271-273 Alfred Street, North Sydney

Precinct Environmental Wind Impact Assessment

Reference: 312844-ARP-WIND-REP-001

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Executive Summary

Arup has been engaged to prepare a detailed quantitative environmental wind assessment in support of a State Significant Development Application (SSDA) for 271-273 Alfred Street, North Sydney.

- Environmental wind impacts specific to the proposed development at 271-273 Alfred Street have been assessed in the wind tunnel study that has been undertaken by CPP (document *CPP23127_271-273 Alfred Street_REP_PW*). The findings of this report do not consider further development throughout the Alfred St precinct, aside from the newly proposed 275 Alfred St envelope that falls under a separate SSDA assessment.
- This specific report has been prepared to consider the cumulative wind impacts of a hypothetical Alfred Street precinct massing that has been conceived by Architects Office of Cortese and Gilder (OCG), as defined in the Environmental Impact Statement EIS and OCG's Architectural Design Report.
    - This plan is specifically to respond to Section F.9.d) in Attachment 1 to the SEARS that requests the SSDA submission to include:
    - *…a masterplan that illustrates how the proposed development integrates with the future potential redevelopment of the wider Alfred Street Precinct, with particular focus on*

This report quantifies the impact of the proposed design on pedestrian wind comfort and safety across the ground plane, using numerical modelling via Computational Fluid Dynamics (CFD) simulations. Modelling was conducted for the hypothetical precinct, including the proposed building at 271-273 Alfred Street, and surrounding precinct massing at 283, 275, and 263-269 Alfred Street. Surrounding context and topography have been explicitly included within a 500 m radius around the site and simulated for 16 wind directions. The directional CFD results were integrated with historical wind climate data recorded at Sydney Airport, corrected to the site location, to obtain wind comfort and safety maps at pedestrian level in and around the site, with respect to the Lawson pedestrian wind criteria.

The site is exposed to prevailing winds from the north-east, south, and north-west, and the proposed developments in the precinct protrude well above the immediate surrounding buildings, which impacts the local wind conditions at the site. The wind is highly contextual, and results illustrate the combined impact of the precinct on the local wind environment. Based on the results, most locations in and around the site are suitable for standing-type activities. The conditions become windier around the corners and narrow through-site links, rendering them suitable for walking, while decreasing to a sitting classification closer to the building façade at the middle of the building.

In particular, the passageway between the proposed building at 271-273 and 275 Alfred Street is impacted by winds from the east quadrant mainly through downwash and the south-west direction through channelling flow, rendering its west side suitable for walking and the east side of the passageway suitable for standing. The separation between towers at the proposed site and 275 Alfred Street modelled with 6 m setback is appropriate; greater separation would be expected to make the passageway windier, and narrower separation would not be expected to improve the conditions further.

The hypothetical precinct plan provided by OCG includes a through-site link between 271-273 Alfred Street and 263-269 Alfred Street massing forms. The eastern end of the through-site link includes a small multistorey building which from a wind perspective is a good design feature and would help in reducing the wind speeds through the site link. As a result, areas closer to the building are suitable for sitting, while those further out are suitable for standing, and wind speeds increase to a walking classification along the north side of the proposed building at 263-269 Alfred Street and through the gap between the multistorey structure and adjacent buildings. Wind conditions in and around the site are generally suitable for the intended space uses. However, if calmer areas (especially at the site link) are desired, e.g. for sedentary zones like cafés and seating, additional local wind mitigation options like screening elements would be required.

The presence of the proposed development at 263-269 Alfred Street, to the south of the target building, would provide significant shielding, which improves the conditions at the site link; however, the winds get accelerated around the southern corners of this proposed building due to downwash, making it appropriate for walking and/or transient walking.

The impact of the proposed precinct does not go beyond Little Alfred Street. While some areas of Little Alfred Street, especially around the corners of the buildings, are inherently windier, the rest of the areas in Little Alfred Street would be suitable for standing, which is comparable to the Neutral Street. The areas closer to and in between the residential houses are suitable for sitting, while areas along streets and in more open and exposed locations are suitable for standing. All areas are considered safe.

From a wind safety perspective, the results show that all the locations in and around the proposed building at 271-273 Alfred Street would pass the safety criterion. Due to the exposure of the proposed development at 263-269 Alfred Street to winds from the south quadrant, there are localised areas around the south corners of this proposed building which would exceed the safety limit for the general public, but still pass the able-bodied threshold which is the proposed limit for this assessment. The south-west corner is impacted more than the south-east due to its exposure to prevailing north-west winds and its increased openness, which allows redirected south winds to enter more readily. As the wind conditions at this location are approaching the safety limit, it is recommended to incorporate wind mitigation measures for this proposed building.

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1. Introduction

1.1 Background

This Environmentally Sustainable Design (ESD) Report has been prepared by Arup on behalf of Tara Shore Pty Ltd ATF John Taylor Family Trust (the Applicant) in support of a State Significant Development Application (SSDA) identified as SSD-103541730 which seeks approval for a 38-storey mixed-use housing development, located at 271-273 Alfred Street, North Sydney (the site).

The site is located within the North Sydney Local Government Area (LGA). The site comprises two allotments which are legally identified as Lot 1 DP 532504 (271 Alfred Street) and SP6830 (273 Alfred Street). It is rectangular in shape and has street frontages to Alfred Street to the west and Little Alfred Street to the east (both measuring approximately 23m). The existing building on the site is a three-storey commercial building. A site aerial is provided in **Figure 1** below.

Figure 1 Site Aerial [*Source: Nearmap edited by Colliers Urban Planning*]

The proposal was declared State Significant Development (SSD) in State Significant Declaration Order (No.15) 2025 (the Order), which specified that the development detailed in EOI No.279422, including a mixed-use development located at the site be declared as SSD. The Order enables SSD-103541730 to be undertaken via the Housing Delivery Authority (HDA) pathway, including a concurrent rezoning proposal to the North Sydney Local Environmental Plan 2013 (North Sydney LEP).

The proposal involves two components: the SSDA and the concurrent rezoning of the site.

- The SSDA component seeks consent for:
- Demolition of the existing building on the site;
- Construction of a 38-storey mixed use development, comprising:
  - 9 levels of basement car parking, comprising plant and bicycle storage area;
  - Commercial tenancies on Level 2;
  - Residential uses on levels 3 and above, comprising 95 apartments.
- Landscaping and public domain works; and
- Extension and augmentation of services and infrastructure as required.
- Lot amalgamation and stratum subdivision of the site.

The rezoning component seeks consent to amend the North Sydney LEP, comprising:

- Rezone the land use zone of the site from E2 Commercial Centre to MU1 Mixed Use;
- Amend the maximum building height from 13m to RL 166.5m;
- Amend the maximum floor space ratio from 3.5:1 to 13.9:1; and

Introduce a site-specific clause requiring 15% of residential Gross Floor Area (GFA) to be used as affordable housing; and managed by a CHP for a period of at least 15 years.

For a detailed project description refer to the Environmental Impact Statement and Rezoning Report prepared by Colliers Urban Planning.

1.2 Relevant SEARS and agency advice to this report

This report has been prepared in response to the Secretary's Environmental Assessment Requirements (SEARs) dated 12 February 2026 for SSD-103541730.

Specifically, this report has been prepared to respond to:

- the SEAR outlined in **Table 1** below; and
- Section F.9.d) in Attachment 1 to the SEARS that requests the SSDA submission to include:

…a masterplan that illustrates how the proposed development integrates with the future potential redevelopment of the wider Alfred Street Precinct, with particular focus on

Table 1. Applicable SEAR.

Item	SEAR	Relevant section
5.2	Environmental Amenity: Assess amenity impacts on the surrounding locality, including lighting impacts, solar access, visual privacy, visual amenity, view loss and view sharing, overshadowing and wind impacts. A high level of environmental amenity for any surrounding residential or other sensitive land uses must be demonstrated.	This report, in particular section 12, addresses the requirements to provide a wind impact assessment which has been prepared by a suitably qualified engineer.

2. Site description

The 271-273 Alfred Street site is located on the eastern side of the Cahill Expressway, bounded by Alfred Street to the west and Little Alfred Street to the east (Figure 2). The proposed project comprises the redevelopment of the subject site. However, to address to the agency request for consideration of a future potential redevelopment scenario, Arup's CFD assessment includes the hypothetical scheme proposed by OCG which considers the following development schemes for the precinct:

- 283 Alfred Street – no future development envisaged;
- 275 Alfred street – considered developed per OCG scheme;
- 263-269 Alfred Street – considered developed per OCG scheme.

High-rise buildings of North Sydney are located further from the site (more than 200 m) in the south-west to north-west directions.

The surrounding area extending from the north to the south-east is predominantly residential, except for a medium-rise building located on the eastern side of Nicholas Street (north-east of the site). To the east–south-east of the site lie Neutral Harbour and Wurrabirri Point. The area from the south-east to south-west comprises a mix of residential and medium-rise developments, with nearby water bodies including Blues Bay, Lavender Bay, and Kirribilli Point.

The surrounding topography generally slopes downward towards Neutral Harbour in the east–south-east direction, decreasing by approximately 37 m over a distance of around 360 m. To the north of the site, the ground falls by approximately 13 m over 150 m before rising steeply beyond this point, while towards the north-east it slopes downward by approximately 38 m over 260 m before rising steadily. To the south, the terrain gradually decreases towards Milsons Point. From the south–south-west to the west, the topography drops by approximately 10 m over 80 m, followed by a steady rise of approximately 15 m, remaining relatively constant thereafter. Towards the west to north-west of the site, the topography rises by approximately 34 m over around 600 m. As a result, the site is fairly exposed to winds from the south quadrant. There is a proposed public space (annotated as "Site Link" in Figure 2) between the subject building and the proposed future development at 263–269 Alfred Street. There is a proposed multistorey building on the eastern side of the Site Link, and the public area will be connected to Little Alfred Street by a street with stairs.

Figure 2. 271-273 Alfred Street surroundings and site description.

The proposed redevelopment rises to a maximum height of approximately 126 m above the street entry ground level. The main entrance is on the west side of the building, bounded by the 263–269 Alfred Street redevelopment building, and Alfred and Little Alfred Streets.

3. Local wind climate

3.1 General

This section summarises the general wind climate for the Sydney area, based on historical wind data recorded at a standard height of 10 m at Sydney Airport. These data are then integrated with a site-specific Computational Fluid Dynamics (CFD) assessment, which explicitly models the precinct geometry and surrounding context within 500 m of the site, to quantify local wind conditions and provide insight into pedestrian-level wind speeds in and around the site.

The arms of the windrose point in the direction from where the wind is coming from. The anemometer is located about 13 km to the south of the site. The directional wind speeds measured here are considered representative of the wind conditions at the site.

It is evident from Figure 3 that strong prevailing winds are organised into three main groups which centre at about the north-east, south, and north-west quadrants.

- **North-East:** These winds are typically associated with maritime air masses, bringing moisture and influencing temperature along the coast. Most common in summer, often bringing cooling relief on hot summer afternoons typically lasting from noon to dusk. These are small-scale temperature driven effects, the larger the temperature differential between land and sea, the stronger the wind.
- **South:** More common in seasonal transitions and often can bring cooler air from the Southern Ocean. These winds are often associated with large synoptic frontal systems and generally provide the strongest gusts during summer.
- **North-West:** Strongest throughout the year, associated with significant synoptic events, varying from hot to cold based on inland conditions and tend to be associated with large scale synoptic events that can be hot or cold depending on inland conditions.

The annual wind rose is overlaid on the site showing the applicable key prevailing wind directions, Figure 4. Based on the historical climate data and appropriate conversion to the site location, the mean wind speed at 10 m height would be 3.9 m/s and the 5% wind speed exceedance at the pedestrian level would be approximately 6.3 m. A general description of flow patterns around buildings is given in Appendix A.2.

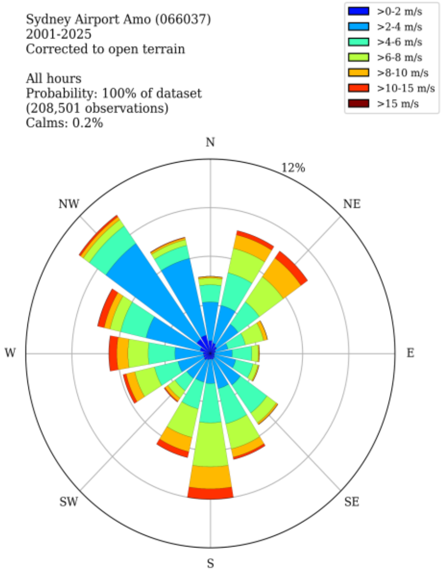

Figure 3. Annual wind rose showing probability of time of wind direction and speed.

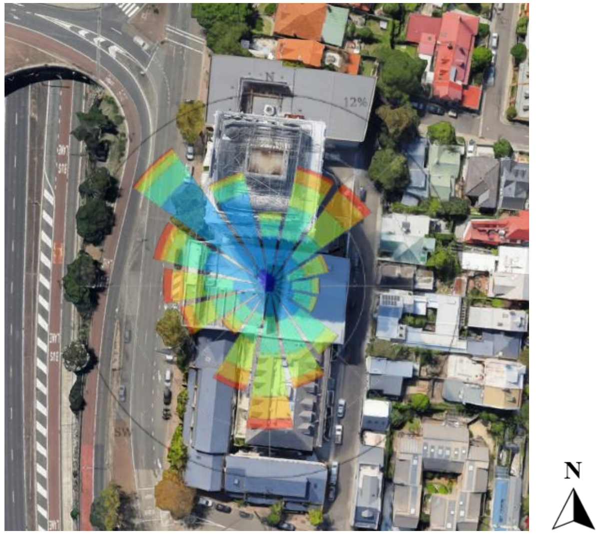

Figure 4. Annual wind rose overlaid on site showing probability of time wind direction and speed.

3.2 Seasonal

The region experiences distinct seasonal variations in wind patterns, each characterized by unique prevailing wind directions and intensities. The seasonal wind roses provide a detailed visual representation of these seasonal wind behaviours, Figure 5.

- **Summer:** Winds predominantly come from the south and north-east quadrants, contributing to warmer temperatures and occasional storms.
- **Autumn:** Wind directions are more variable, with prevailing winds from the south and north-west. Wind speeds are moderate, reflecting a mix of winter and summer influences.
- **Winter:** Dominated by strong winds from the west to north-west, resulting in cooler weather and dynamic conditions.
- **Spring:** Features a range of prevailing wind directions with stronger and more frequent winds, marking dynamic and sometimes turbulent atmospheric conditions.

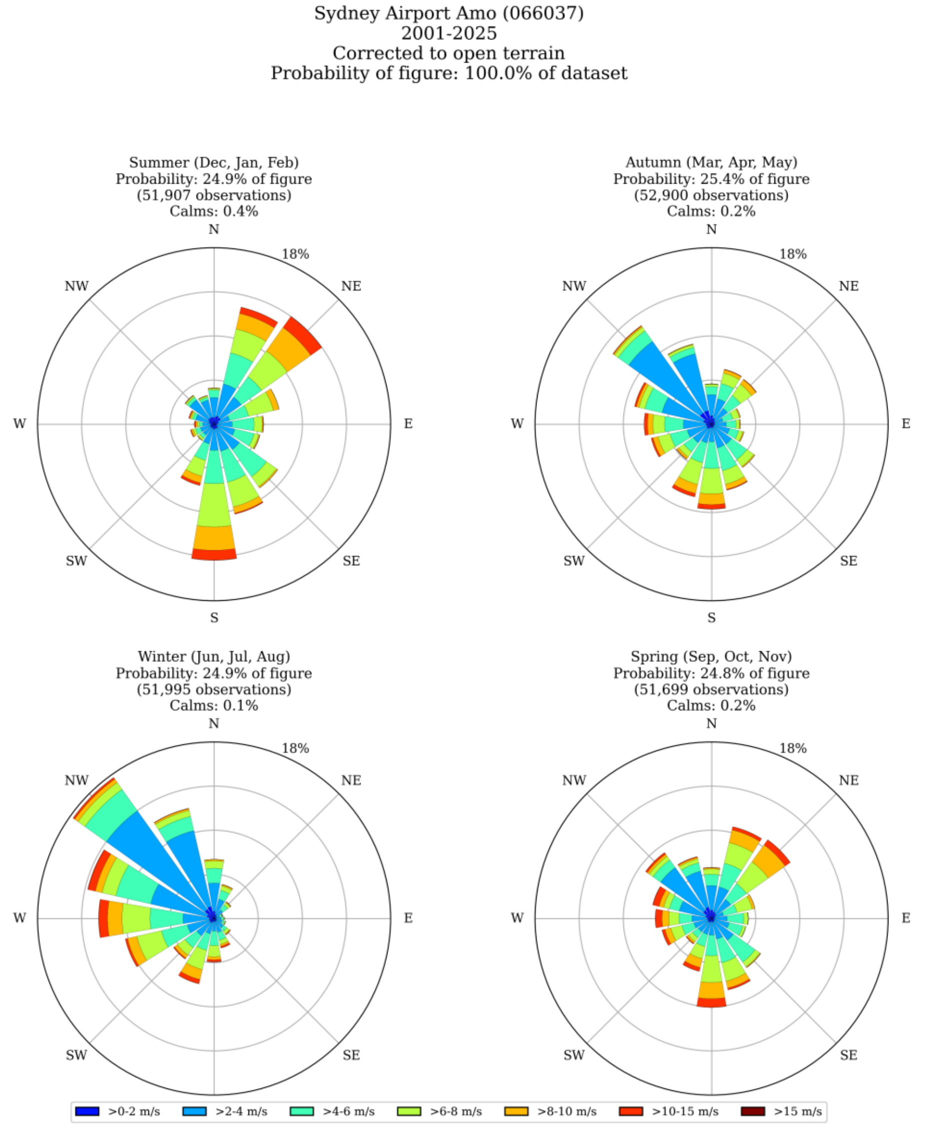

Figure 5. Seasonal wind roses showing probability of time of wind direction and speed.

3.3 Diurnal

Based on the diurnal wind roses recorded at Sydney Airport Figure 6, the following observations can be made regarding wind prevalence and strength throughout the day:

Morning: Winds typically come from the north-west, with consistent and moderate strength.

Noon: The prevalent wind direction shifts to the south, with south winds becoming more frequent and stronger, while north-west winds, though less frequent, become stronger.

Afternoon: Winds shift to the north-east, becoming dominant as the day warms up. These winds are strong, contributing to the windiest period of the day.

Evening: North-east winds continue to prevail, maintaining their strength into the evening, while south winds diminish.

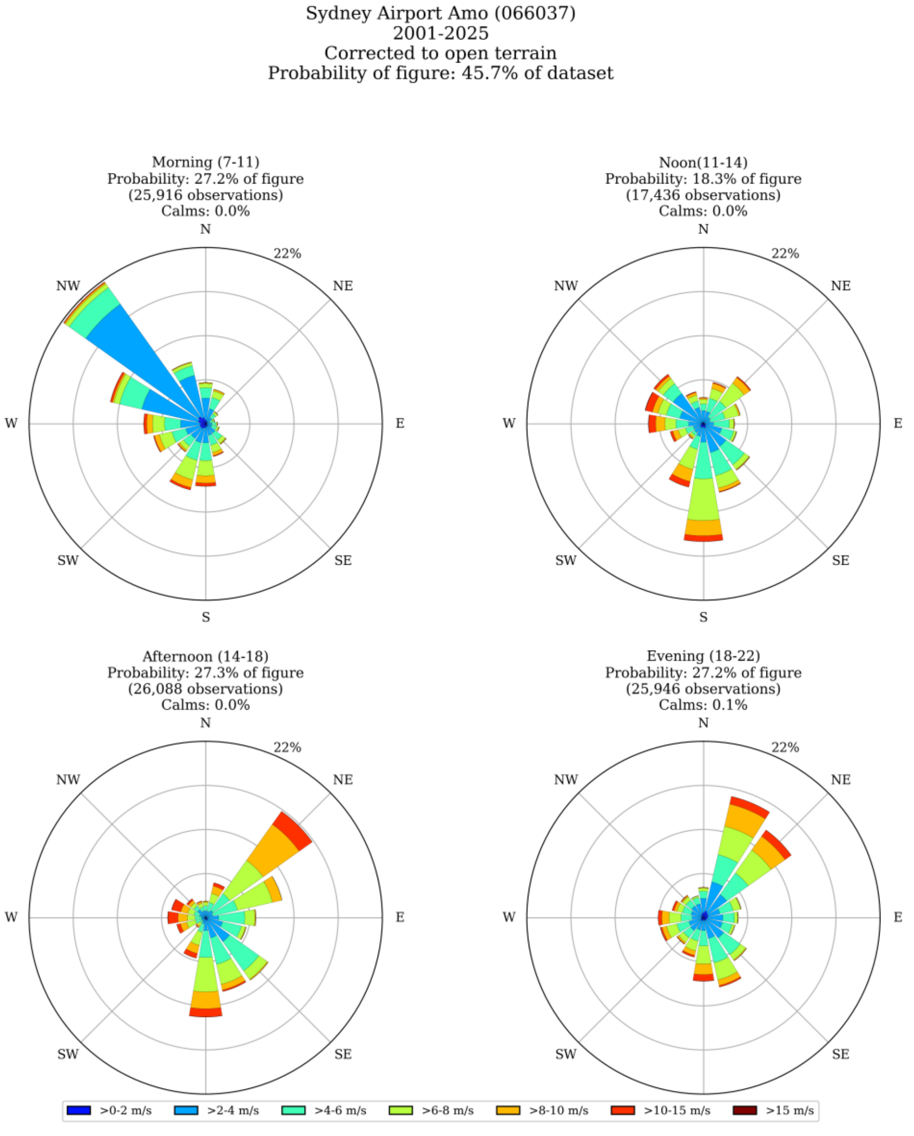

Figure 6. Diurnal wind roses showing probability of time of wind direction and speed.

3.4 Based on Temperature

Based on the temperature wind roses recorded at Sydney Airport, Figure 7, the following observations can be made regarding wind prevalence and strength throughout the day:

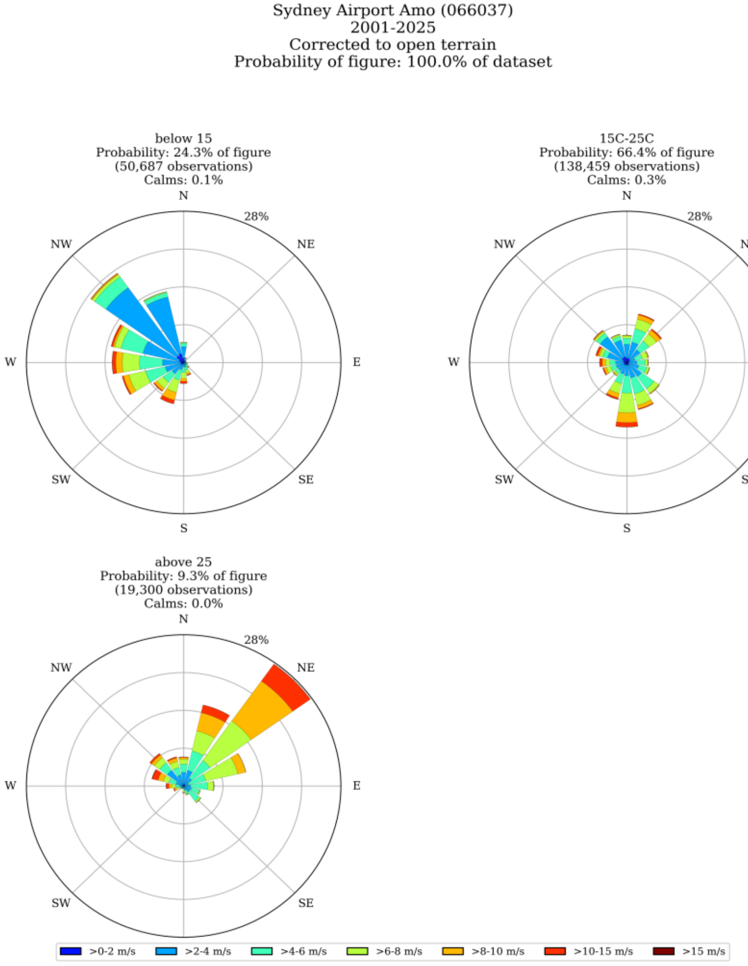

Figure 7. Temperature based wind roses showing probability of time of wind direction and speed.

Shielding desired:

-Accounts for 24.4% of the time.

-Prevailing winds from the west and north-west.

-Shielding from these directions is recommended for comfort in cooler conditions.

Preferable range:

-Occurs for 66% of the time.

-Winds are most prevalent from the south and north-east.

-This range is ideal for thermal comfort, with moderate wind - conditions.

Breeze desired:

-Accounts for only 9.6% of the time.

-Winds generally come from the north-east.

-A breeze from this direction is preferable for cooling during hotter conditions.

4. 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.

The SSDA has no wind assessment criteria. The criteria used in the North Sydney Council DCP (2025) specifies that wind speeds along public streets, and in public spaces, should not exceed 13 m/s. It is not stated whether this wind speed is a gust or mean, as such it is assumed to correspond to a 3-second gust after the work of Melbourne (1978), and would relate to a 'pedestrian standing' type classification.

To combat the limited information associated with the North Sydney Council DCP and based on the discussion with the Department of Planning and Environment, the wind controls used in this wind assessment are based on the work of Lawson (1990) as described in Table 2.

The wind criteria are based on the maximum of the mean or gust equivalent mean wind speed to evaluate a location. The gust wind speed gives a measure of the short-term fluctuating turbulent nature of the wind, and the mean wind speed indicates the longer duration impact on pedestrians. At low mean wind speeds, the gust equivalent mean (GEM) is generally the critical parameter, but in accelerated flow, such as downwash, the mean conditions are dominant.

There are not many locations within North Sydney that would satisfy the level of wind amenity without some form of shielding as discussed in the Section of local wind climate. This study instead proposes the comfort to be based on Lawson walking criterion and safety to be based on able-bodied people criterion which, to some extent, corresponds to walking to objective/business walking criterion of comfort criteria.

Table 2. Pedestrian comfort and safety criteria for various activities based on amended Lawson criteria (1978)

Comfort (max. of mean or GEM wind speed exceeded 5% of the time)		
<2 m/s	● (purple)	Dining
2-4 m/s	● (blue)	Sitting
4-6 m/s	● (green)	Standing
6-8 m/s	● (yellow)	Walking
8-10 m/s	● (orange)	Objective walking or cycling
>10 m/s	● (red)	Uncomfortable
Safety (max. of mean or GEM wind speed exceeded 0.022% of the time)		
<15 m/s		General access
<20 m/s		Able-bodied people (less mobile or cyclists not expected)
>20 m/s		Unsafe

5. Computational model

5.1 Methodology

The numerical CFD simulations were conducted for the proposed development using steady-state Reynolds-Averaged Navier-Stokes (RANS) method. The urban context including surrounding buildings within a radius of 500 m around the site was explicitly modelled, with topography surrounding the site included in the model, Figure 9, Figure 10. The context is placed in a much larger domain based on best practice guideline for the CFD simulation of flows in urban environment, Figure 8. The Atmospheric Boundary Layer (ABL) profile corresponding to the respective terrain characteristics of the site were imposed as inlet boundary conditions and the simulations were conducted for 16 wind directions with 22.5° interval. The results were then integrated with the historical wind climate data and analysed based on Lawson criteria to provide wind comfort and safety maps for the assessment area at the pedestrian level in and around the precinct.

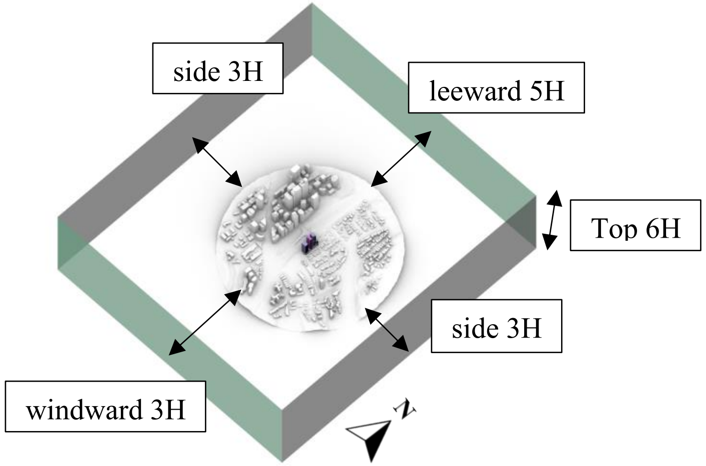

Figure 8. Typical Simulation Domain (dimensions in meters).

Probes at different locations around the site and parameter residuals were used to monitor the convergence of the results and ensure the solution reached a converged steady state solution.

5.2 3D Geometry

For this study, the proposed site and hypothetical precinct were modelled based on the precinct architectural designs received from OCG on 10th April 2026. The urban context including surrounding buildings within a radius of 500 m around the site was explicitly modelled.

The geometry has been simplified to the standards defined by CFD best practices balancing detail and computational efficiency. Any details with the measurement below 0.5 m on the target building have been simplified unless necessary for the assessment. The site link between the two buildings 27-273 Alfred Street and 263-269 Alfred Street connecting the Alfred Street to Little Alfred Street was modelled accurately keeping the details necessary for the CFD simulations. The two stairs in the site link shown in Figure 11 and Figure 12 have been simplified and represented as a continuous slope with an equivalent overall height for each step, for the purposes of the assessment. Sunshades on the target building and adjacent building have been retained in their original form.

Figure 9. Isometric view of the CFD model.

Figure 10. Planview of the overall model.

Figure 11. Closeup view of the site link from East of the site.

Figure 12. Close up view of the site link from the west of the site.

5.3 Mesh Strategy and Resolution

A computational mesh was constructed comprising of approximately 16-17 million dominant hexahedral elements. The grid resolution is finest around the proposed building where greater resolution is required. The computational mesh size increases with distance from the regions of most interest. Other mesh sizing controls including varying the level of mesh refinement were used to more accurately capture the effects of important surrounding buildings from an aerodynamic perspective. A mesh sensitivity study was conducted to reduce the effect of mesh size on the solution.

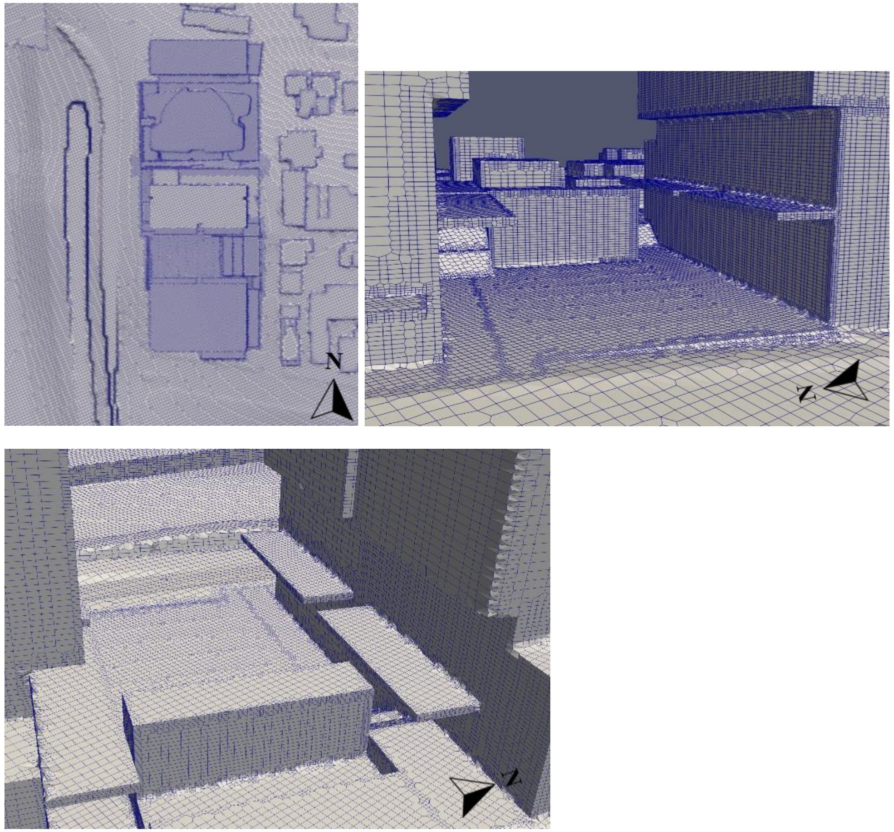

Figure 13. mesh resolution from top view (top-left) of the precinct, from the west (top-right) and from the east (bottom).

5.4 Boundary Conditions

A complete ESDU analysis was conducted to evaluate the wind speed correction factors needed for different wind directions based on directional terrain characteristics of the site and weather station. The effect of terrain outside the 1 km diameter urban context was implicitly modelled using rough wall functions reproducing the surface roughness characteristics and correction factors were used to adjust the wind speeds for the pedestrian level based on effective roughness length.

Simulation boundary conditions:

Inlet boundary: Atmospheric Boundary Layer (ABL) profiles were applied based on the Richards & Hoxey (1993) methodology, tailored to terrain categories relevant to each wind direction.

Outlet boundary: Outflow (zero-gradient) conditions are applied.

Ground boundary:

-Domain Topography: Explicitly modelled ground was assigned standard wall functions.

-Context Topography: Unmodelled ground adopted effective aerodynamic roughness lengths matching the ABL profile.

-Ocean: Special ABL wall treatment was used with a roughness length (z_0) of 0.002 m.

Sky boundary: A shear-stress condition was applied to the top boundary to counter streamwise pressure inhomogeneities.

Side boundaries: Slip conditions were implemented at lateral boundaries.

6. Results and discussion

Pedestrian wind comfort and safety results are presented in this section. Wind speed measurements were taken at a height of 2 m above ground level for 16 wind directions. The directional wind velocities were integrated with the local wind climate data detailed in Section 3 and the Lawson wind criteria for comfort and safety as detailed in Section 4. Directional results on the ground plane are presented in Appendix A.1.

For assessment against the criteria, the 3 s gust is estimated based on measured turbulent kinetic energy using:

$$\mathrm{U}_{3s\ gust} = \mathrm{U}_{\mathrm{hourly}} + 3.0 \cdot \sigma_{\mathrm{u}}$$

where considering isotropic turbulence, standard deviation of wind speed would can be calculated using:

$$\sigma = (2/3k)^{0.5}.$$

Given the nature of the numerical modelling—particularly steady-state RANS with high resolution of flow features—very localised areas of elevated wind speeds may appear, potentially exceeding safety or comfort thresholds. In reality, due to variations in gusts and wind direction, such exceedances are unlikely to occur unless they affect a significantly larger area. Hence, for the purposes of this assessment, exceedance areas smaller than 1 m² are excluded from further discussion, as they are deemed to fall within an acceptable threshold.

An area of 120 m around the precinct was included for the detailed assessment, which is greater than the recommended assessment zone in the AWES guidelines for pedestrian wind effects criteria (2014).

6.1 How to read the map

The pedestrian wind comfort and safety maps for the assessment area of the proposed precinct are shown in Figure 14 and Figure 15 respectively.

Regarding the wind comfort map, six classifications are defined: Dining, Sitting, Standing, Walking, Objective Walking, and Uncomfortable. These are based on areas experiencing wind speeds below the relevant thresholds for at least 95% of the time. Accordingly, if an area is classified as suitable for Walking, it does not mean it is unsuitable for stationary activities; rather, the proportion of time it is suitable for those activities is reduced (i.e., less than 95%). Objective Walking, sometimes referred to as Business Walking, applies to transient spaces where it is expected that able-bodied individuals and cyclist would be present.

Regarding the wind safety map, any area highlighted (above 20 m/s) is classified as unsafe. Areas coloured in two shades of orange (15-20 m/s) are approaching the threshold but are still considered safe for able-bodied people, which considered the limit for this assessment. These are ‘sensitive’ areas that may exceed safety limits if nearby potential new buildings exacerbate conditions. Areas with safe conditions for general public are coloured in shades of green (<15 m/s), with the darkest indicating the calmest conditions.

6.2 Pedestrian Wind Comfort and Safety

The wind comfort and safety maps for the proposed precinct based on the Lawson criteria is presented in Figure 14 and Figure 15 respectively.

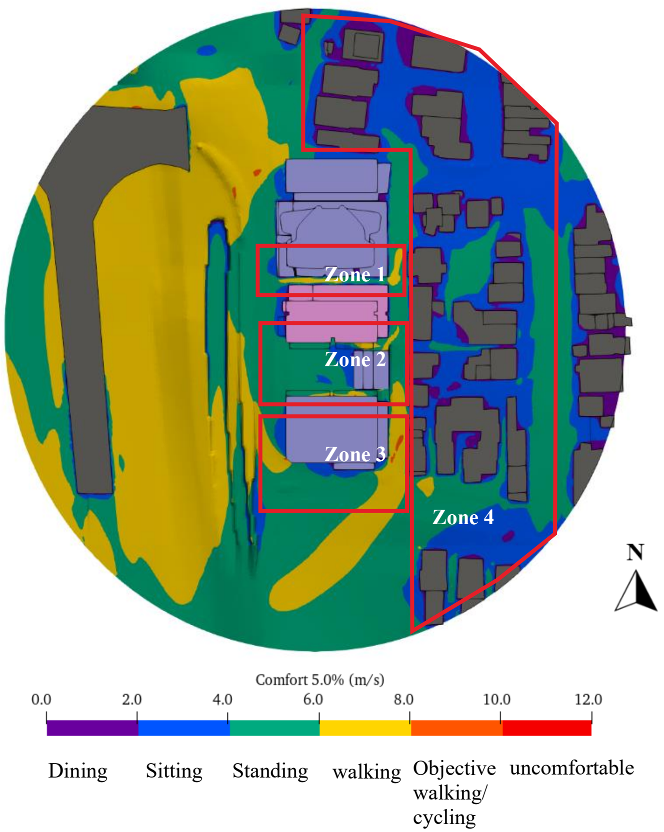

Figure 14. Wind comfort classification based on Lawson Criteria at 2 m above local ground level.

The wind comfort classification represents the maximum of the mean or gust equivalent mean with a 5% exceedance probability. The wind safety classification is determined by the maximum of the mean or gust equivalent mean wind speed with an exceedance probability of 0.0228%.

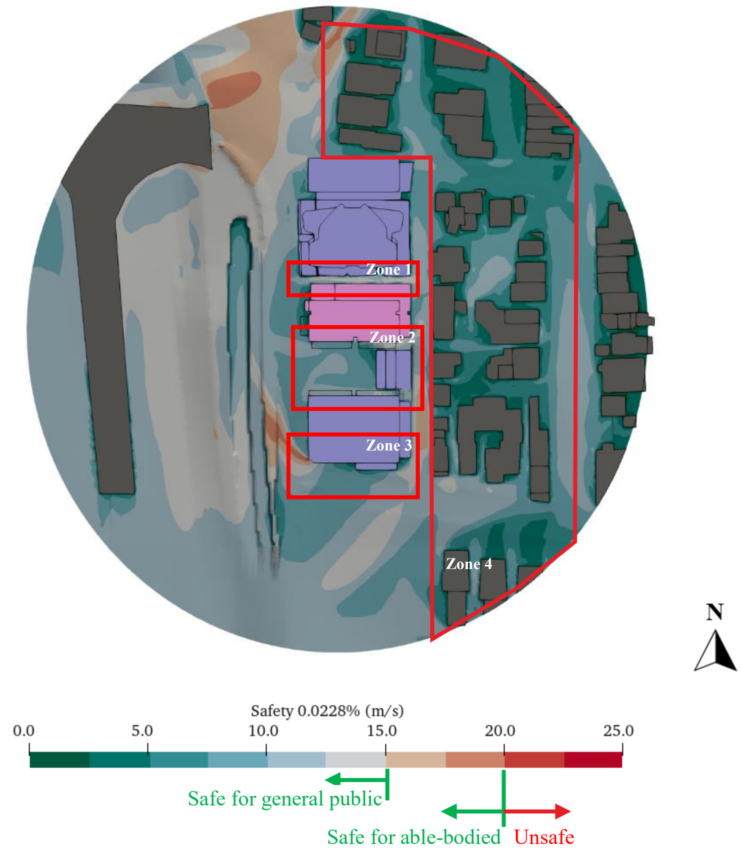

Figure 15. Wind safety classification based on Lawson Criteria at 2 m above local ground level.

The wind comfort results show the majority of locations in and around the site are suitable for standing-type activities. The conditions become windier around the corners and narrow through-site links rendering them suitable for walking, while decrease to sitting classification closer to the building façade at the middle of the building.

It is important to note that, given wind conditions are quite contextual, and any changes to the arrangement or shape of the buildings in the precinct would alter the local wind conditions.

The wind safety results show that all locations in and around the proposed building at 271-273 Alfred Street pass the safety criterion for able bodied individuals (proposed threshold) and general public except for the southern corners of the adjacent building at 263-269. While the results at the narrow site links approach the safety limit, they do not exceed the Lawson safety limit.

To discuss the comfort and safety in more details, the maps have been divided into four major zones of interest:

- Zone 1 is the Passageway between the target building (271-273 Alfred Street) and the 275 Alfred Street,
- Zone 2 is the site link between the target building and the 263-269 Alfred Street,
- Zone 3 is southern part of 263-269 Alfred street, and
- Zone 4 is the surrounding residential area from north to the south-east side of the target building.

6.2.1 Zone 1: Passageway between 271-273 and 275 Alfred Steet

This passageway is mainly affected by downwash winds from the east quadrant and channelling flow from the south-west direction. Winds from the east impinging on the towers induce downwash, which would be felt further to the west of the passageway. Winds from the south-west would induce channelling flow throughout the entire length of the passageway. Integrating these wind conditions with historic weather data to provide probabilistic results reveals that the wind conditions on the west side of the passageway are suitable for walking (as it is more frequently impacted), while the conditions on the east side are more suitable for standing.

The separation between the tower forms at 271-273 and 275 Alfred Street helps to suppress the wind shear acceleration around the corners of these buildings. Widening the gap further would actually have a counterproductive effect, as it allows the accelerated wind shear around the corners to form and superimpose, resulting in further acceleration. Reducing the gap would also lead to a similar result. Refer to the section on channelling flow between buildings in Appendix A.2 for more information and the critical separation distance.

From a wind safety perspective, all locations in this passageway are below the safety limit for the general public, although areas towards the west are approaching this limit.

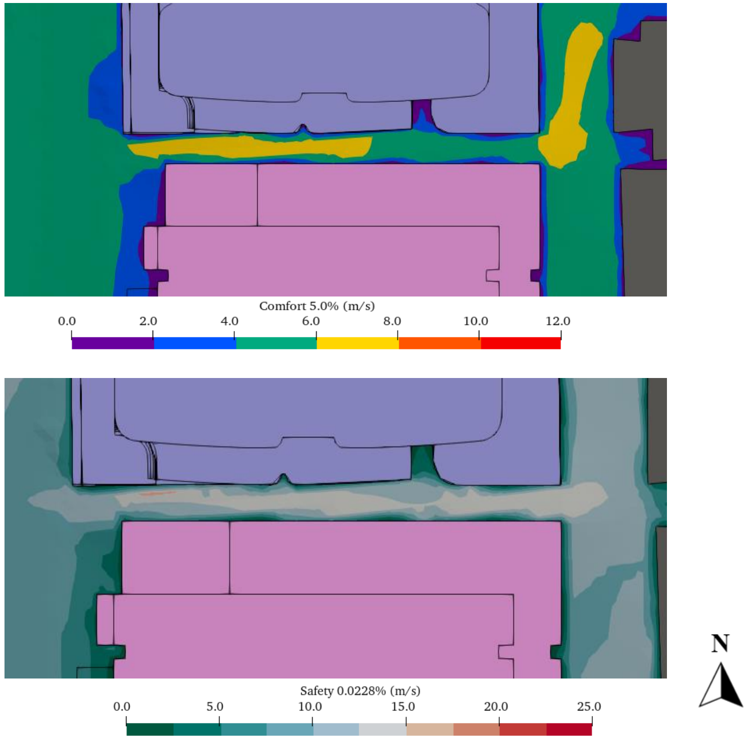

Figure 16. Zoomed-In view of comfort map (top) and safety map (bottom) for zone 1 – passageway between 271-273 and 275 Alfred Street.

6.2.2 Zone 2: Site link between 271-273 and 263-269 Alfred Steet

The wind comfort results show that the majority of locations in the site link are suitable for standing-type activities, while reducing to sitting closer to the multistorey building to the east of the site link, and increasing to walking between this structure and the adjacent development.

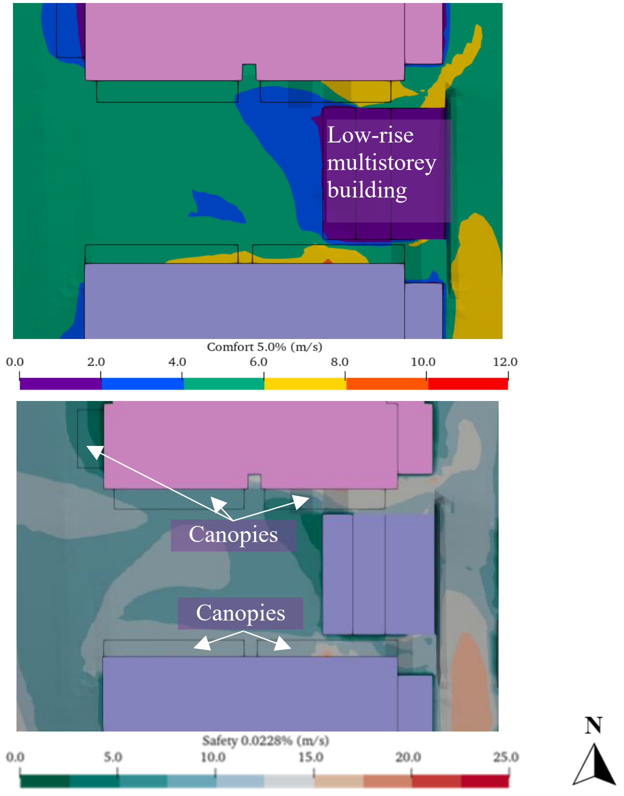

Figure 17. Zoomed-In view of comfort map (top) and safety map (bottom) for zone 2 – site link between 271-273 and 263-269 Alfred Street.

The presence of the low-rise multistorey building in the site link is a good design feature, as it creates back pressure for winds from the west quadrant and provides wind shielding for winds from the east quadrant. Both effects help reduce the wind impact on the site link, and its impact is more pronounced closer to the façade. As a result, areas closer to the building are suitable for sitting, while those further out are suitable for standing. It is expected the removal of this multistorey building would result in the sitting classification area to disappear, with walking areas expanding into this region from the east corners of the adjacent buildings.

These current estimated wind classifications would be suitable for the intended use of the space. While there are canopies shown for 271-273 and 263-239 Alfred St building facade facing the site link, shown in Figure 17 with black borders, the areas closer to the building façade are still rated as walking, especially towards the south side. This is due to the wind in these areas being primarily horizontal flow channelling through this gap. If calmer areas are required, or if sedentary zones such as cafés or seating are planned for this space, mitigation measures in form of vertical screens (ideally attached to the building façade in the through site link) would be required to locally improve wind conditions. The exact location of these potential vertical screens would be dependent of the location of seating areas. The effectiveness of the vertical screens is discussed in Appendix A.2, Vertical Screens.

6.2.3 Zone 3: Areas to the south of 263-269 Alfred Steet

The presence of the massing at 263-269 Alfred Street would provide significant shielding to the Ground plane areas south of the proposed site (i.e. at the through-site line). This is because wind from the south is redirected via downwash along the 263-269 Alfred Street massing. This wind would accelerate around the 263-269 Alfred Street tower corners, making the southern corners of this massing windier and suitable only for walking.

The walking zone would penetrate more into Little Alfred Street. This outcome was expected, as the site is at the top of a hill and exposed to winds from the south quadrant. The areas around the corners are expected to be used as transitory spaces for walking. Wind conditions would be improved by setting the tower back from the southern side of the podium or by providing a continuous canopy that wraps around the southern corners of the building at 263-269 Alfred Street. Both measures would help mitigate downwash generated as winds from the south impinge on the southern aspect of the building.

From wind safety perspective, there are localised areas around the south corners of this proposed building that would exceed the safety limit for the general public, but still pass for the able-bodied limit. The south-west corner is impacted more than the south-east, due to its exposure to prevailing north-west winds and its increased openness, which allows redirected south winds to enter more readily.

This assessment proposed the safety limit for the able-bodied (<20 m/s) as discussed in the Section 9, and hence, no areas are classified as unsafe. However, it is still recommended to improve the conditions at the south side of the adjacent building through wind mitigation strategies. The potential mitigations include, but are not limited to, setting back the tower from the south edge of the podium, rounding the corners of the tower, reducing its height, tapering the building, or installing an extensive continuous awning towards the south wrapping around the corners. The more effective mitigations require a change in build form, while building attachment/ canopy would require to be appropriately deep and continuous wrapping around the corners.

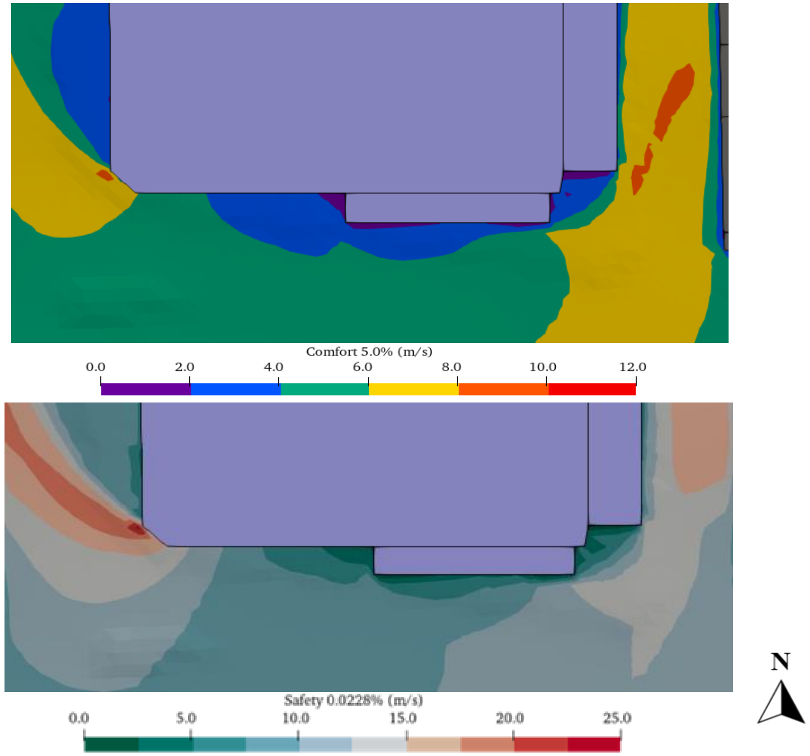

Figure 18. Zoomed-In view of comfort map (top) and safety map (bottom) for zone 3 - Areas to the south of 263-269 Alfred Street.

6.2.4 Zone 4: Residential area

The impact of the proposed precinct does not go beyond the Alfred St. While some areas of Little Alfred Street, especially around the corners of the buildings are inherently windier, the rest of the areas in Little Alfred Street would be suitable for Standing which is comparable to the Neutral Street. The areas closer to and in between the residential houses is suitable for Sitting, while along Streets and in a more open and exposed areas are suitable for Standing. All areas are considered safe.

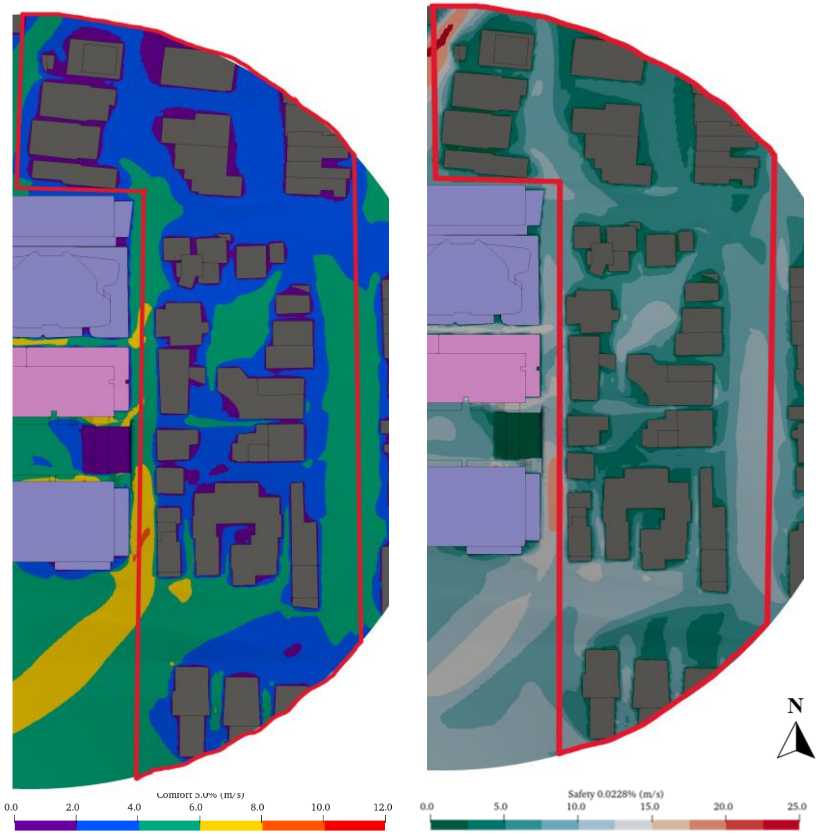

Figure 19. Zoomed-In view of comfort map (left) and safety map (right) for zone 4 – residential area.

6.3 Percentage usability

To provide further insight into space usability, results were analysed to illustrate how often different areas would be suitable for different activity types. These maps illustrate the percentage of time wind speeds in pedestrian areas around the site fall below 2, 4, 6, and 8 m/s—corresponding to Dining, Sitting and Standing, and Walking activities when considered on 5% exceedance basis. Areas less often suitable are shown in yellow, while those suitable more frequently are indicated in green and blue.

Figure 20 shows the percentage for time that the wind speed is below 2 m/s. Based on the Lawson comfort criterion for Dinning, if wind speed at a location is below 2 m/s for 95% of the time or more, that location is rated as suitable for Dining. It is evident from Figure 20 that while no area in the Site Link meets the Lawson comfort Dining classification, these locations are suitable for this type of activity for 70-80% of time. The percentage probability drops to 40-50% of the time around corners.

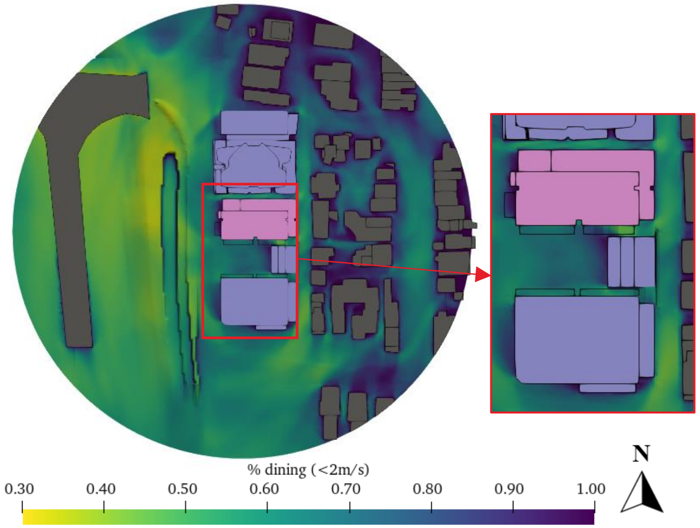

Figure 20. Percentage of time areas meet wind speed associated with dining activity.

The wind speed needs to be under 4 m/s at least 95% of time to be classified as suitable for Sitting type activities according to Lawson criteria. It is shown in Figure 21 that around the target site the condition is met predominantly 60-90% of the time. The most unsuitable location is at the south-east corner of 263-269 Alfred Street. where the percentage usability drops to 60-70%. The locations in the Site Link closer to the multistorey building meet the Lawson Criterion for Sitting they are suitable for 95% of time or more, which would decrease to 85-95% usability moving towards the west.

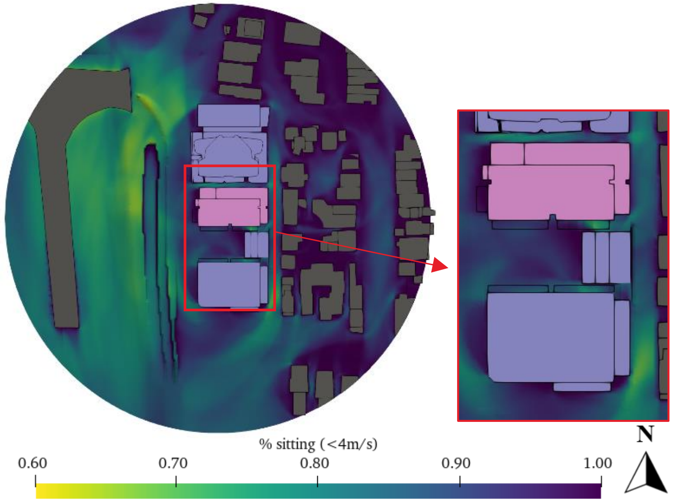

Figure 21. Percentage of time areas meet wind speed associated with Sitting activity.

For most locations in and around the site, 90-100% percentage of time the local wind speed is below 6 m/s, except around corner where it drops to 80-90%, Figure 22. Wind speed at all locations in and around the site are less than 8 m/s for 95% of time or more, Figure 23.

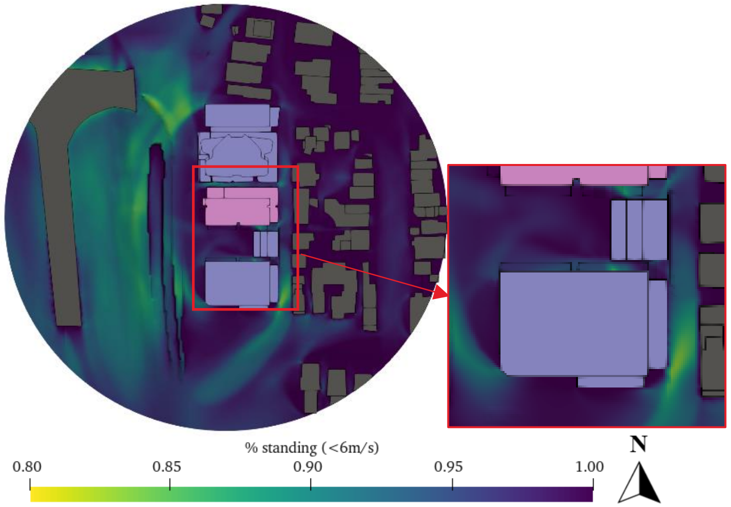

Figure 22. Percentage of time areas meet wind speed associated with Standing activity.

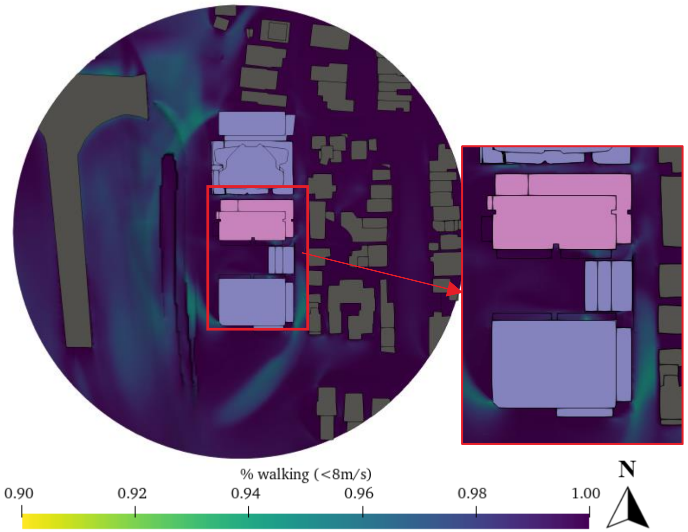

Figure 23. Percentage of time areas meet wind speed associated with walking activity.

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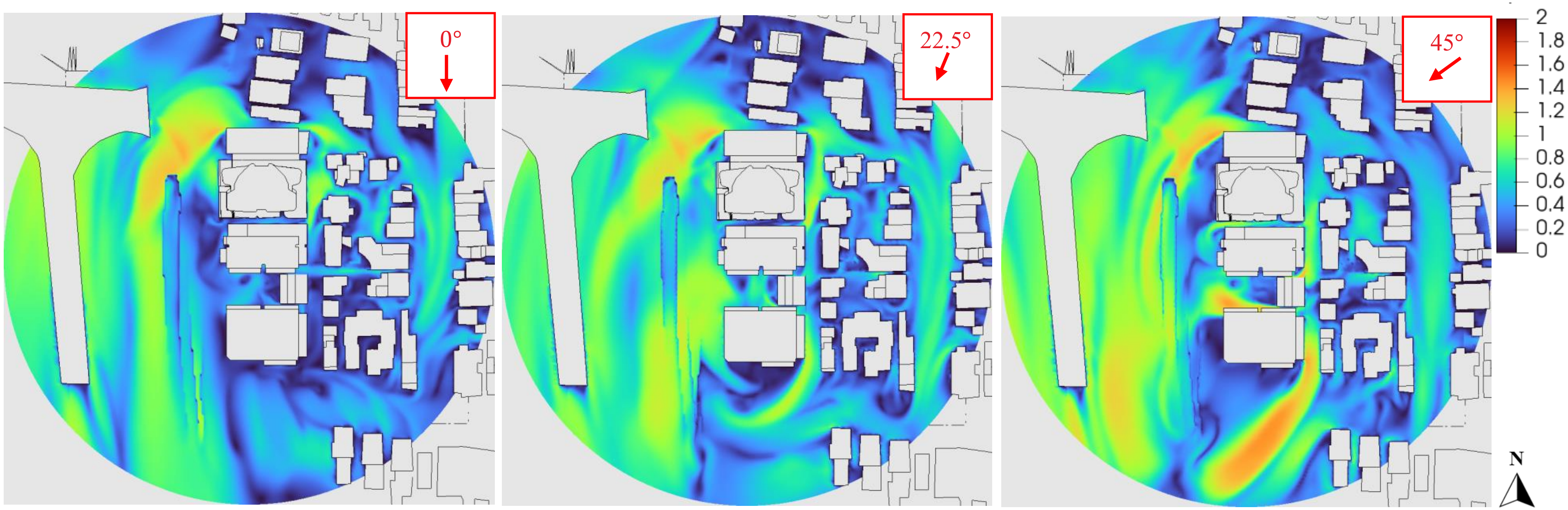
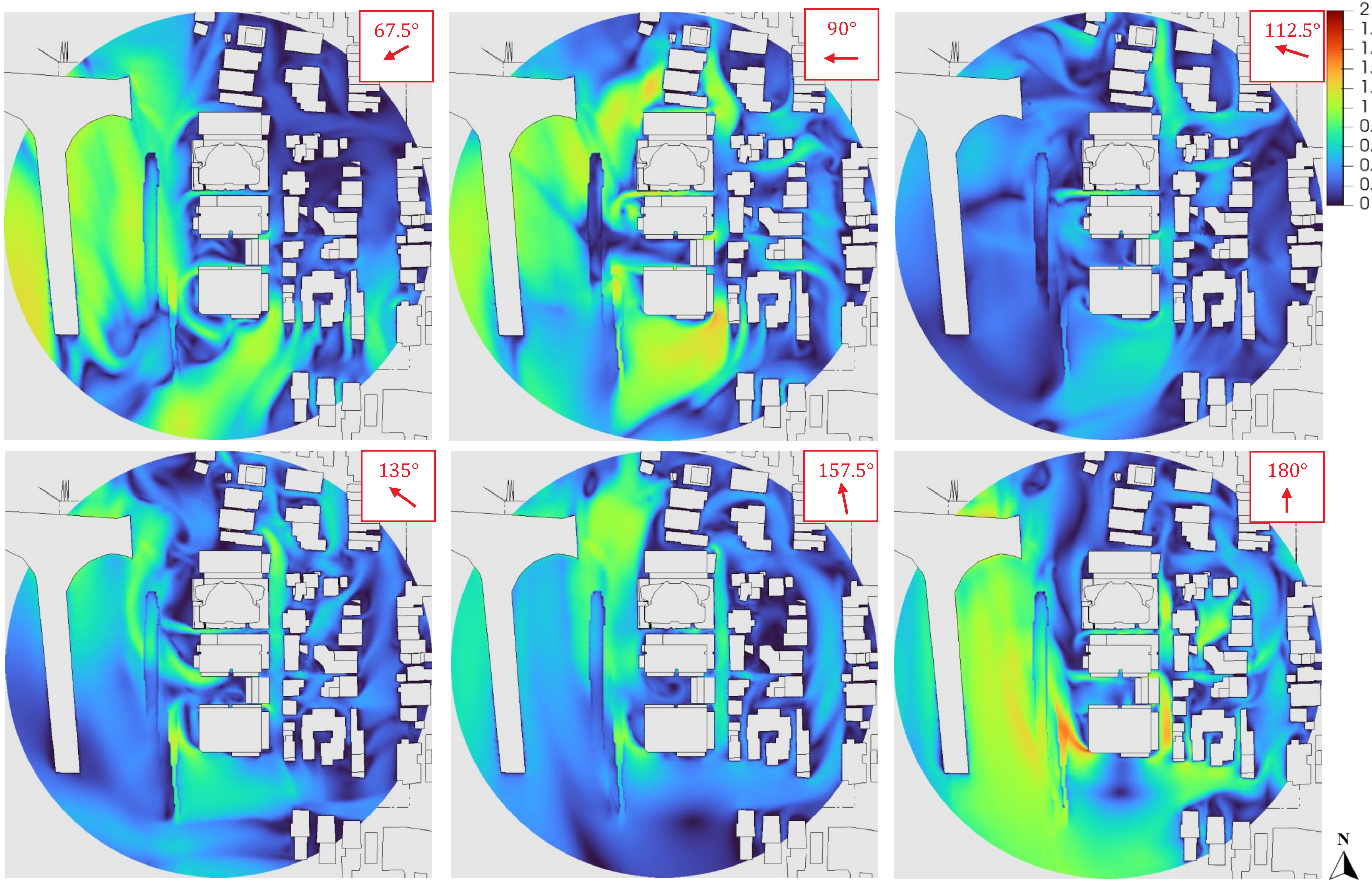
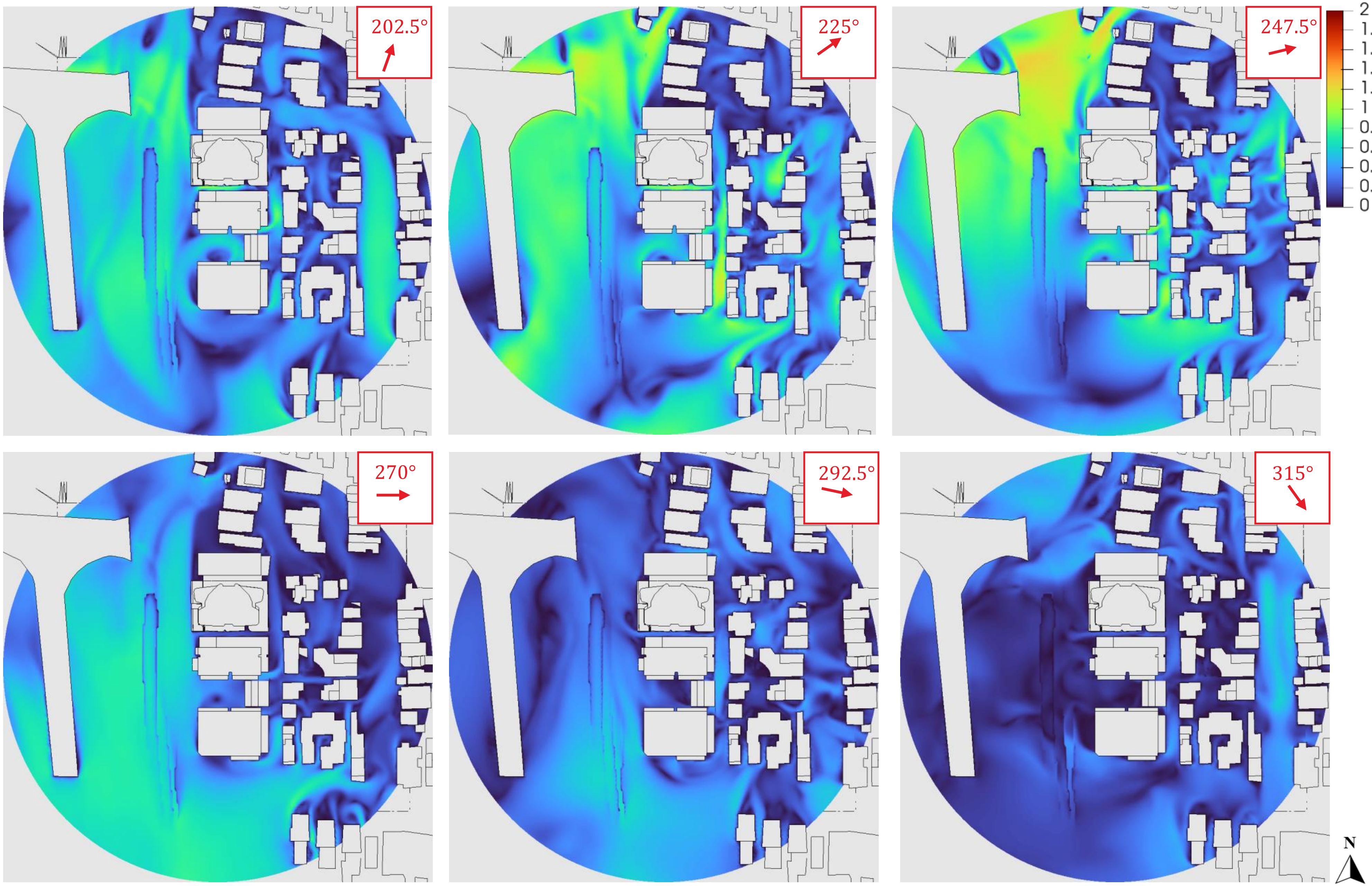
A.1 Directional results

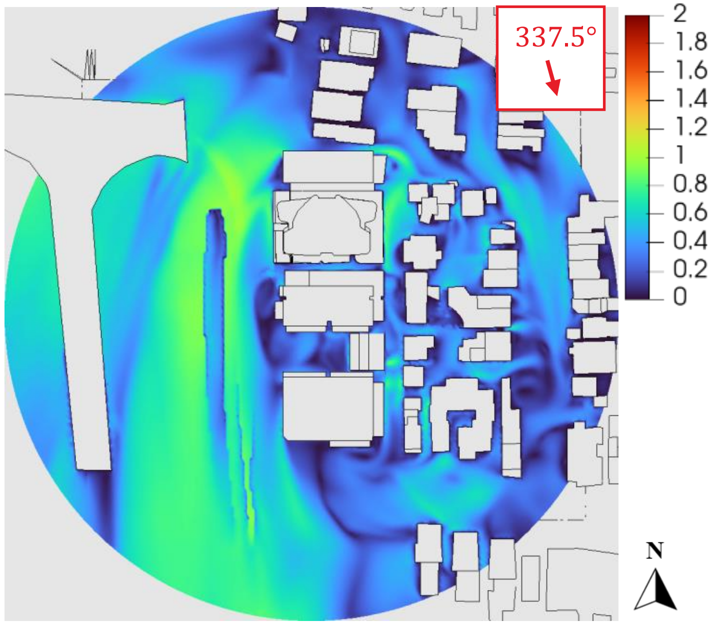
This section presents the simulation results for all 16 wind directions analysed in this environmental wind impact assessment. Each result shows the distribution of normalised velocity across the assessment area comparing wind behaviour from different directions. This normalised velocity is defined as the ratio of the local velocity at 2m height to the freestream velocity at 10 m height. The legend indicates the magnitude of the normalised velocity ranging from blue at 0 m/s representing lower wind speed region to red at 2 m/s representing higher relative wind speeds. The velocity contours are represented at the pedestrian heigh of 2 m from the local ground level.




67.5°
90°
112.5°
135°
157.5°
180°
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
N



202.5°
225°
247.5°
270°
292.5°
315°
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
N

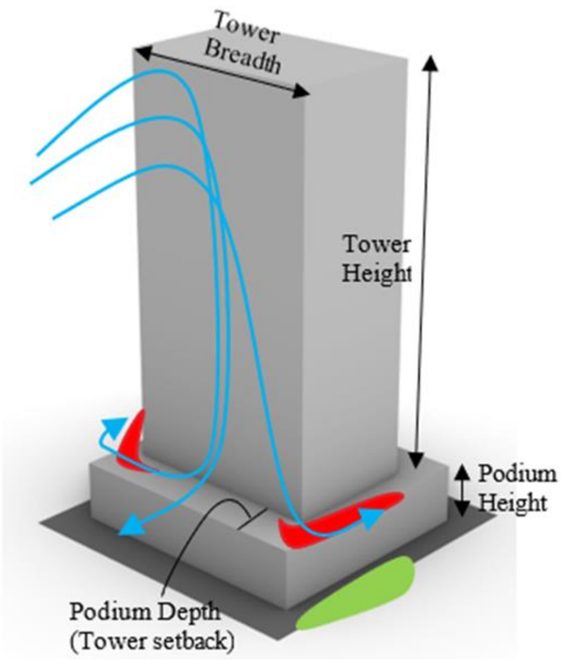


337.5°
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
N

A.2 Urban wind flow mechanism

In urban environments, the interaction between buildings and prevailing winds gives rise to several key flow mechanisms that influence pedestrian wind conditions. Among the most important are downwash, where wind is diverted downward by tall structures; channelling, which accelerates airflow through gaps between buildings; and the complex flow patterns that emerge when multiple buildings interact. Understanding these flow mechanisms is essential for the effective design and planning of comfortable and safe public spaces in city settings.

In this report, the breath of building is the horizontal dimension of the building in the windward face and depth is the building dimension along the wind.



Podium with setback

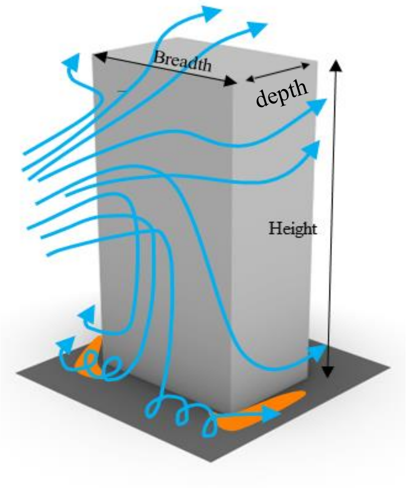
A horizontal element—such as a podium—is the most effective architectural measure to intercept and divert downwash away from ground level, but its performance depends strongly on podium depth, height, tower shape and orientation, Figure on the left. Wind-tunnel and CFD studies show podium depth controls the intensity and horizontal extent of the diverted flow, and would typically reduce peak pedestrian winds immediately around the building base.

For isolated towers, practical planning guidance often uses a horizontal setback in the order of ~8 m together with a podium of several storeys (~4 storeys) as a guideline to materially reduce ground level downwash; however, these values are site-sensitive and should not be treated as universal prescriptions.

For quick engineering guidance, one can use a pragmatic rule-of-thumb:

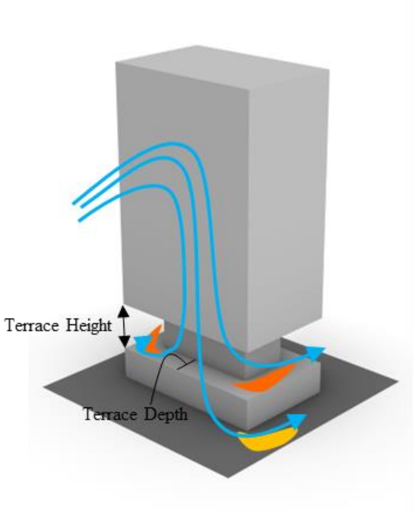
- Design tower setbacks of roughly 5–10% of tower height on windward (for example ~5–10 m for a 100 m building).
- Reduce the setback requirement towards the lower end (~5% or ~5 m) when the narrow face is presented to the prevailing wind or when corner rounding and other mitigations are also applied.
- Move it toward the upper end (~10%) when the broad face is windward with little to no mitigation measures.

In terms of the vertical position of the setback (i.e., height oof podium), a podium set too high (e.g., mid-tower) will not intercept the downwash before it descends, while a very low podium (e.g., only one storey) will deflect flow and reach the pedestrian level before getting properly dissipated and decelerated. In practice a multi-storey podium with the total height of ~10–20 m (~3–6 storeys) gives the best balance of diverting downwash.



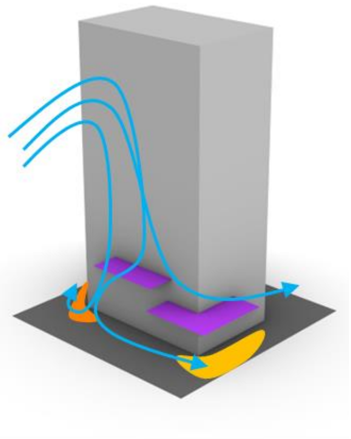
Downwash Effect

When wind approaches an isolated building, it decelerates at the windward face, producing a high-pressure region with its peak—the stagnation point—typically occurs at about two-thirds of the building height. That high-pressure "bubble" extends horizontally from the façade by roughly one-half of the building height or width, whichever is smaller. The flow then accelerates downward and around the windward corners toward lower-pressure regions; this is called downwash, and its mechanism produces the strongest winds at ground level at the windward corners and along the building sides, as shown in Figure on the left. Winds orthogonal to the building face would create the greatest downwash which would accelerate around the corners of the building. A higher building with a broader windward face tends to create more downwash flow; Therefore, where feasible, orient narrow façades to the prevailing wind to encourage predominantly horizontal flow around the building. Depending on orientation and isolation, uncomfortable downwash can be expected for buildings taller than about 6-8 storeys.



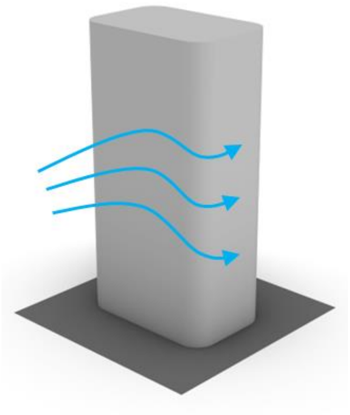
Podium without setback (inset terrace)

For the downwash mitigation to be effective, there should be a horizontal element extending from the façade that would partially block flow moving downward. A podium without tower setback (e.g., inset terrace), Figure on the left for example, is less effective than a podium with setback since it lacks a protruding component to stop air movement. however, if it is designed properly with sufficient height to depth ratio, it could be somewhat effective. The downwash reaching this space would expand into the inset terrace. For the depth of terrace to be effective, given the downwash expansion angle, the height to depth ratio of the terraces should be above 3-1. So, for example for a 4 m deep terrace, the height of the terrace should be at least 12 m. This height is to allow sufficient time for wind moving down to fill the terrace space. While this method could potentially improve wind conditions on ground level, in practice, the depth of typical terrace is designed much less than a typical podium depth, and the height to depth ratio is around 1, hence the impact is limited.



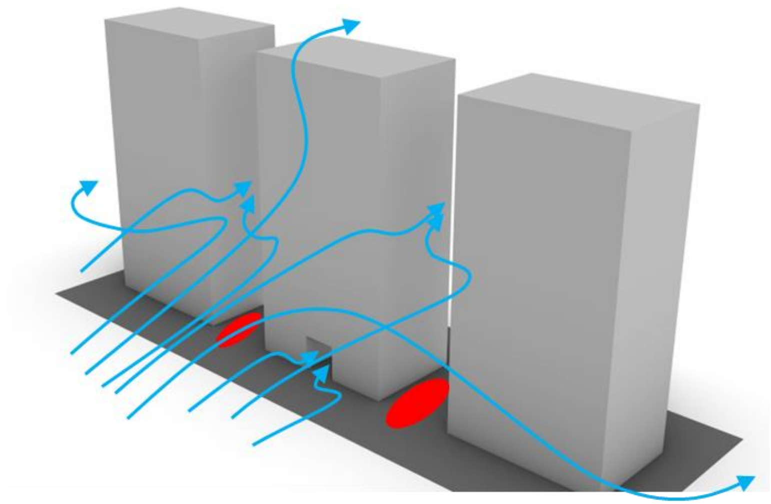
Awnings

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. 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. While awnings at the middle of the building would provide rain protection, it is typically not essential for wind protection as the wind would slow down reaching ground level. To be most effective, it is recommended that awnings wrap around the corners continuously, as shown in Figure on the left.



Rounded corners

Rounding or chamfering corners, Figure on the left, reduces downwash by encouraging the flow to pass around the building at higher levels horizontally, whereas concave curvature of the windward face can increase downwash. Rounding or chamfering corners, shown in Figure on the left, reduces downwash by encouraging the flow to pass around the building at higher levels horizontally, whereas concave curvature of the windward face can increase downwash. For rounded corners to be effective they should be at least 10% of building breadth, where breadth is the horizontal dimension of the building in windward face. While rounding the edges of building on higher elevations would encourage the flow to go horizontally around the building, having a rounded podium would create higher accelerations. This is further discussed in the following section when there are multiple buildings. Therefore, it is

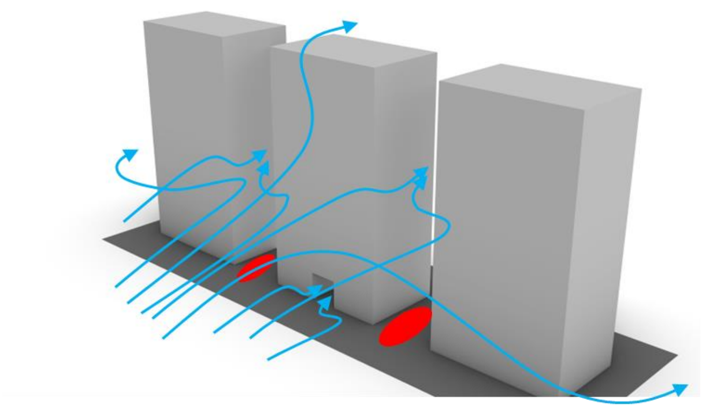


Channelling between buildings

The wind speed channelled in between buildings is highest for moderate gaps (typically around one-third to one-half of the building's breadth, rather than extremely narrow or very wide). This is because at a certain range of building separation, the corner accelerated streams from adjacent buildings would merge, forming an enhanced accelerated zone. This impact is amplified when buildings form a row, or an upwind building is much taller (those create stronger pressure differences and downwash); people feel the strongest winds along the passage centreline and at entrances/sidewalks.

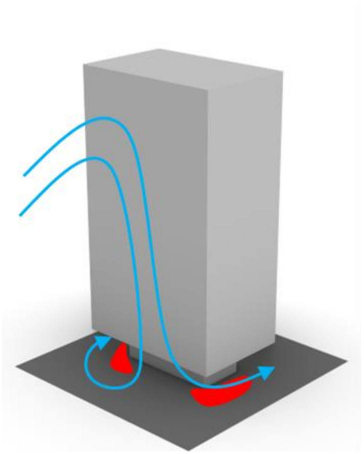
The critical separation distance, where the wind speed amplification would be highest, is dependent mainly on adjacent buildings' height and breadth. It is recommended that the separation to be outside this critical range where possible. This range is estimated using a building influence scale parameter, defined as S= $(\boldsymbol{B_l} \times \boldsymbol{B_s}^2)^{1/3}$, where in buildings with a height greater than horizontal dimension, $\boldsymbol{B_l}$ and $\boldsymbol{B_s}$ are the height and breadth of building, respectively. It is recommended that the separation distance to be outside of 0.2S to 0.6S range. For example, for a building of 100 m tall and 20 m wide:

- S is $(\mathbf{100} \times \mathbf{20^2})^{\mathbf{1/3}} \sim \mathbf{34}$ m
- The critical range to avoid would be 0.2×34 to 0.6×34 ~ 7-20 m (i.e., separation should be <7 m or >20 m).



Through-site links

Through-site links and building-through openings, Figure on the left, typically experience constant strong wind flow due to differential pressure between the openings causing wind to be funnelled through these openings. Through-site links and building-through openings, example shown in Figure on the left, typically experience constant strong wind flow due to differential pressure between the openings causing wind to be funnelled through these openings. Typically, these openings would experience higher wind speeds inside when winds come at ±45 angle to the link axis. Having a rounded entrance to form a nozzle shape entry would encourage more flow at wider directions to enter the opening, while presence of immediate upstream or downstream buildings would provide some level of blockage or back pressure, which would reduce the wind impact by changing the pressure at the opening.



Colonnades/undercrofts

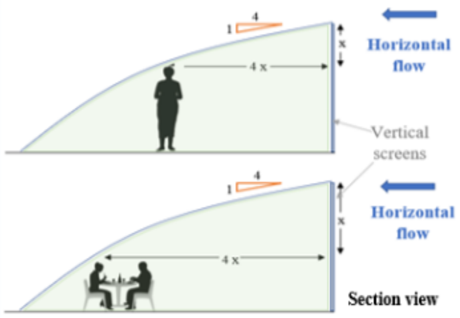
Similar to through-site links, colonnades/undercrofts at the base of a building have the potential to increase the wind speeds, due to an increase in the pressure differential, example shown in Figure on the left. A ground level recessed, rounded or chamfered corner have a similar effect as an undercroft, resulting in windier conditions. Rounding the corners of tower section at higher elevations would be a positive design feature resulting in less downwash at ground level, rounding the corners at the base would have counteractive outcome as it would increase the wind speed around the corners. This would apply for through-site links, colonnades, and channelling from between buildings. Consequently, an optimal design approach is to incorporate rounded corners on the tower section while maintaining straight edges at the base.

Vertical Screens

There are simple mitigation measures for reducing the impact of channelling flow and in general horizontally dominant wind flow patterns, including breaking the straight path with vertical screens to create a more convoluted path, landscaping planters, restricting wind flow at narrowest point, inclusion of down-stand façades (i.e., drop down screen from ceiling inside the thoroughfare), or space programming and planning decisions to move seating areas out of the jet and close to the entry, that would greatly reduce the wind impact on the public when wind is channelling in between buildings.

The wind flow patterns over a vertical barrier are illustrated in Figure below, showing that there will be a small region of calm near the windward wall and a wake region in the immediate lee of the barrier. The mean wind speed in the wake areas drops significantly compared with the incident flow. With increasing distance from the barrier, the flow starts recovering to its undisturbed state. A vertical barrier or screen would typically shield an area downstream equal to four to five times its height, when the wind is normal to the screen.

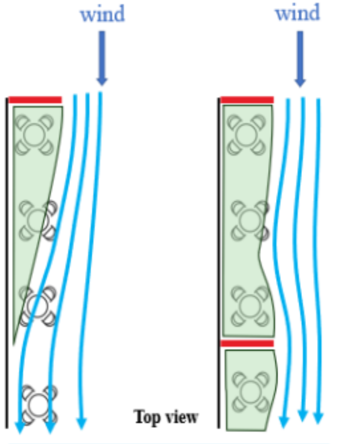
Vertical screens can provide shielding up to approximately four times their height. If the aim is to protect seated individuals, the shielding should be four times the difference between the head height and the top of the balustrade. If the balustrade is on the rooftop, given the upward wind component, this factor increases to about five and the balustrade provides more shielding. In locations with a downward wind component, such as lower-level terraces, this would reduce to three times.



For example:

Considering people sitting and standing have the heights of 1.2 m, 1.7 respectively:

A 3 m vertical screen would protect 7.2 m away for a sitting person and 5.2 m for standing person.



Staggered vertical screens, spaced at four to five times their width apart, would encourage the wind to skip and flow over them, reducing wind penetration to the designated seating area between the panels.

A.3 Wind speed criteria

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 3. 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 3. Summary of wind effects on pedestrian

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. 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:

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

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 25 and Figure 26and Figure 28. 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 26with definitions of the intended use of the space categories defined in Figure 24.

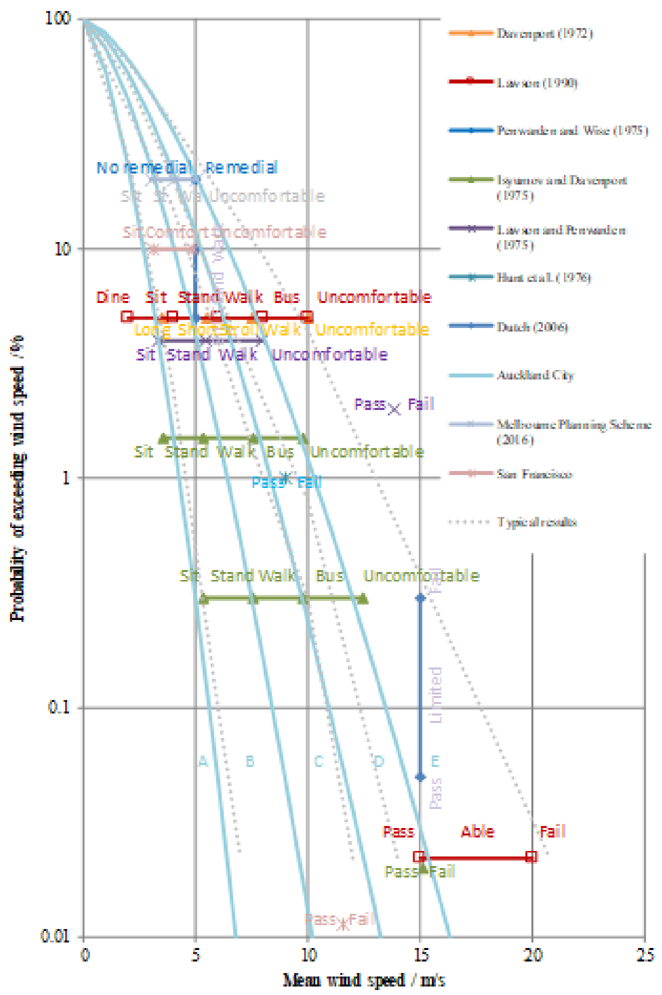


Figure 24. Probabilistic comparison between wind criteria based on mean wind speed.

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 25. Auckland Utility Plan (2016) wind categories.

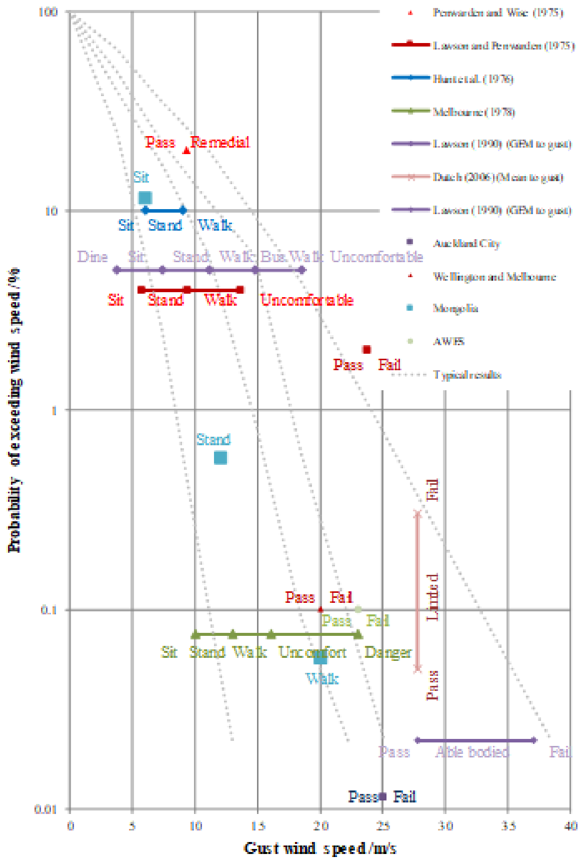


Figure 26. Probabilistic comparison between wind criteria based on 3 s gust wind speed.

A.4 Reference documents

In preparing the assessment, the following documents have been referenced to understand the building massing and features:

- 90064_271-273 Alfred Street North Sydney_02_Close Context_R8.3dm
- 90064_271-273 Alfred Street North Sydney_03_Building_R8.3dm
- 90064_271-273 Alfred Street North Sydney_07_275 Alfred Street_R8.3dm
- 260218_271-273 Alfred Street_Facade Materiality.pdf