.3	Y	12.0	6.1	Y	11.3	5.6	Y	10.1
	15	>6 to 8	3.8	Y	7.5	4.0	Y	8.0	3.8	Y	7.6
	16	>6 to 8	4.5	Y	9.3	5.7	Y	11.4	5.5	Y	11.1
	20	>6 to 8	6.4	Y	11.6	6.5	Y	11.8	6.9	Y	13.0
	30	>6 to 8	5.5	Y	10.3	5.4	Y	10.3	5.3	Y	10.4
	37	>6 to 8	6.1	Y	11.5	6.8	Y	12.5	6.3	Y	12.0
Terraces	42	>4 to 6							1.6	Y	3.6
	43	>4 to 6							3.9	Y	7.6
	44	>4 to 6							4.3	Y	8.3
	45	>4 to 6							4.8	Y	10.2

LEGEND

Comfort Criteria
- Outdoor Dining
- Pedestrian Sitting
- Pedestrian Standing
- Pedestrian Walking
- Business Walking
- Uncomfortable

Safety Criteria
- Passes safety criteria
- Able bodied
- Fails safety criteria

6.1.1 – Existing development with existing surroundings

In the surrounding area of the proposed development, the wind conditions at pedestrian level in the existing configuration are generally classified as suitable for pedestrian standing and sitting. Some specific locations exceed the standing criterion with a pedestrian walking rating, Table 4 and Figure 13.

Wind conditions to the north of the northern tower site, Locations 1 to 7 along Hunter Street, are generally rated as suitable for pedestrian standing from a comfort perspective with the exception of Location 1, which is at the border between pedestrian sitting and standing, and Location 7, which slightly exceeds the pedestrian standing threshold and is rated as suitable for pedestrian walking. This area is generally affected by winds from the north-east quadrant, in the form of channelled flow along Philip and Hunter Streets augmented by downwash from the north façade of the existing buildings along these streets such as Chifley Tower, 8 Chifley Square, and 126 Philip Street.

Areas to the north of Martin Place along Castlereagh Street are relatively calm, with Locations 8-11 rated as suitable for pedestrian sitting. Conditions along Elizabeth Street are slightly windier, mostly

rated suitable for pedestrian standing with the exception of Locations 14 and 15, being slightly above and below the threshold with the respective higher and lower ratings. The test locations along Martin Place, Locations 16, 20, and 37 are rated as suitable for pedestrian standing and walking.

All locations pass the distress criterion.

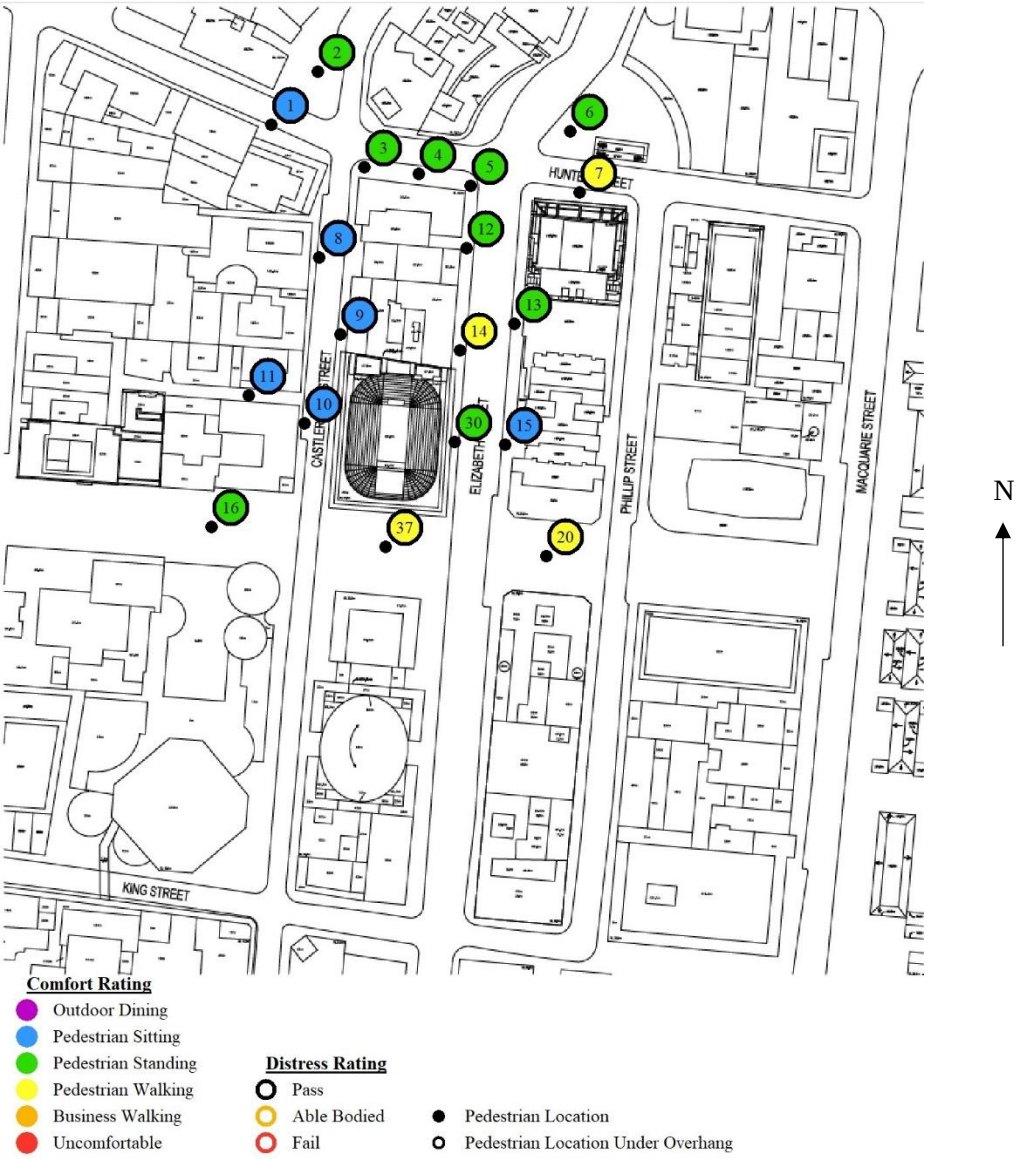


Figure 13: Pedestrian wind speed measurement locations with comfort/distress ratings – Configuration A, existing buildings

6.1.2 – Maximum envelope of proposed development with existing surroundings

With the inclusion of the proposed buildings in the maximum envelope configuration, wind conditions at ground level are generally similar to the existing conditions, with most locations being classified as suitable for pedestrian standing or sitting, Figure 14. Four locations were found to degrade

in comfort rating relative to the existing case, however conditions in many areas are near the threshold between two categories and increases in wind speeds are mostly relatively minor.

Conditions to the north of the development site are slightly degraded by the addition of the tower. Locations 4.1 and 5.1 are classified as suitable for pedestrian walking in this configuration. These areas are most strongly affected by winds from the east. The proposed tower is significantly taller than the existing building, and will therefore produce stronger downwash at the ground plane. Areas along Castlereagh Street are largely unaffected by the addition of the proposed development.

Wind conditions along Martin Place to the east and west of the proposed development, Locations 16.1, 20.1, and 37.1, are similar to the existing conditions.

All locations pass the distress criterion.

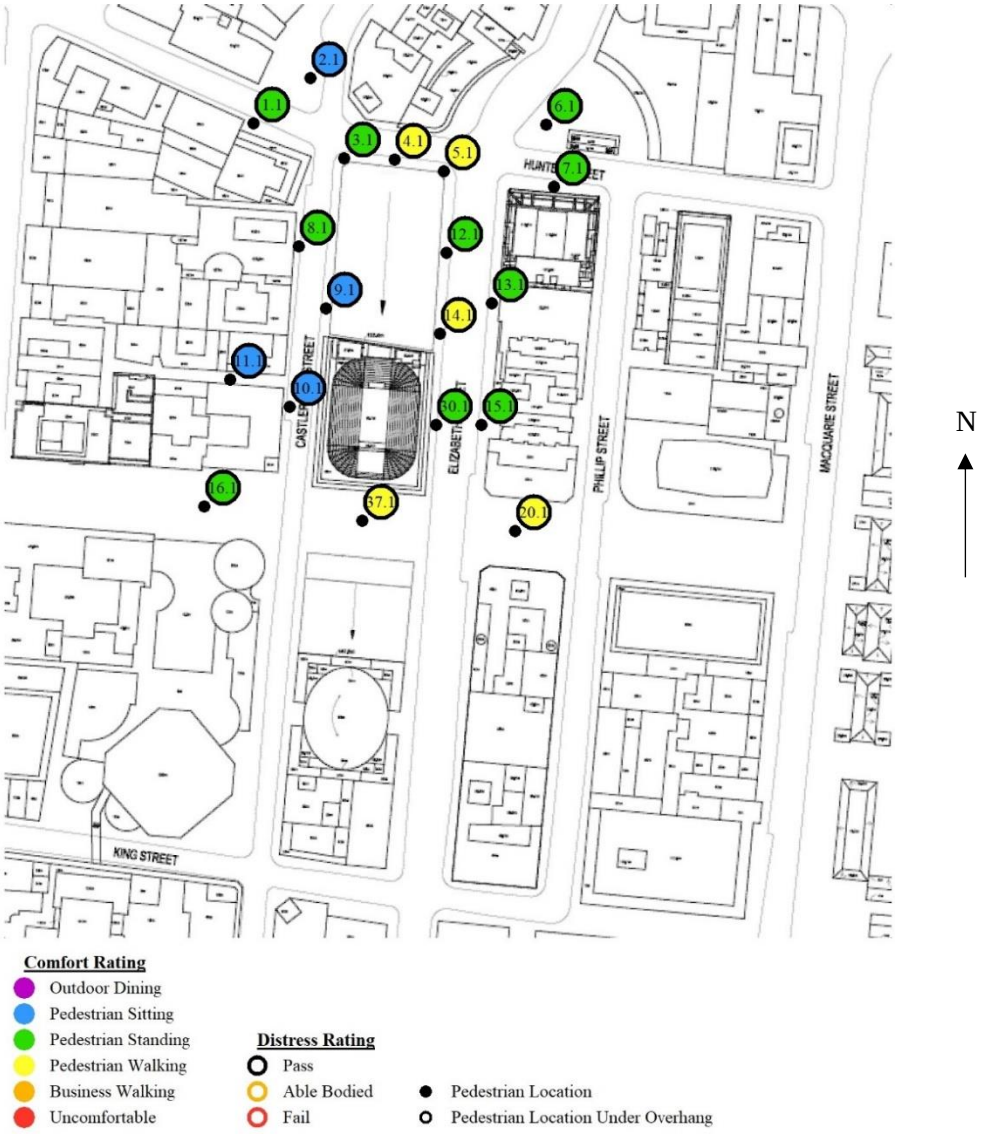


Figure 14: Pedestrian wind speed measurement locations with comfort/distress rating – Configuration B, maximum envelope of proposed buildings

6.1.3 – Detailed tower shape of proposed development with existing surroundings

Conditions in Configuration C are generally similar to the existing configuration, Figure 15. The rounded tower shape significantly reduces the downwash observed in the maximum envelope configuration, and all test locations remain in an equal or better comfort category compared with the existing configuration. Some locations show an improvement in comfort category in this configuration, though the 5% exceedance wind speed is just below the boundary between two comfort categories, and the quantifiable difference in conditions between Configurations A and C is not significant. Overall, wind conditions in this configuration are largely similar to the existing configuration, with wind speeds slightly increasing at some locations and slightly decreasing at others. All locations pass the distress criterion.

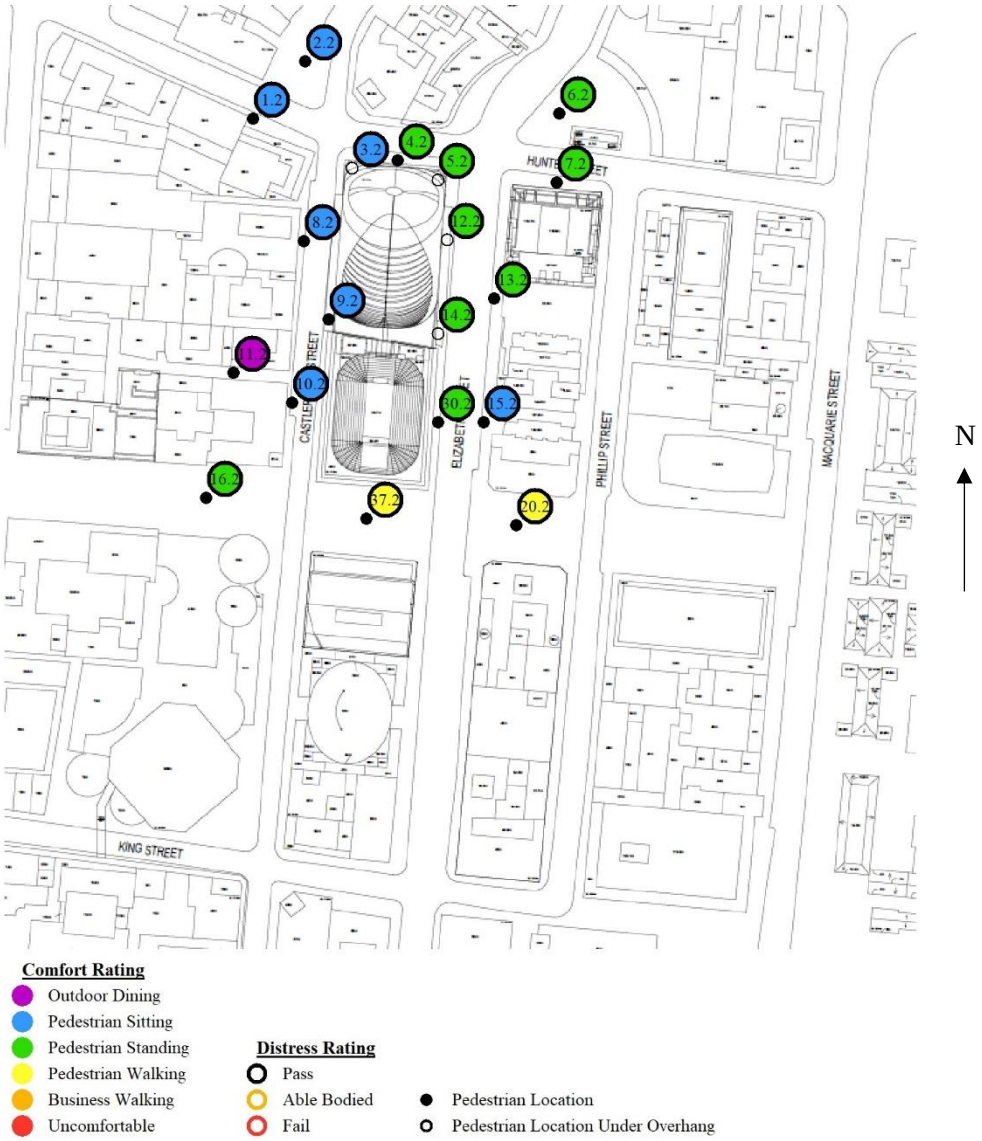


Figure 15: Pedestrian wind speed measurement locations with comfort/distress ratings – Configuration C, detailed tower shape of proposed buildings

Subsequent to the wind tunnel testing, the design has been amended to extend the awning on the east side of the tower over the station entrance at the corner of Hunter and Elizabeth Streets. This modification is considered unlikely to significantly impact wind conditions at this location, however may provide some benefit by offering further protection from flow downwashing off the tower.

6.1.4 – Podium terraces

In addition to the ground level points tested in all three configurations, testing was conducted on the podium terraces for Configuration C, Figure 16. The terraces to the north and east are inset in the building façade and hence well protected, leading to a wind comfort rating of outdoor dining and pedestrian sitting. The terraces to the south extend out from the façade and are hence more exposed and rated as suitable for pedestrian standing. These terraces are still somewhat protected by the massing of the surrounding buildings of the CBD in most directions and by the subject tower itself to the north. All locations in the on the podium terraces pass the Lawson distress criterion.

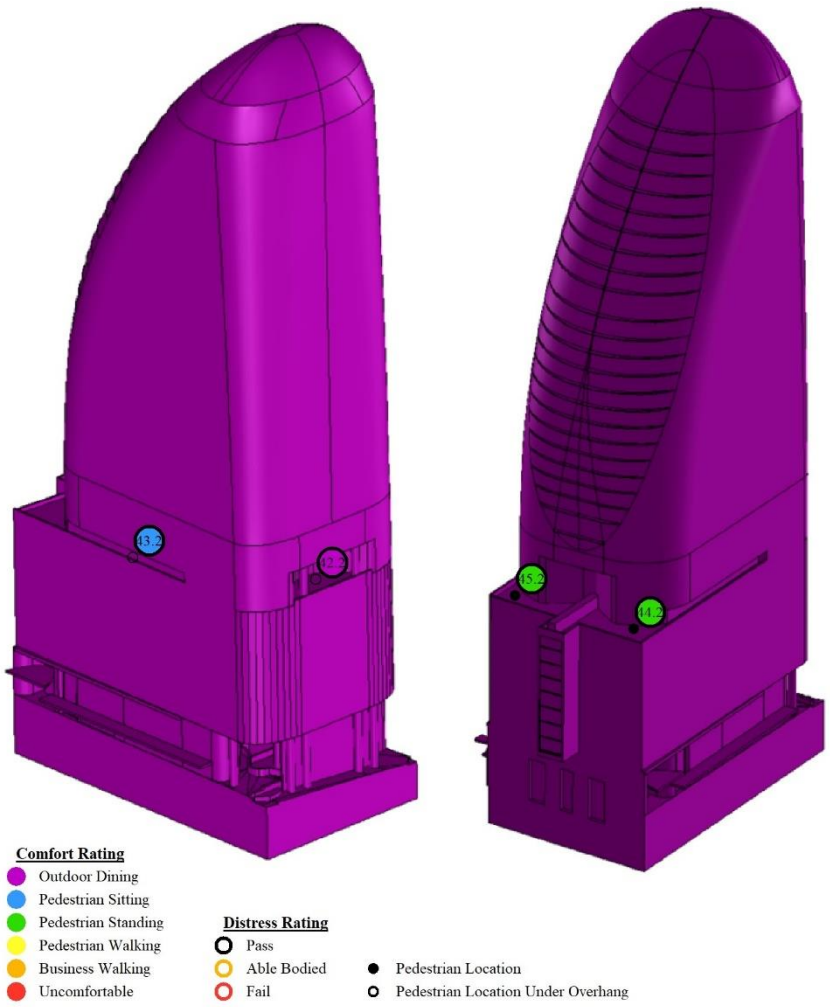


Figure 16: Pedestrian wind speed measurement locations with comfort/distress ratings – Podium terraces

7. CONCLUSIONS

A wind tunnel investigation of the pedestrian level wind environment in and around the proposed Sydney Metro Martin Place Integrated Station Development has been conducted. At street level, the existing wind environment near the development site is generally suitable for pedestrian sitting and standing.

The addition of the proposed towers creates some changes to wind flow patterns in the area, causing some areas to be windier and providing shelter for others. In general, conditions at the ground plane remain similar to the existing. The maximum envelope of the proposed tower on the North Site causes local degradation of the wind conditions compared with the existing configuration due to increased downwash, however the rounded shape of the proposed tower helps mitigate this downwash. As required in the 'Consolidated Design Guidelines', all areas are assessed as suitable for the intended use of space in this section of the city, and conditions near the station entrances meet the pedestrian standing criterion or better.

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.

CPP (2017) Wind Tunnel Test for Martin Place Overstation, Final Report CPP9973_Martin Place Overstation_REP_PW_06R01, 14th October 2017.

CPP (2018) Wind Tunnel Test for Martin Place Overstation, Final Report CPP9973_Martin Place Overstation_REP_PW_11R02, 20th July 2018.

City of Sydney, (2011), "Central of Sydney Development Control Plan 1996".

City of Sydney, (2012), "Sydney Development Control Plan 2012".

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*.

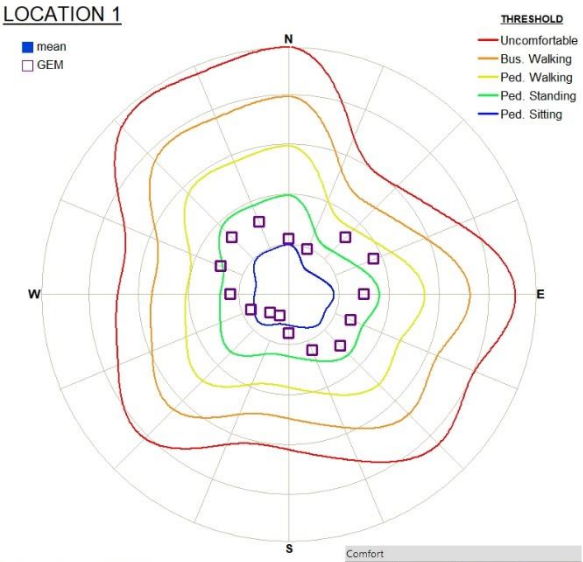
Penwarden, A.D. (1973), "Acceptable wind speeds in towns", Building Science, Vol.8, pp. 259-267.

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

Appendix 1: Directional Wind Results

Configuration A – Existing

LOCATION 1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	14.48	28.79	28.79
4	0.43	3.78	3.78
6	0.01	0.21	0.21
8	0.00	0.01	0.01
10	0.00	0.00	0.00

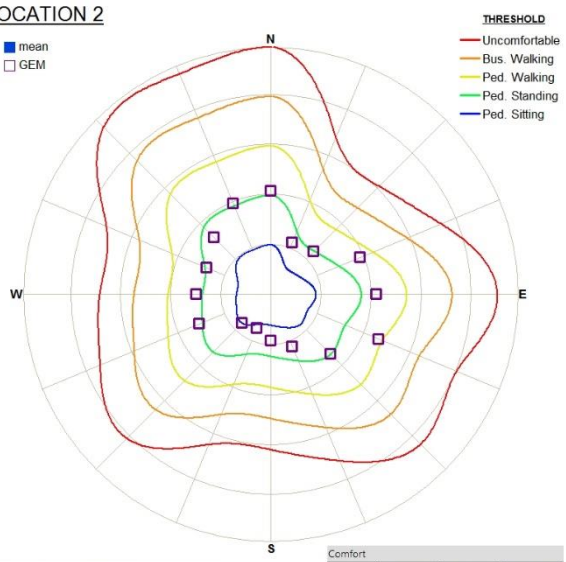
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.7	3.7	3.7
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	5.7	7.1	7.1
Rating	Pass	Pass	Pass

LOCATION 2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	16.18	39.96	39.96
4	1.29	5.91	5.91
6	0.07	0.38	0.38
8	0.00	0.02	0.02
10	0.00	0.00	0.00

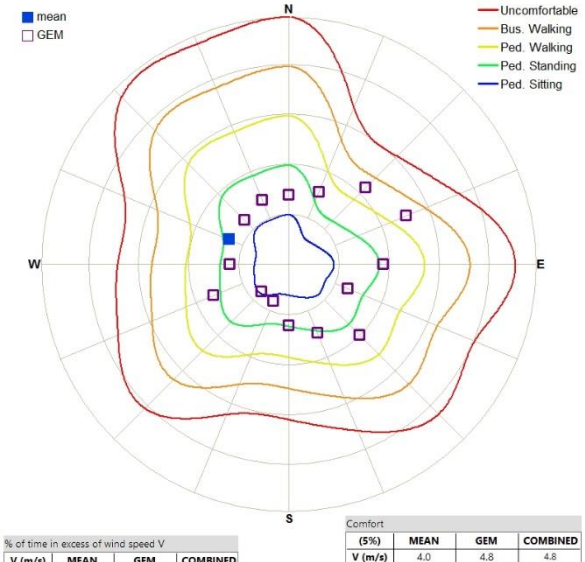
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.0	4.1	4.1
Rating	Ped Sitting	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.8	8.0	8.0
Rating	Pass	Pass	Pass

LOCATION 3



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	30.76	42.00	42.06
4	5.17	9.42	9.44
6	0.49	1.68	1.68
8	0.01	0.16	0.16
10	0.00	0.00	0.00

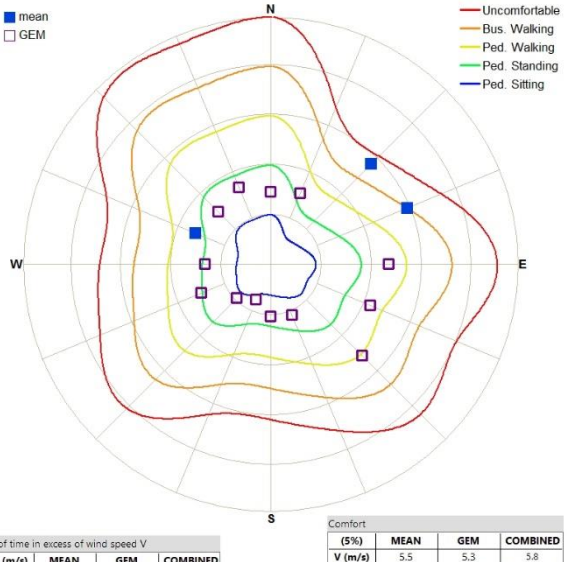
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.0	4.8	4.8
Rating	Ped Sitting	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	7.7	9.2	9.2
Rating	Pass	Pass	Pass

LOCATION 4



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	33.34	44.05	44.79
4	9.81	12.60	13.56
6	4.25	2.93	4.68
8	1.08	0.42	1.11
10	0.22	0.03	0.23

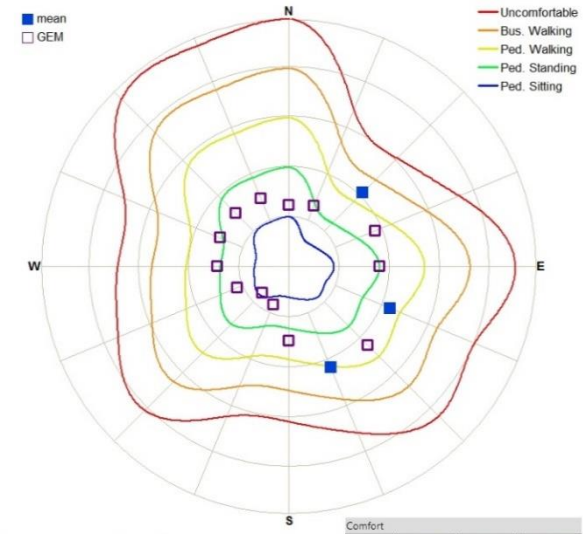
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.5	5.3	5.8
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.8	10.1	11.8
Rating	Pass	Pass	Pass

LOCATION 5



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	37.19	45.07	45.64
4	9.38	10.74	11.81
6	1.33	1.17	1.47
8	0.13	0.08	0.14
10	0.00	0.00	0.00

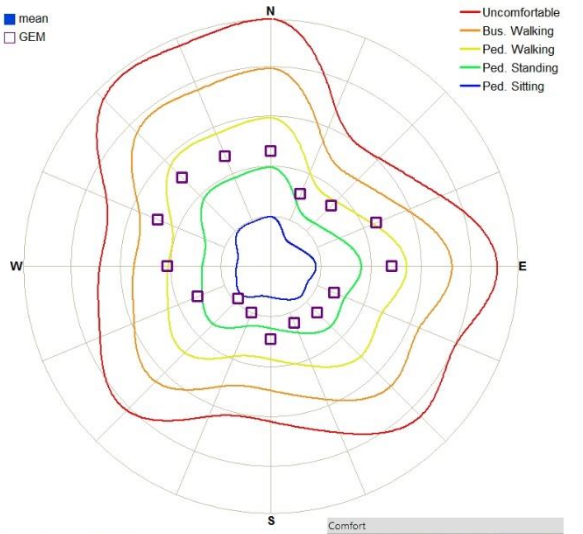
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.7	4.7	4.8
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.2	8.8	9.2
Rating	Pass	Pass	Pass

LOCATION 6



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	36.25	55.65	55.65
4	4.65	12.83	12.83
6	0.60	2.09	2.09
8	0.09	0.34	0.34
10	0.01	0.05	0.05

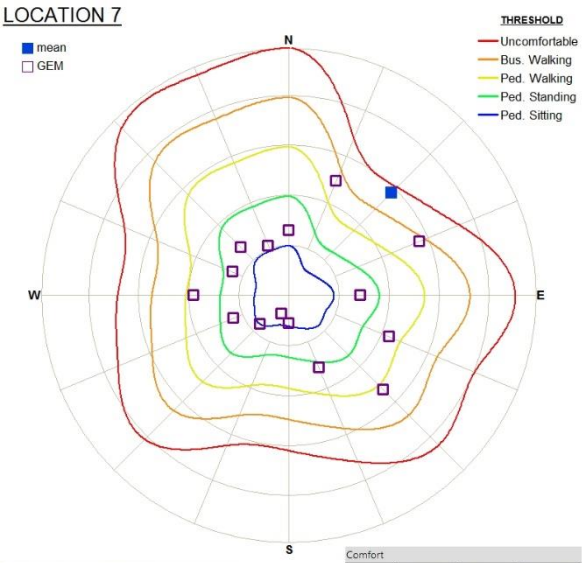
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.9	5.0	5.0
Rating	Ped Sitting	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.4	10.7	10.7
Rating	Pass	Pass	Pass

LOCATION 7



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	26.14	40.10	40.15
4	9.55	15.54	15.64
6	3.38	5.78	5.94
8	1.00	1.19	1.31
10	0.26	0.23	0.28

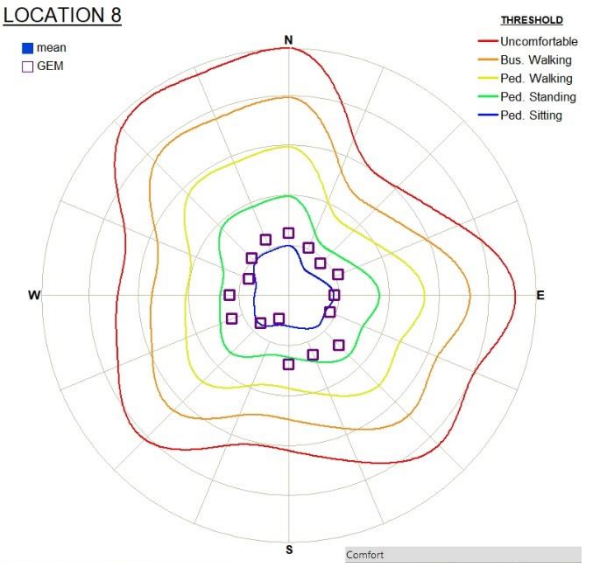
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.1	6.2	6.2
Rating	Ped Standing	Ped Walking	Ped Walking

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	12.1	11.8	12.1
Rating	Pass	Pass	Pass

LOCATION 8



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	10.54	25.97	25.97
4	0.46	1.34	1.34
6	0.01	0.04	0.04
8	0.00	0.00	0.00
10	0.00	0.00	0.00

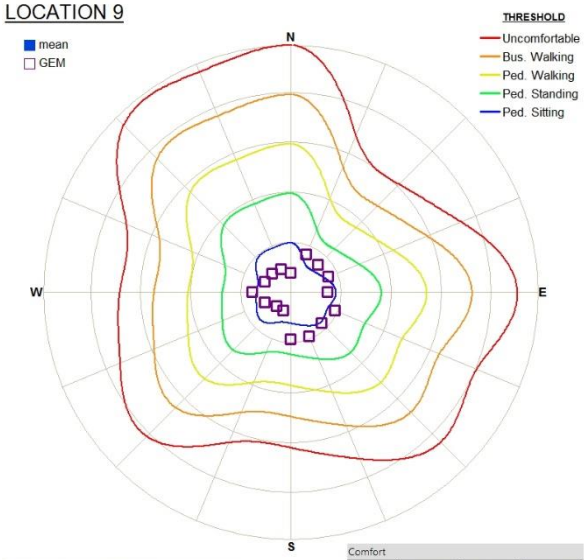
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.4	3.2	3.2
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	5.5	6.3	6.3
Rating	Pass	Pass	Pass

LOCATION 9



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	1.20	8.96	8.96
4	0.00	0.06	0.06
6	0.00	0.00	0.00
8	0.00	0.00	0.00
10	0.00	0.00	0.00

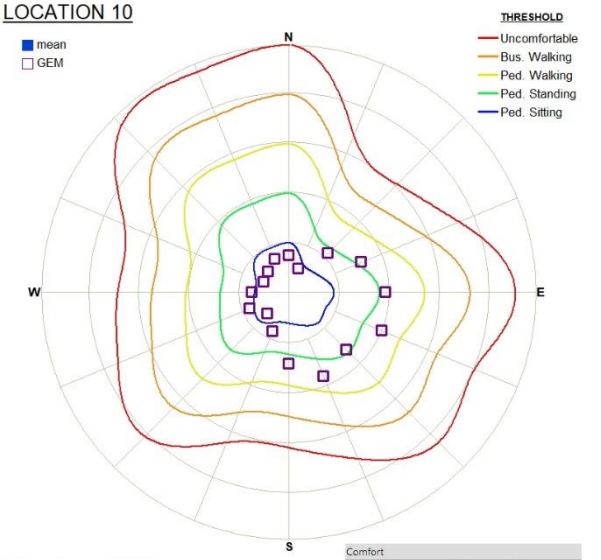
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	1.5	2.2	2.2
Rating	Outdoor Dining	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	3.2	4.3	4.3
Rating	Pass	Pass	Pass

LOCATION 10



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	12.99	28.30	28.30
4	0.44	3.79	3.79
6	0.01	0.23	0.23
8	0.00	0.01	0.01
10	0.00	0.00	0.00

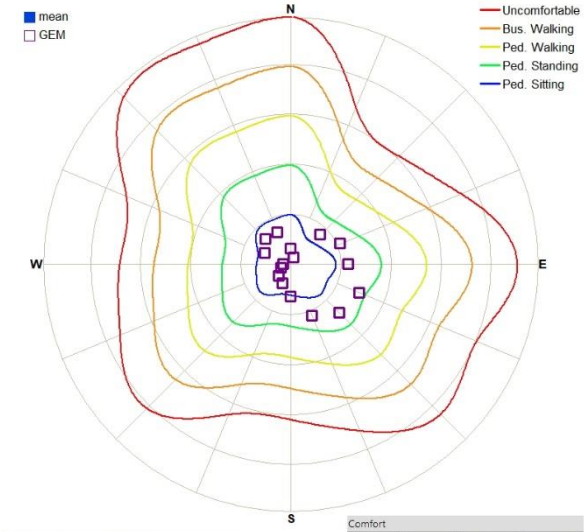
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.6	3.8	3.8
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	5.6	7.5	7.5
Rating	Pass	Pass	Pass

LOCATION 11



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	6.60	12.02	12.02
4	0.12	0.22	0.22
6	0.00	0.00	0.00
8	0.00	0.00	0.00
10	0.00	0.00	0.00

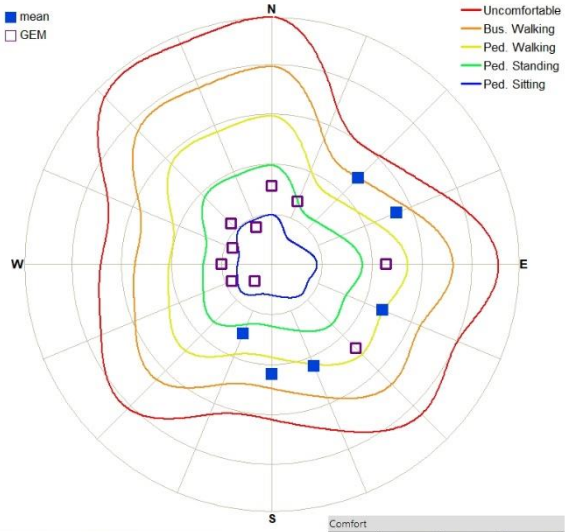
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.1	2.5	2.5
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	4.7	5.1	5.1
Rating	Pass	Pass	Pass

LOCATION 12



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	40.11	45.84	46.65
4	16.17	16.03	18.45
6	4.29	3.28	4.49
8	0.67	0.39	0.68
10	0.06	0.02	0.06

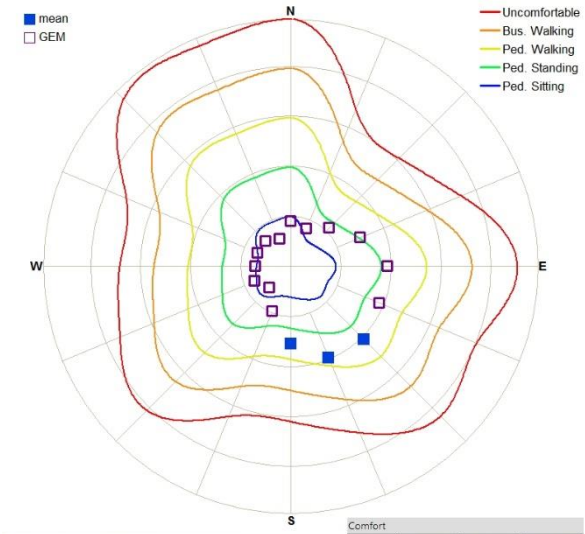
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.7	5.5	5.8
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.6	9.9	10.6
Rating	Pass	Pass	Pass

LOCATION 13



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	24.22	31.35	32.03
4	4.37	4.27	5.21
6	0.36	0.26	0.39
8	0.02	0.01	0.02
10	0.00	0.00	0.00

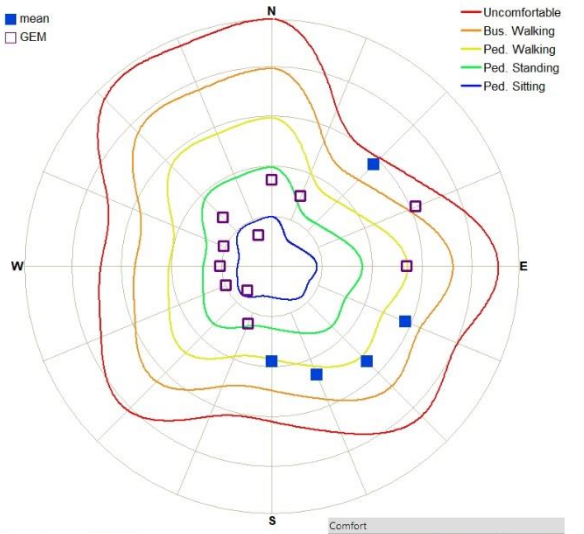
Comfort

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

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	8.1	7.6	8.1
Rating	Pass	Pass	Pass

LOCATION 14



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	43.41	48.03	49.05
4	18.70	17.48	19.93
6	6.16	4.68	6.53
8	1.36	0.87	1.51
10	0.27	0.08	0.29

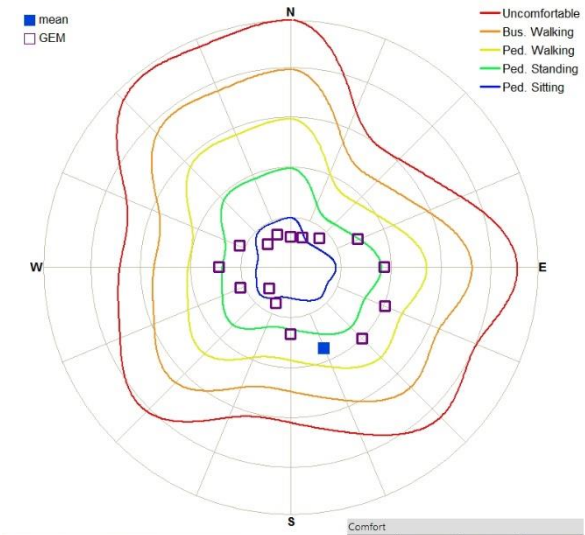
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	6.2	5.8	6.3
Rating	Ped Walking	Ped Standing	Ped Walking

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	12.0	10.9	12.0
Rating	Pass	Pass	Pass

LOCATION 15



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	25.09	30.88	31.05
4	3.11	3.89	4.04
6	0.18	0.20	0.22
8	0.01	0.01	0.01
10	0.00	0.00	0.00

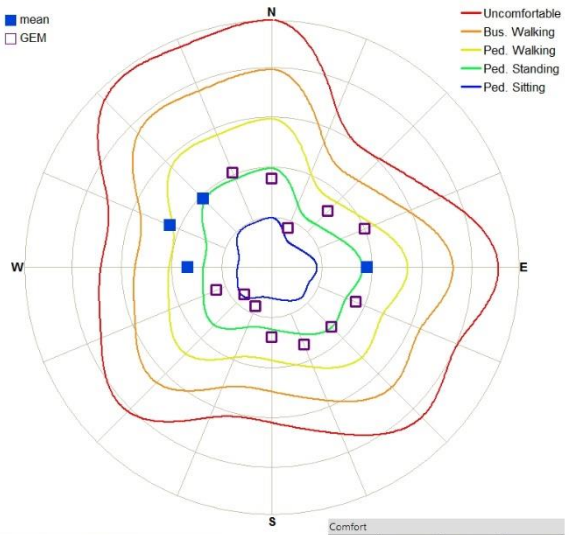
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.6	3.8	3.8
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	7.4	7.3	7.5
Rating	Pass	Pass	Pass

LOCATION 16



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	39.99	46.09	47.76
4	5.08	7.70	8.32
6	0.74	0.66	0.96
8	0.12	0.04	0.13
10	0.01	0.00	0.01

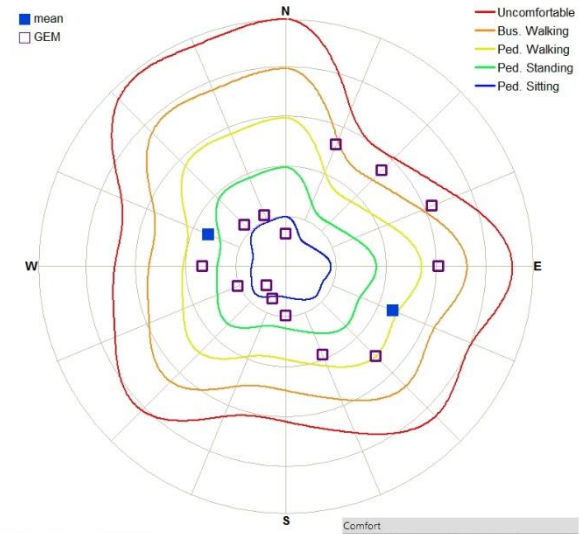
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.0	4.4	4.5
Rating	Ped Sitting	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.3	8.3	9.3
Rating	Pass	Pass	Pass

LOCATION 20



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	36.20	44.57	45.00
4	14.09	18.09	18.27
6	4.31	6.75	6.82
8	0.68	1.37	1.38
10	0.06	0.20	0.20

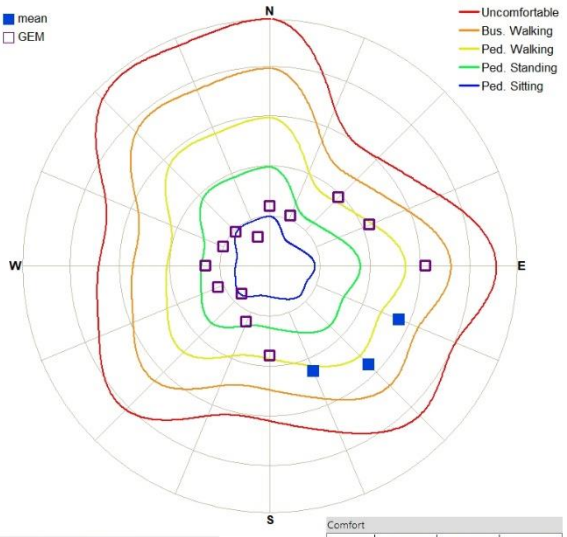
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.7	6.4	6.4
Rating	Ped Standing	Ped Walking	Ped Walking

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.6	11.6	11.6
Rating	Pass	Pass	Pass

LOCATION 30



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	35.62	45.37	45.91
4	11.54	14.54	15.90
6	1.80	2.26	2.90
8	0.20	0.19	0.30
10	0.02	0.02	0.03

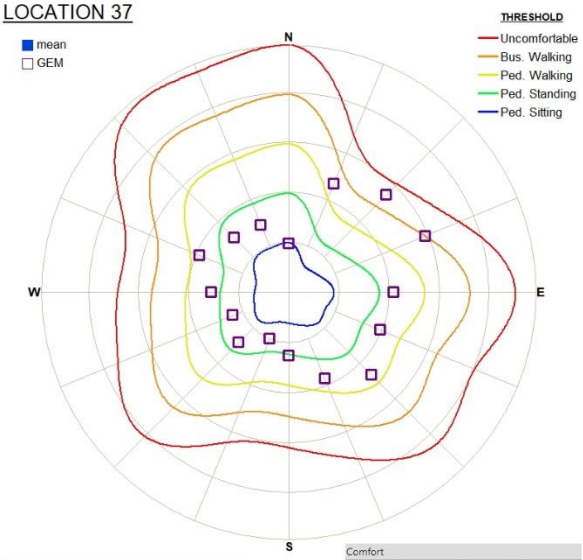
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.0	5.2	5.5
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.9	9.7	10.3
Rating	Pass	Pass	Pass

LOCATION 37



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	35.07	52.23	52.23
4	9.92	16.72	16.72
6	2.62	5.43	5.43
8	0.35	1.06	1.06
10	0.02	0.17	0.17

Comfort

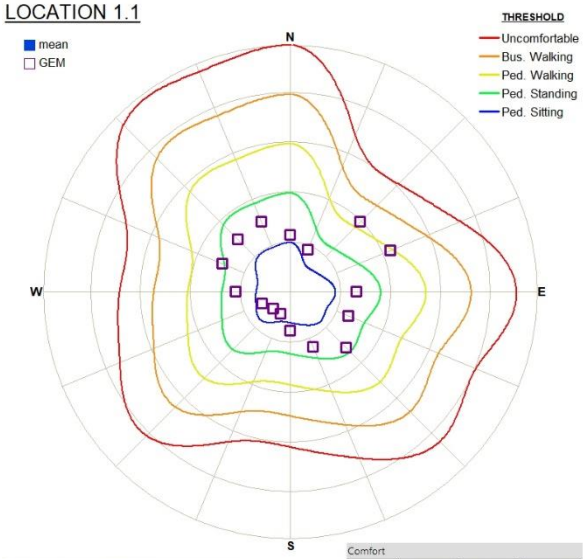
(5%)	MEAN	GEM	COMBINED
V (m/s)	5.1	6.1	6.1
Rating	Ped Standing	Ped Walking	Ped Walking

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.9	11.5	11.5
Rating	Pass	Pass	Pass

Configuration B – Maximum envelope of proposed buildings

LOCATION 1.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	16.97	27.80	27.80
4	2.50	5.88	5.88
6	0.18	0.73	0.73
8	0.00	0.04	0.04
10	0.00	0.00	0.00

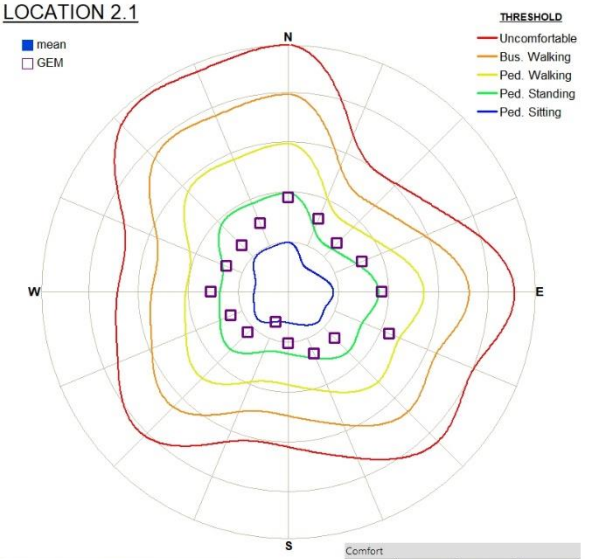
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.3	4.2	4.2
Rating	Ped Sitting	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	7.0	8.3	8.3
Rating	Pass	Pass	Pass

LOCATION 2.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	17.43	38.67	38.67
4	0.75	5.02	5.02
6	0.03	0.23	0.23
8	0.00	0.01	0.01
10	0.00	0.00	0.00

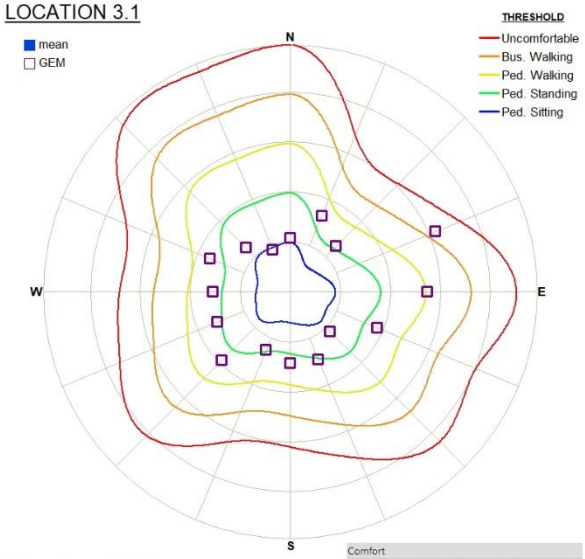
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.8	4.0	4.0
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.2	7.4	7.4
Rating	Pass	Pass	Pass

LOCATION 3.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	27.92	46.61	46.61
4	3.42	10.09	10.09
6	0.11	2.05	2.05
8	0.00	0.38	0.38
10	0.00	0.03	0.03

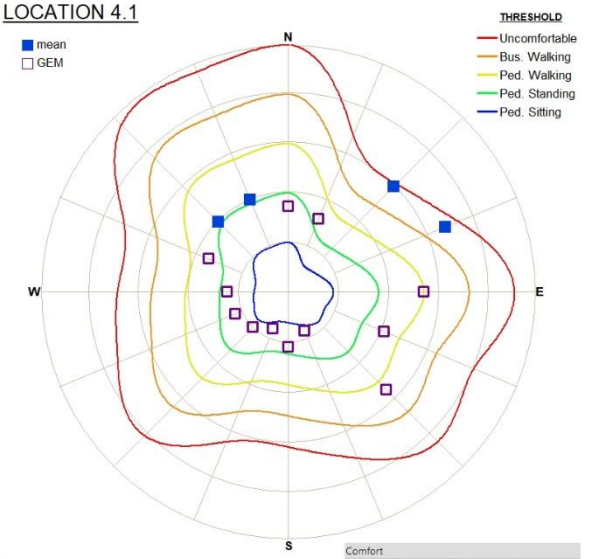
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.7	4.8	4.8
Rating	Ped Sitting	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.8	10.2	10.2
Rating	Pass	Pass	Pass

LOCATION 4.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	36.29	46.08	47.56
4	11.31	14.11	15.11
6	5.31	4.42	5.98
8	1.78	0.76	1.84
10	0.41	0.11	0.41

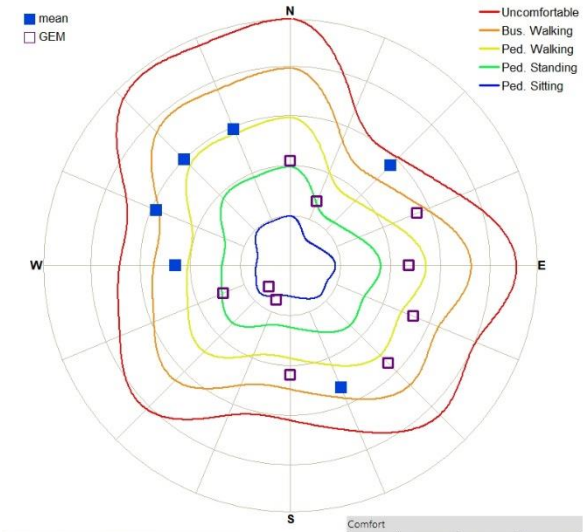
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	6.0	5.7	6.3
Rating	Ped Walking	Ped Standing	Ped Walking

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	12.6	11.1	12.6
Rating	Pass	Pass	Pass

LOCATION 5.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	58.41	61.49	65.95
4	24.76	24.27	27.70
6	7.86	7.00	9.03
8	2.10	1.23	2.26
10	0.48	0.17	0.50

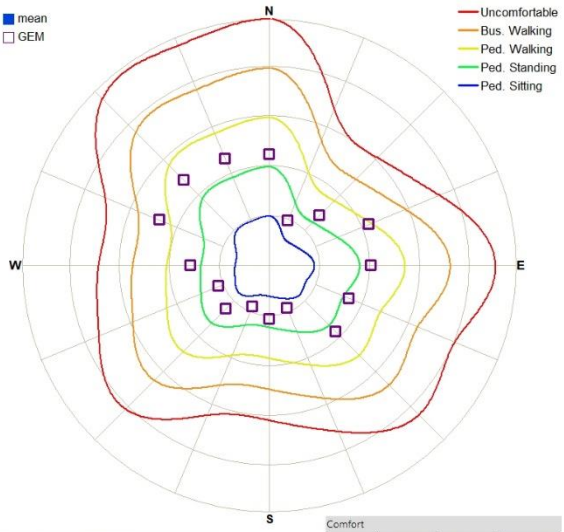
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	6.6	6.4	6.8
Rating	Ped Walking	Ped Walking	Ped Walking

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	13.0	11.5	13.0
Rating	Pass	Pass	Pass

LOCATION 6.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	27.30	47.39	47.39
4	2.60	7.86	7.86
6	0.66	1.25	1.25
8	0.14	0.24	0.24
10	0.01	0.03	0.03

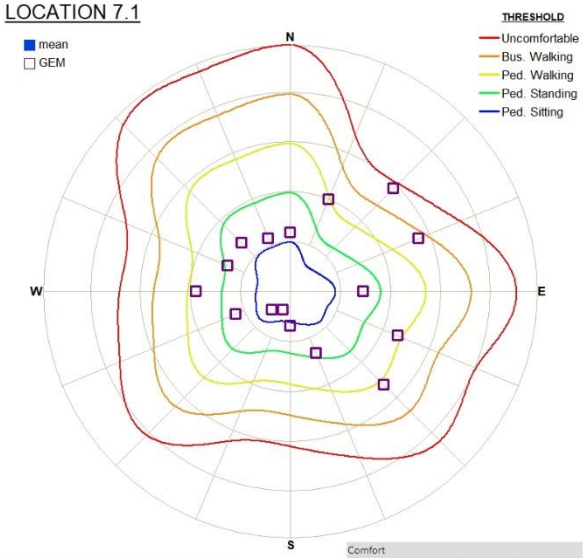
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.3	4.4	4.4
Rating	Ped Sitting	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.4	10.3	10.3
Rating	Pass	Pass	Pass

LOCATION 7.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	26.00	39.44	39.44
4	7.79	14.54	14.54
6	2.97	5.02	5.02
8	0.87	1.19	1.19
10	0.21	0.29	0.29

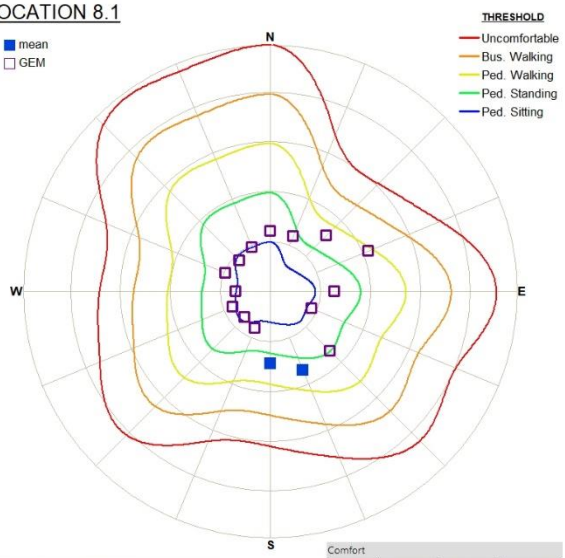
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.8	5.9	5.9
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.8	12.2	12.2
Rating	Pass	Pass	Pass

LOCATION 8.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	21.19	30.77	31.64
4	2.06	4.71	5.44
6	0.11	0.27	0.34
8	0.00	0.01	0.01
10	0.00	0.00	0.00

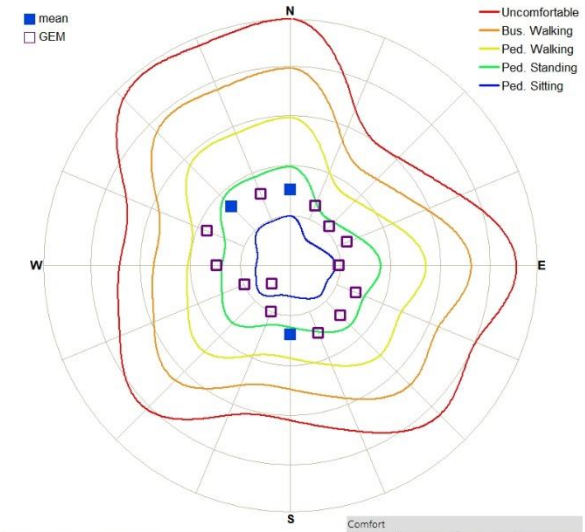
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.3	3.9	4.0
Rating	Ped Sitting	Ped Sitting	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	7.1	7.2	7.4
Rating	Pass	Pass	Pass

LOCATION 9.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	26.66	38.04	39.05
4	2.50	3.26	3.59
6	0.21	0.25	0.28
8	0.01	0.01	0.01
10	0.00	0.00	0.00

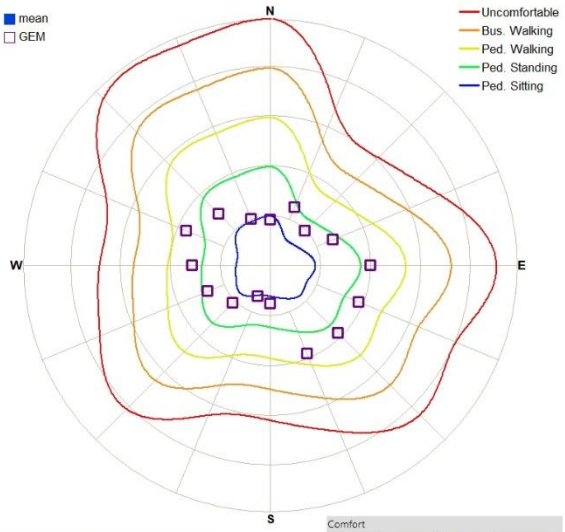
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.4	3.6	3.7
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	7.3	7.7	7.7
Rating	Pass	Pass	Pass

LOCATION 10.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	19.91	36.23	36.23
4	1.20	5.02	5.02
6	0.04	0.45	0.45
8	0.00	0.03	0.03
10	0.00	0.00	0.00

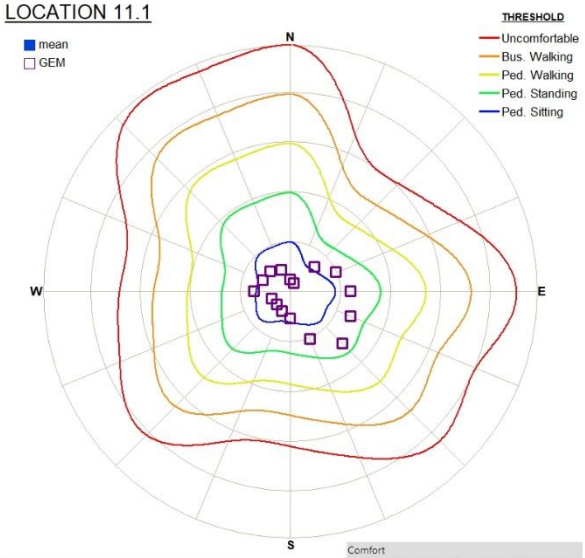
Comfort

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

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.2	8.1	8.1
Rating	Pass	Pass	Pass

LOCATION 11.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	6.65	9.81	9.81
4	0.11	0.16	0.16
6	0.00	0.00	0.00
8	0.00	0.00	0.00
10	0.00	0.00	0.00

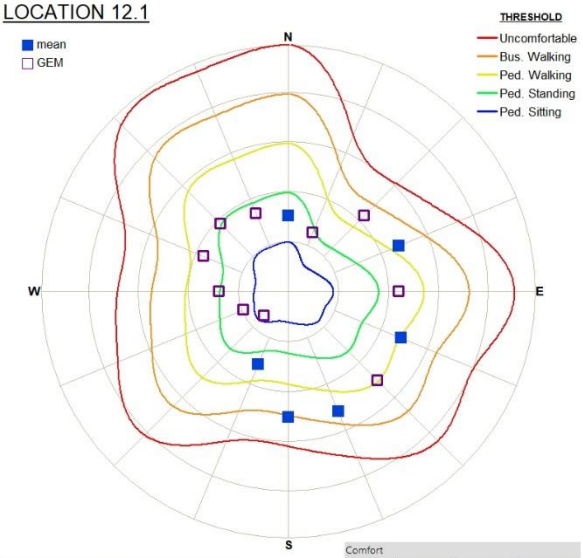
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.1	2.4	2.4
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	4.7	4.9	4.9
Rating	Pass	Pass	Pass

LOCATION 12.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	48.17	54.68	55.87
4	19.45	17.91	21.75
6	4.45	3.06	4.99
8	0.80	0.31	0.88
10	0.11	0.02	0.11

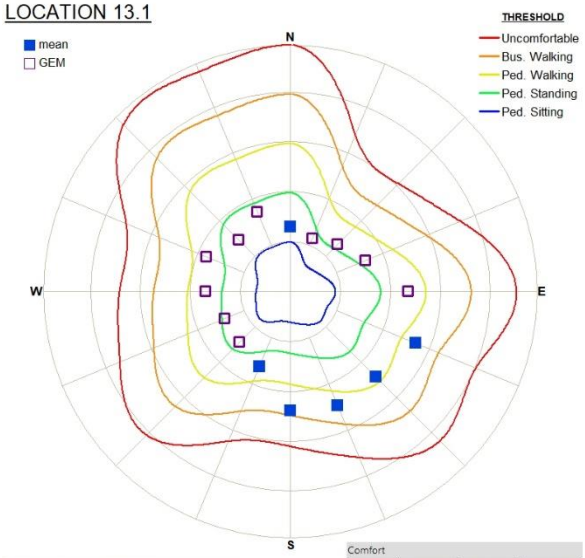
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.8	5.5	6.0
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.6	9.8	11.6
Rating	Pass	Pass	Pass

LOCATION 13.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	44.50	52.90	54.67
4	14.24	12.51	17.43
6	2.99	1.49	3.30
8	0.55	0.13	0.57
10	0.08	0.01	0.08

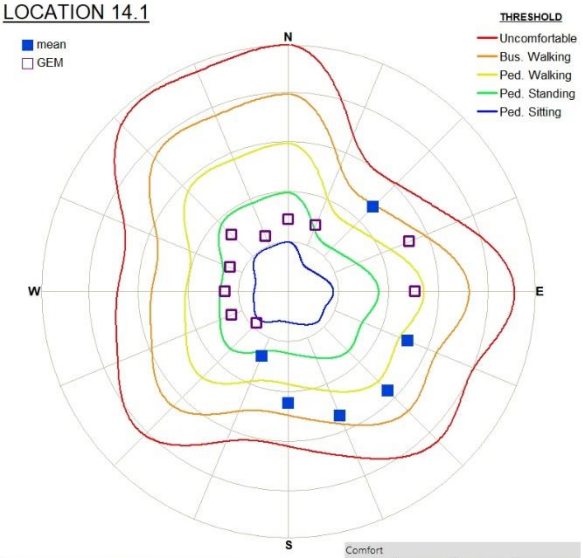
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.4	4.9	5.5
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.1	9.2	11.1
Rating	Pass	Pass	Pass

LOCATION 14.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	46.02	51.25	52.83
4	20.26	17.20	21.69
6	5.52	3.50	5.65
8	0.91	0.44	0.93
10	0.10	0.02	0.10

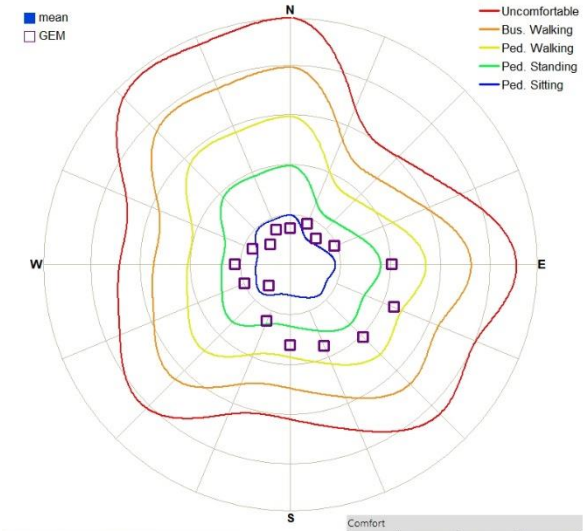
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	6.1	5.5	6.1
Rating	Ped Walking	Ped Standing	Ped Walking

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.3	10.0	11.3
Rating	Pass	Pass	Pass

LOCATION 15.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	22.83	32.37	32.37
4	3.21	5.51	5.51
6	0.19	0.42	0.42
8	0.01	0.02	0.02
10	0.00	0.00	0.00

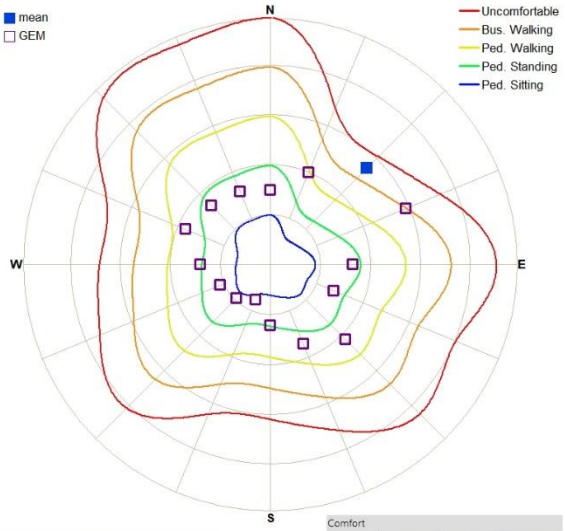
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.6	4.0	4.0
Rating	Ped Sitting	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	7.3	8.0	8.0
Rating	Pass	Pass	Pass

LOCATION 16.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	29.70	47.30	47.32
4	8.16	13.34	13.38
6	3.18	4.38	4.46
8	0.71	0.85	0.90
10	0.15	0.14	0.16

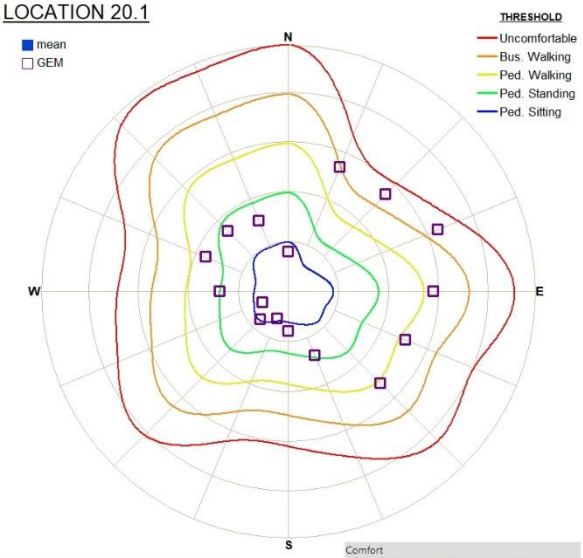
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.1	5.7	5.8
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.4	11.3	11.4
Rating	Pass	Pass	Pass

LOCATION 20.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	31.99	42.92	42.92
4	13.20	17.60	17.60
6	3.99	6.98	6.98
8	0.62	1.59	1.59
10	0.04	0.22	0.22

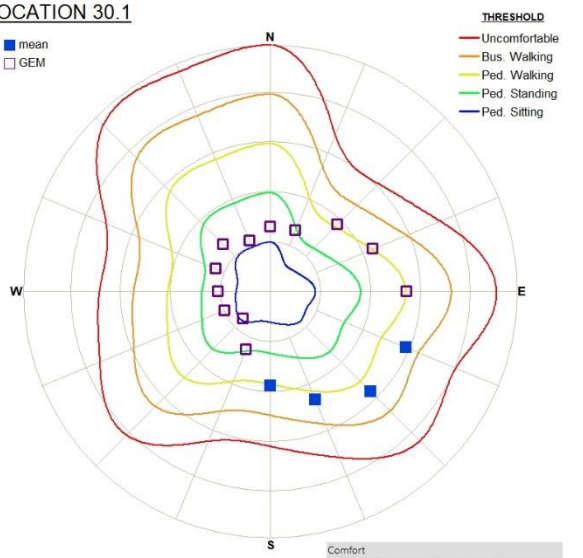
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.6	6.5	6.5
Rating	Ped Standing	Ped Walking	Ped Walking

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.4	11.8	11.8
Rating	Pass	Pass	Pass

LOCATION 30.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	40.69	46.27	47.35
4	14.83	14.06	16.94
6	2.63	1.73	3.01
8	0.30	0.13	0.32
10	0.03	0.01	0.03

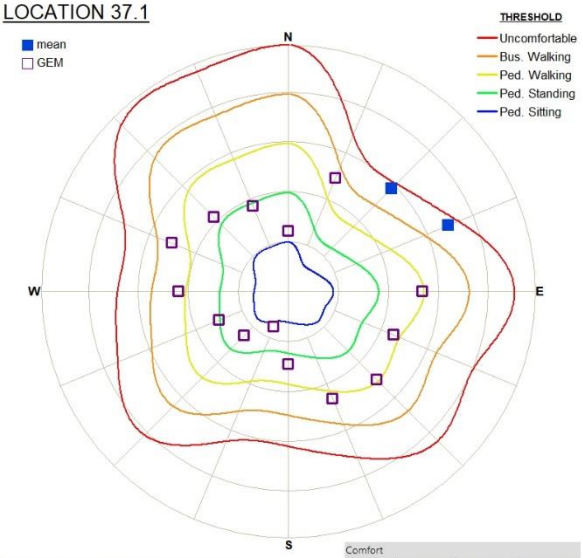
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.3	5.1	5.4
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.3	9.1	10.3
Rating	Pass	Pass	Pass

LOCATION 37.1



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	44.58	59.94	60.12
4	14.17	23.37	23.82
6	5.92	7.56	8.37
8	1.87	1.57	2.28
10	0.39	0.23	0.45

Comfort

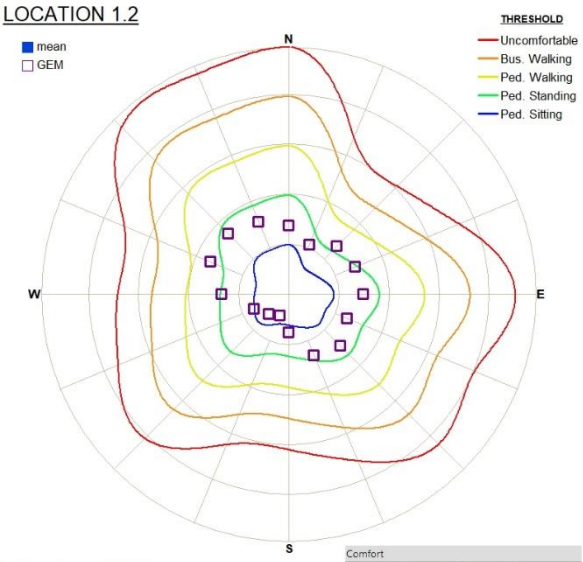
(5%)	MEAN	GEM	COMBINED
V (m/s)	6.3	6.5	6.8
Rating	Ped Walking	Ped Walking	Ped Walking

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	12.5	11.7	12.5
Rating	Pass	Pass	Pass

Configuration C – Detailed shape of proposed buildings

LOCATION 1.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	16.22	30.84	30.84
4	0.67	2.52	2.52
6	0.03	0.19	0.19
8	0.00	0.01	0.01
10	0.00	0.00	0.00

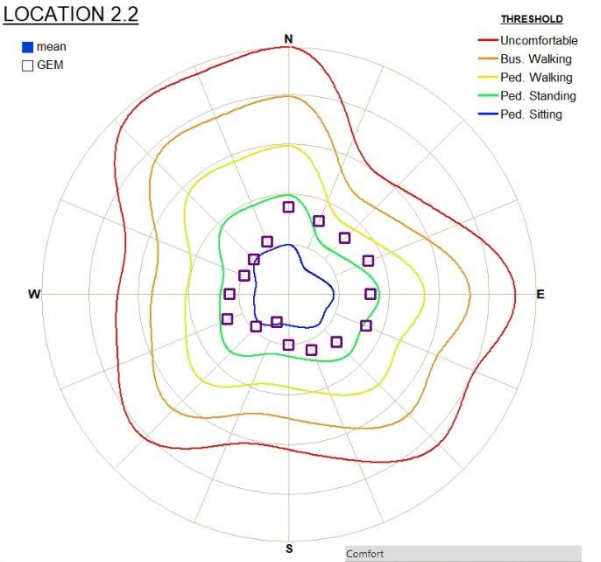
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.7	3.5	3.5
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.1	7.3	7.3
Rating	Pass	Pass	Pass

LOCATION 2.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	11.57	33.76	33.76
4	0.05	4.16	4.16
6	0.00	0.14	0.14
8	0.00	0.00	0.00
10	0.00	0.00	0.00

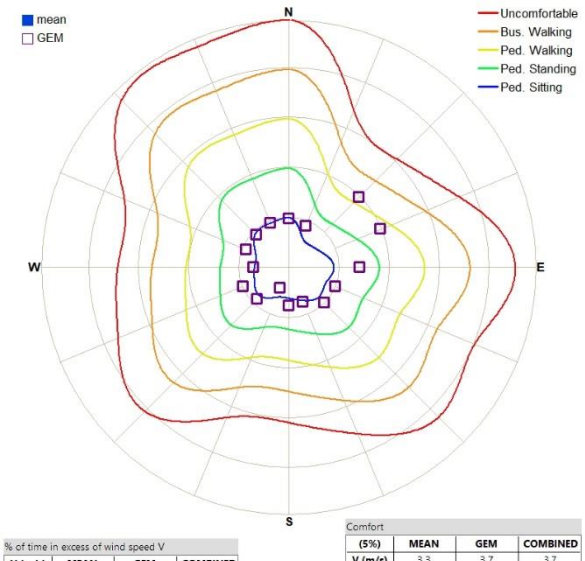
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.4	3.8	3.8
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	4.1	6.8	6.8
Rating	Pass	Pass	Pass

LOCATION 3.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	10.05	19.06	19.06
4	3.47	4.46	4.46
6	0.52	0.59	0.59
8	0.03	0.04	0.04
10	0.00	0.00	0.00

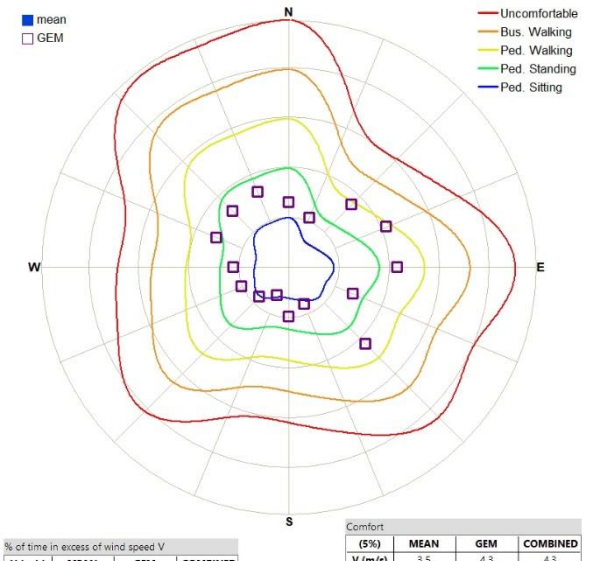
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.3	3.7	3.7
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	8.2	8.3	8.3
Rating	Pass	Pass	Pass

LOCATION 4.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	19.15	34.15	34.15
4	2.98	6.90	6.90
6	0.13	0.62	0.62
8	0.00	0.02	0.02
10	0.00	0.00	0.00

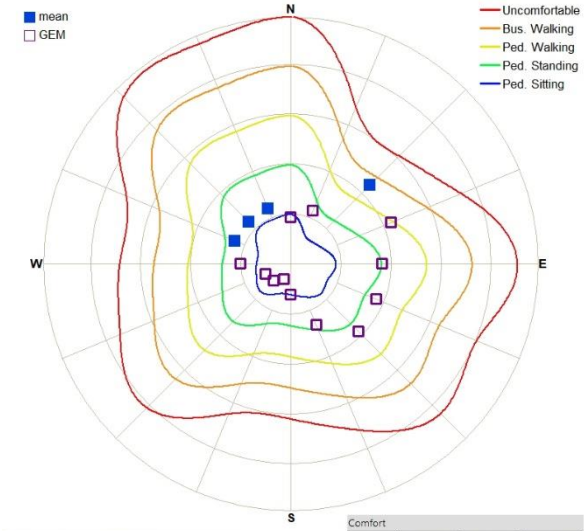
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.5	4.3	4.3
Rating	Ped Sitting	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.8	7.9	7.9
Rating	Pass	Pass	Pass

LOCATION 5.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	22.45	28.26	29.12
4	5.86	6.51	7.17
6	1.18	0.81	1.35
8	0.18	0.05	0.18
10	0.01	0.00	0.01

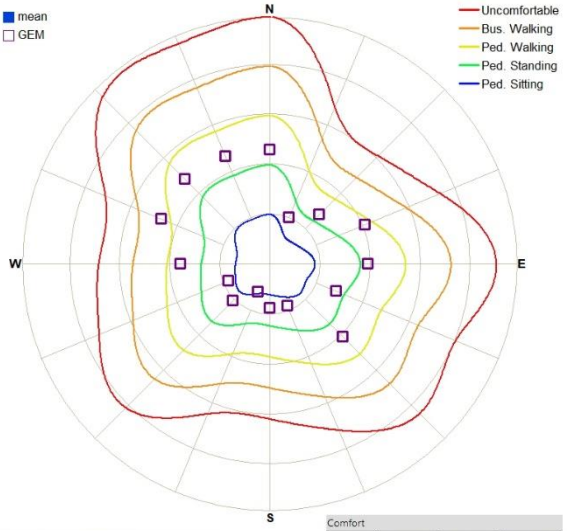
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.2	4.3	4.5
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.3	8.4	9.3
Rating	Pass	Pass	Pass

LOCATION 6.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	24.65	42.95	42.95
4	2.62	7.78	7.78
6	0.58	1.29	1.29
8	0.11	0.23	0.23
10	0.01	0.03	0.03

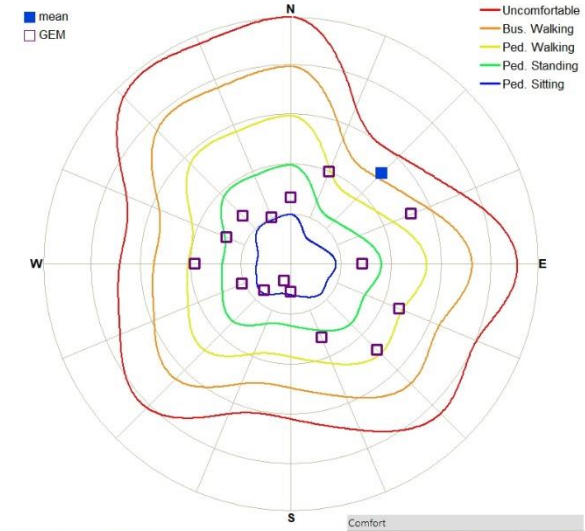
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.3	4.4	4.4
Rating	Ped Sitting	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.2	10.2	10.2
Rating	Pass	Pass	Pass

LOCATION 7.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	25.64	38.90	38.91
4	6.98	13.93	13.95
6	2.18	3.68	3.72
8	0.48	0.56	0.57
10	0.06	0.06	0.06

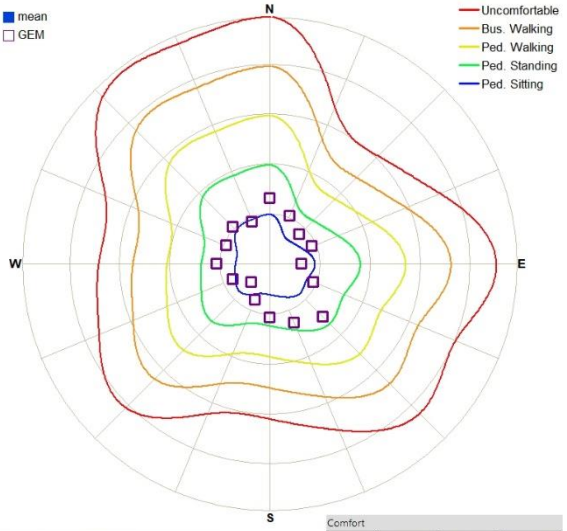
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.5	5.6	5.6
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.7	10.6	10.7
Rating	Pass	Pass	Pass

LOCATION 8.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	10.62	21.84	21.84
4	0.25	0.53	0.53
6	0.00	0.01	0.01
8	0.00	0.00	0.00
10	0.00	0.00	0.00

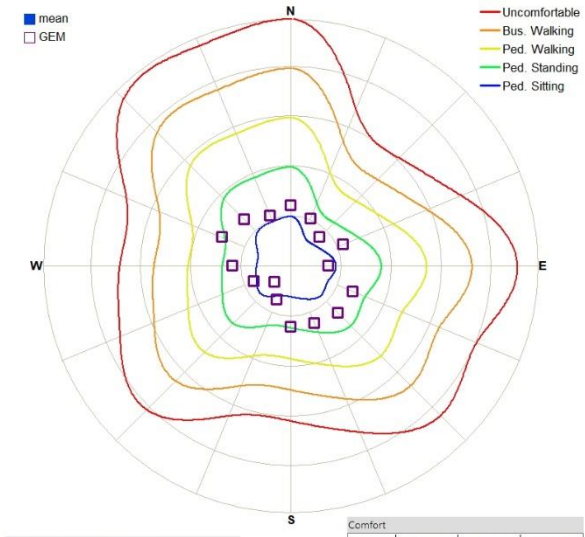
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.5	2.9	2.9
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	5.1	5.4	5.4
Rating	Pass	Pass	Pass

LOCATION 9.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	14.50	26.01	26.01
4	0.48	1.35	1.35
6	0.01	0.05	0.05
8	0.00	0.00	0.00
10	0.00	0.00	0.00

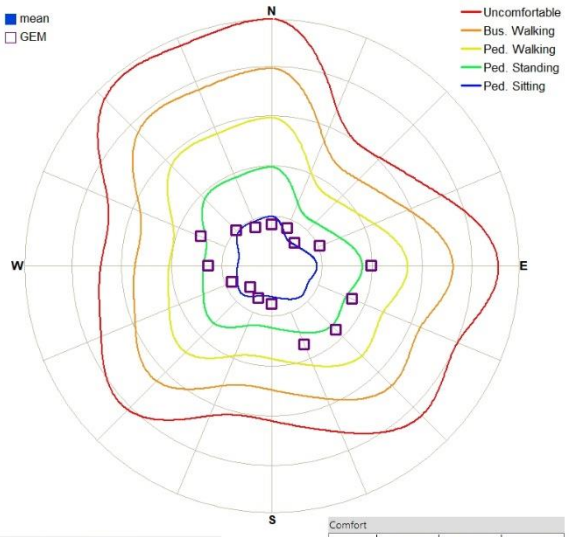
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.6	3.1	3.1
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	5.5	6.3	6.3
Rating	Pass	Pass	Pass

LOCATION 10.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	9.57	23.69	23.69
4	0.20	2.59	2.59
6	0.00	0.15	0.15
8	0.00	0.00	0.00
10	0.00	0.00	0.00

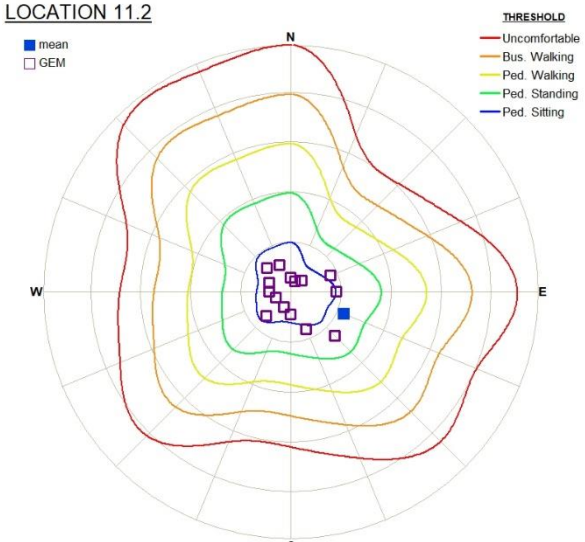
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.4	3.5	3.5
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	5.0	7.1	7.1
Rating	Pass	Pass	Pass

LOCATION 11.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	3.00	4.50	4.55
4	0.02	0.03	0.03
6	0.00	0.00	0.00
8	0.00	0.00	0.00
10	0.00	0.00	0.00

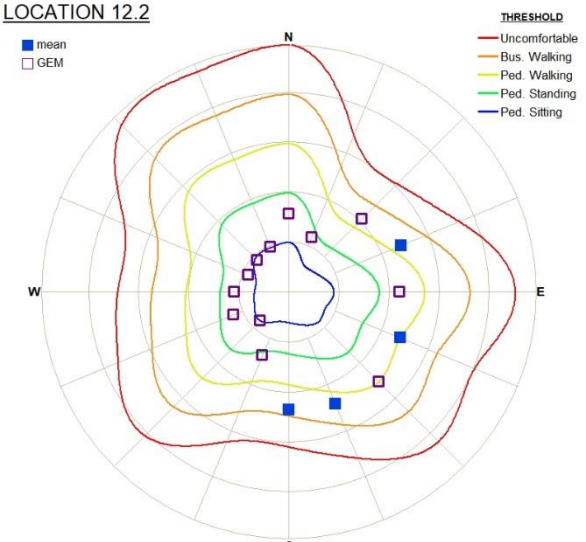
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	1.7	1.9	1.9
Rating	Outdoor Dining	Outdoor Dining	Outdoor Dining

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	4.0	4.1	4.1
Rating	Pass	Pass	Pass

LOCATION 12.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	40.24	46.59	47.75
4	16.90	14.75	18.48
6	3.54	2.30	3.78
8	0.51	0.20	0.53
10	0.06	0.01	0.06

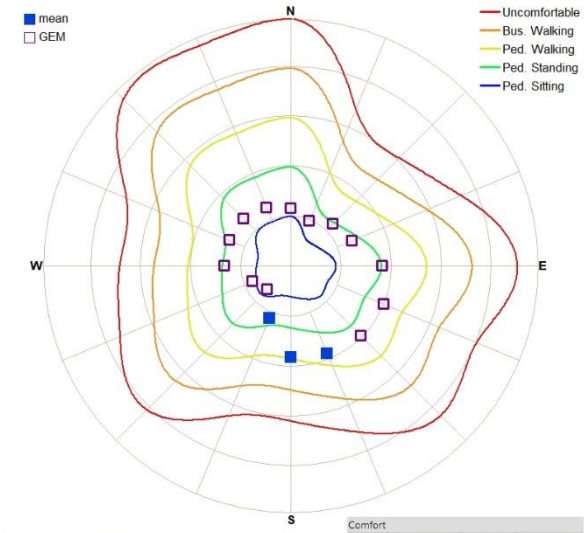
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.6	5.2	5.6
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.8	9.5	10.9
Rating	Pass	Pass	Pass

LOCATION 13.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	31.49	38.92	40.24
4	5.87	4.93	6.90
6	0.65	0.26	0.67
8	0.05	0.01	0.05
10	0.00	0.00	0.00

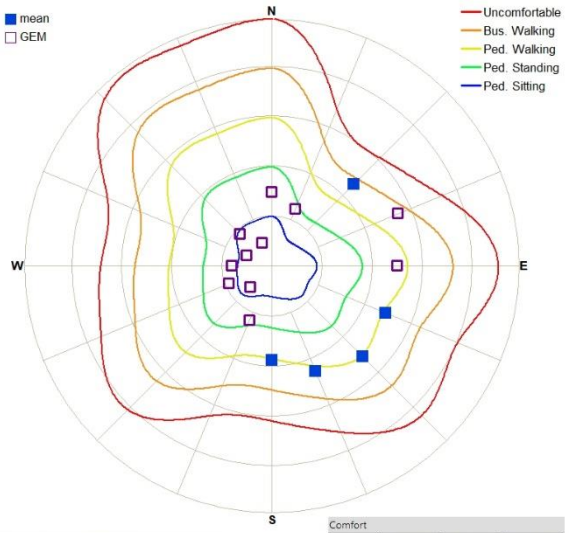
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.1	4.0	4.2
Rating	Ped Standing	Ped Sitting	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	8.5	7.5	8.5
Rating	Pass	Pass	Pass

LOCATION 14.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	39.68	42.24	43.44
4	15.16	13.94	16.59
6	3.01	2.72	3.75
8	0.41	0.31	0.50
10	0.02	0.01	0.03

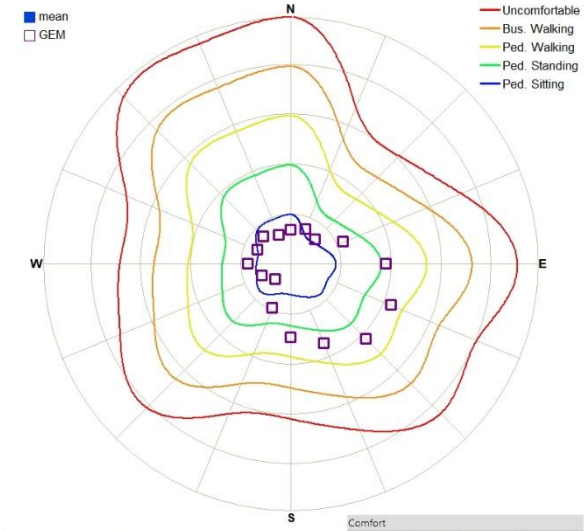
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.4	5.3	5.6
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.0	9.6	10.1
Rating	Pass	Pass	Pass

LOCATION 15.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	19.20	27.61	27.61
4	2.40	4.23	4.23
6	0.13	0.29	0.29
8	0.00	0.01	0.01
10	0.00	0.00	0.00

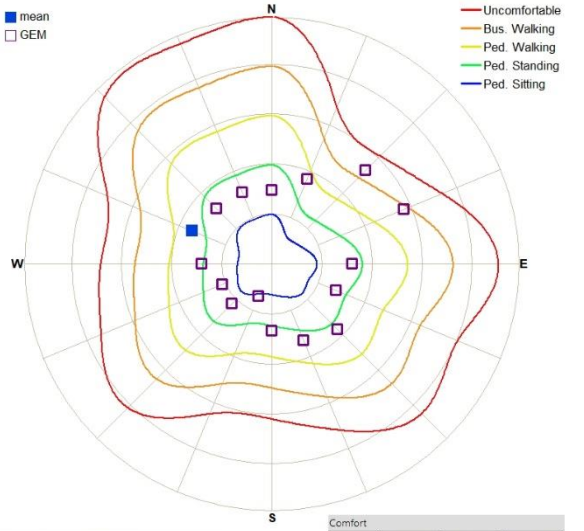
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.4	3.8	3.8
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	7.0	7.6	7.6
Rating	Pass	Pass	Pass

LOCATION 16.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	29.78	45.64	45.67
4	7.41	12.29	12.30
6	2.14	3.84	3.84
8	0.35	0.68	0.69
10	0.02	0.11	0.11

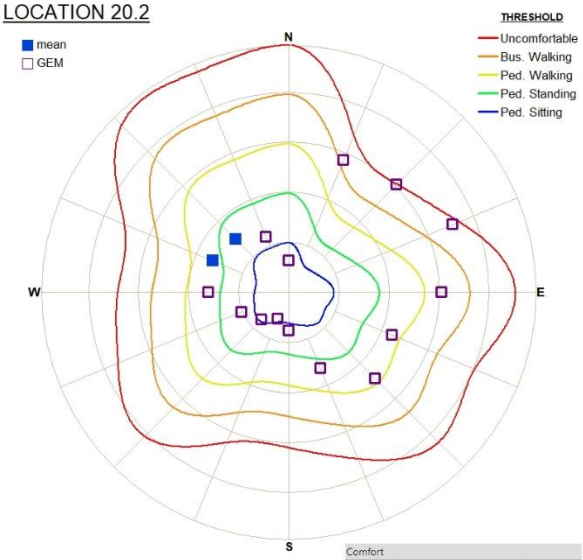
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.7	5.5	5.5
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.0	11.1	11.1
Rating	Pass	Pass	Pass

LOCATION 20.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	32.12	43.01	43.21
4	11.73	18.09	18.12
6	3.76	8.25	8.27
8	0.58	2.69	2.69
10	0.04	0.57	0.57

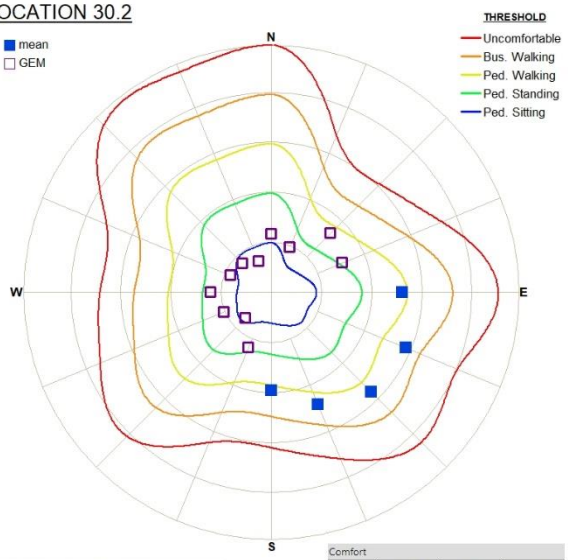
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.5	6.9	6.9
Rating	Ped Standing	Ped Walking	Ped Walking

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.4	13.0	13.0
Rating	Pass	Pass	Pass

LOCATION 30.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	35.19	41.88	43.18
4	12.57	10.90	14.29
6	2.48	1.17	2.65
8	0.33	0.10	0.33
10	0.04	0.00	0.04

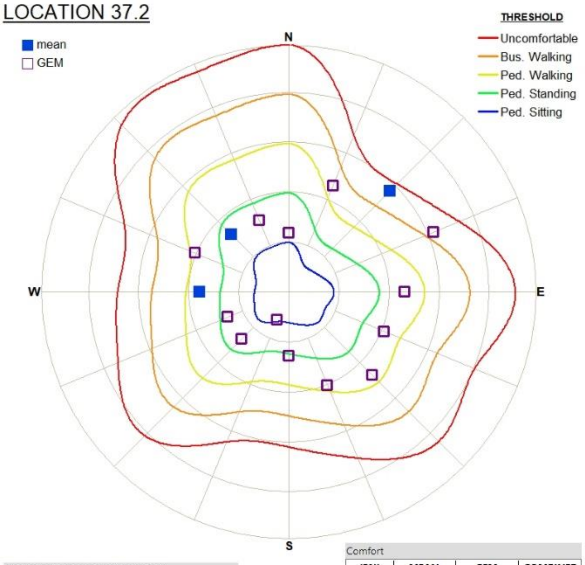
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.2	4.7	5.3
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	10.4	9.0	10.4
Rating	Pass	Pass	Pass

LOCATION 37.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	36.42	52.63	52.94
4	10.56	18.26	18.49
6	4.71	5.83	6.16
8	1.25	1.17	1.40
10	0.25	0.18	0.26

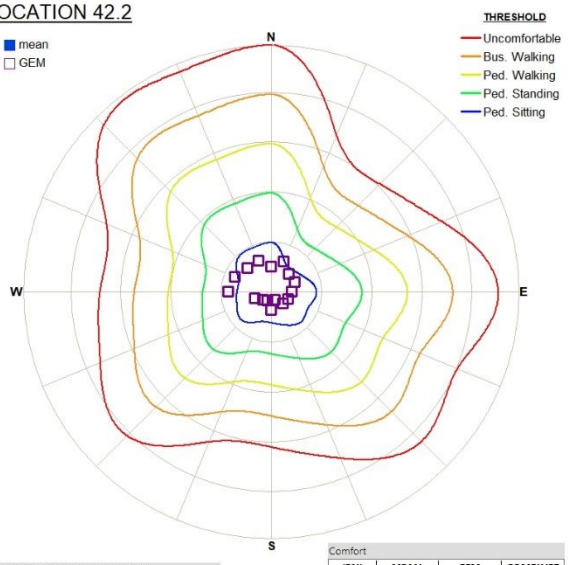
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	5.8	6.2	6.3
Rating	Ped Standing	Ped Walking	Ped Walking

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	11.9	11.6	12.0
Rating	Pass	Pass	Pass

LOCATION 42.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	0.56	1.84	1.84
4	0.00	0.00	0.00
6	0.00	0.00	0.00
8	0.00	0.00	0.00
10	0.00	0.00	0.00

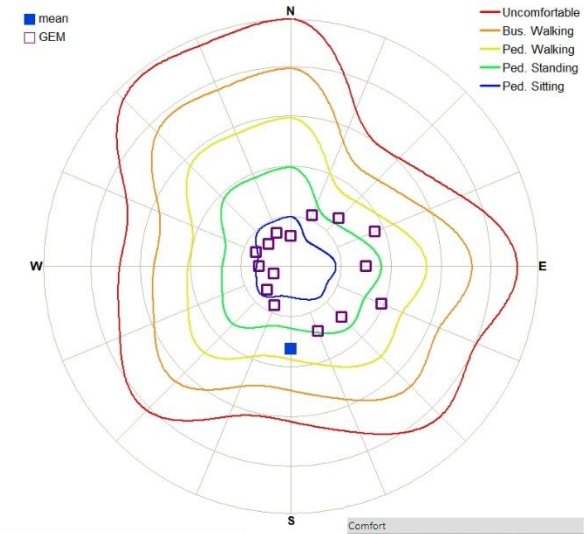
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	1.3	1.6	1.6
Rating	Outdoor Dining	Outdoor Dining	Outdoor Dining

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	2.8	3.6	3.6
Rating	Pass	Pass	Pass

LOCATION 43.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	23.72	30.08	30.35
4	3.48	4.04	4.51
6	0.20	0.19	0.27
8	0.01	0.00	0.01
10	0.00	0.00	0.00

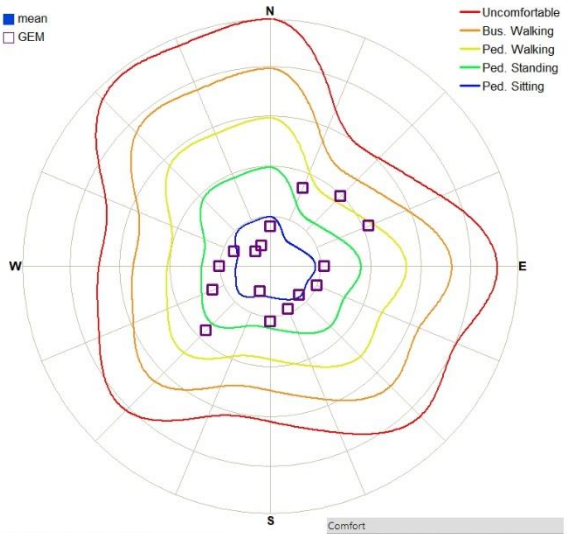
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	3.6	3.8	3.9
Rating	Ped Sitting	Ped Sitting	Ped Sitting

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	7.5	7.2	7.6
Rating	Pass	Pass	Pass

LOCATION 44.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	12.99	27.35	27.35
4	1.47	6.70	6.70
6	0.06	0.74	0.74
8	0.00	0.04	0.04
10	0.00	0.00	0.00

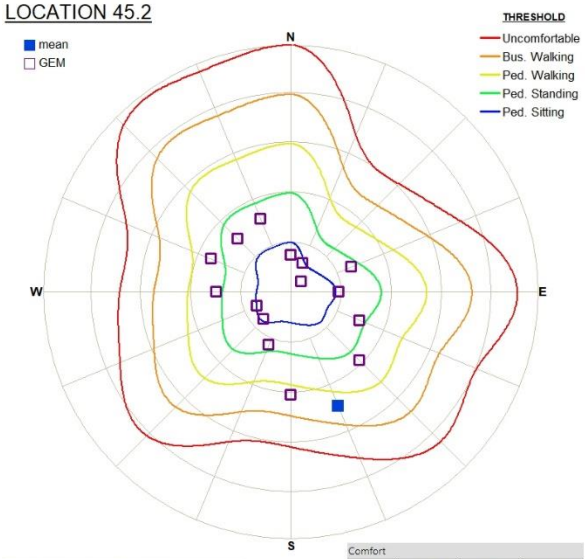
Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	2.9	4.3	4.3
Rating	Ped Sitting	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	6.4	8.3	8.3
Rating	Pass	Pass	Pass

LOCATION 45.2



% of time in excess of wind speed V

V (m/s)	MEAN	GEM	COMBINED
2	23.47	34.57	34.80
4	6.96	8.89	9.42
6	1.20	1.46	1.71
8	0.16	0.16	0.23
10	0.02	0.02	0.03

Comfort

(5%)	MEAN	GEM	COMBINED
V (m/s)	4.4	4.6	4.8
Rating	Ped Standing	Ped Standing	Ped Standing

Safety

(0.022%)	MEAN	GEM	COMBINED
V (m/s)	9.9	9.7	10.2
Rating	Pass	Pass	Pass