BELMONT PARK – PRECINCT A

BURWOOD, WA

PEDESTRIAN WIND ASSESSMENT

PROJECT # 2201503
JUNE 20, 2022

SUBMITTED TO

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1. INTRODUCTION

RWDI Australia Pty Ltd (RWDI) was retained to undertake the pedestrian wind assessment for the proposed Belmont Park – Precinct A masterplan located in Burswood Peninsula, WA (aerial view of site shown in Image 1).

The site is located in the northernmost portion of the Burswood Peninsula with the Swan River foreshore wrapping around the northern boundary of the precinct and the Belmont Park Racecourse forming a boundary to the south. Further from the site, across the Swan River, are residential / commercial buildings to the north with the Perth Central Business District further to the west and the Maylands Golf Course to the east. The Optus Stadium and Crown Perth are situated further to the south of the project site.

The Precinct is part of a larger redevelopment around the Racecourse with 2-3 storey residential townhouses along the outer foreshore edge and nine towers with heights of 19 storeys atop 3-5 storey podia, as shown in Image 2. It has been assumed based on earlier design iterations of the Precinct that the retail / commercial elements are planned at the corners of the Racecourse Lot Towers facing the Boulevard with most outdoor areas planned for active pedestrian use (see Image 2). Furthermore, the tower heights and orientations are also assumed based on an earlier revision of the Precinct.

The areas of interest around the site include the general streetscape of the proposed masterplan, podium level amenities, and the retail elements within the precinct. Conceptual wind flows around the precinct are provided to identify key zones of high wind activity and to guide the design process from a wind environment perspective.

Image 1: Aerial View of the Existing Site and Surroundings
Source: Nearmap

2. SITE & BUILDING INFORMATION

Image 2: Overall Masterplan of the Development Site with Potential Commercial Locations indicated with (●)

2. METHODOLOGY

Predicting wind speeds and occurrence frequencies around a building is a complex process and involves the combined assessment of building geometry, orientation, position and height of surrounding buildings, upstream terrain and the local wind climate. Over the years, RWDI has conducted thousands of wind-tunnel model studies and CFD assessments on pedestrian wind conditions around buildings, yielding a broad knowledge base of potential flow behaviour. In some situations, this knowledge and experience, together with literature, allows for a reliable, consistent and efficient desktop estimation of pedestrian wind conditions without wind-tunnel testing during early designs of a development precinct.

The qualitative approach used for this assessment provides a screening-level estimation of potential wind conditions. Conceptual wind control measures to improve wind comfort are recommended where necessary to aid in the design process. During this early stage where the design of the precinct can change rapidly, it is highly recommended to incorporate CFD simulations to guide the design process from a wind and thermal comfort perspective. Once the design has matured, the predicted conditions can be quantified, and conceptual wind control measures can be refined further through physical scale model tests in a boundary-layer wind tunnel.

RWDI's assessment is based on the following:

- A review of the regional long-term meteorological data from Perth International Airport;
- Critical review of the updated masterplan for Precinct A received by RWDI in January 2022;
- Extensive wind-tunnel and CFD studies undertaken by RWDI for similar projects in the region;
- Our engineering judgment, experience and expert knowledge of wind flows around buildings1-3; and,
- Use of software developed by RWDI (Windestimator2) for estimating the potential wind conditions around generalised building forms.

Note that studies such as those relating to cladding and structural wind loads, door operability, building air quality, noise, vibration, etc. are not part of the scope of this assessment.

1. H. Wu, C.J. Williams, H.A. Baker and W.F. Waechter (2004), "Knowledge-based Desk-Top Analysis of Pedestrian Wind Conditions", *ASCE Structure Congress 2004,* Nashville, Tennessee.
2. H. Wu and F. Kriksic (2012). "Designing for Pedestrian Comfort in Response to Local Climate", *Journal of Wind Engineering and Industrial Aerodynamics*, vol.104-106, pp.397-407.
3. C.J. Williams, H. Wu, W.F. Waechter and H.A. Baker (1999), "Experience with Remedial Solutions to Control Pedestrian Wind Problems", *10th International Conference on Wind Engineering*, Copenhagen, Denmark.

3. METEOROLOGICAL DATA

Wind statistics recorded at Perth International Airport between 2000 and 2021 (inclusive) were used as reference for the wind conditions in the areas. The distribution of wind frequency and directionality for the summer (Nov-Apr) and winter (May-Oct) seasons are shown in Image 3.

The records indicate that winds from the northeast and south-east are predominant during the winter season with secondary winds from east and west directions. These winds can impact the outdoor thermal comfort of a precinct. During the summer season, strong inland winds from east are prevalent with winds from the southwest sector.

Strong winds of a mean speed greater than 30 km/h measured at the airport (at an anemometer height of 10 m) occur for 9% and 4.2% of the time during the summer and winter seasons, respectively. Strong winds are commonly observed during the summers and are an inland wind approaching from the east with secondary winds from southwest direction.

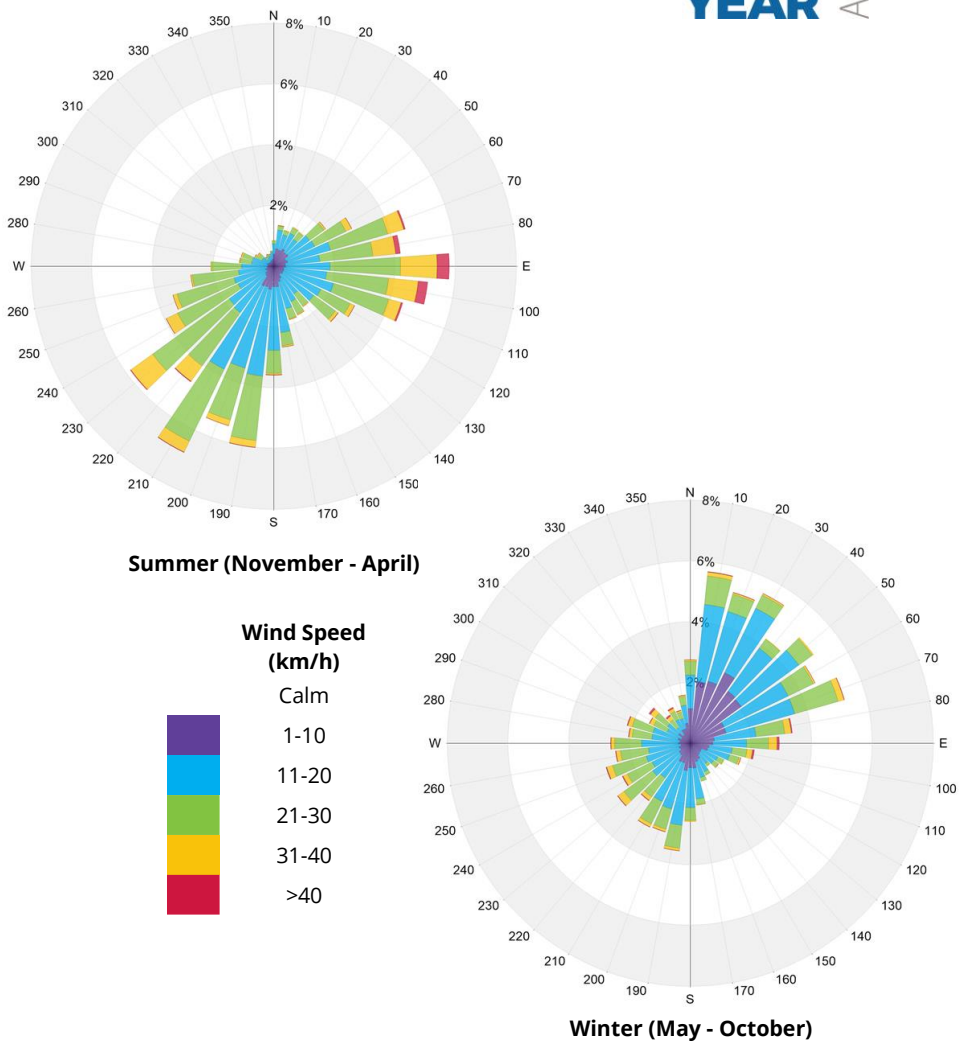


Image 3: Directional distribution of winds approaching Perth International Airport (2000 to 2021)

4. RWDI PEDESTRIAN WIND CRITERIA

4.1 Safety Criterion

Pedestrian safety is associated with excessive gusts that can adversely affect a pedestrian's balance and footing. If strong winds that can affect a person's balance (83 km/h) occur more than 0.1% of the time or 9 hours per year, the wind conditions are considered severe. These generally coincide with areas of high wind activity noted in the report.

4.2 Pedestrian Comfort Criteria

The RWDI pedestrian wind comfort criteria are used in the current study. These criteria have been developed by RWDI through research and consulting practice since 1974 and have also been widely accepted by municipal authorities, building designers and the city planning community. These are categorised based on typical pedestrian activities:

Sitting (≤ 10 km/h): Calm or light breezes desired for outdoor seating areas where one can read a paper without having it blown away.

Standing (≤ 14 km/h): Gentle breezes suitable for main building entrances and bus stops.

Strolling (≤ 17 km/h): Moderate winds that would be appropriate for window shopping and strolling along a downtown street, plaza or park.

Walking (≤ 20 km/h): Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle w/o lingering.

Uncomfortable: The comfort category for walking is not met.

Note that these wind speeds are assessed at the pedestrian height (i.e., 1.5m above ground or the concerned floor level), typically lower than those recorded at the airport (10m height and open terrain). Wind conditions are considered suitable for sitting, standing, strolling or walking if the associated mean wind speeds are expected for at least 80% of the time. Wind control measures are typically required at locations where winds are rated as uncomfortable or they exceed the wind safety criterion.

Furthermore, not that these criteria for wind forces represent average wind tolerance. These are sometimes subjective and regional differences in wind climate and thermal conditions as well as variations in age, health, clothing, etc. can also affect people's perception of the wind climate.

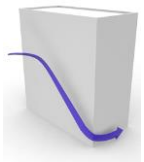
For the current development, wind speeds comfortable for walking or strolling are appropriate for sidewalks; lower wind speeds comfortable for standing are required for building entrances and bus-stops where pedestrians may linger, and calm wind speeds suitable for sitting are desired in areas where passive activities are anticipated, such as the outdoor dining and amenity terraces.

5. RESULTS AND DISCUSSION

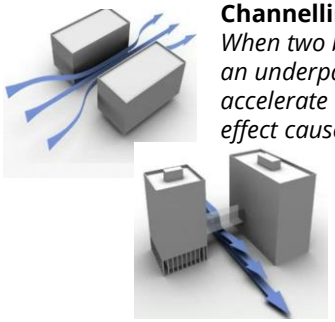
5.1 General Wind Flow around Buildings

In our discussion of wind conditions on and around the proposed development, reference may be made to the following generalised wind flows (see Image 4). If these building / wind combinations occur for prevailing winds, there is a greater potential for increased wind activity and uncomfortable or potentially unsafe conditions.

Downwashing
Tall buildings tend to intercept the stronger winds at higher elevations and redirect them to the ground level. This is often the main cause for wind accelerations around large buildings at the pedestrian level.



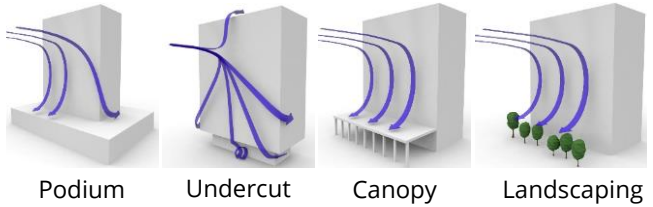
Corner Acceleration
Winds approach at an oblique angle to a tall façade and are deflected down causing a localised increase in the wind activity or corner acceleration around the exposed building corner(s) at pedestrian level.

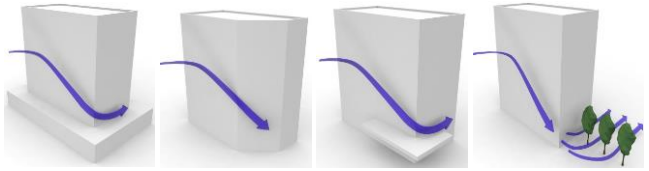


Channelling
When two buildings are situated side by side or an underpass is created, wind flow tends to accelerate through the space due to channeling effect caused by the narrow gap.

Image 4: General wind flow around buildings

Design details such as setting back a tower from the edges of a podium, deep canopies close to ground level, wind screens / tall trees with dense landscaping, etc. (Image 5) can help reduce high wind activity. The choice and effectiveness of these measures would depend on the exposure and orientation of the site with respect to the prevailing wind directions and the size and massing of the proposed buildings.





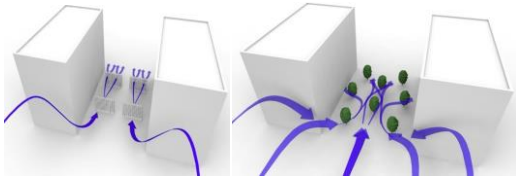


Image 5: Examples of Common Wind Control Measures

5. RESULTS AND DISCUSSION

5.2 Existing Site Conditions

The existing site is currently vacant with several walkways intended for active pedestrian use. Considering the open exposure of the site to the prevailing winds with the site located on the peninsula and the local wind climate, wind conditions in and around the existing site are likely to be comfortable for walking. The existing vegetation will likely improve wind conditions further. Winds exceeding the safety criterion are not expected.

5.3 Future Wind Conditions

The expected wind flow patterns around the precinct due to the proposed built-form interaction with the prevailing winds of the region are illustrated in Images 7-9. Given the overall height and scale of the development, high wind activity is expected in and around the Racecourse Lot Towers. These expected wind conditions are summarised in Image 10.

The areas that are likely exposed to high wind activity are marked with 'C' in the various images of the report. These areas would require mitigation measures to ensure comfort and safety of patrons. The mitigation options presented in this report will be refined further with the future wind tunnel testing planned for the proposed development site.

Primary Easterly Winds

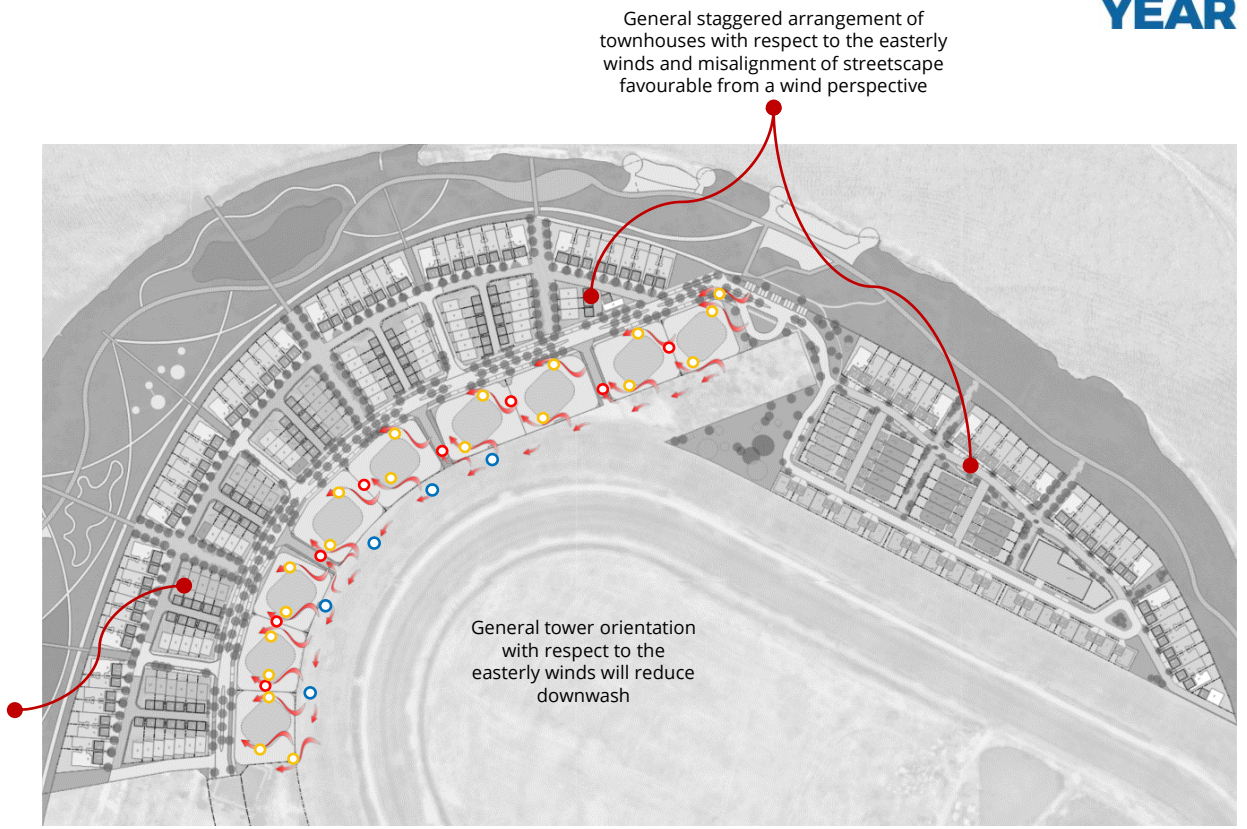
The easterly winds are the strongest and the most prevalent winds of the region. Also, these are warm inland winds that are more common during the summers and, therefore, can influence the thermal comfort of outdoor spaces within the Precinct. The expected wind interaction of the easterly winds with the Precinct is shown in Image 7.

The overall orientation of the towers is expected to reduce the likelihood of the easterly winds downwashing off the façade of the towers. In addition, the townhouses located to the west of the precinct are expected to be generally shielded from these winds due to the shielding provided by the adjacent upstream towers. The staggered arrangement of the townhouses with respect to the easterly winds is also a positive design feature that will likely improve wind conditions within the various laneways and pedestrian footpaths along the roads. The Boulevard will also be shielded from these winds due to the general arrangement of the townhouses.

However, due to the relative exposure of the towers and little upstream shielding afforded by neighbouring built-form, the winds are expected to accelerate around the various exposed corners of the buildings throughout the precinct. These winds can also channel between the tower forms creating regions of high wind activity (see Images 7 and 10). The podia of the Towers A - I may also redirect these winds along the racecourse leading to higher wind speeds along the track.

5. RESULTS AND DISCUSSION

Image 7: Expected Wind Flow Pattern Around Precinct A – Easterly Winds



5. RESULTS AND DISCUSSION

North-Easterly Winter Winds

The expected wind interactions of the north-easterly winds is shown in Image 8. The north-easterly winds are generally more prevalent during the winters and, therefore, might have an impact on the perceived outdoor thermal comfort within the Precinct.

Due to the staggered arrangement of the townhouses with respect to the north-easterly winds, calmer wind conditions are generally expected within the various laneways of the Precinct. The Boulevard will generally be shielded from higher wind speeds due to the proposed setbacks / massing and arrangement of the towers atop the podia.

However, to the north of the precinct and west of Apt Lots H & I, the north-easterly winds are expected to pick up speeds after accelerating around the corner of the podium and side-streaming along the Boulevard. Similar side-streaming is expected along the Racecourse track. The orientation of the northern towers (F-I) with these winds is also expected to result in downwash off the tower façade along the northern aspects. The narrow aspect of the exposed towers atop the podia will likely reduce the overall impact of these winds on the ground plane. However, the downwashed winds can wrap around the exposed corners and create regions of high wind activity atop the podia. These winds can then also funnel between the tower forms creating uncomfortable / unsafe wind conditions for the podia amenities (see Image 10). The towers located to the south will generally be shielded from this effect.

South-Westerly Summer Winds

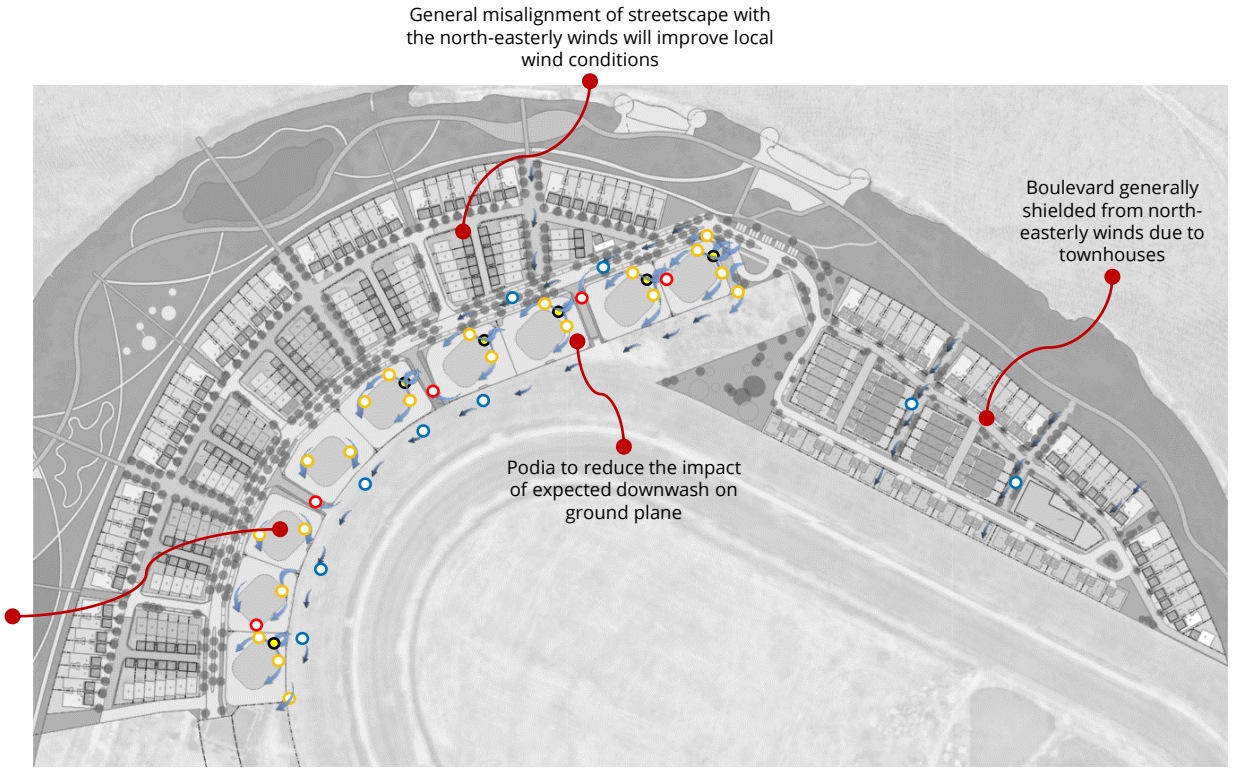
The expected wind interactions of the south-westerly winds is shown in Image 9. These winds are generally prevalent in Perth; however, the position of the Precinct upwind of the Perth Central Business District would likely reduce the impact of these winds. These winds can be beneficial for cooling during the summer period.

Noting the orientation of the southern towers (A-D) with respect to these winds, it is expected that the south-westerly winds will downwash off the tower façade along the associated southern aspects. These can create regions of high wind activity at exposed corners and funnel through the tower forms creating uncomfortable / unsafe wind regions atop the podia. These accelerated winds are expected to impact the podia level amenities. The northern towers (E-I) are expected to be shielded from this effect. However, the winds can accelerate around the exposed corners of these towers.

The majority of the townhouses and links will be shielded from these winds due to the adjacent tower forms as well as the general misalignment of the winds with the streetscape. However, the southern part of the Boulevard will likely be exposed to higher winds as these wrap around the podium. The south-westerly winds can also side-stream along the eastern front of the tower block and impact the Racecourse track as indicated in Image 9.

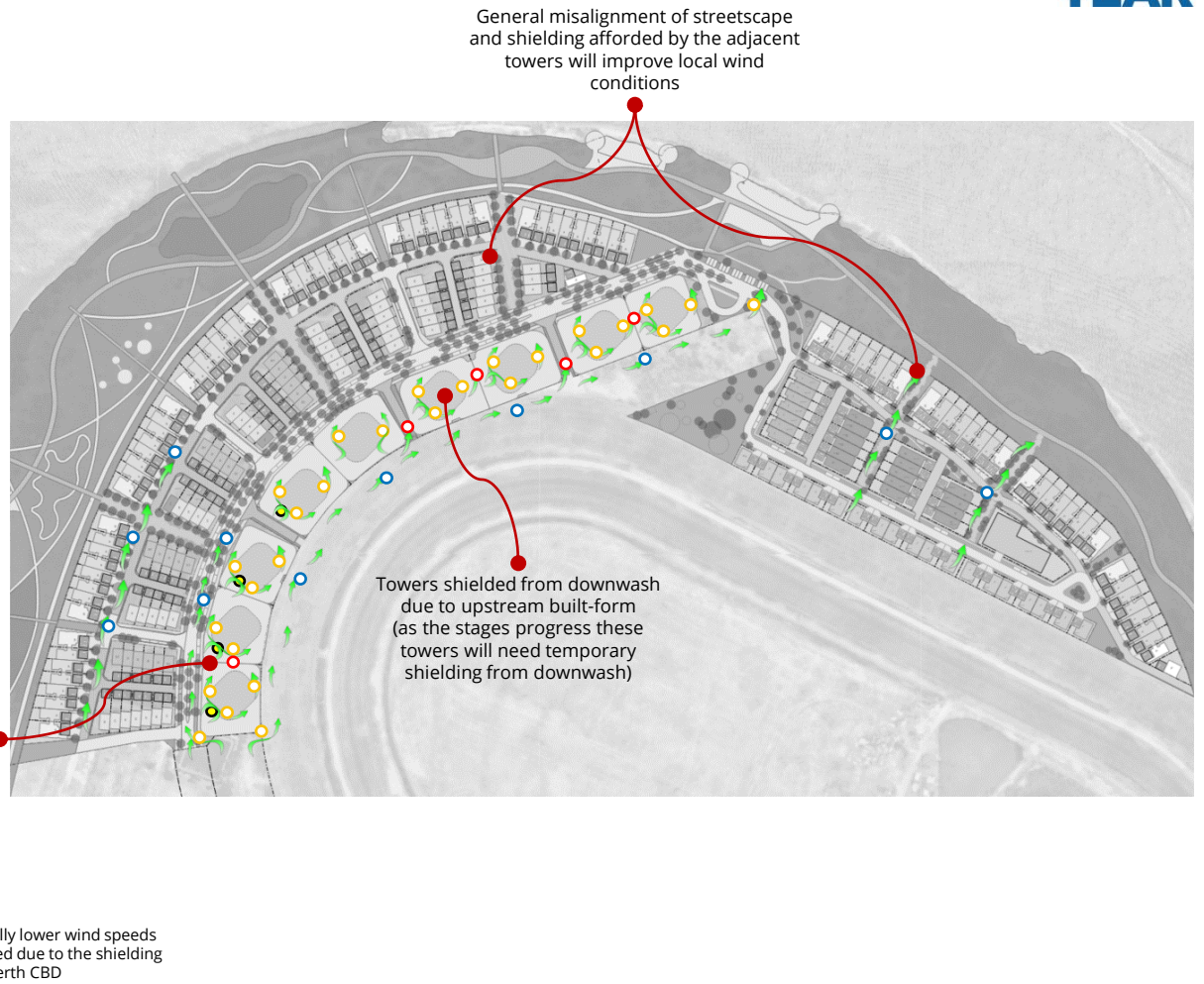
5. RESULTS AND DISCUSSION

Image 8: Expected Wind Flow Pattern Around Precinct A – North-Easterly Winds



5. RESULTS AND DISCUSSION

Image 9: Expected Wind Flow Pattern Around Precinct A – South-Westerly Winds



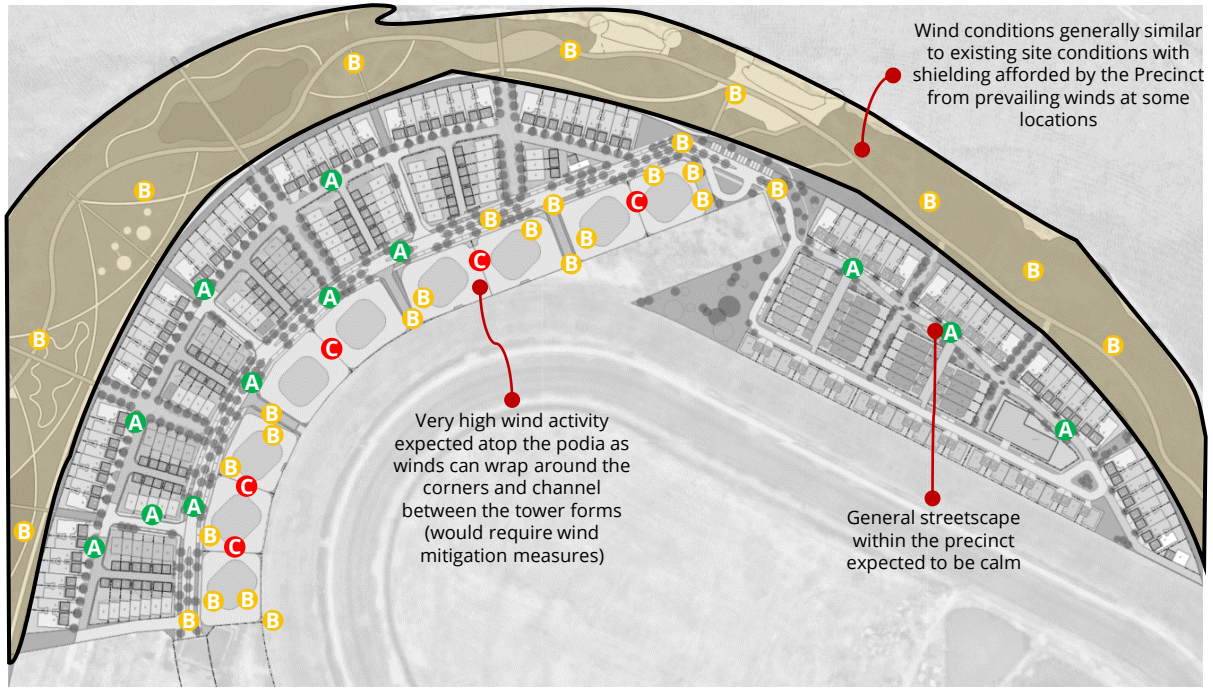
5. RESULTS AND DISCUSSION

Image 10: Expected Wind Activity Around Precinct A

A — Low – Moderate wind activity expected. Likely to be suitable for sitting or standing (e.g., outdoor seating, entrances to buildings etc.)

B — Moderate - High wind activity expected. Likely to be suitable for Strolling and Walking (e.g., pedestrian areas).

C — Very High Wind Activity. Not suitable for pedestrian use, likely unsafe.



6. DESIGN RECOMMENDATIONS

Ground Level

Given the previous discussions and summary of wind conditions presented in Image 10, it is anticipated that most areas around the site on ground level and along the various links and roads of precinct will be suitable for sitting and standing use with some localised areas suitable for active pedestrian use. Trees with dense undergrowth and interlocking canopies not only improve wind conditions in their immediate vicinity and further downstream but also provide relief from sun exposure. These are recommended along the various streetscapes and footpaths to ensure a comfortable microclimate within the Precinct.

It is noted from the analysis that wind conditions at the exposed corners of the podia will generally be uncomfortable for passive pedestrian use such as outdoor dining and café seating. It is recommended to relocate these retail elements away from the corners and closer to the center of the podia where these will be more shielded from the prevailing winds. Inclusion of wrap-around awnings or dense vegetation (green islands) along the corners of the podia are recommended as these will considerably improve the local wind conditions in these areas and further downstream along the Boulevard. Similarly, it is recommended to locate the primary entrances to the apartments along the Boulevard and towards the center of the podia. Recessing the entrances within the podia with vegetation around to buffer the winds is also recommended to ensure comfortable wind conditions.

Podia Amenities

The wind conditions noted on top of the podia will generally benefit from additional mitigation measures including the use of extensive landscaping and screening interspersed within the space and particularly around any outdoor seating proposed here. Image 11 shows concepts of various wind mitigation measures that should be considered during the early design stage. The orientation and detailing of these elements can be refined further as part of the detailed design stage.

Wrap-around awnings are also recommended for the towers to reduce the impact of downwash at the following locations:

- Along the southern aspect: Towers A-D
- Along the norther aspect: Towers A and E-I.

Private Terraces

It is generally recommended to include inset balconies for all towers to ensure comfortable wind conditions in these spaces. Corner balconies are generally susceptible to winds accelerating around these spaces due to pressure-driven flows. If corner balconies are planned, it is recommended to include screening along at least one of the exposed aspects of these balconies or to incorporate 1.5m high impermeable balustrades around the perimeter of the balconies.

6. DESIGN RECOMMENDATIONS

Perimeter screening and vegetation on terraces

Localised louvers screening around seating areas

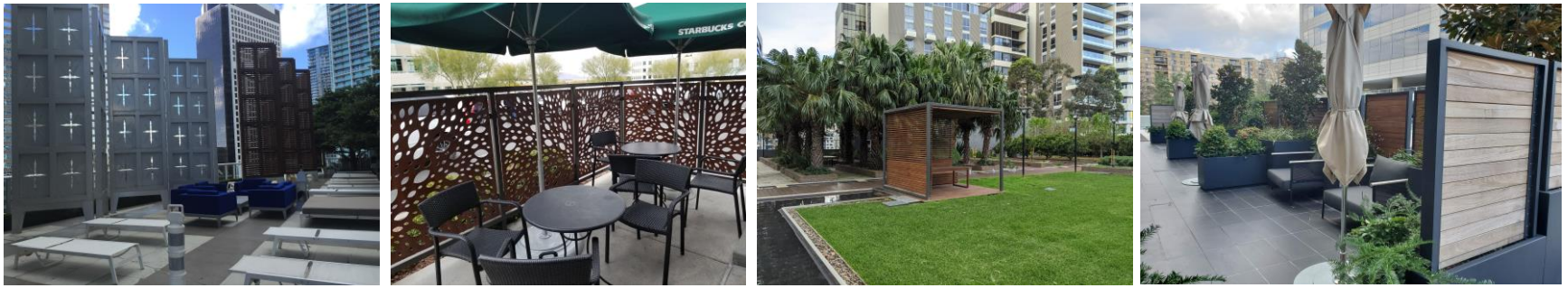


Image 12: Examples of Wind Control Measures

6. SUMMARY

Wind conditions on and around the proposed Belmont Park – Precinct A masterplan located in Burswood Peninsula are discussed in this report. The qualitative assessment is based on the review of local wind climate and the current design of the proposed precinct. The impact of the surrounding buildings (including future proposed buildings) and the local land topography has also been considered. The assessment is based on our experience with wind tunnel testing and CFD analysis of similar buildings within the region.

Conceptual wind flows around the Precinct are discussed in the report for the prevailing wind directions to identify key wind sensitive areas within the Precinct. General design advice in the form of conceptual mitigation measures is also presented. It is to be noted that the mitigation options discussed in this report are based on the assumptions and flow activity noted here. These will be refined further once the design and programming of the Precinct has advanced further.

7. APPLICABILITY OF ASSESSMENT

The assessment discussed in this report pertains to the proposed development in accordance with the drawings and information received in June 2022. In the event of any significant changes to the design, construction or operation of the building or addition of surroundings in the future, RWDI could provide an assessment of their impact on the wind conditions discussed in this report. It is the responsibility of others to contact RWDI to initiate this process.

Statement of Limitations

This report entitled Pedestrian Wind Assessment, dated June 20, 2022 was prepared by RWDI Australia Pty Ltd ("RWDI"). The findings and conclusions presented in this report have been prepared for the Client and are specific to the project described herein ("Project"). The conclusions and recommendations contained in this report are based on the information available to RWDI when this report was prepared. Because the contents of this report may not reflect the final design of the Project or subsequent changes made after the date of this report, RWDI recommends that it be retained by Client during the final stages of the project to verify that the results and recommendations provided in this report have been correctly interpreted in the final design of the Project.

The conclusions and recommendations contained in this report have also been made for the specific purpose(s) set out herein. Should the Client or any other third party utilize the report and/or implement the conclusions and recommendations contained therein for any other purpose or project without the involvement of RWDI, the Client or such third party assumes any and all risk of any and all consequences arising from such use and RWDI accepts no responsibility for any liability, loss, or damage of any kind suffered by Client or any other third party arising therefrom.

Finally, it is imperative that the Client and/or any party relying on the conclusions and recommendations in this report carefully review the stated assumptions contained herein and to understand the different factors which may impact the conclusions and recommendations provided.