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30 August 2021

Sydney Olympic Park High School – Environmental Wind Assessment – Revised SSDA drawings

Dear Sir/Madam,

Please find herein a brief letter detailing the expected impact of the changes on the local wind climate due to revised SSDA drawings. Quantitative wind tunnel testing was undertaken for the reference scheme (July, 2021), with the quantitative environmental wind report included in Appendix A of this letter. As the general massing of the building has not changed since the testing, a qualitative review of the proposed scheme (Woods Bagot) has been undertaken to assess any potential impacts on local wind conditions, in comparison to the quantitative wind tunnel testing undertaken for the reference scheme.

The architectural drawings of the proposed scheme (dated 21 August 2021) by Woods Bagot are compared with the reference scheme in Figure 1. The differences between these drawings have been reviewed from a pedestrian-level environmental wind perspective.

The main changes between the reference and proposed schemes from a wind perspective includes less façade articulation, and changes to the locations and size of the through-links circulation areas and entrances. As the overall massing of the building has not changed, these changes are expected to produce similar wind conditions around the site, only changing the distribution of more localised windy areas.

In general, there are no significant changes to the overall massing of the proposed development compared with the reference scheme, therefore impacts on local wind conditions are expected to be negligible. Winds from the west to north-west, and the south-east are the dominant prevailing wind direction for the site.

At ground level, the main difference between the schemes, from a wind perspective, is the angled southern entrance in the proposed scheme. The pressure driven flow through this laneway will be fastest at the narrowest section: the northern entry. During strong winds from the south, the tapered configuration will create a more noticeable jet of air into the central courtyard, compared with the reference scheme with a constant cross-section where the same higher wind speed would occur along the length of the link, Figure 1. The tapered design is beneficial to localise the affected wind area, however to further improve conditions in the courtyard the narrowest section could be located to the south in a transient zone.

On the upper levels, the main difference between the schemes, aside from reduced façade articulation, is the reduced number of flow paths between east and west, forming a larger through-link in the southern elbow of the building. The mechanism driving flow through these circulation areas is pressure driven and therefore, the wind comfort conditions are expected to remain the same as the reference scheme, with the same wind speed affecting a larger area. These areas would potentially benefit from local amelioration strategies, such as vertical blockage to the east, vegetation and/or sectioned seating areas, which could be developed further during detailed design.

In summary, the outcomes of the quantitative wind report for the reference scheme remain the same for the proposed scheme. All locations are predicted to be suitable for their intended use from a comfort perspective, with the majority of locations classified as suitable for pedestrian standing. The target conditions would be met at all locations. It is considered that all locations within the proposed development would remain meeting the safety criterion.

I hope this is of assistance, please do not hesitate to contact me on (02) 9320 9921, if you have any questions regarding any aspect of this report.

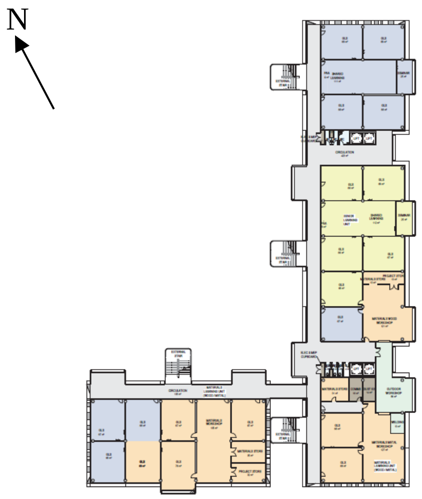
Yours sincerely,

Graeme Wood
Associate Principal

Figure 1: Comparison between reference and proposed scheme floor plans at various levels (cont.)

Level 03 Floor Plan

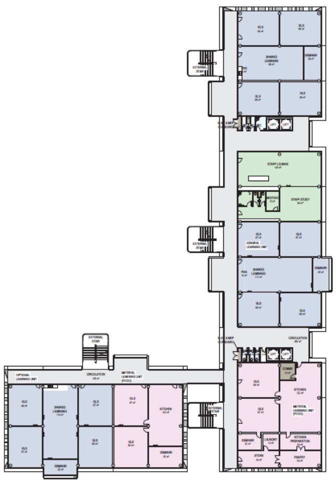
Reference Scheme



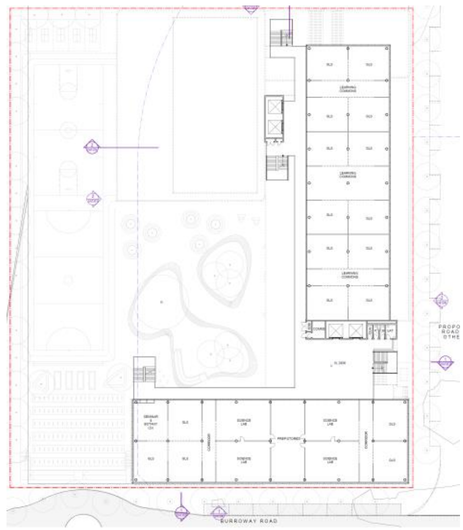
Proposed Scheme

Level 04 Floor Plan

Reference Scheme

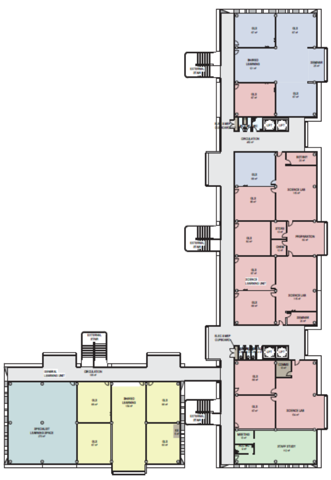


Proposed Scheme



Level 05 Floor Plan

Reference Scheme



Proposed Scheme

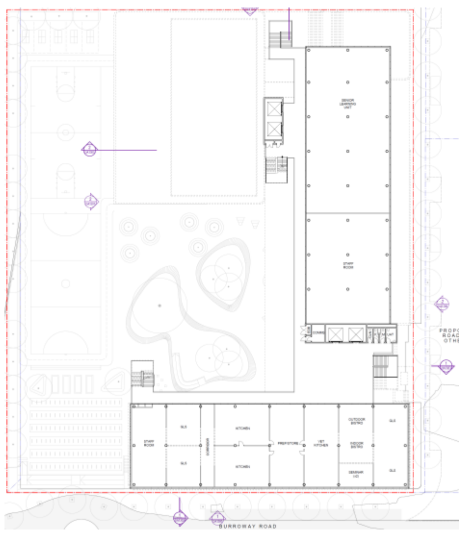


Figure 1: Comparison between reference and proposed scheme floor plans at various levels

Appendix A

Quantitative Wind Report (Reference Scheme)

School Infrastructure NSW

Sydney Olympic Park New High School

Environmental Wind Assessment

Wind

Rev. 03 | 30 August 2021

Job number 282687-00

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Document verification

ARUP

Job title		Sydney Olympic Park New High School		**Job number** 282687-00	
Document title		Environmental Wind Assessment		**File reference**	
Document ref		Wind			
Revision	**Date**	**Filename**	SOPNHS Wind_REP_2021-07-02.docx		
Initial release	2 Jul 2021	**Description**	Initial qualitative release		
			Prepared by	Checked by	Approved by
		Name	Lauren Boysen	Graeme Wood	Graeme Wood
Revision 01	8 Jul 2021	**Filename**	SOPNHS Wind_REP_2021-07-08.docx		
		Description	Minor updates as per client comments.		
			Prepared by	Checked by	Approved by
		Name	Lauren Boysen	Graeme Wood	Graeme Wood
Revision 02	29 Jul 2021	**Filename**	SOPNHS Wind_REP_20210729.docx		
		Description	Updated to included quantitative wind tunnel results.		
			Prepared by	Checked by	Approved by
		Name	Lauren Boysen	Graeme Wood	Graeme Wood
Revision 03	30 Aug 2021	**Filename**	SOPNHS Wind_REP_20210830.docx		
		Description	Updated client text		
			Prepared by	Checked by	Approved by
		Name	Graeme Wood		Graeme Wood
				Issue Document verification with document	✓

Executive Summary

Arup have been commissioned by the School Infrastructure NSW to provide a quantitative environmental wind assessment of Stages 1 and 2 of the proposed development, the Sydney Olympic Park New High School, on the pedestrian level wind conditions for comfort and safety in and around the site.

Wind-tunnel testing was conducted by Vipac in the proposed final configuration. Arup analysed the wind-tunnel results with respect to the local wind climate comparing the results with the City of Sydney comfort and safety criteria and to provide greater interpretation of the comfort classifications. The results presented in this report are based on Arup's analysis.

This report has been prepared to address Secretary's Environmental Assessment Requirements (SEARs) key issue No.4.

Quantitatively, integrating the directional wind conditions around the site with the wind climate, all locations are predicted to be suitable for their intended use from a comfort perspective, with the majority of locations classified as suitable for pedestrian standing. The target comfort criteria are met at all locations.

It is considered that all locations within the proposed development would meet the safety criterion.

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1 Introduction

School Infrastructure NSW have engaged Arup to provide a quantitative environmental wind assessment for Stages 1 and 2 of the proposed Sydney Olympic Park New High School development.

This report discusses the results of the wind-tunnel testing study including interpretive discussion on the impact of the proposed development on the pedestrian level wind comfort and safety.

2 Client provided background information

2.1 Proposal

The proposed development is for the construction of a school to be known as Sydney Olympic Park New High School. The school is to be developed in two stages, Figure 1. The SSDA will seek consent for both Stage One and Stage Two. While Stage Two is submitted as part of this proposal, construction is subject to approval of additional funding.

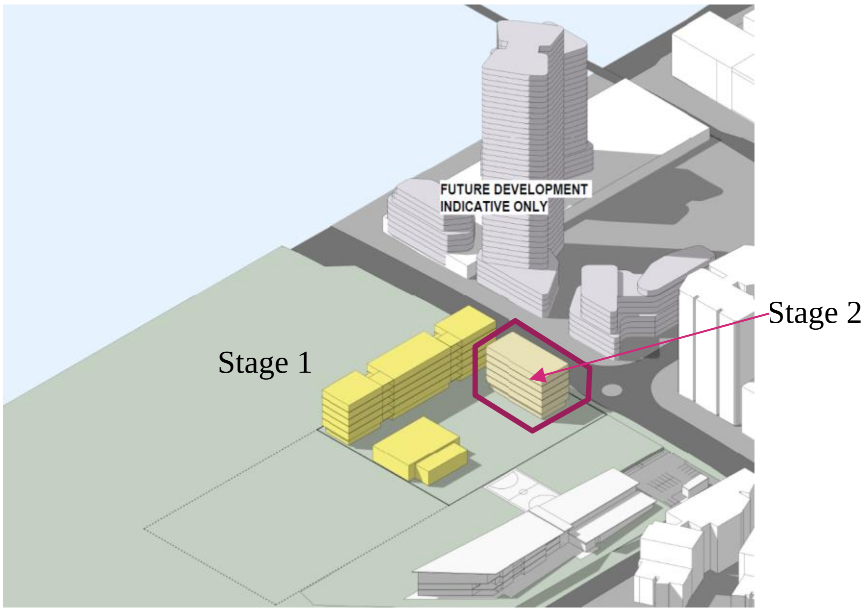

Figure 1: Proposed staging plan (source: Group GSA)

Stage One will provide for a Stream 5 high school, catering for up to 850 students. Stage Two will bring the school up to a Stream 9 school capability catering up to 1,530 students.

The play space required to meet the need of students for Stage One can be generally accommodated onsite, within the 9,511 m^2 available. Additional play space may be required to accommodate the increased student numbers anticipated during Stage 2. The proposed adjoining play space comprises an area of around 8,800 m^2, and will be subject to a Joint Use Arrangement and available for public use outside school hours. The future Wentworth Point Peninsula Park will result in an open space area of approximately 4 ha.

The remainder of the peninsula (TfNSW land) is under review and will be subject to a separate approval process. Redevelopment of this land will include the new access road proposed off Burroway Road along the eastern boundary of the subject site and is proposed to include car parking, drop-off zones and delivery zones.

2.2 Site description

The proposed development is located within the peninsula of Wentworth Point at 7-11 Burroway Road, Wentworth Park across parts of three lots; Lot 202 DP1216628, Lot 203 DP1216628, and Lot 204 DP1216628, Figure 2. The site forms part of the Wentworth Point Planned Precinct, which was rezoned in 2014 for the purposes of high density residential, public recreation, school and business purposes.

The site is approximately 9,511 m^2 in area, with a frontage of approximately 91 m to Burroway Road. It currently contains vacant land, which is cleared of all past development, and almost entirely cleared of native vegetation.

The surrounding area is generally characterised by high rise residential and mixed-use developments. The site is directly adjacent to the Wentworth Point Peninsula Park and immediately east of Wentworth Point Public School.

Figure 2: Site Aerial Map (source: Group GSA)

3 Proposed development description

The proposed development consists of multiple buildings/wings, which form a 'U-shape' around various outdoor sport and other areas, Figure 3 - Figure 8. The Hall, located to the north, is single storey and detached from the main building. The remaining buildings form an ‘L-shape’, consisting of two six-storey buildings (Stage 1 to the east of the site, along the Proposed Road, and Stage 2 facing Burroway Road). There are three through-site links through the six-storey buildings as annotated in Figure 4.

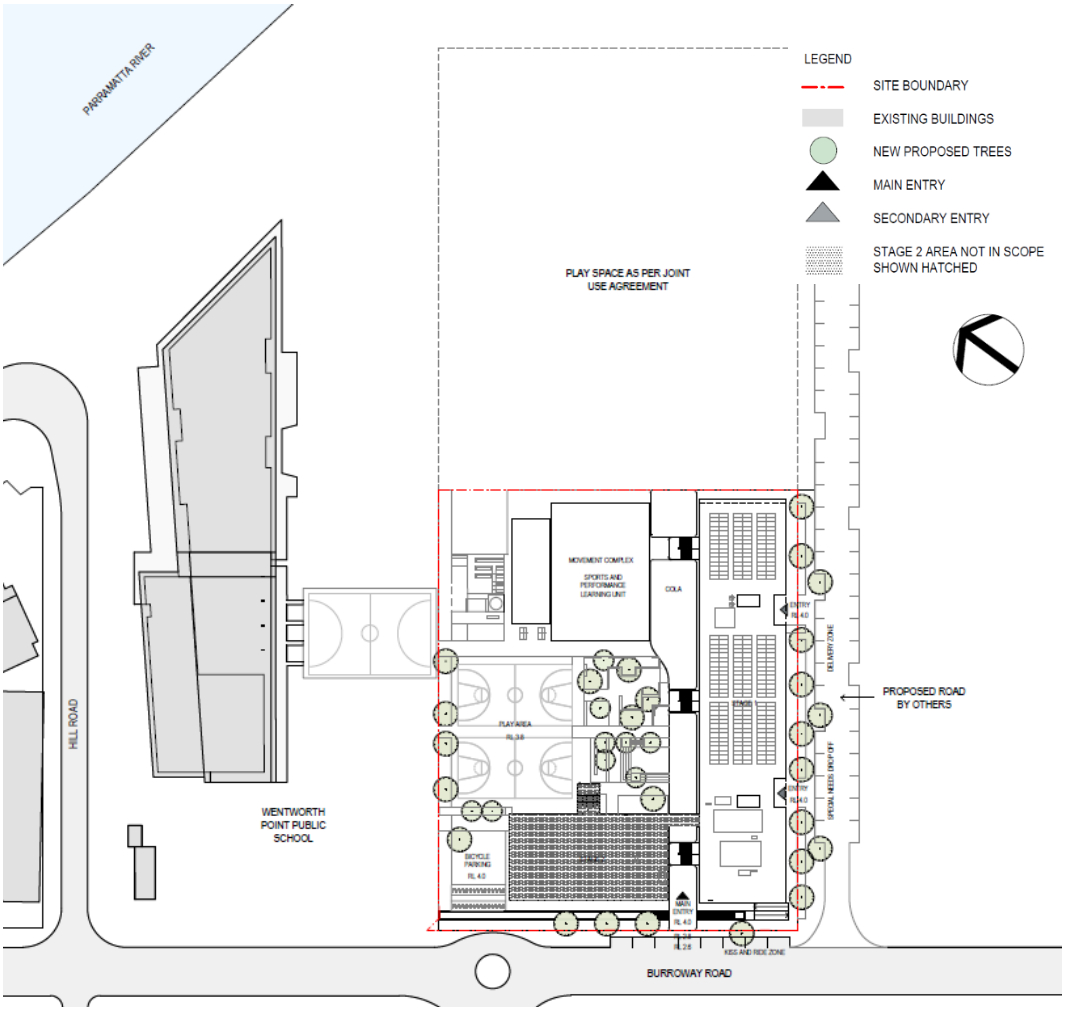

Figure 3: Site plan and orientation

Figure 4: Various floor plans

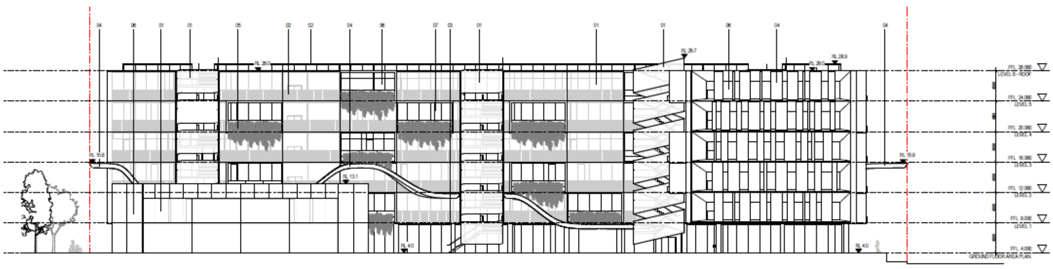

Figure 5: West elevation

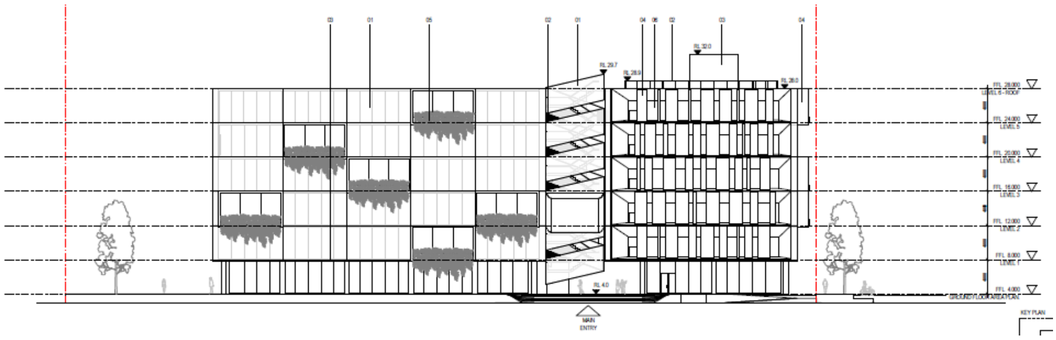

Figure 6: South elevation

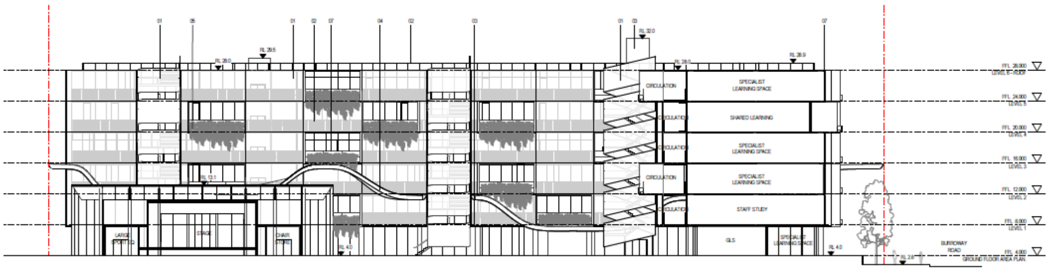

Figure 7: Section looking south-east

Figure 8: Render – view from south (source: Group GSA)

4 Secretary’s Environmental Assessment Requirements

DPIE has issued SEARs for the proposed development. This report has been prepared having regard to the relevant SEARs as follows, Table 1.

Table 1: Applicable SEAR

SEAR	Comment / Reference
4. Environmental Amenity: *Provide a wind impact assessment, including a wind tunnel study, prepared by a suitably qualified person that considers the impact of the proposed development having regard to the surrounding development and pedestrian amenity and comfort and includes mitigation management measures to manage any impacts.*	This report addresses the requirements providing a quantitative wind impact assessment prepared by a suitable qualified person. Quantification has used physical (wind-tunnel) modelling.

5 Wind assessment

5.1 Modelling

Wind-tunnel testing was conducted in one configuration (proposed), Figure 9. The construction of the physical model was based on the SSDA plans by Group GSA, dated 9 June 2021.

The wind-tunnel testing programme conducted by Vipac (2021) was in accordance with the requirements of AWES (2019) and appropriate for the investigation. Appropriate wind speed and turbulence profiles were used for the study. Measurements were taken at 51 test locations in and around the site. Testing was conducted for 36 wind directions and integrated with the local wind climate. Testing was conducted without landscaping, as the primary purpose of the testing is for pedestrian safety and landscaping may not be relied on during extreme events.

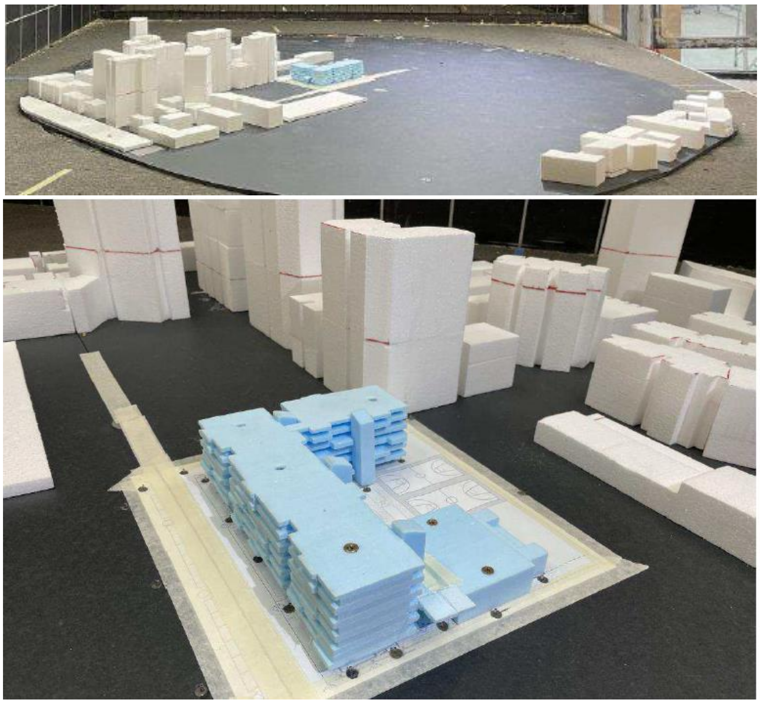

Figure 9: Photograph of the constructed model viewed from the south-south-east (top) and close-up from the east (bottom)

Arup analysed the wind tunnel test results for comparison with various comfort criteria and to provide greater interpretation of the comfort classifications. Arup has analysed the results using the Bankstown climate data, for years 1995 to 2021 and for hours 6 am to 10 pm in line with City of Sydney (2016) criteria (refer to Section 5.3). A general description on flow patterns around buildings is given in Appendix 1.

5.2 Local wind climate

The wind frequency and direction information measured by the Bureau of Meteorology anemometer at a standard height of 10 m at Bankstown Airport from 1995 to present (July, 2021) have been used in this analysis, Figure 10. The Bankstown airport anemometer is located about 13.5 km to the south-west of the site. The arms of the wind rose point in the direction from where the wind is coming from. The directional wind speeds measured here are considered representative of the wind conditions at the site.

Cold and hot winds tend to come from the west and east quadrants respectively. Typically, mornings tend to have lighter winds increasing in intensity through the day.

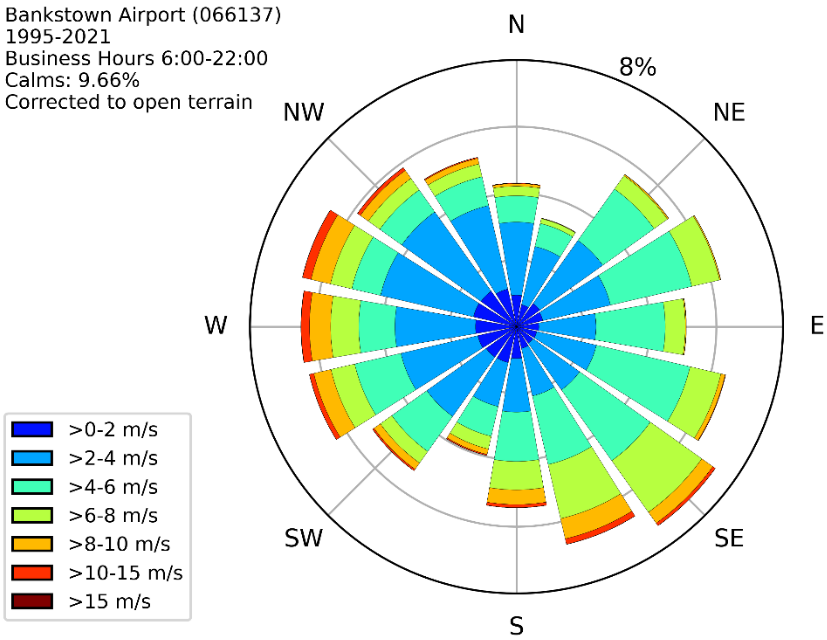

Figure 10: Wind rose showing probability of time of wind direction and speed for business hours

The corrected mean wind speed at a height of 10 m is about 3.8 m/s, and the 5% exceedance mean wind speed is 8.2 m/s.

5.3 Specific wind controls

Wind comfort is generally measured in terms of wind speed and rate of change of wind speed, where higher wind speeds and gradients are considered less comfortable. Air speed has a large impact on thermal comfort and are generally welcome during hot summer conditions. This assessment is focused on wind speed in terms of mechanical comfort.

There have been many wind comfort criteria proposed, and a general discussion is presented in Appendix 2.

The current Wentworth Point Precinct Development Control Plan 2014 wind controls, applicable to this project, states wind speed requirements for buildings over seven storeys. Given the subject development is six storeys, these criteria do not apply to the project. As such, the wind controls used in this wind assessment are based on the current draft Central Sydney Planning Strategy 2016-2036 wind controls, which are based on the work of Lawson (1990), described in Figure 20 and Table 2. The criteria are applicable for business hours, between 6 am and 10 pm.

Although not applicable for a building of this size, the Wentworth Point Precinct Development Control Plan 2014 wind controls are based on the Sydney DCP (2012) criteria, which tend to result in a similar comfort classification to the current draft Central Sydney Planning Strategy 2016-2036 wind controls.

The comfort classification is based on the wind speed exceeded for 5% of the time. These categories are subjective to the individual. The wind speed is the greater of the mean or gust-equivalent mean (GEM) wind speed. The GEM is defined as the peak 3 s gust wind speed divided by 1.85; and aims to account for location where gustiness is prevalent.

The safety criterion in the Central Sydney Planning Strategy 2016-2036 is based on a 0.5 s gust wind speed of 24 m/s occurring once in an hour per annum during daylight hours. The comfort criteria are based on a 5% of the time exceedance during daylight hours. It is evident from Figure 20 that the Central Sydney Planning Strategy 2016-2036 safety criterion are conservative. The Lawson safety criterion mean wind speed of 15 m/s would correspond to a 0.5 s gust wind speed of 30 m/s. The results have differentiated between the two levels of acceptability.

Table 2: Pedestrian comfort criteria for various activities

Comfort (max. of mean or GEM wind speed exceeded 5% of the time)		
● (purple)	≤2 m/s	Dining
● (blue)	2-4 m/s	Sitting
● (green)	4-6 m/s	Standing
● (yellow)	6-8 m/s	Walking
● (orange)	8-10 m/s	Objective walking or cycling
● (red)	>10 m/s	Uncomfortable
Safety (0.5 s gust wind speed in an hour, exceeded 0.017% of the time)		
○	≤24 m/s	Pass

Transferring the 5% of the measured wind speed to ground level would result in a wind speed of about 6 m/s, which is classified as on the boundary of pedestrian standing and walking. This is considered representative of the relatively exposed wind conditions in this area.

Target wind conditions would be pedestrian standing inside the School and walking around the perimeter.

5.4 Results and discussion

Wind speed measurements were taken at 51 locations to evaluate pedestrian wind comfort and safety, as described in Figure 11 with summary results in Table 3. Wind speed measurements were taken at a height of about 1.5 m above ground level for 36 wind directions. Test locations were chosen at building corners where strong winds would be expected as well as in more recreational areas. Three test locations were included on the Level 5 external walkways.

The directional wind tunnel results were combined with the wind climate data detailed in Section 5.2 and the Central Sydney Planning Strategy 2016-2036 wind criteria for comfort and safety. The directional results of the analysis at each test location are presented in Appendix 4. Example results are presented in Figure 12.

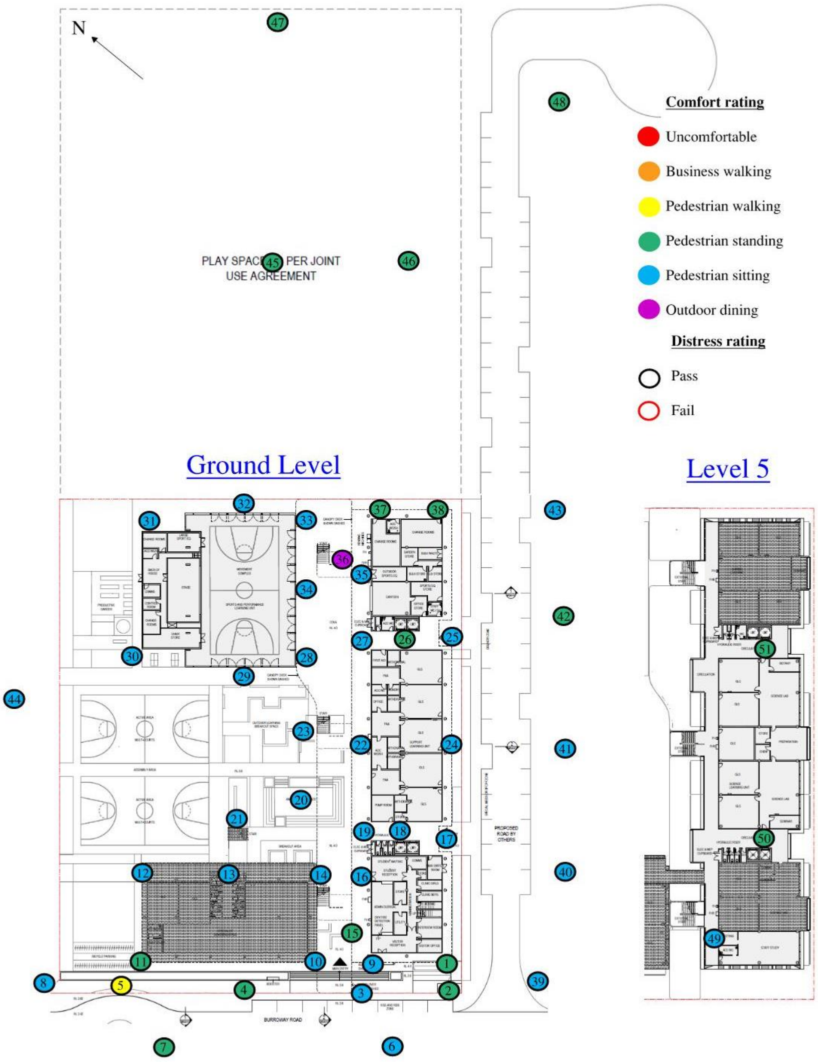

Figure 11: Summary of test locations and comfort and safety classifications

Table 3: Summary of target and result classification for comfort and safety

	Comfort (GEM 5% exceedance)					Safety
Location	**< 4 m/s**	**< 6 m/s**	**< 8 m/s**	**Comfort classification**	**Wind speed (m/s)**	**0.0171% 0.5s gust (m/s)**
1	94%	100%	100%	standing	4.2	14.1
2	90%	99%	100%	standing	4.7	14.9
3	98%	100%	100%	sitting	3.6	12.4
4	93%	99%	100%	standing	4.3	16.8
5	67%	89%	98%	walking	6.9	19.8
6	97%	100%	100%	sitting	3.7	13.3
7	84%	98%	100%	standing	5.3	17.7
8	96%	100%	100%	sitting	3.9	13.8
9	98%	100%	100%	sitting	3.6	12.3
10	97%	100%	100%	sitting	3.8	12.3
11	79%	96%	99%	standing	5.9	20.4
12	96%	100%	100%	sitting	3.9	14.6
13	98%	100%	100%	sitting	3.4	12.6
14	95%	100%	100%	sitting	4.0	8.6
15	90%	98%	100%	standing	4.9	18.9
16	97%	100%	100%	sitting	3.6	14.4
17	98%	100%	100%	sitting	3.7	13.7
18	97%	100%	100%	sitting	3.8	8.7
19	99%	100%	100%	sitting	3.2	11.1
20	98%	100%	100%	sitting	3.6	11.8
21	99%	100%	100%	sitting	2.8	10.8
22	100%	100%	100%	sitting	2.6	10.4
23	100%	100%	100%	sitting	2.8	10.3
24	96%	100%	100%	sitting	3.9	13.9
25	99%	100%	100%	sitting	3.2	11.5
26	81%	96%	100%	standing	5.9	16.1
27	96%	100%	100%	sitting	3.8	11.9
28	98%	100%	100%	sitting	3.3	13.2
29	99%	100%	100%	sitting	3.1	11
30	96%	100%	100%	sitting	3.8	16.4
31	99%	100%	100%	sitting	3.3	11.7
32	96%	100%	100%	sitting	3.8	11.8
33	100%	100%	100%	sitting	2.9	10.3
34	97%	100%	100%	sitting	3.6	10.9
35	96%	100%	100%	sitting	3.8	14.4
36	100%	100%	100%	dining	1.9	5.8
37	92%	99%	100%	standing	4.5	14.8
38	93%	99%	100%	standing	4.4	14.9
39	96%	100%	100%	sitting	3.9	12.3
40	96%	100%	100%	sitting	3.9	12.7
41	96%	100%	100%	sitting	3.9	14.7
42	91%	99%	100%	standing	4.8	17
43	97%	100%	100%	sitting	3.7	13.6
44	96%	100%	100%	sitting	3.9	13.8
45	86%	98%	100%	standing	5.1	16.9
46	87%	98%	100%	standing	5.1	17.8
47	82%	97%	100%	standing	5.6	16.6
48	85%	98%	100%	standing	5.1	15.9
49	98%	100%	100%	sitting	3.4	12.6
50	90%	99%	100%	standing	4.9	14.8
51	91%	99%	100%	standing	4.7	17.5

LEGEND

Comfort criterion

≤2	Outdoor dining
>2 to 4	Pedestrian Sitting
>4 to 6	Pedestrian standing
>6 to 8	Pedestrian Walking
>8 to10	Business Walking
>10	Uncomfortable

Safety criterion

≤24	Pass
>24	Fail

The polar plot, to the left of Figure 12, shows the influence of wind direction relative to the local wind climate. The distance of the point from the centre of the plot is wind speed, whereas the contours provide reference to the wind climate. The polar plot provides information on the incident strong wind directions, and whether a steady or gusty wind thereby allowing appropriate mitigation measures to be developed.

The probability chart, to the right of Figure 12, plots the integrated probability of exceeding a particular wind speed for the location against the mean/GEM wind speed. This graph clearly illustrates the expected probability distribution of wind speed at a specific location: for example, the mean wind speed exceeded for 5% of time would be about 4.7 m/s as illustrated in Figure 12. The 0.5 and 3 s gust wind speed can be estimated by multiplying this value by 2.0 and 1.85 respectively. The solid red line shows the measured results and crosses the 5% probability level to the left of the diamond symbol for the Sydney planning scheme (2016) criteria, and therefore, would be classified as suitable for pedestrian standing.

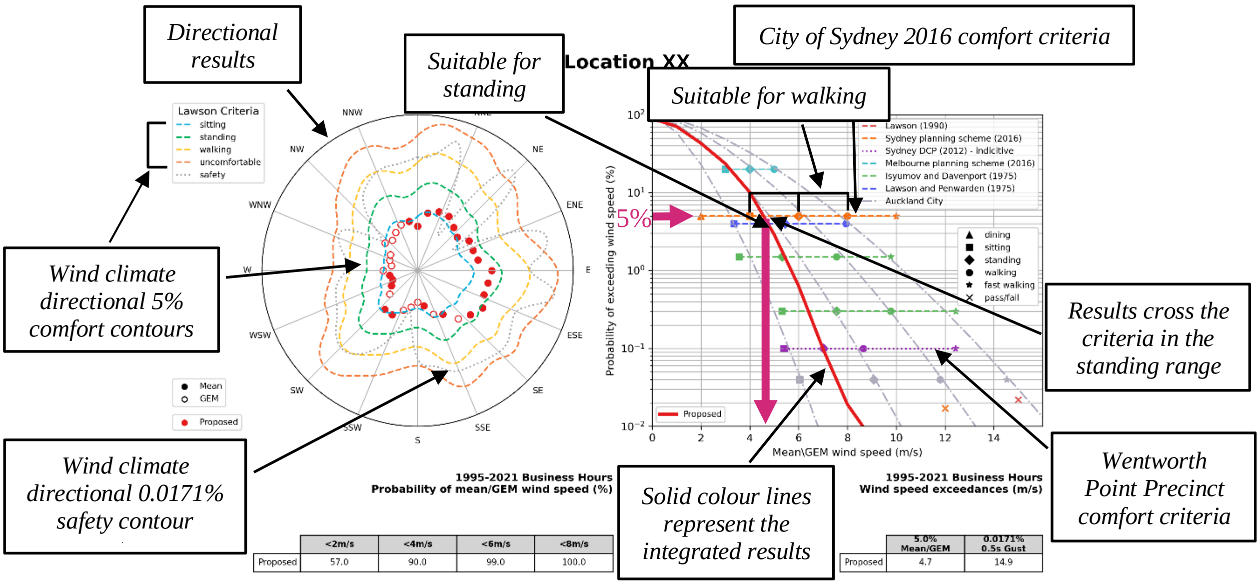

Figure 12: Example results - probabilistic comparison between wind criteria based on mean wind speed (for the hours between 6 am and 10 pm)

On Figure 12, various internationally recognised wind comfort criteria for assessing the wind climate are presented, with the various symbols indicating the comfort category targets for specific activities. The Wentworth Point Precinct DCP criteria are equivalent to the purple criteria on Figure 12 (Sydney DCP (2012)).

The criteria used for this assessment are the current draft Central Sydney Planning Strategy 2016-2036 wind controls, as per Section 5.3. The table on the left of Figure 12 gives the percentage of time that the wind speed would be less than the wind speed for the various classification categories. In the example, the wind speed associated with the dining and sitting criteria would be expected to occur for 57% and 90% of the time respectively. The table to the right provides the integrated wind speeds associated with the 5% of the time mean/GEM (comfort criterion) and 0.0171% 0.5 s gust (safety criterion).

5.5 Predicated wind conditions

In general, from a comfort perspective, wind conditions at ground level are predicted to be suitable for their intended use. The majority of locations are predicted to be suitable for pedestrian sitting. Some locations are predicted to be suitable for pedestrian standing; these locations are typically adjacent to building corners or the main entrance walkways. Location 5 is the only location categorised as suitable for walking, which is appropriate for its location, being located on the south-western boundary of the site in a transient area at the front of the school.

On level 5, wind comfort conditions in the walkways are predicted to be suitable for pedestrian standing (locations 50 and 51) and sitting (49), with no concerns with respect their intended circulation usage.

All locations meet the target comfort criterion of pedestrian standing inside the school, and pedestrian walking on main thoroughfares.

There are no safety concerns, with all locations meeting the safety criterion.

5.5.1 Summary

The inclusion of any exposed building changes the local wind environment; increasing the wind speed for some directions and reducing it for others. Quantitatively, integrating the directional wind conditions around the site with the wind climate, all locations are predicted to be suitable for pedestrian standing, if not pedestrian sitting, with the exception of Location 5, which is predicted to be suitable for pedestrian walking. All locations are predicted to be suitable for their intended use from a comfort perspective, with the target comfort criteria being met at all locations

It is considered that all locations within the proposed development would meet the safety criterion.

References

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City of Sydney (2016), Central Sydney Planning Strategy 2016-2036.

City of Melbourne (2017), Melbourne Planning Scheme.

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Appendix 1. Wind flow mechanisms

An urban environment generates a complex wind flow pattern around closely spaced structures, hence it is exceptionally difficult to generalise the flow mechanisms and impact of specific buildings as the flow is generated by the entire surrounds. However, it is best to start with an understanding of the basic flow mechanisms around an isolated structure.

Isolated building

When the wind hits an isolated building, the wind is decelerated on the windward face generating an area of high pressure, Figure 13, with the highest pressure at the stagnation point at about two thirds of the height of the building. The higher pressure bubble extends a distance from the building face of about half the building height or width, whichever is lower. The flow is then accelerated down and around the windward corners to areas of lower pressure, Figure 13. This flow mechanism is called **downwash** and causes the windiest conditions at ground level on the windward corners and along the sides of the building.

Rounding the building corners or chamfering the edges reduces downwash by encouraging the flow to go around the building at higher levels. However, concave curving of the windward face can increase the amount of downwash. Depending on the orientation and isolation of the building, uncomfortable downwash can be experienced on buildings of greater than about 6 storeys.

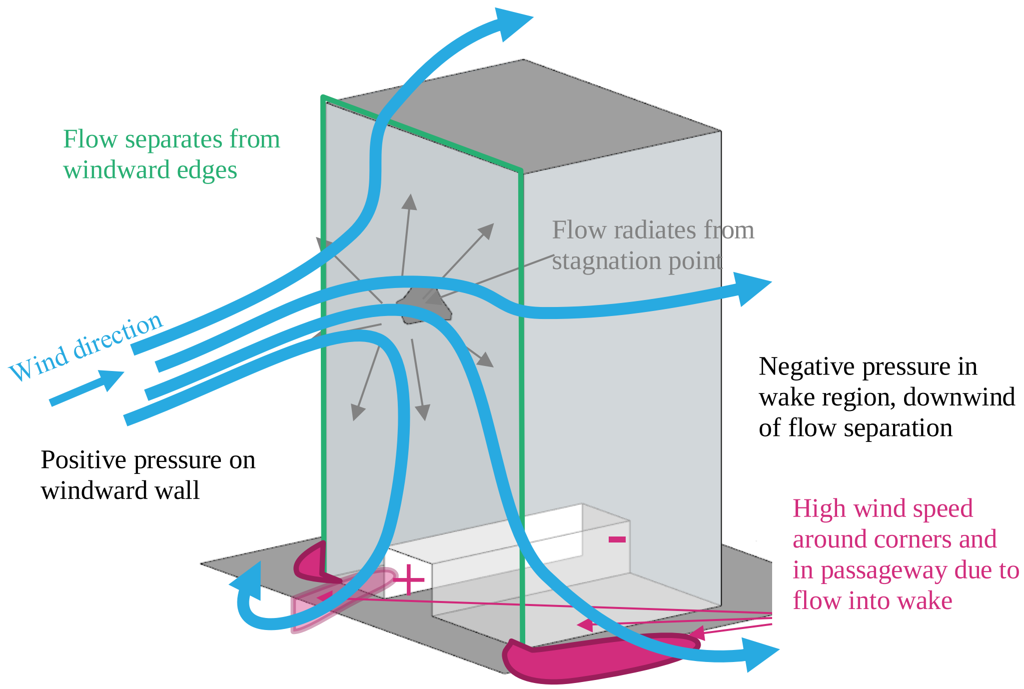


Figure 13: Schematic wind flow around tall isolated building

Techniques to mitigate the effects of downwash winds at ground level include the provision of horizontal elements, the most effective being a podium to divert the downward flow away from pavements and building entrances, but this will generate windy conditions on the podium roof, Figure 11. Generally, the lower the podium roof and deeper the setback from the podium edge to the tower improves the ground level wind conditions. The provision of an 8 m setback on an isolated building is generally sufficient to improve ground level conditions, but is highly dependent on the building isolation, orientation to prevailing wind directions, shape and width of the building, and any plan form changes at higher level.

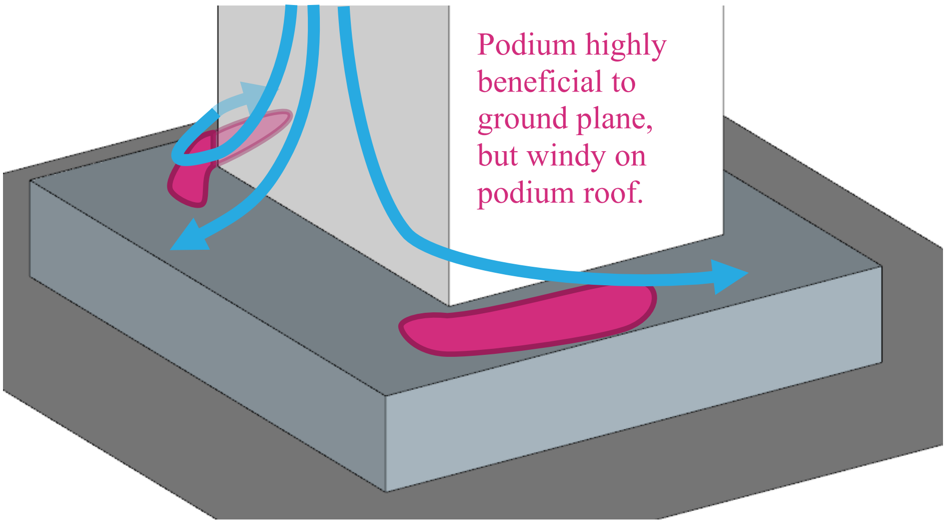


Figure 14: Schematic flow pattern around building with podium

Awnings along street frontages perform a similar function as a podium, and generally the larger the horizontal projection from the façade, the more effective it will be in diverting downwash flow, Figure 15. Awnings become less effective if they are not continuous along the entire façade, or on wide buildings as the positive pressure bubble extends beyond the awning resulting in horizontal flow under the awning.

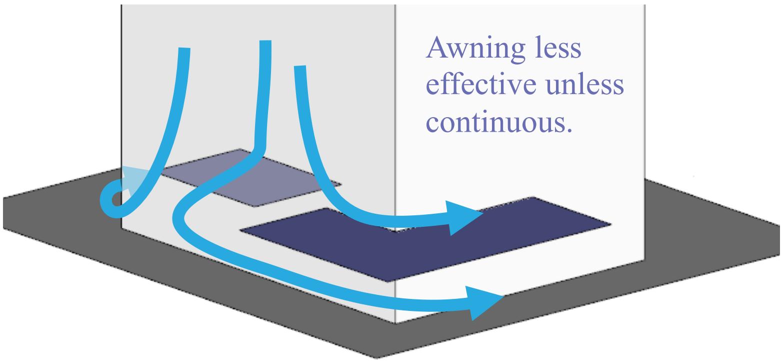


Figure 15: Schematic flow pattern around building with awning

It should be noted that colonnades at the base of a building with no podium generally create augmented windy conditions at the corners due to an increase in the pressure differential, Figure 16. Similarly, open through-site links through a building cause wind issues as the environment tries to equilibrate the pressure generated at the entrances to the link, Figure 13. If the link is blocked, wind conditions will be calm unless there is a flow path through the building, Figure 17. This area is in a region of high pressure and therefore the is the potential for internal flow issues. A ground level recessed corner has a similar effect as an undercroft, resulting in windier conditions, Figure 17.

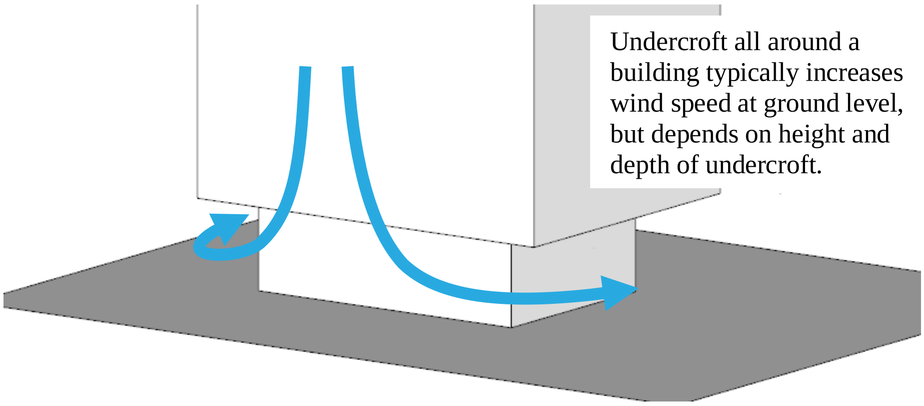


Figure 16: Schematic of flow patterns around isolated building with undercroft

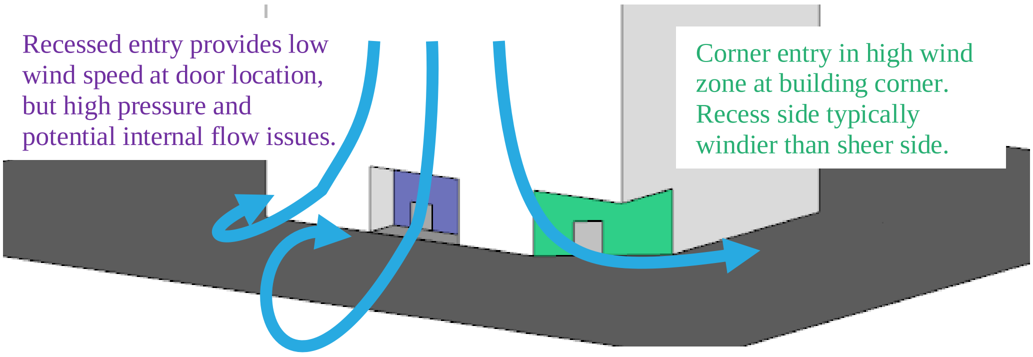


Figure 17: Schematic of flow patterns around isolated building with ground articulation

Multiple buildings

When a building is located in a city environment, depending on upwind buildings, the interference effects may be positive or negative, Figure 18. If the building is taller, more of the wind impacting on the exposed section of the building is likely to be drawn to ground level by the increase in height of the stagnation point, and the additional negative pressure induced at the base. If the upwind buildings are of similar height then the pressure around the building will be more uniform hence downwash is typically reduced with the flow passing over the buildings.

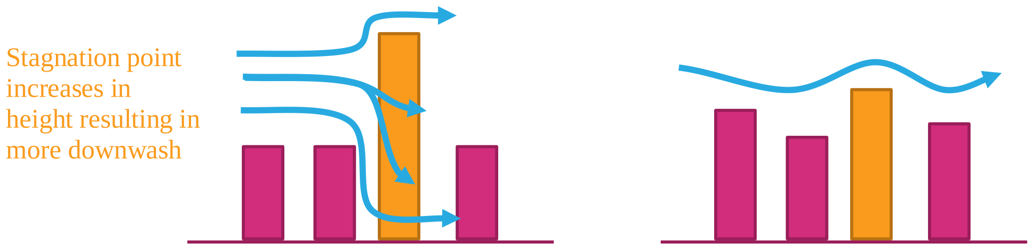


Figure 18: Schematic of flow pattern interference from surrounding buildings

The above discussion becomes more complex when three-dimensional effects are considered, both with orientation and staggering of buildings, and incident wind direction, Figure 19.

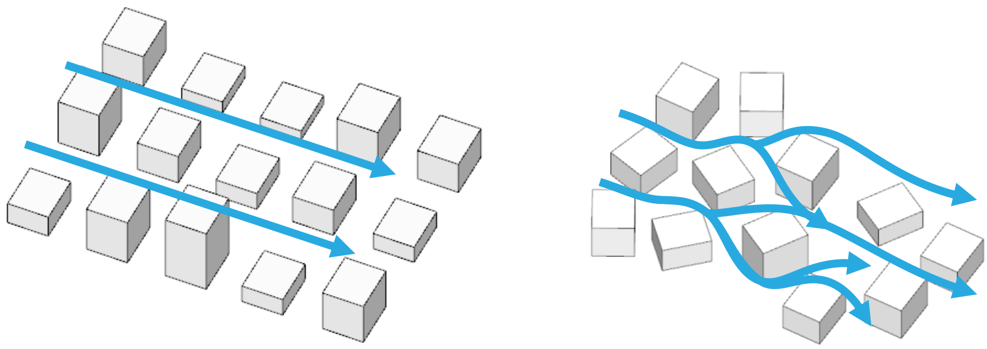


Figure 19: Schematic of flow patterns through a grid and random street layout

Channelling occurs when the wind is accelerated between two buildings, or along straight streets with buildings on either side, Figure 19(L), particularly on the edge of built-up areas where the approaching flow is diverted around the city massing and channelled along the fringe by a relatively continuous wall of building facades. This is generally the primary mechanism driving the wind conditions for this perimeter of a built-up area, particularly on corners, which are exposed to multiple wind directions. The perimeter edge zone in a built-up area is typically about two blocks deep. Downwash is more important flow mechanism for the edge zone of a built-up area with buildings of similar height.

As the city expands, the central section of the city typically becomes calmer, particularly if the grid pattern of the streets is discontinued, Figure 19(R). When buildings are located on the corner of a central city block, the geometry becomes slightly more important with respect to the local wind environment.

Appendix 2. Wind speed criteria

General discussion

Primary controls that are used in the assessment of how wind affects pedestrians are the wind speed, and rate of change of wind speed. A description of the effect of a specific wind speed on pedestrians is provided in Table 4. It should be noted that the turbulence, or rate of change of wind speed, will affect human response to wind and the descriptions are more associated with response to mean wind speed.

Table 4: Summary of wind effects on pedestrians

Description	Speed (m/s)	Effects
Calm, light air	0–2	Human perception to wind speed at about 0.2 m/s. Napkins blown away and newspapers flutter at about 1 m/s.
Light breeze	2–3	Wind felt on face. Light clothing disturbed. Cappuccino froth blown off at about 2.5 m/s.
Gentle breeze	3–5	Wind extends light flag. Hair is disturbed. Clothing flaps.
Moderate breeze	5–8	Raises dust, dry soil. Hair disarranged. Sand on beach saltates at about 5 m/s. Full paper coffee cup blown over at about 5.5 m/s.
Fresh breeze	8–11	Force felt on body. Limit of agreeable wind on land. Umbrellas used with difficulty. Wind sock fully extended at about 8 m/s.
Strong breeze	11–14	Hair blown straight. Difficult to walk steadily. Wind noise on ears unpleasant. Windborne snow above head height (blizzard).
Near gale	14–17	Inconvenience felt when walking.
Gale	17–21	Generally impedes progress. Difficulty with balance in gusts.
Strong gale	21–24	People blown over by gusts.

Local wind effects can be assessed with respect to a number of environmental wind speed criteria established by various researchers. These have all generally been developed around a 3 s gust, or 1 hour mean wind speed. During strong events, a pedestrian would react to a significantly shorter duration gust than a 3 s, and historic weather data is normally presented as a 10 minute mean.

Despite the apparent differences in numerical values and assumptions made in their development, it has been found that when these are compared on a probabilistic basis, there is some agreement between the various criteria. However, a number of studies have shown that over a wider range of flow conditions, such as smooth flow across water bodies, to turbulent flow in city centres, there is less general agreement among. The downside of these criteria is that they have seldom been benchmarked, or confirmed through long-term measurements in the field, particularly for comfort conditions. The wind criteria were all developed in temperate climates and are unfortunately not the only environmental factor that affects pedestrian comfort.

For assessing the effects of wind on pedestrians, neither the random peak gust wind speed (3 s or otherwise), nor the mean wind speed in isolation are adequate. The gust wind speed gives a measure of the extreme nature of the wind, but the mean wind speed indicates the longer duration impact on pedestrians. The extreme gust wind speed is considered to be suitable for safety considerations, but not necessarily for serviceability comfort issues such as outdoor dining. This is because the instantaneous gust velocity does not always correlate well with mean wind speed, and is not necessarily representative of the parent distribution. Hence, the perceived ‘windiness’ of a location can either be dictated by strong steady flows, or gusty turbulent flow with a smaller mean wind speed.

To measure the effect of turbulent wind conditions on pedestrians, a statistical procedure is required to combine the effects of both mean and gust. This has been conducted by various researchers to develop an equivalent mean wind speed to represent the perceived effect of a gust event. This is called the ‘gust equivalent mean’ or ‘effective wind speed’ and the relationship between the mean and 3 s gust wind speed is defined within the criteria, but two typical conversions are:

$$U_{GEM} = \frac{(U_{mean} + 3 \cdot \sigma_u)}{1.85} \text{ and } U_{GEM} = \frac{1.3 \cdot (U_{mean} + 2 \cdot \sigma_u)}{1.85}$$

It is evident that a standard description of the relationship between the mean and impact of the gust would vary considerably depending on the approach turbulence, and use of the space.

A comparison between the mean and 3 s gust wind speed criteria from a probabilistic basis are presented in Figure 20 and Figure 22. The grey lines are typical results from modelling and show how the various criteria would classify a single location. City of Auckland has control mechanisms for accessing usability of spaces from a wind perspective as illustrated in Figure 20 with definitions of the intended use of the space categories defined in Figure 21.

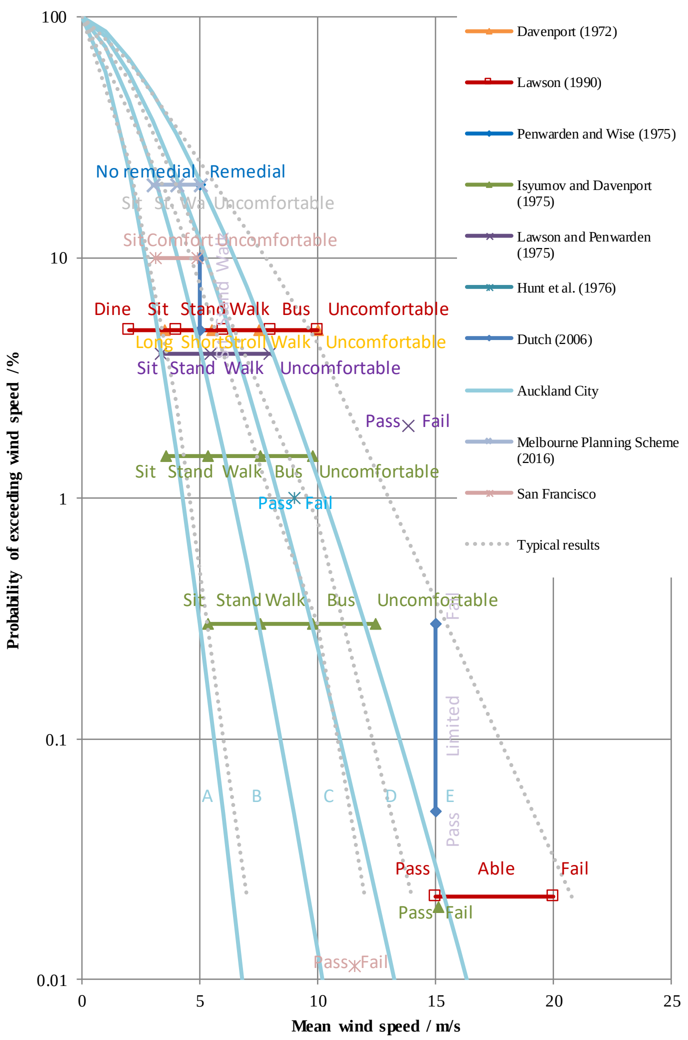


Figure 20: Probabilistic comparison between wind criteria based on mean wind speed

Category A	Areas of pedestrian use or adjacent dwellings containing significant formal elements and features intended to encourage longer term recreational or relaxation use i.e. public open space and adjacent outdoor living space
Category B	Areas of pedestrian use or adjacent dwellings containing minor elements and features intended to encourage short term recreation or relaxation, including adjacent private residential properties
Category C	Areas of formed footpath or open space pedestrian linkages, used primarily for pedestrian transit and devoid of significant or repeated recreational or relaxational features, such as footpaths not covered in categories A or B above
Category D	Areas of road, carriage way, or vehicular routes, used primarily for vehicular transit and open storage, such as roads generally where devoid of any features or form which would include the spaces in categories A - C above.
Category E	Category E represents conditions which are dangerous to the elderly and infants and of considerable cumulative discomfort to others, including residents in adjacent sites. Category E

Figure 21: Auckland Utility Plan (2016) wind categories

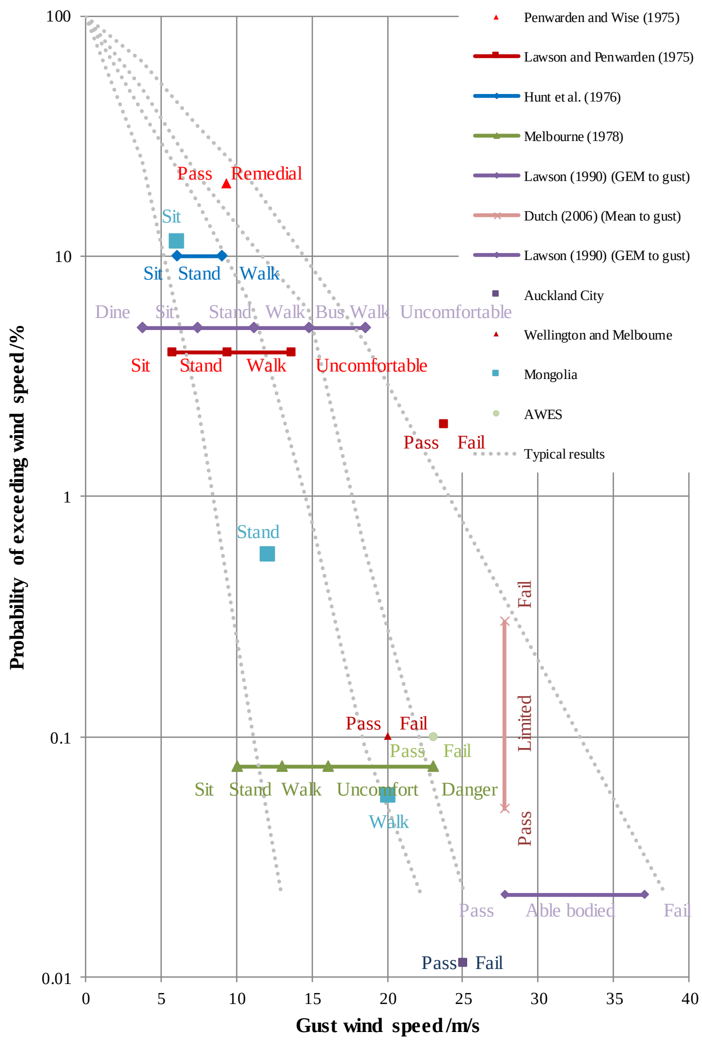


Figure 22: Probabilistic comparison between wind criteria based on 3 s gust wind speed

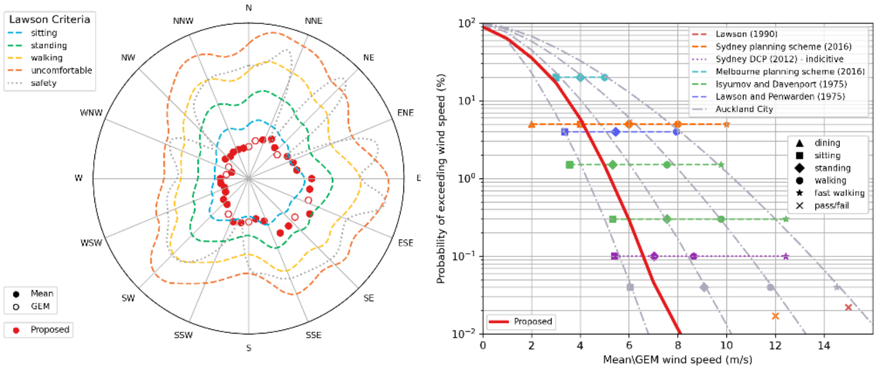
Appendix 3. Reference documents

In preparing the assessment, the following documents, dated 9 June 2021, have been referenced to understand the building massing and features.

- SSDA0000 - DRAWING SCHEDULE.pdf
- SSDA1100 - SITE PLAN EXISTING.pdf
- SSDA1101 - SITE PLAN DEMOLITION.pdf
- SSDA1102 - SITE PLAN PROPOSED.pdf
- SSDA2000 - GROUND FLOOR GA PLAN.pdf
- SSDA2001 - LEVEL 1 GA PLAN.pdf
- SSDA2002 - LEVEL 2 GA PLAN.pdf
- SSDA2003 - LEVEL 3 GA PLAN.pdf
- SSDA2004 - LEVEL 4 GA PLAN.pdf
- SSDA2005 - LEVEL 5 GA PLAN.pdf
- SSDA2006 - LEVEL 6 ROOF PLAN.pdf
- SSDA2100 - GFA PLANS.pdf
- SSDA3001 - BUILDING ELEVATIONS 01.pdf
- SSDA3002 - BUILDING ELEVATIONS 02.pdf
- SSDA3101 - BUILDING SECTIONS 01.pdf
- SSDA3102 - BUILDING SECTIONS 02.pdf
- SSDA4000 - SHADOW DIAGRAMS JUNE 21.pdf

Appendix 4: Directional results

Location 1



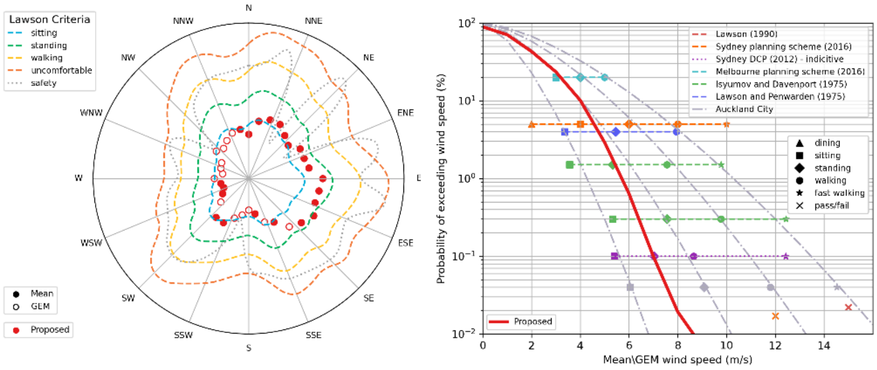
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	64.0	94.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	4.2	14.1

Location 2



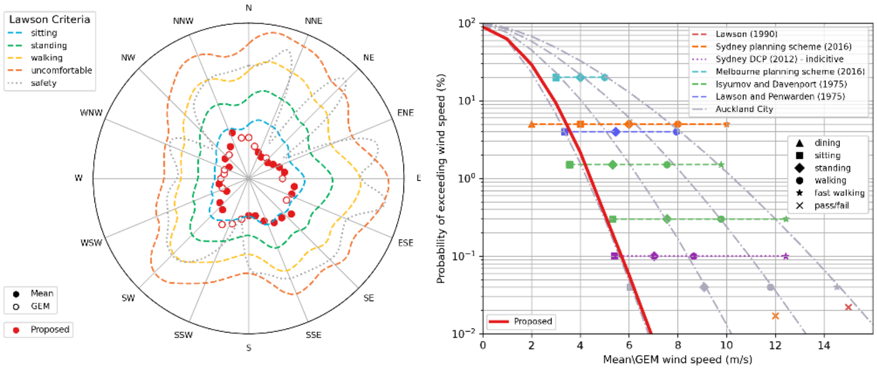
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	57.0	90.0	99.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	4.7	14.9

Location 3



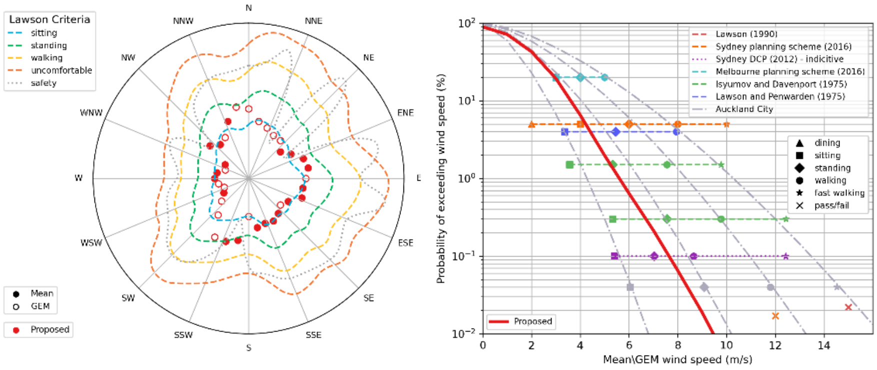
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	71.0	98.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.6	12.4

Location 4



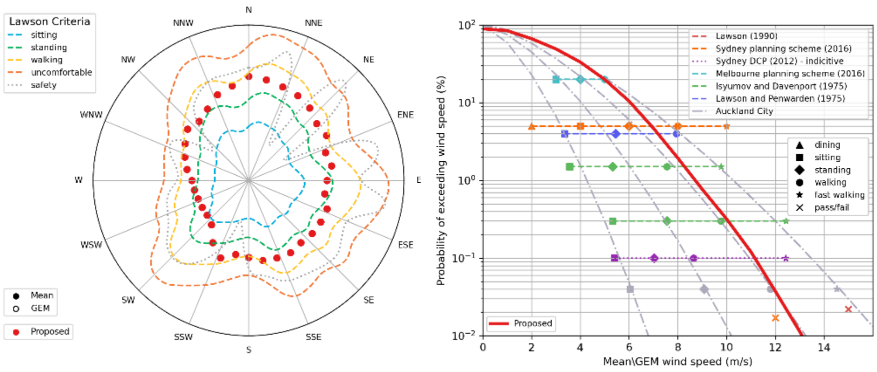
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	57.0	93.0	99.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	4.3	16.8

Location 5



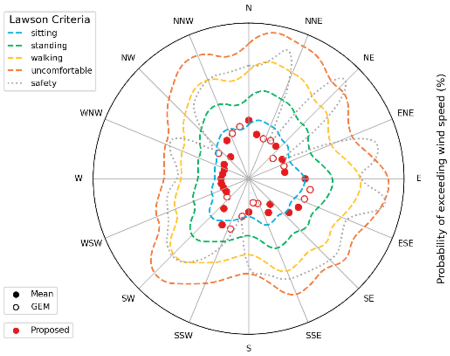
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

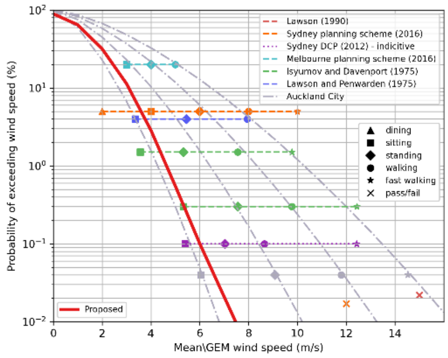
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	33.0	67.0	89.0	98.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	6.9	19.8

Location 6





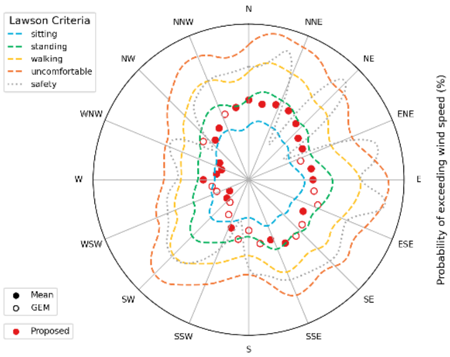
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

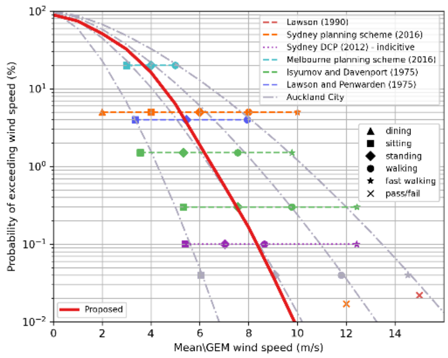
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	68.0	97.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.7	13.3

Location 7





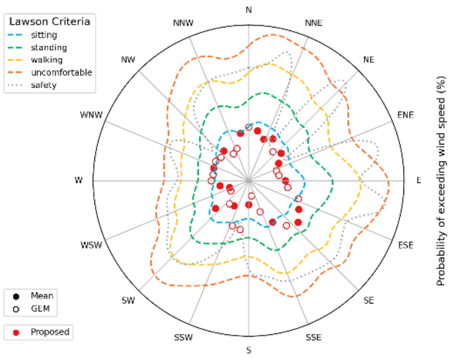
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

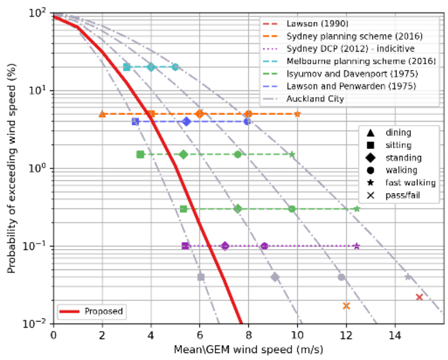
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	49.0	84.0	98.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	5.3	17.7

Location 8





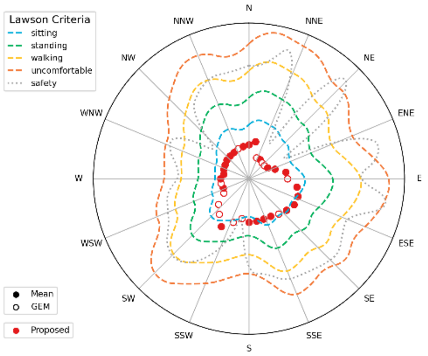
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

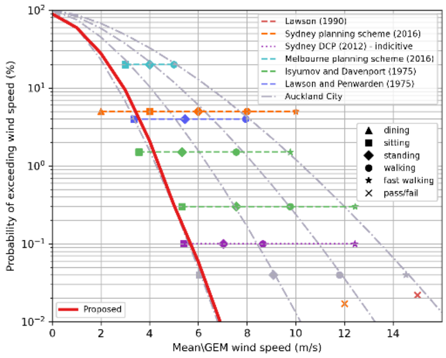
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	69.0	96.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.9	13.8

Location 9





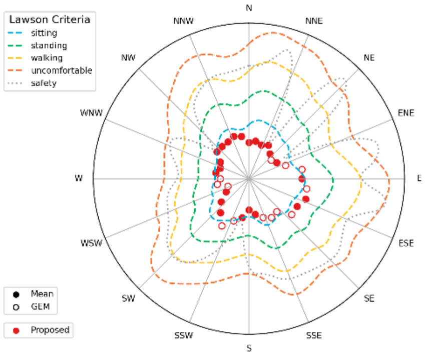
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

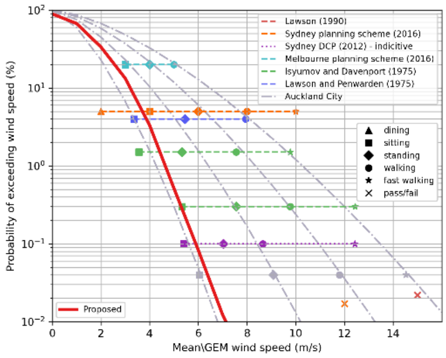
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	72.0	98.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.6	12.3

Location 10





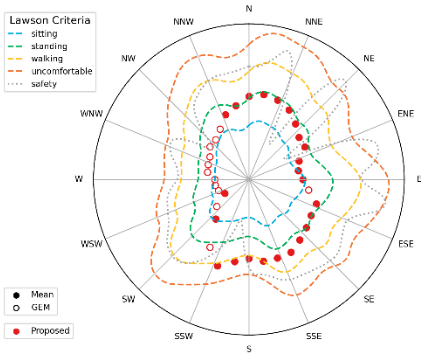
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

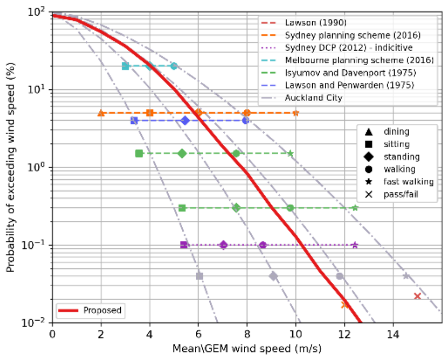
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	66.0	97.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.8	12.3

Location 11





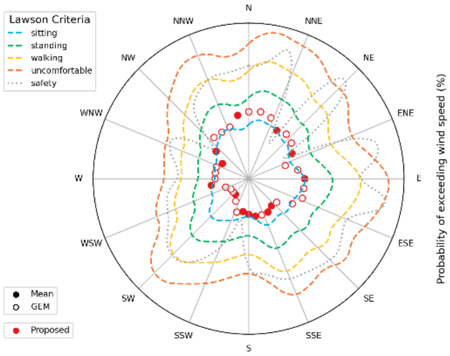
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

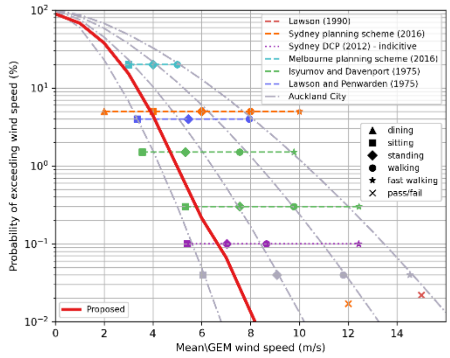
	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	45.0	79.0	96.0	99.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	5.9	20.4

Location 12



1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

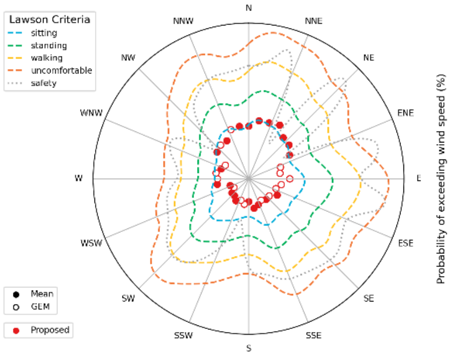


1995-2021 Business Hours
Wind speed exceedances (m/s)

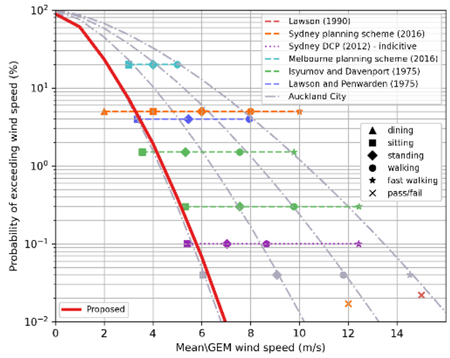
	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	62.0	96.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.9	14.6

Location 13



1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

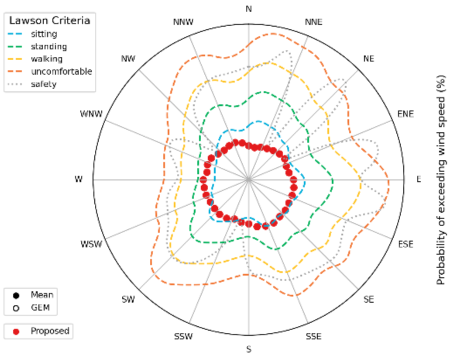


1995-2021 Business Hours
Wind speed exceedances (m/s)

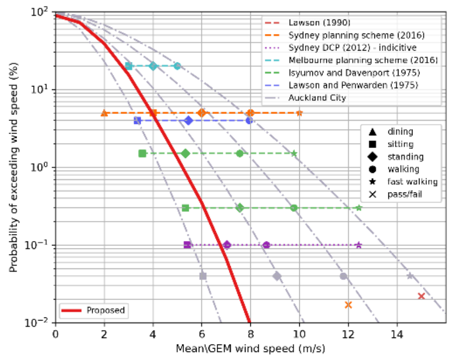
	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	77.0	98.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.4	12.6

Location 14



1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

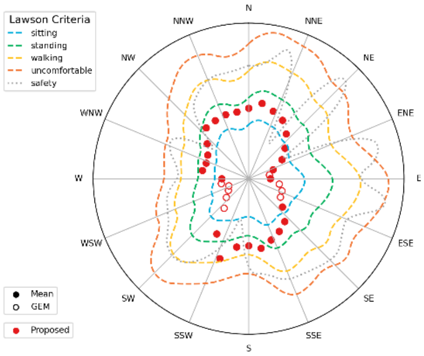


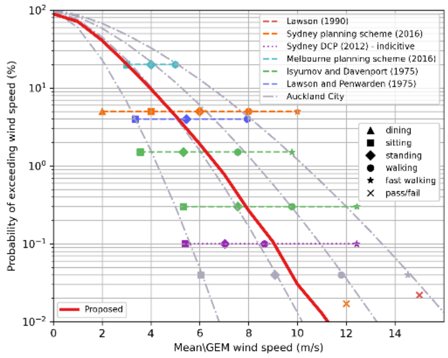
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	61.0	95.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	4.0	8.6

Location 15





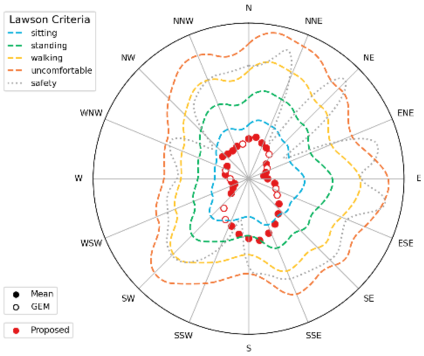
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

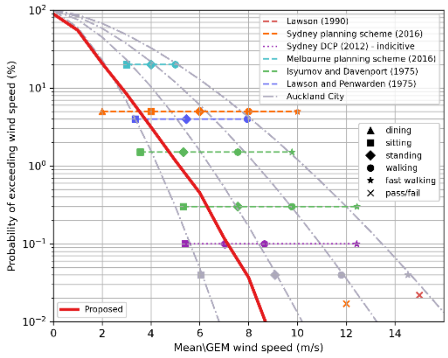
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	59.0	90.0	98.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	4.9	18.9

Location 16





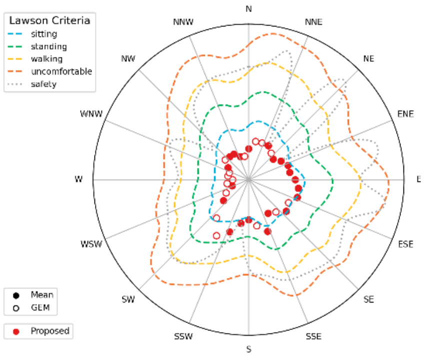
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

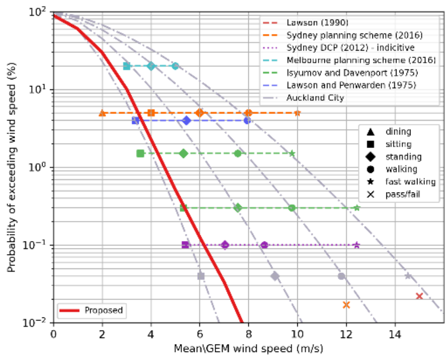
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	79.0	97.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.6	14.4

Location 17





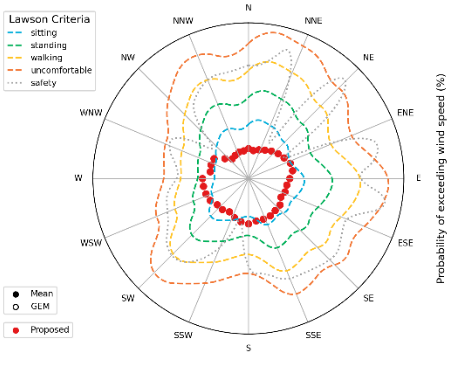
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

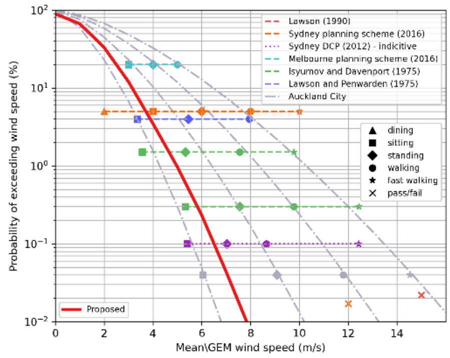
	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	70.0	98.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.7	13.7

Location 18



1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

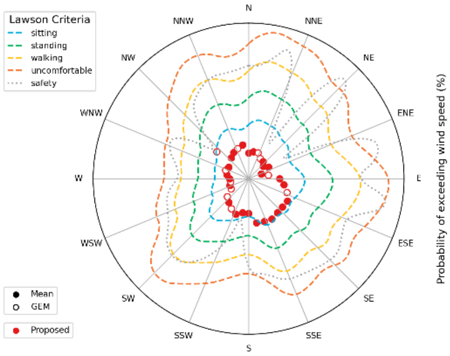


1995-2021 Business Hours
Wind speed exceedances (m/s)

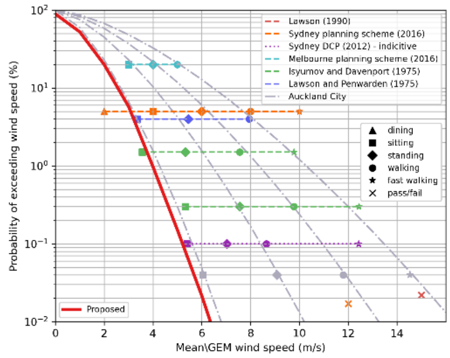
	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	67.0	97.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.8	8.7

Location 19



1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

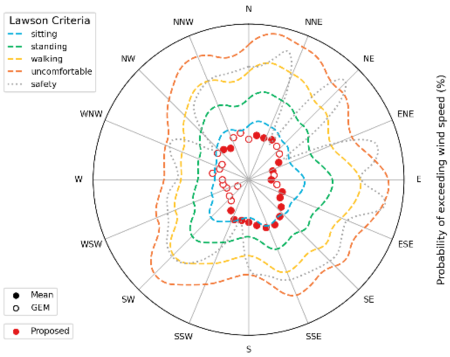


1995-2021 Business Hours
Wind speed exceedances (m/s)

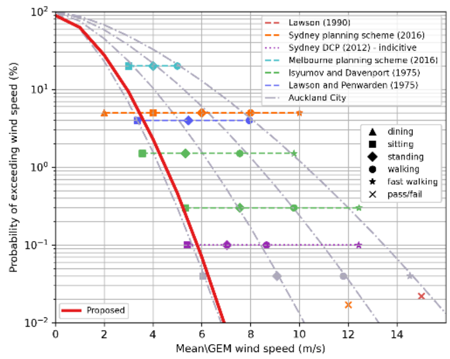
	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	80.0	99.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.2	11.1

Location 20



1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

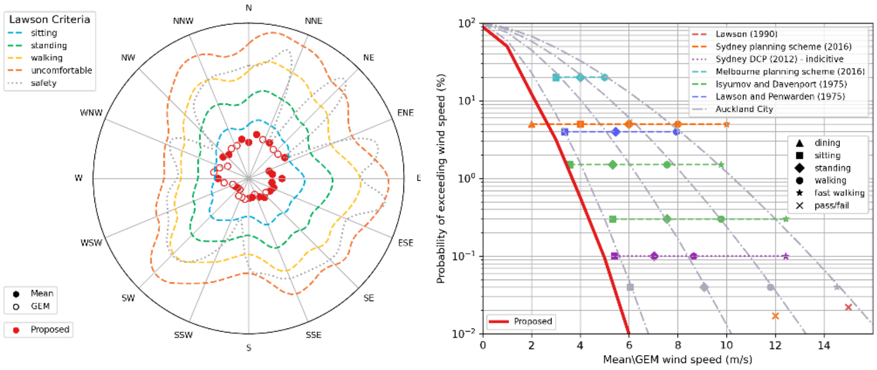


1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	72.0	98.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.6	11.8

Location 21



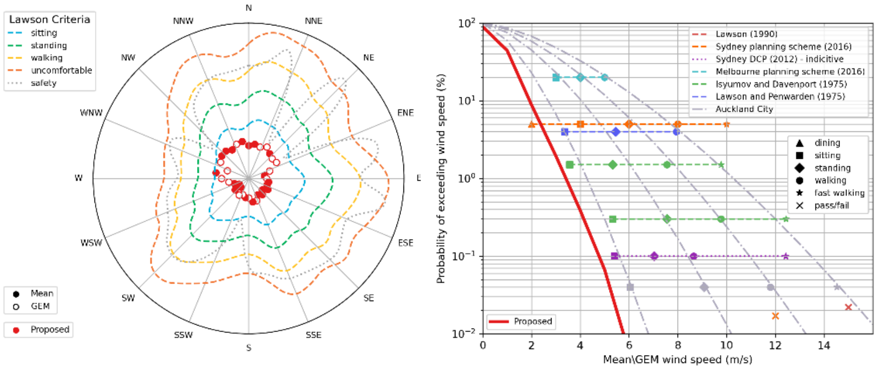
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	88.0	99.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	2.8	10.8

Location 22



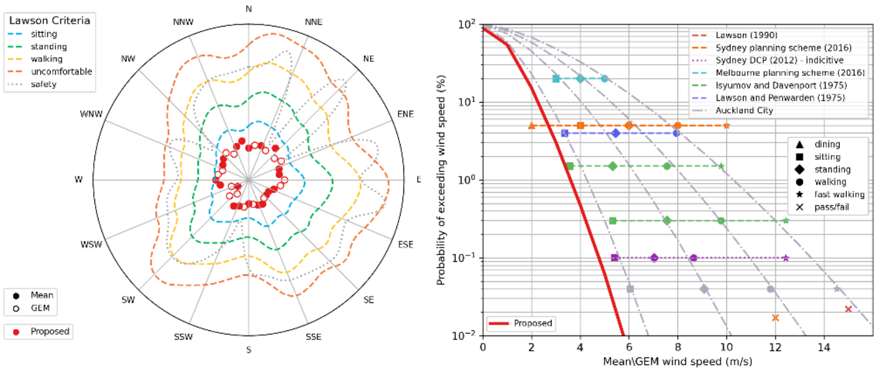
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	91.0	100.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	2.6	10.4

Location 23



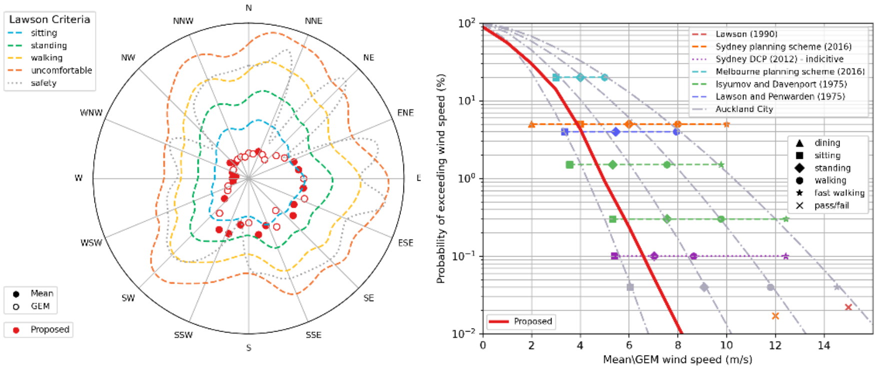
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	85.0	100.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	2.8	10.3

Location 24



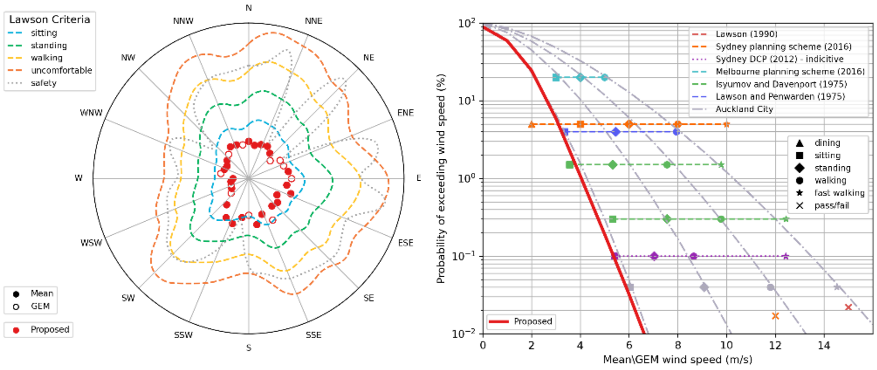
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	70.0	96.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.9	13.9

Location 25



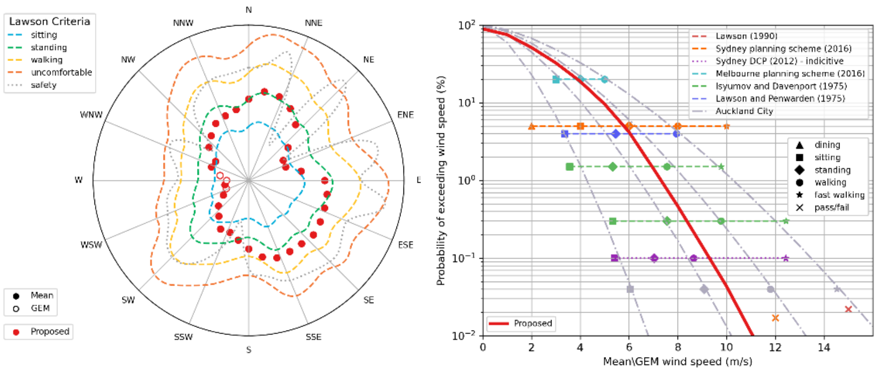
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	75.0	99.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.2	11.5

Location 26



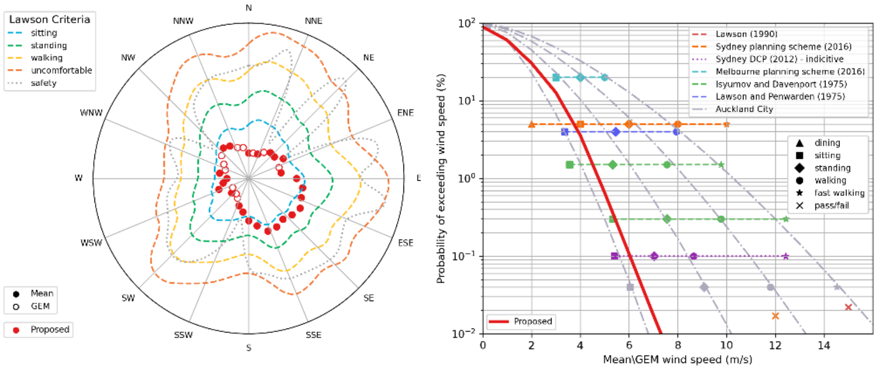
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	49.0	81.0	96.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	5.9	16.1

Location 27



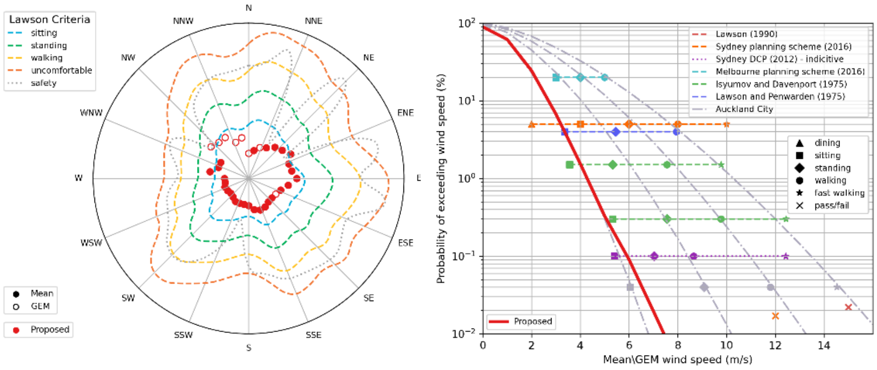
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	70.0	96.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.8	11.9

Location 28



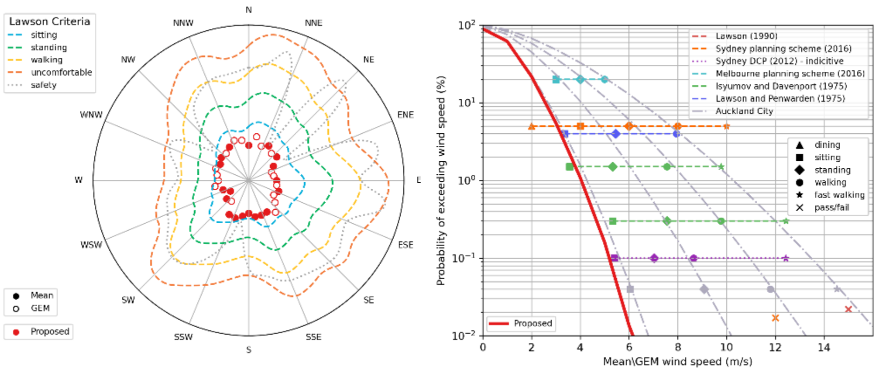
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	76.0	98.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.3	13.2

Location 29



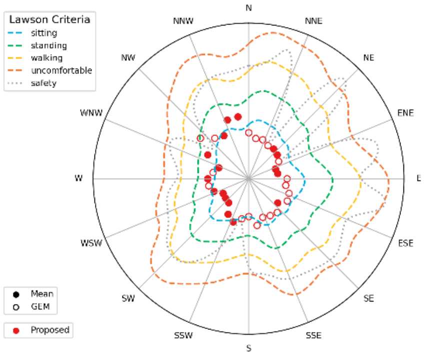
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

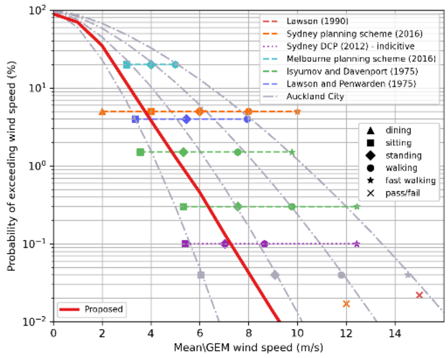
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	78.0	99.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.1	11.0

Location 30





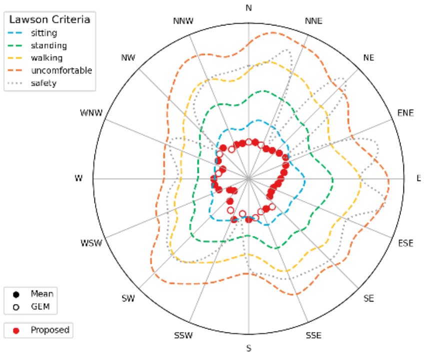
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

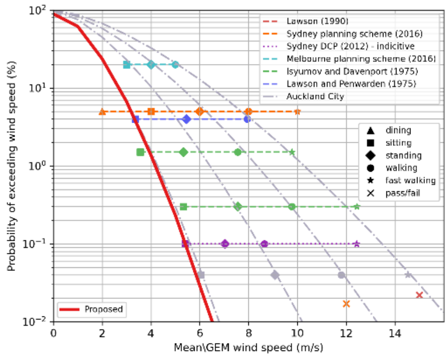
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	65.0	96.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.8	16.4

Location 31





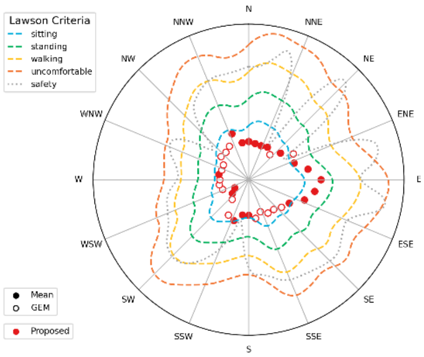
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

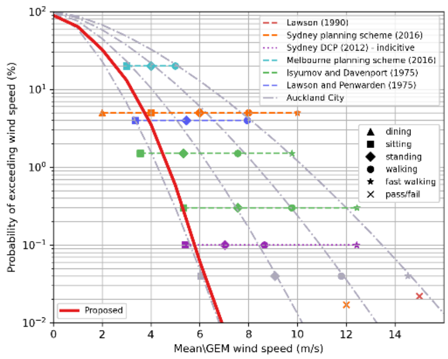
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	76.0	99.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.3	11.7

Location 32





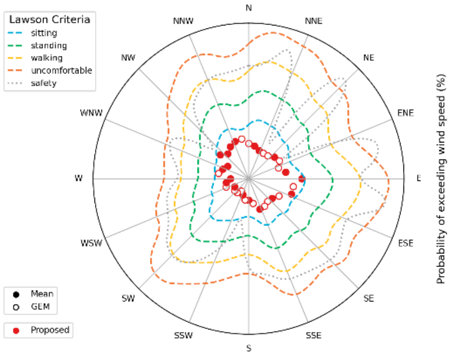
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

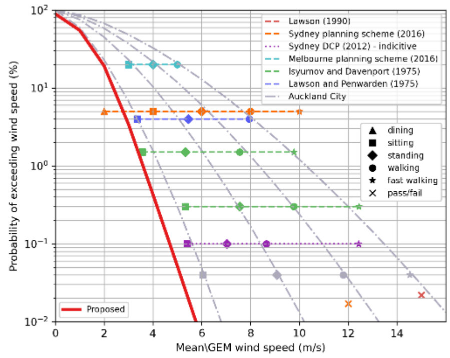
	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	67.0	96.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.8	11.8

Location 33



1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

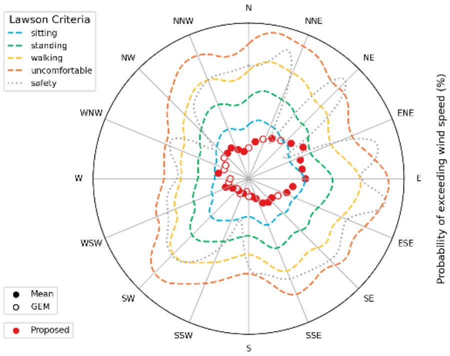


1995-2021 Business Hours
Wind speed exceedances (m/s)

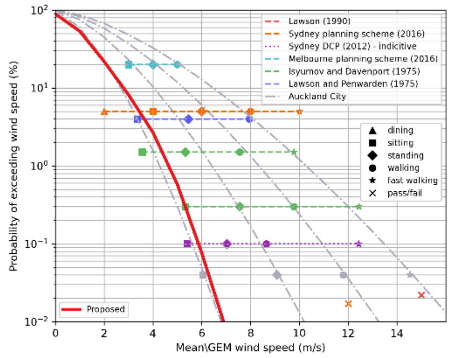
	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	81.0	100.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	2.9	10.3

Location 34



1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

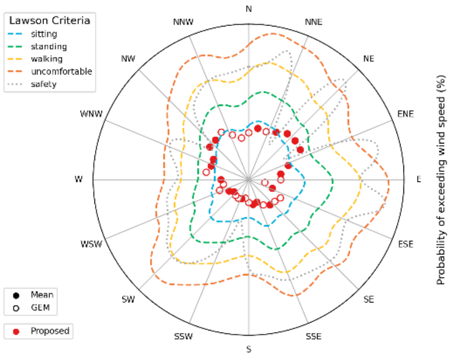


1995-2021 Business Hours
Wind speed exceedances (m/s)

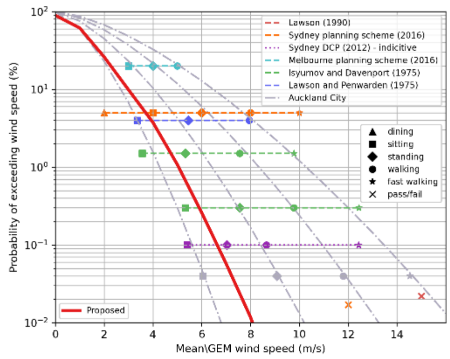
	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	78.0	97.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.6	10.9

Location 35



1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

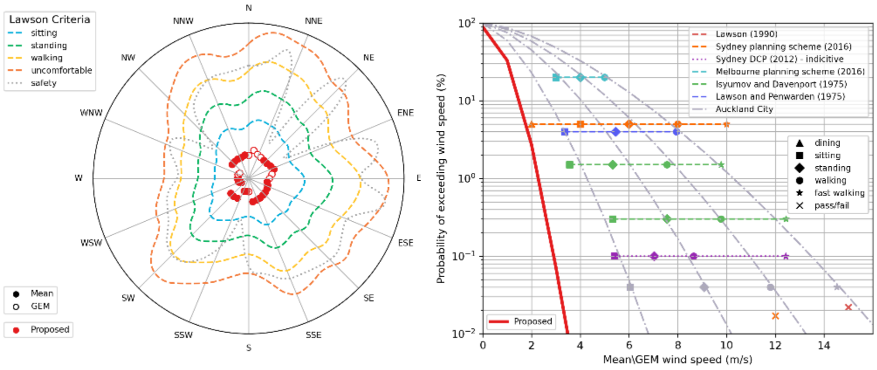


1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	74.0	96.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.8	14.4

Location 36



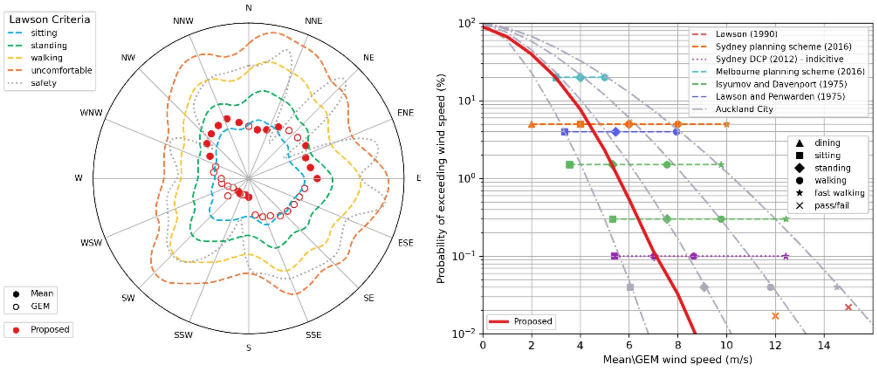
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	97.0	100.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	1.9	5.8

Location 37



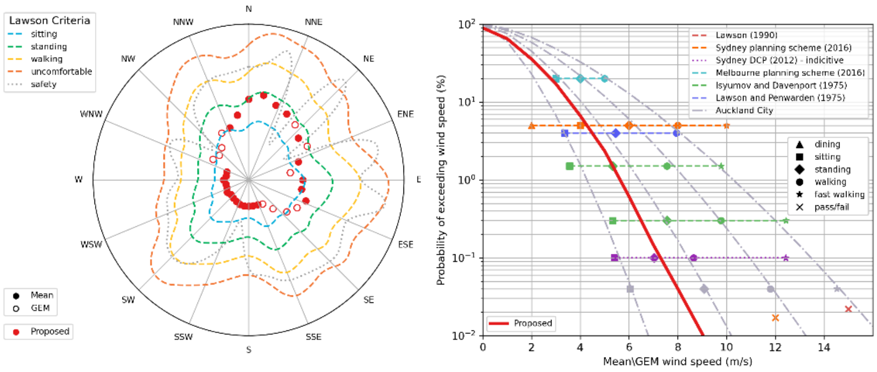
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	60.0	92.0	99.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	4.5	14.8

Location 38



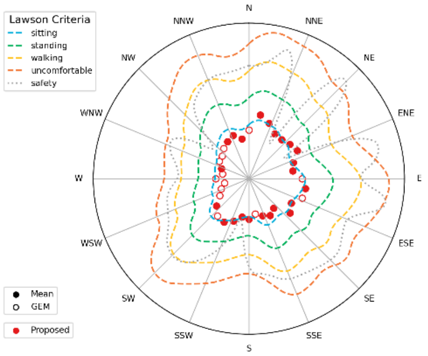
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

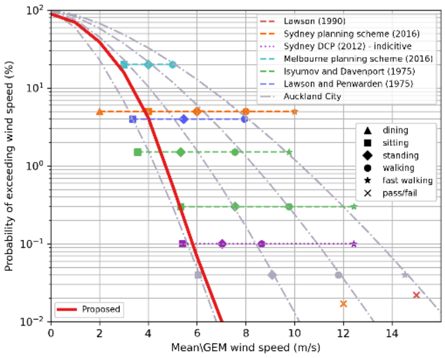
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	64.0	93.0	99.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	4.4	14.9

Location 39





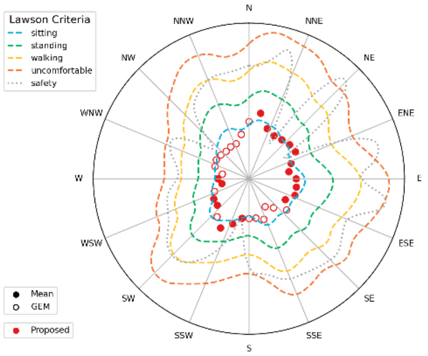
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

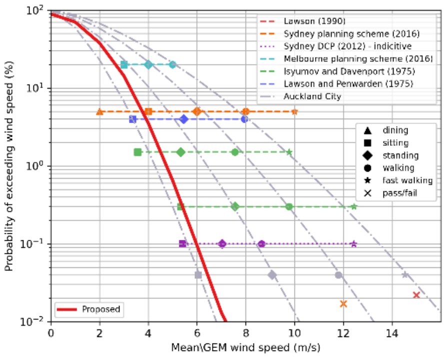
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	61.0	96.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.9	12.3

Location 40





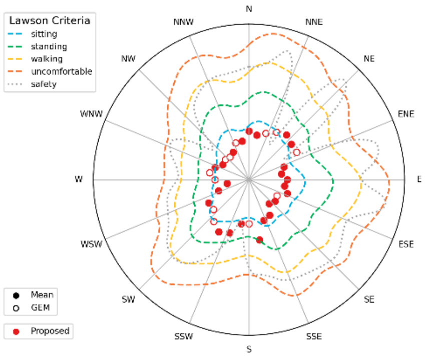
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

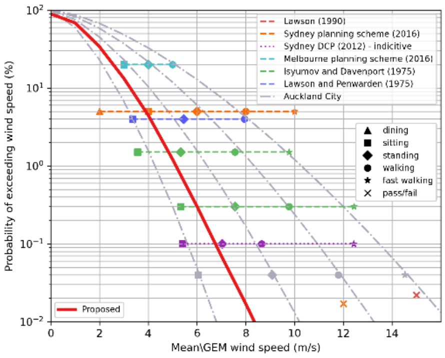
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	62.0	96.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.9	12.7

Location 41





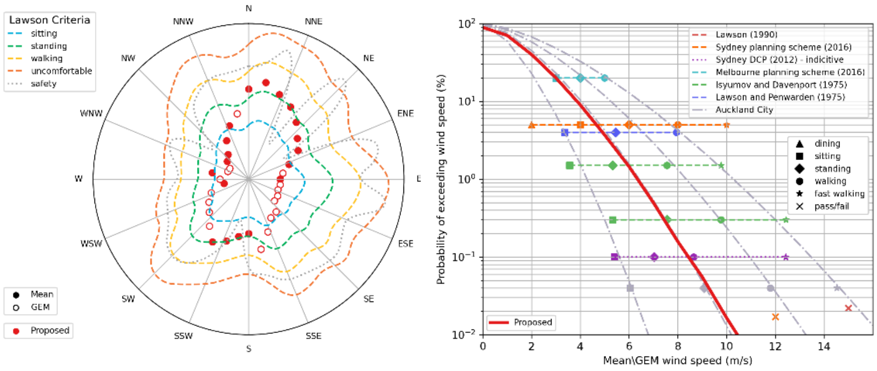
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	66.0	96.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.9	14.7

Location 42



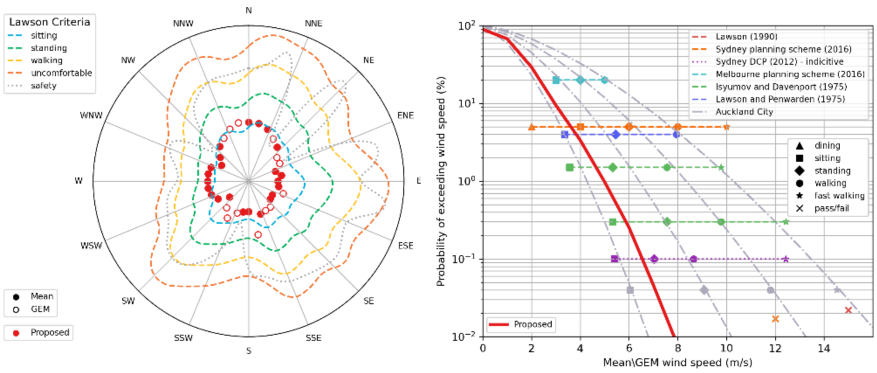
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	60.0	91.0	99.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	4.8	17.0

Location 43



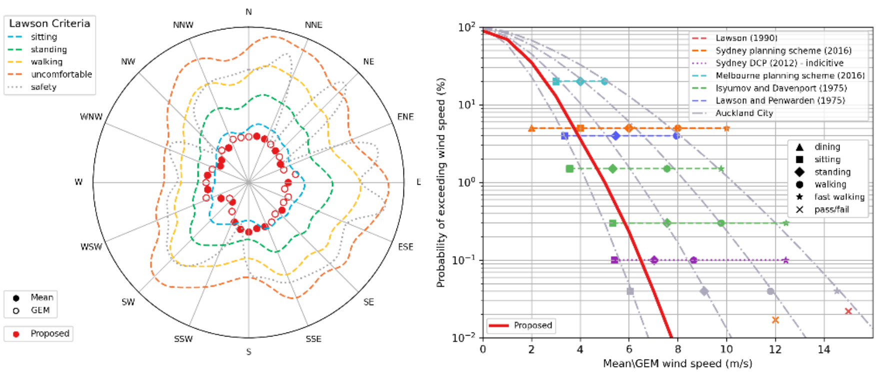
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	71.0	97.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.7	13.6

Location 44



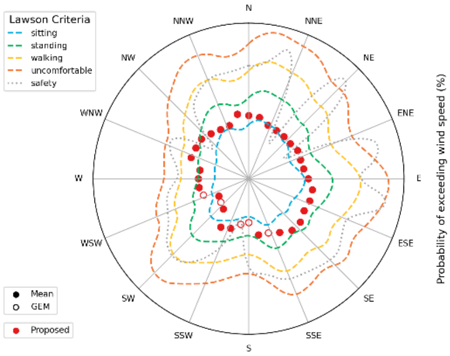
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

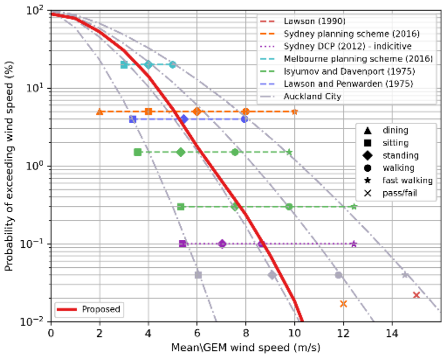
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	65.0	96.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.9	13.8

Location 45





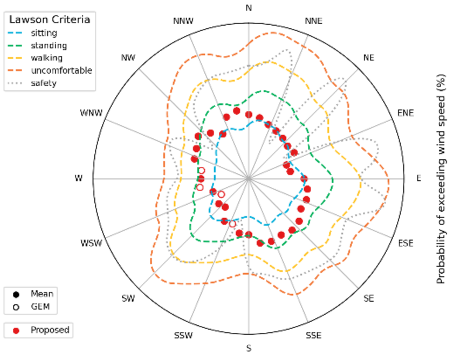
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

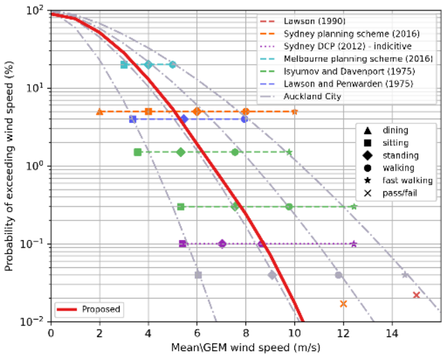
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	47.0	86.0	98.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	5.1	16.9

Location 46





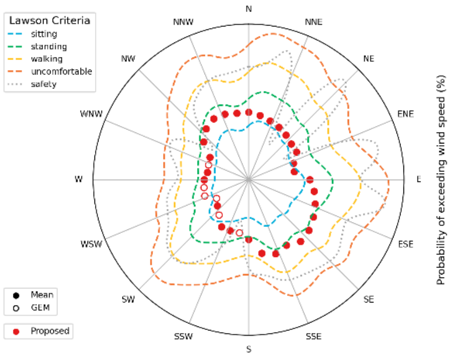
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

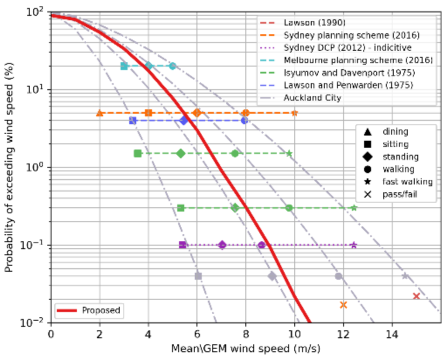
1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	48.0	87.0	98.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	5.1	17.8

Location 47





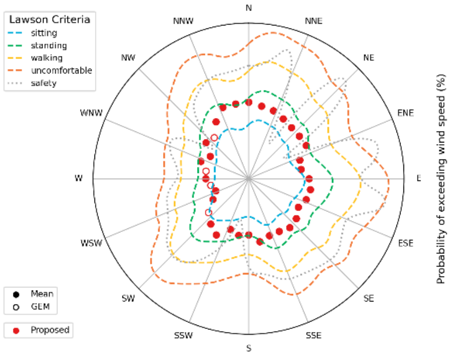
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

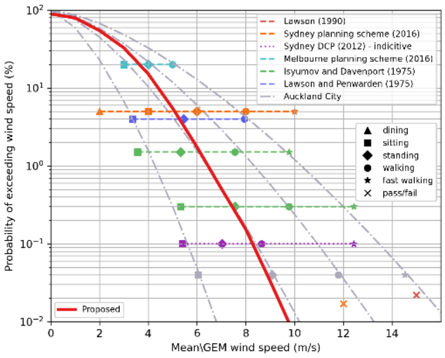
	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	46.0	82.0	97.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	5.6	16.6

Location 48



1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

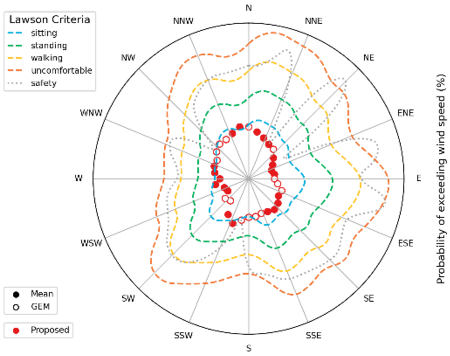


1995-2021 Business Hours
Wind speed exceedances (m/s)

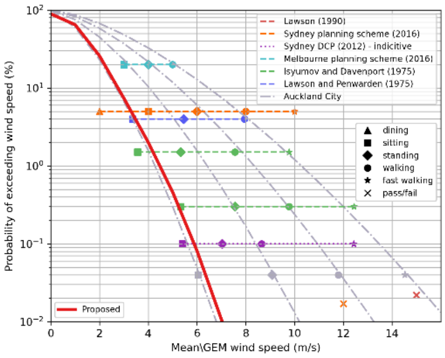
	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	46.0	85.0	98.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	5.1	15.9

Location 49



1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

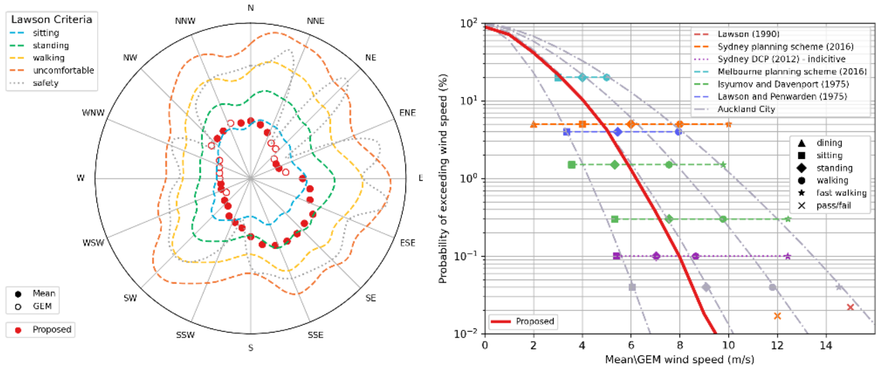


1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	74.0	98.0	100.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	3.4	12.6

Location 50



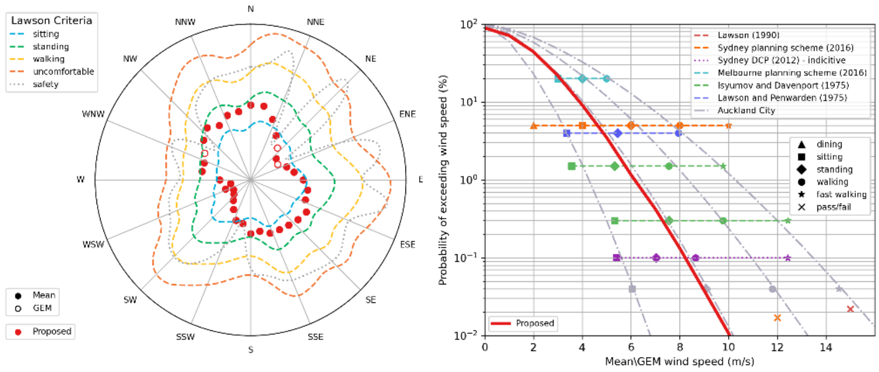
1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	59.0	90.0	99.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	4.9	14.8

Location 51



1995-2021 Business Hours
Probability of mean/GEM wind speed (%)

1995-2021 Business Hours
Wind speed exceedances (m/s)

	<2m/s	<4m/s	<6m/s	<8m/s
Proposed	56.0	91.0	99.0	100.0

	5.0% Mean/GEM	0.0171% 0.5s Gust
Proposed	4.7	17.5