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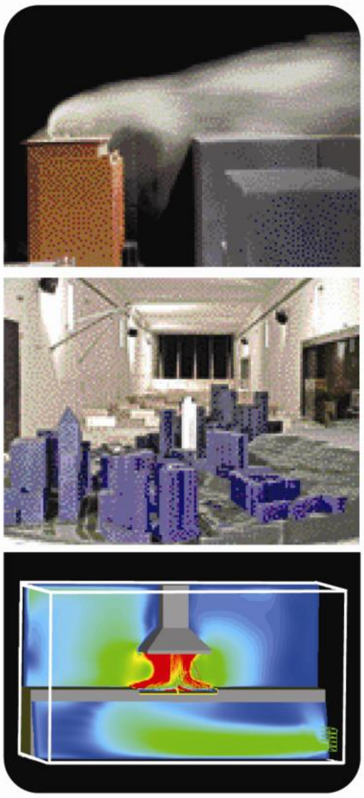
WIND ENGINEERING AND AIR QUALITY CONSULTANTS

FINAL REPORT

Revision 2



Wind Assessment for:

IVANHOE ESTATE

Macquarie Park, NSW, Australia

Frasers Property Ivanhoe
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Level 23, 6 O'Connell Street
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CPP Project 11743

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Executive Summary

This report provides an opinion based qualitative assessment of the impact of the proposed Ivanhoe Estate masterplan on the local pedestrian-level wind environment. This assessment is based on knowledge of the local wind climate.

With reference to the City of Ryde DCP criteria, the environmental wind conditions around the proposed development are expected to be suitable for pedestrian walking from a comfort perspective and pass the safety criterion. The pattern of the proposed buildings is expected to encourage channelling of winds through the main roads throughout the precinct.

DOCUMENT VERIFICATION

Date	Revision	Prepared by	Checked by	Approved by
12/10/2017	Initial release	JP	PB	PB
4/12/2017	Updated drawings	CR	CR	CR
12/12/2017	Minor revisions	CR	CR	CR

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Introduction

Cermak Peterka Petersen Pty. Ltd. has been engaged by Frasers Property Ivanhoe to provide an opinion based assessment of the impact of the proposed Ivanhoe Estate masterplan on the local wind environment. The site of approximately 400 m by 200 m is located in Macquarie Park on the southern side of Herring Road and the eastern side of Epping Road, approximately 400 m south of Macquarie University campus, Figure 1. The surrounding area is dominated by low- to medium-rise buildings, with the towers of Macquarie Park Village directly to the north-west being of similar height to the proposed development. The site is proposed to be developed in 8 stages and to include mixed-use primarily residential buildings 8-24 storeys height, Figure 2 and Figure 3.

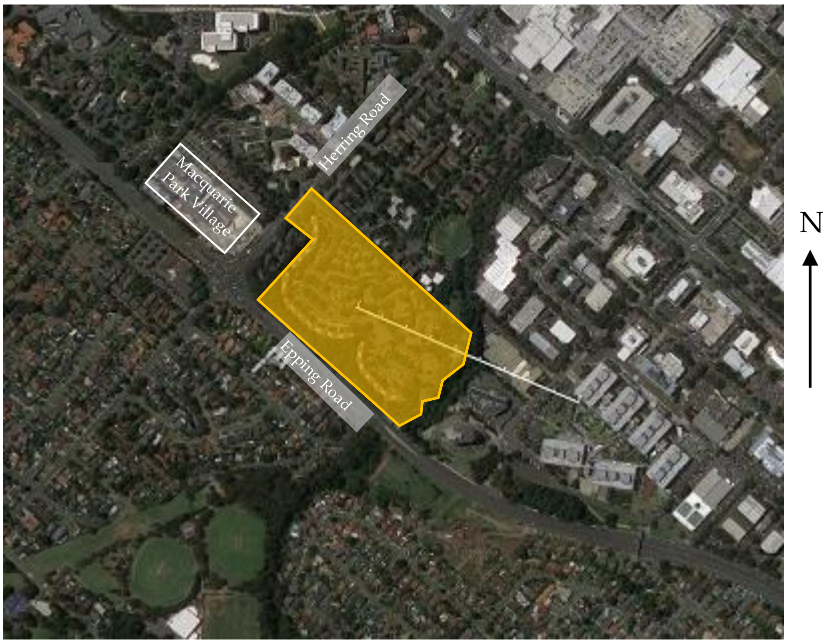


Figure 1: Aerial view with proposed development site highlighted (Google Earth, 2017)

Figure 2: Masterplan of the proposed development
(Frasers Property Ivanhoe, 2017)

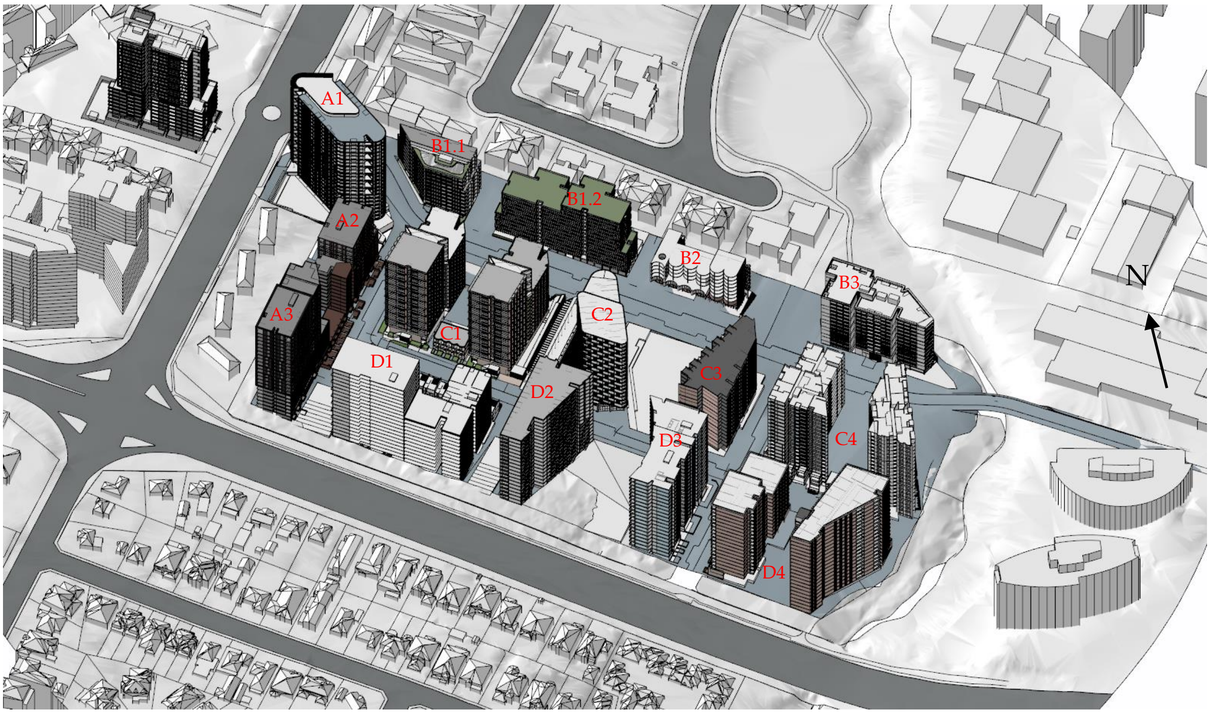


Figure 3: 3d sketch of the masterplan of the proposed development
(Frasers Property Ivanhoe, 2017)

Macquarie Park Wind Climate

The proposed development is located about 19 km to the north of the Bankstown Airport Bureau of Meteorology anemometer and 21 km to the north-west of the Sydney Airport anemometer. The general wind roses for Bankstown and Sydney Airports are presented in Figure 4. In coastal Sydney, winds from the north-east tend to be summer sea breezes and bring welcome relief on summer days, but dissipate with distance from the coast and are significantly diminished at Bankstown. In terms of distance from the coast, the site is located approximately halfway between the two airports. For this development, a superstation has been created by analysing data at both stations from 1995-2016 and performing statistics on the extended dataset. The result of this analysis is indicated in Figure 4.

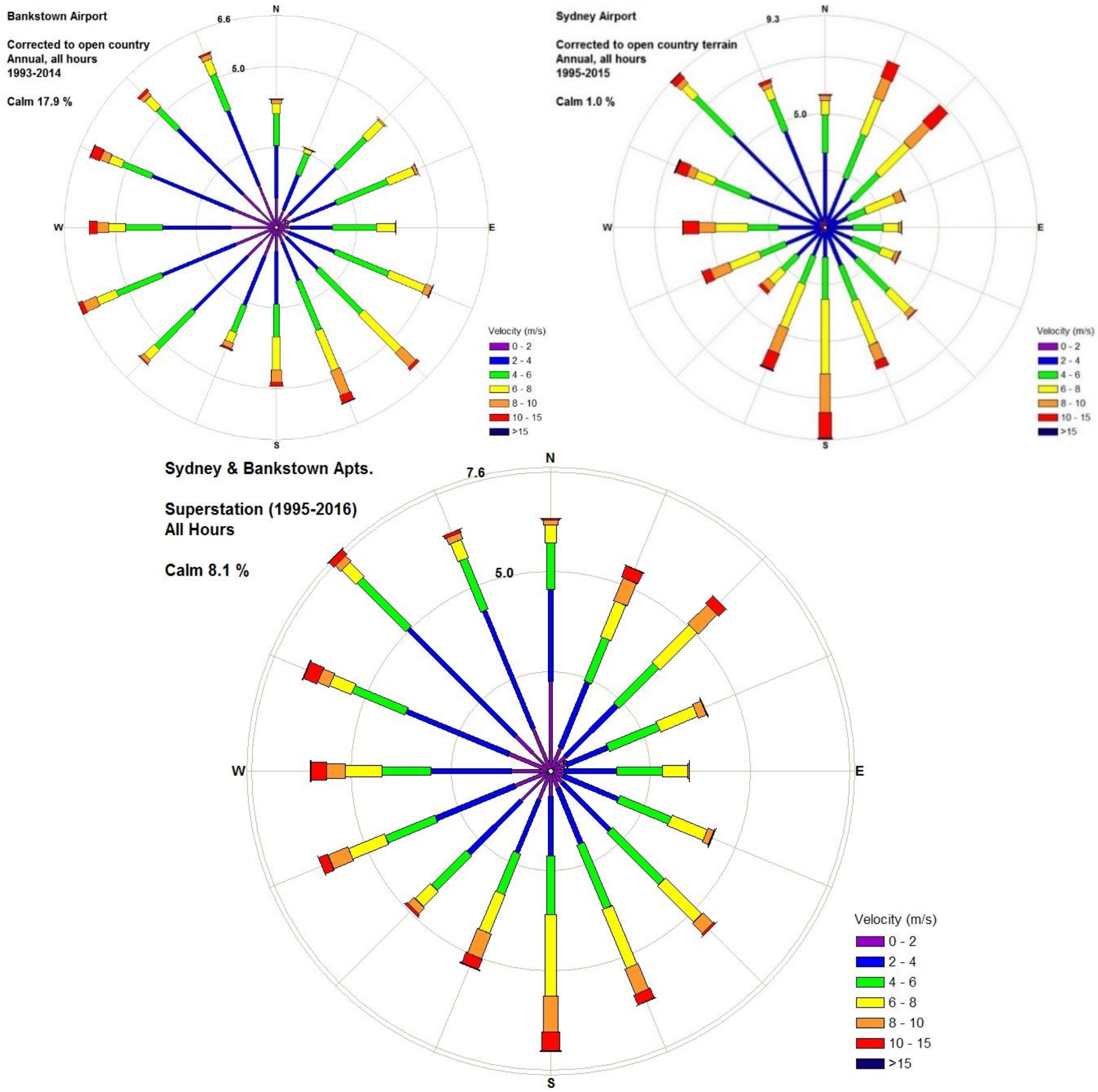


Figure 4: Wind roses for Bankstown and Sydney Airports (top), and superstation (bottom)

Winds from the south-east, which tend to be cold, are often caused by frontal systems that can last several days and occur throughout the year with reduced frequency in winter. Winds from the west tend to be the strongest of the year and are associated with large weather patterns and thunderstorm activity. These winds occur throughout the year, but are reduced in frequency in summer, and can be cold or warm depending on the inland conditions. The prevailing wind directions associated with rain are from the south and west quadrants. This wind assessment is focused on these prevailing wind directions. Seasonal wind roses for Bankstown Airport are presented in Appendix 1.

Environmental Wind Speed Criteria

It is generally accepted that wind speed and the rate of change of wind velocity are the primary parameters that should be used in the assessment of how wind affects pedestrians. Local wind effects can be assessed with respect to a number of environmental wind speed criteria established by various researchers. 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 remarkably good agreement.

The City of Ryde 2014 development control plan (DCP) has specific wind assessment criteria for the Macquarie Park Corridor based on the maximum allowable wind velocities stating: *Buildings shall not create uncomfortable or unsafe wind conditions in the public domain, which exceeds the Acceptable Criteria for Environmental Wind Conditions.* The specified acceptable criteria are described in Table 1 for both pedestrian comfort and distress, and they appear to be derived from the criteria developed by Davenport (1972) and Melbourne (1978). The DCP criteria require the use of both a mean and gust equivalent mean (GEM) wind speed to assess the suitability of specific locations, as well as an annual maximum gust wind speed. The criteria based on the mean wind speeds define when the steady component of the wind causes discomfort, whereas the GEM wind speeds define when the wind gusts cause discomfort. For outdoor dining type activities, a more stringent criterion would be required. The annual maximum gust wind speed of 23 m/s is understood to be a safety criterion as defined by Melbourne (1978), although the necessity for directionality is not included. The gust wind speed may be suitable for safety considerations, but not necessarily for serviceability comfort issues. 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. Therefore, the weekly criteria defined in the DCP are considered most adequate to assess pedestrian comfort. It is noted that the DCP requires a wind tunnel study to be conducted for buildings over 9 storeys in height.

From a wind perspective, Bankstown Airport is relatively mild, with an average wind speed at 10 m reference height of approximately 3.7 m/s (6 kt, 11 kph), and five percent of the time the mean wind speed is approximately 9.1 m/s (17 kt, 31 kph). Converting the five percent of the time mean wind speed to typical pedestrian level at the site using Standards Australia (2011) would result in about 5.8 m/s (11 kt, 20 kph). Comparing this with the comfort criteria of Table 1 indicates that pre-existing winds at any comparable location with a similar built environment surrounding the proposed development site would be classified as acceptable for footpaths and pedestrian walkways. Specific building massing of the proposed development and their interaction with approaching wind flows will dictate the actual wind environment at the site and the resulting wind acceptability levels; these are explored in detail below.

Table 1: Pedestrian comfort criteria for various activities as defined in the DCP

Weekly maximum wind speed (understood as the maximum hourly mean wind speed exceeded 5% of the time as defined by Davenport (1972))	
< 3.5 m/s	Outdoor dining, amphitheatres etc. (sitting activities, long exposure)
3.5 – 5.5 m/s	Retail centres and streets, parks and recreational areas (standing activities)
5.5 – 7.5 m/s	Footpaths and pedestrian accessways (walking)
7.5 – 10 m/s	Infrequently used laneways, private balconies
Annual maximum gust wind speed (understood as the maximum gust wind speed exceeded in an hour for 0.1% of the time as defined by Melbourne (1978))	
< 10/13 m/s	Outdoor dining, amphitheatres etc. (sitting activities, long exposure)
10 – 13 m/s	Retail centres and streets, parks and recreational areas (standing activities, short exposure)
13 – 16 m/s	Footpaths and pedestrian accessways (walking)
16 – 23 m/s	Infrequently used laneways, private balconies

The weekly maximum wind speed is either a mean wind speed or a gust equivalent mean (GEM) wind speed. The GEM wind speed is equal to the 3 s gust wind speed divided by a gust factor, usually defined as 1.85.

Wind Flow Mechanisms

When wind hits a large isolated building, it is accelerated down and around the windward corners, as shown in Figure 5; this flow mechanism is called downwash. In Figure 5 smoke is being released into the wind flow to allow the wind speed, turbulence, and direction to be visualised. The image on the left shows smoke being released across the windward face, and the image on the right shows smoke being released into the flow at about third height in the centre of the face. Downwash will be a primary driving mechanism influencing the wind environment for this development. Figure 5 also shows that the wind at mid and upper levels on a building can accelerate substantially round the corners. When balconies are located on these corners they may be breezy, Figure 6(L), and used less by the owner than intended. However, if the balconies are large enough, articulated, or have partition privacy fins then areas of local calmer conditions may exist. Owners quickly become familiar with when and how to use their balconies.

Channelling occurs when the wind is accelerated between two buildings, or along straight streets with buildings on either side, Figure 6(R).

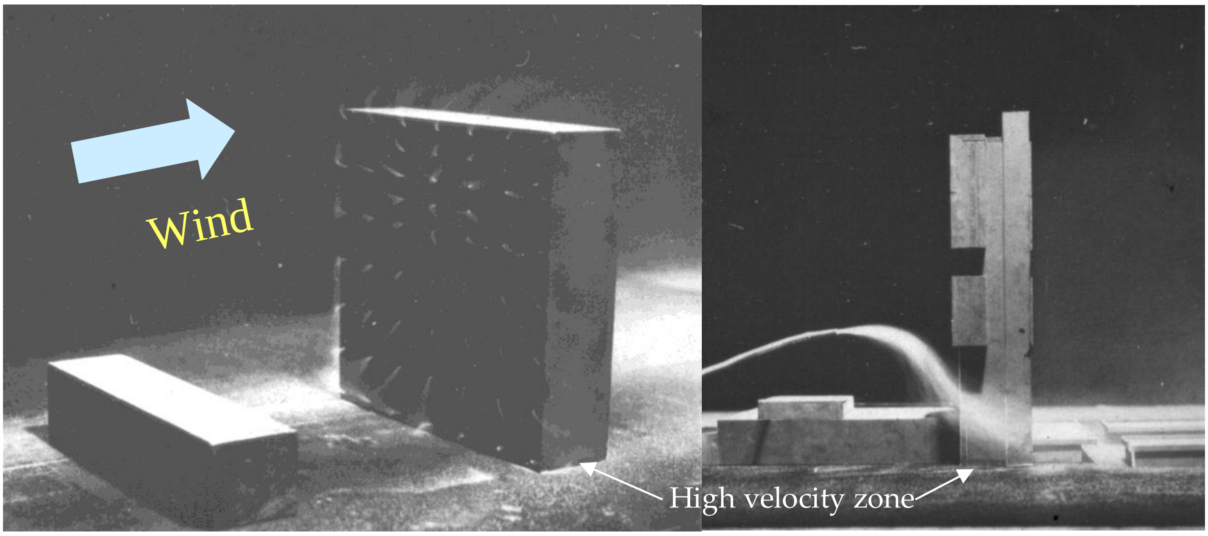


Figure 5: Flow visualisation around a tall building

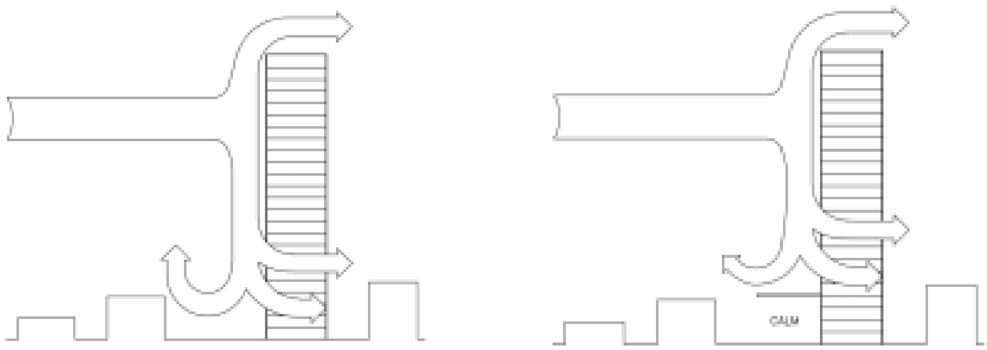
Figure 6: Visualisation through corner balconies (L) and channelling between buildings (R)

Wind Impact Planning Guidelines

It is well known that the design of a building will influence the quality of the ambient wind environment at its base. Below are some suggested wind mitigation strategies that should be adopted into precinct planning guidelines and controls (see also Cochran, 2004).

Building form - Canopies

A large canopy may interrupt the flow as it moves down the windward face of the building. This will protect the entrances and sidewalk area by deflecting the downwash at the second storey level, Figure 7. However, this approach may have the effect of transferring the breezy conditions to the other side of the street. Large canopies are a common feature near the main entrances of major office buildings.



Downwash to street level may generate windy conditions for pedestrians. This is particularly true for buildings much taller than the surrounding buildings.

A large canopy is a common solution to this pedestrian-wind problem at street level.

Figure 7: Canopy Windbreak Treatment.

Building form - Podiums

The architect may elect to use an extensive podium for the same purpose if there is sufficient land and it complies with the design mandate, Figure 8. This is a common architectural feature for many major projects in recent years, but it may be counterproductive if the architect wishes to use the podium roof for long-term pedestrian activities, such as a pool or tennis court.

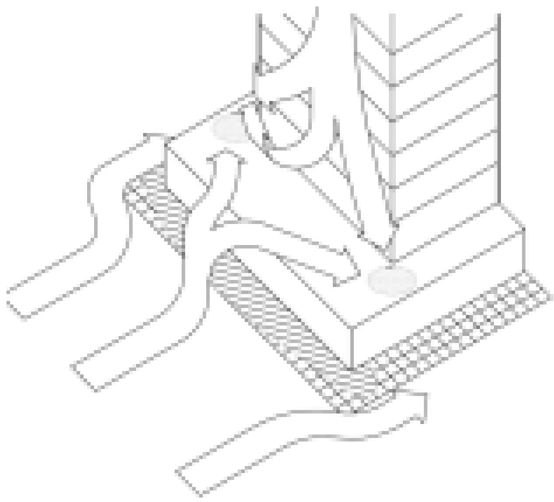


Figure 8: The tower-on-podium massing often results in reasonable conditions at ground level, but the podium may not be useable.

Building form - Arcades

Another massing issue, which may be a cause of strong ground-level winds, is an arcade or thoroughfare opening from one side of the building to the other. This effectively connects a positive pressure region on the windward side with a negative pressure region on the lee side; a strong flow through the opening often results, Figure 9. The uninvitingly windy nature of these open areas is a contributing reason behind the use of arcade airlock entrances (revolving or double sliding doors).

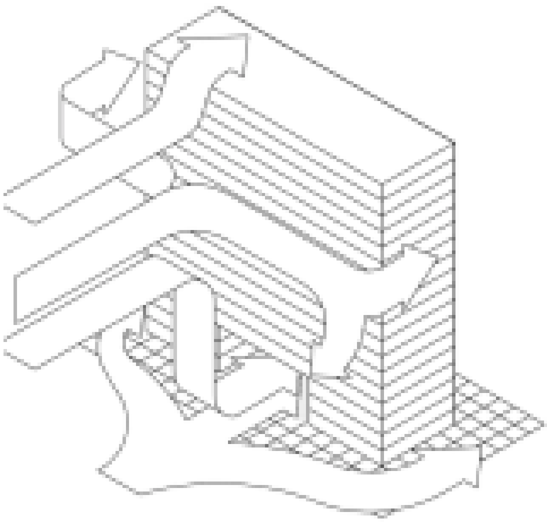
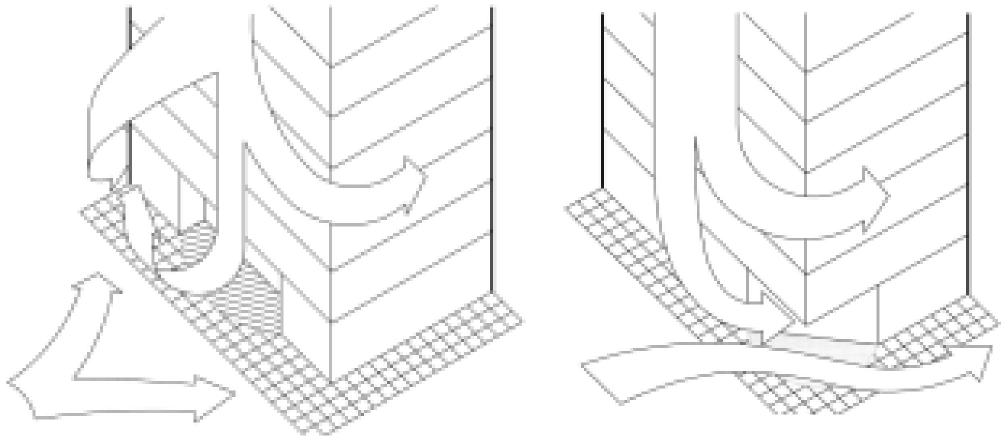


Figure 9: An arcade or open column plaza under a building frequently generates strong pedestrian wind conditions.

Building form - Alcove

An entrance alcove behind the building line will generally produce a calmer entrance area at a mid-building location, Figure 10. In some cases, a canopy may not be necessary with this scenario, depending on the local geometry and directional wind characteristics. The same undercut design at a building corner is usually quite unsuccessful, Figure 10. This is due to the accelerated flow mechanism described in Figure 5 and the ambient directional wind statistics. If there is a strong directional wind preference, and the corner door is shielded from those common stronger winds, then the corner entrance may work. However, it is more common for a corner entrance to be adversely impacted by this local building geometry. The result can range from simply unpleasant conditions to a frequent inability to open the doors.



A mid-building alcove entrance usually results in an inviting and calm location.

Accelerated corner flow from downwash often yields an unpleasant entrance area.

Figure 10: Alcove Windbreak Treatment.

Building form –façade profile and balconies

The way in which a building's vertical line is broken up may also have an impact. For example, if the floor plans have a decreasing area with increased height the flow down the stepped windward face may be greatly diminished. To a lesser extent the presence of many balconies can have a similar impact on ground level winds, although this is far less certain and more geometry dependent. Apartment designs with many elevated balconies and terrace areas near building ends or corners often attract a windy environment to those locations. Mid-building balconies, on the broad face, are usually a lot calmer, especially if they are recessed. Corner balconies are generally a lot windier and so the owner is likely to be selective about when the balcony is used or endeavours to find a protected portion of the balcony that allows more frequent use, even when the wind is blowing.

Use of Canopies, Trellises and High Canopy Foliage

Downwash Mitigation - As noted earlier, downwash off a tower may be deflected away from ground-level pedestrian areas by large canopies or podium blocks. The downwash then effectively impacts the canopy or podium roof rather than the public areas at the base of the tower, Figure 8. Provided that the podium roof area is not intended for long-term recreational use (e.g. swimming pool or tennis court), this massing method is typically quite successful. However, some large recreational areas may need the wind to be deflected away without blocking the sun (e.g. a pool deck), and so a large canopy is not an option. Downwash deflected over expansive decks like these may often be improved by installing elevated trellis structures or a dense network of trees to create a high, bushy canopy over the long-term recreational areas. Various architecturally acceptable ideas may be explored in the wind tunnel prior to any major financial commitment on the project site.

Horizontally accelerated flows between two tall towers, Figure 6(R), may cause an unpleasant, windy, ground-level pedestrian environment, which could also be locally aggravated by ground topography. Horizontally accelerated flows that create a windy environment are best dealt with by using vertical porous screens or substantial landscaping. Large hedges, bushes or other porous media serve to retard the flow and absorb the energy produced by the wind. A solidity ratio (i.e. proportion of solid area to total area) of about 60-70% has been shown to be most effective in reducing the flow's momentum. These physical changes to the pedestrian areas are most easily evaluated by a model study in a boundary-layer wind tunnel.

Environmental Wind Assessment

The proposed developments in the precinct include buildings of up to 24 storeys in height, which are taller than most of the surrounding buildings, Figure 3. The precinct is primarily surrounded by low-rise buildings with the exception of several towers of similar height to the north-west, Figure 1 and Figure 3. The site has significant slope of approximately 23 m rising from the south-east to the north-west side of the site, Figure 11.

The buildings in the precinct are arranged in a relatively regular pattern, Figure 2, and the majority do not present any horizontal articulation with height, such as podia and building setbacks. A number of the buildings will adopt negative setbacks, as per the Masterplan Design Guidelines authored by Bates Smart, Figure 12.

Figure 11: Section of the proposed masterplan (Frasers Property Ivanhoe, 2017)

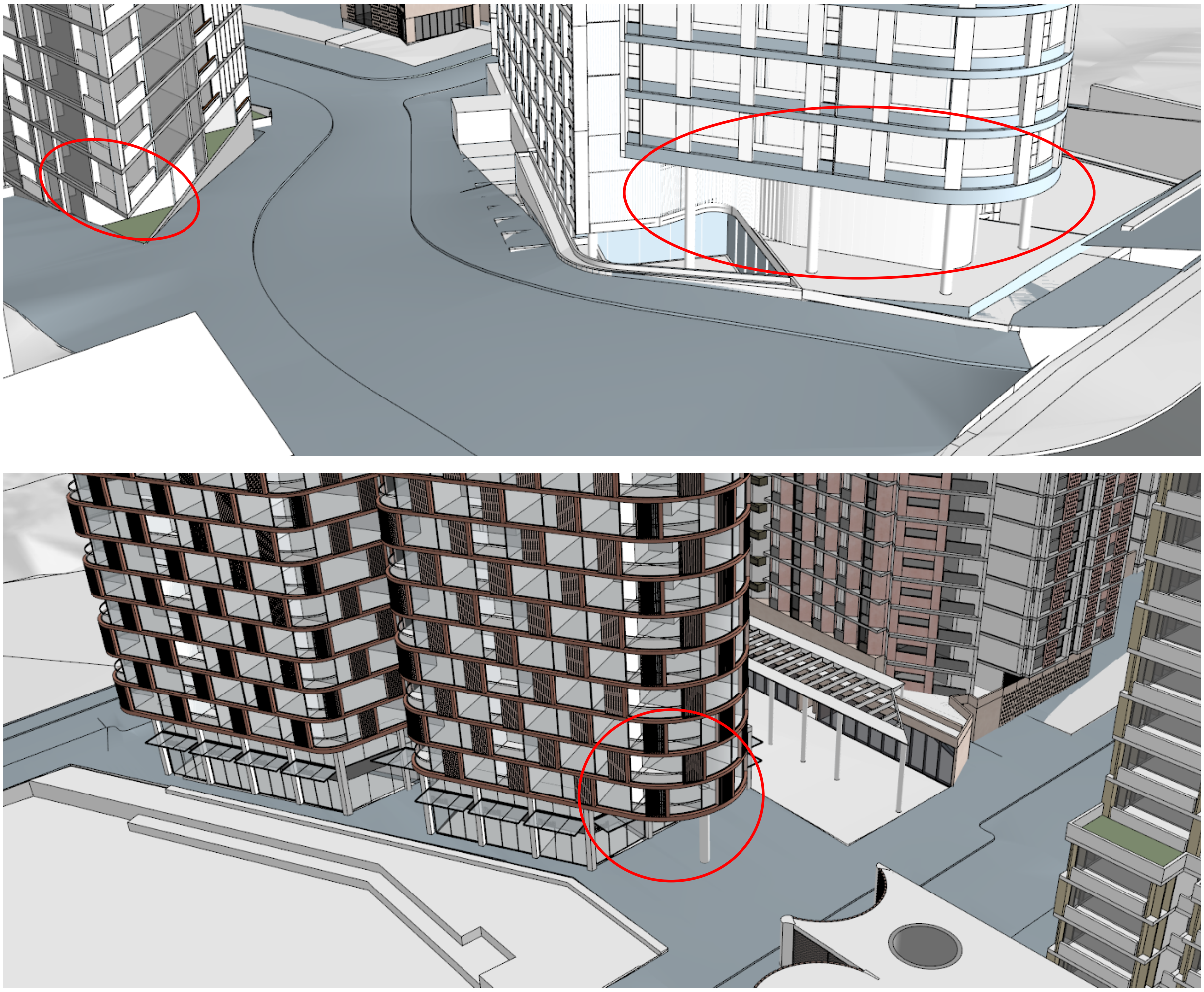


Figure 12: Renders of buildings in the precinct with negative setback (Frasers Property Ivanhoe, 2017)

The regular distribution pattern of buildings encourages channelling effects that can cause uncomfortably windy conditions in the streets aligning with the prevailing wind directions. The sheer façade of a tall building, such as those in the precinct, has the potential to produce significant downwash flow, which will accelerate around the windward corners at the base of the towers. The inclusion of a colonnade or reverse podium on the side walls of such buildings has the potential to induce strong winds through these areas. The wind climate is not expected to be strong enough to cause safety issues. Some mitigation measures are expected to be required to achieve a wind environment that would be deemed suitable by patrons in café and recreational areas. It is understood that these measures will be evaluated as part of the wind tunnel and CWE test programme.

Winds from the west

Winds from the west quadrant reach the site relatively unimpeded, as the upstream buildings are primarily low-rise structures which provide no significant shielding to the site. The buildings in the masterplan mostly do not have major facades facing west, which is expected to reduce the amount of downwash being generated for winds from the north-west to west. The mostly narrow facades of the buildings along Epping Road facing south-west would be expected to generate some downwash for winds from the south-west, which would lead to windy conditions at ground level particularly near the building corners along Epping Road, Figure 13. The inclusion of setbacks or awnings on that side could minimise the impact of the downwash at ground level.

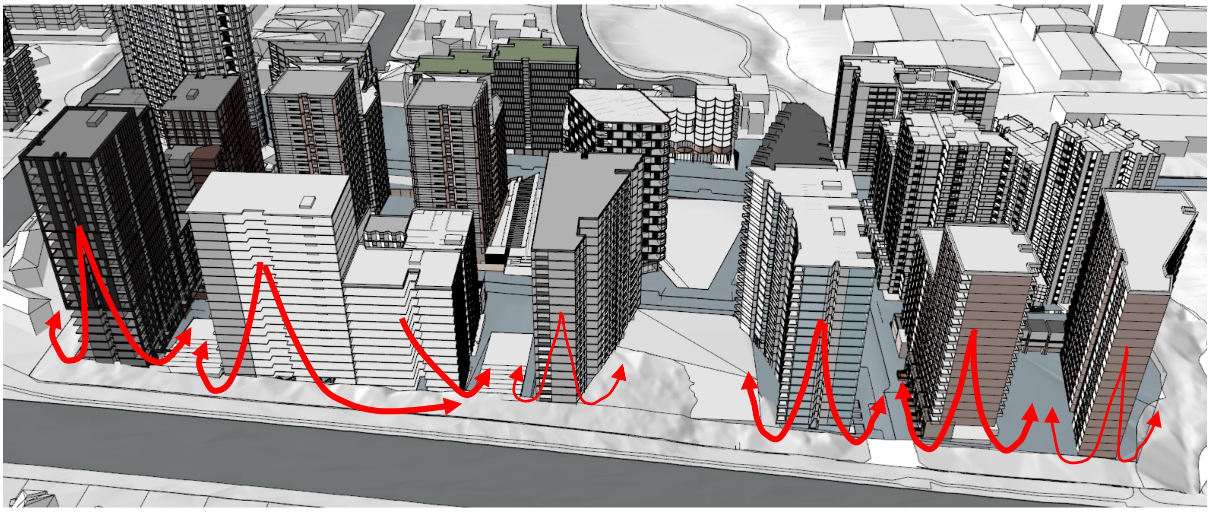


Figure 13: Downwash on south-western facades along Epping Road

Furthermore, several roads in the precinct align with winds from the south-west, and would hence be expected to cause channelling effects along these roads, Figure 14. Any areas along these roads that are intended for stationary use would be expected to require some level of mitigation to improve the wind conditions. An arrangement of the buildings that disrupts the straight flow path through the precinct would minimise the channelling effect. Alternatively, local screening around seating areas particularly in the retail area in the centre of the precinct, or dense evergreen landscaping could be added to provide protection for seated pedestrians in these areas.

Figure 14: Channelling winds from the south-west

Winds from the south-east

The significant slope of the terrain is expected to accelerate winds from the south-east quadrant into the site. Channelling can be expected around the precinct, especially between the buildings located along the two main roads running through the precinct parallel to Epping Road.

It is understood that these roads are primarily intended for use as an accessway and would not generally be used for outdoor seating. If any long term stationary outdoor activities are intended for the areas along these main roads, wind mitigation in the form of local screens or dense landscaping would be recommended.

The building shape and orientation on the south-eastern side of the precinct aids in reducing the amount of downwash generated for winds from the south-east.

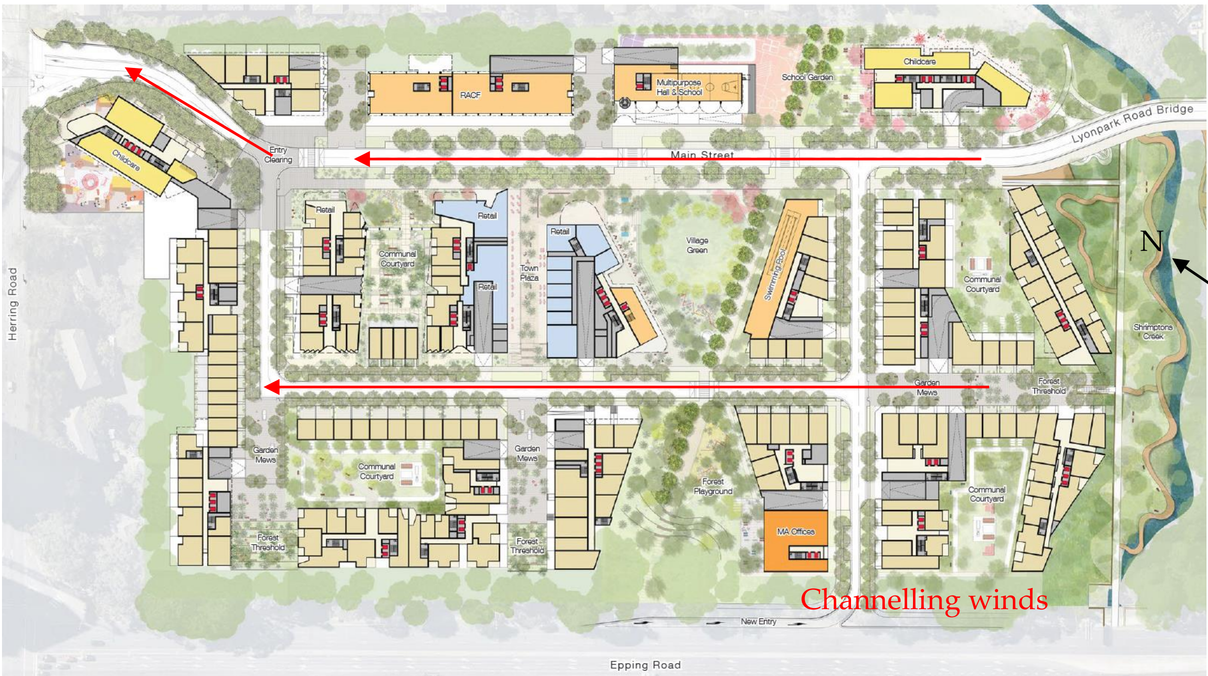


Figure 15: Channelling winds from the south-east

Winds from the east-south-east have potential to generate downwash from the wide exposed façade of the tallest tower in the precinct at the Herring Road entrance causing windy conditions around the base of the tower particularly near the corners. The rounded shape of the tower is beneficial to reduce the amount of downwash, however the wide east façade is still expected to generate downwash for winds impacting that side, Figure 16. Protection in the form of a canopy on the northern side of A1 is recommended to help mitigate potentially strong wind conditions at the lobby.

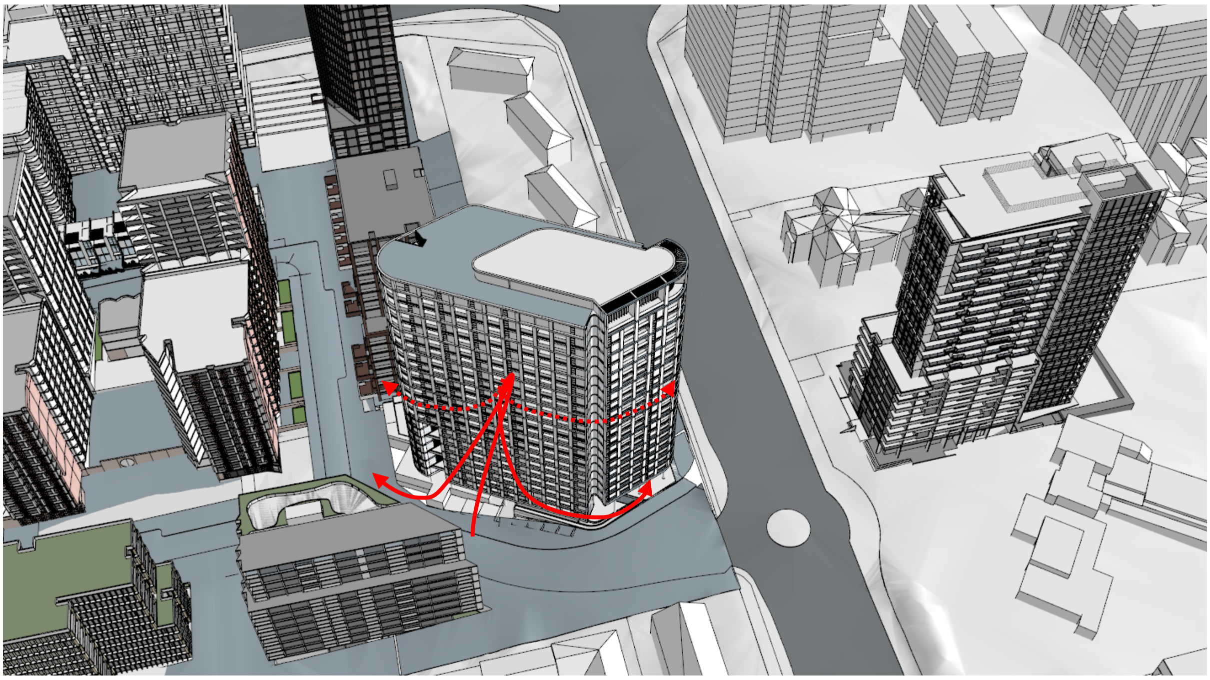


Figure 16: Downwash on the east façade on Herring Road

Computational wind engineering (CWE)

A detailed computational study of the site is currently underway and will provide comfort ratings throughout the site. This study is to be followed by a wind tunnel study to validate and modify the computational data as required, as well as to provide safety ratings which require wind tunnel testing.

Summary

In general, wind conditions in and around the proposed masterplan site are expected to be suitable for use as a main public accessway. In relation to the DCP criteria, the wind conditions around the precinct are expected to be classified as suitable for pedestrian standing and walking from a comfort perspective with the exception of some localised hotspots, and to pass the distress criterion.

Mitigation measures would be required in most areas if comfortable wind conditions for outdoor seating are required. In the absence of tower setbacks, it is expected that horizontal awnings will be required in many locations to help mitigate downwash and wind driven rain. Wind tunnel testing and CFD will be required to better quantify these conditions and required mitigation within the localised problem areas.

Conclusion

Cermak Peterka Petersen Pty. Ltd. has provided an opinion based assessment of the impact on the local wind environment of the proposed Ivanhoe Estate masterplan.

The proposed development includes buildings that are taller than most surrounding buildings. The environmental wind conditions at ground level around the proposed development are expected to meet the comfort criteria for pedestrian standing and walking and to pass the safety criterion. The regular distribution pattern of the buildings would be expected to cause channelling effects particularly for winds from the south-west and south-east quadrant.

Mitigation measures would be expected to be required for intended seating areas to protect from downwash and channelled winds. In the absence of tower setbacks, horizontal awnings would be recommended to deflect downwash above ground level.

References

City of Ryde Council (2014) City of Ryde Development Control Plan 2014, Part: 4.5 Macquarie Park Corridor.

Cochran L., (2004) Design Features to Change and/or Ameliorate Pedestrian Wind Conditions, Proceedings of the ASCE Structures Congress, Nashville, Tennessee, May 2004.

Davenport, A.G., (1972), An approach to human comfort criteria for environmental conditions, Colloquium on Building Climatology, Stockholm.

Melbourne, W.H., (1978), Criteria for Environmental Wind Conditions, Journal of Wind Engineering and Industrial Aerodynamics, vol. 3, pp. 241-249.

Standards Australia (2011), Structural design actions Part 2: Wind actions, AS/NZS1170.2:2011.

Appendix 1: Wind Climate Analysis - Seasonal