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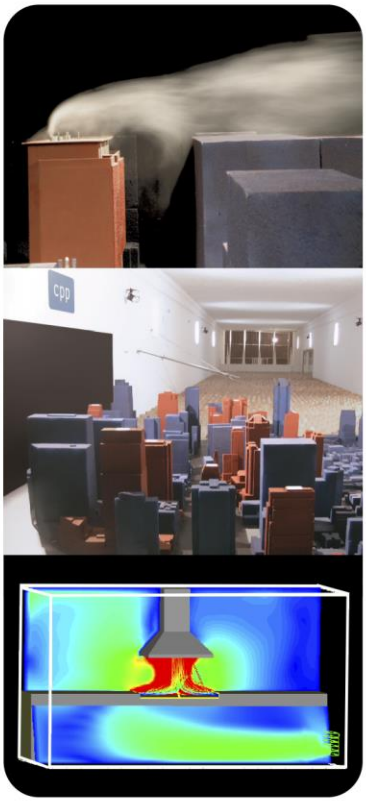
WIND ENGINEERING AND AIR QUALITY CONSULTANTS

Final Report



Qualitative Wind Assessment for:

52 McLaren Street

North Sydney, NSW, Australia

Prepared for:

GHD Woodhead

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1 INTRODUCTION

Cermak Peterka Petersen Pty. Ltd. has been engaged by GHD Woodhead to provide a qualitative assessment of the impact of the proposed 52 McLaren Street development on the wind conditions in the surrounding areas.

The subject site is located at the northern end of the North Sydney CBD, Figure 1. The proposed development consists of two buildings, hereafter referred to as North Building (30 m) and South Building (79 m). The two buildings share an underground car park and a three-storey podium, Figure 2 and Figure 3. As the buildings are larger than most of the surrounding structures, particularly to the north and west, the addition of the proposed development is expected to have some impact on the local wind conditions, with the extents broadly discussed in this report.

Figure 1: Aerial view of the proposed development site (Google Earth, 2021).

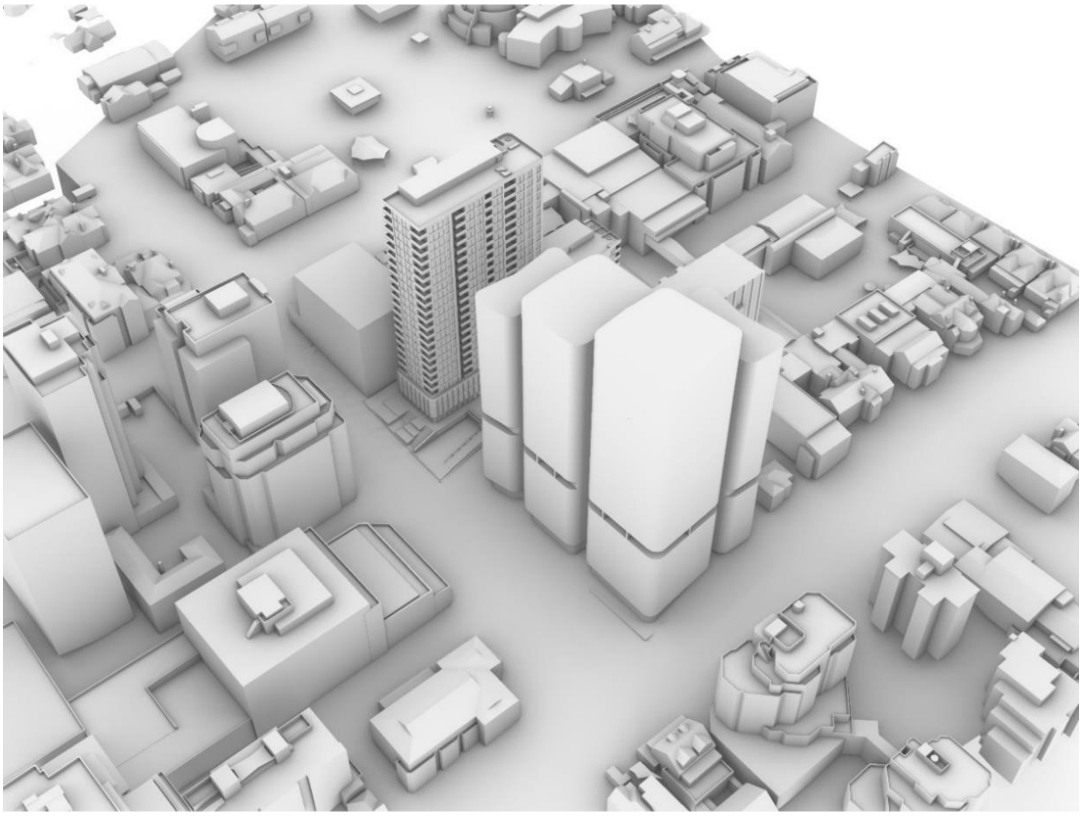

Figure 2: Visualization of the proposed development, including adjacent under-construction towers at 168 Walker Street, viewed from the south-east.

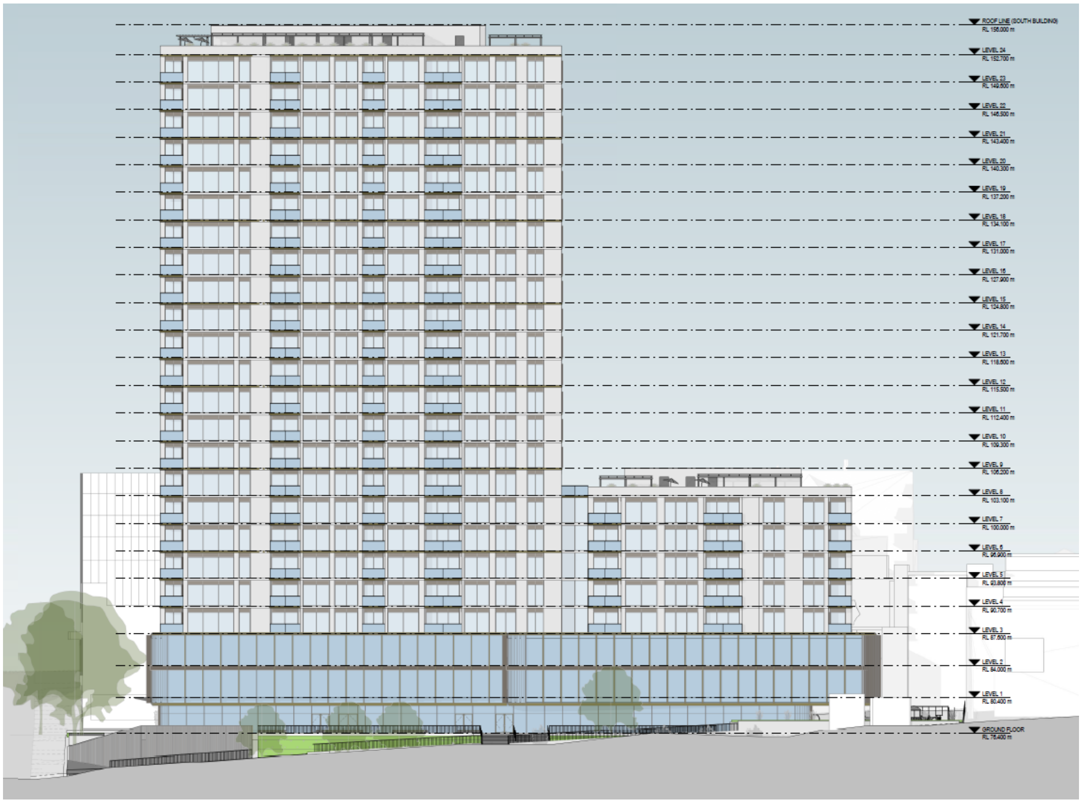

Figure 3: East elevation of the proposed development.

2 SYDNEY WIND CLIMATE

The proposed development lies approximately 14 km to the north of the Sydney Airport Bureau of Meteorology anemometer. To enable a qualitative assessment of the wind environment, the wind frequency and direction information measured by the Bureau of Meteorology at a standard height of 10 m at Sydney Airport from 1995 to 2019 have been used in this analysis. The wind rose for Sydney Airport is shown in Figure 4 and is considered to be representative of prevailing winds at the site. Strong prevailing winds are organised into three main groups which centre at about north-east, south, and west. This wind assessment is focused on these prevailing strong wind directions.

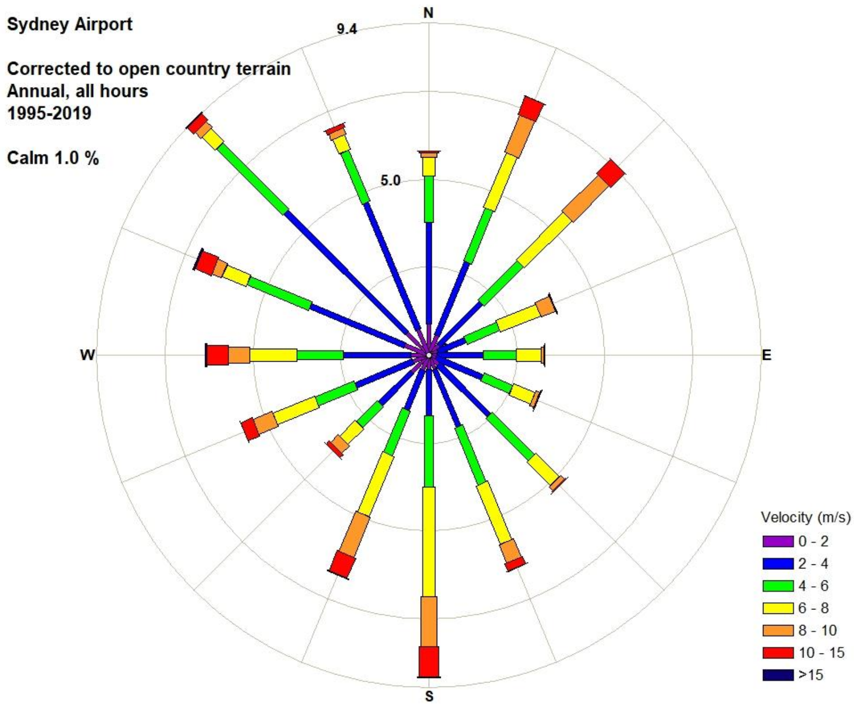

Figure 4: Wind rose for Sydney Airport.

3 ENVIRONMENTAL WIND 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 North Sydney Council DCP (2013) specifies that developments should not result in wind speeds exceeding 13 m/s at footpaths and accessible outdoor spaces. It is not clear whether this is a mean or gust wind speed nor the required frequency of occurrence throughout the year. It is expected that this metric is derived from the work of Melbourne (1978), which specifies that this is a maximum 3 s gust wind speed in an hour, occurring for 0.1% of the year from each direction. A location meeting this requirement would be suitable for pedestrian standing activities such as window shopping. The DCP wind speed is interpreted as a comfort rather than a safety criterion. A once per annum gust wind speed may not be representative of the day-to-day pedestrian wind conditions around the site from a comfort perspective. To address this limitation, the criteria of Lawson (1990) are adopted for this study. This approach provides a similar comfort classification as the North Sydney DCP but gives significantly more information regarding the serviceability wind climate, which is more applicable for general use of the area by pedestrians. The criteria of Lawson are described in Table 1 for both pedestrian comfort and distress/safety. The benefits of these criteria over many in the field are that they use both a mean and gust equivalent mean (GEM) wind speed to assess the suitability of specific locations. 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. The level and severity of these comfort categories can vary based on individual preference, so calibration to the local wind environment for all wind directions is recommended when evaluating with Lawson ratings. Another benefit of these from a comfort perspective is that the 5% of the time event is appropriate for a precinct to develop a reputation from the general public.

Furthermore, interpretation of these wind levels can be aided by the description of the effects caused by winds of various magnitudes on people. The earliest quantitative description of wind effects was established by Sir Francis Beaufort in 1806, for use at sea; the Beaufort scale is reproduced in Table 2 including qualitative descriptions of wind effects.

Table 1: Pedestrian comfort criteria for various activities.

Comfort (max. wind speed exceeded 5% of the time)	
<2 m/s	Outdoor dining
2 – 4 m/s	Pedestrian sitting (considered to be of long duration)
4 – 6 m/s	Pedestrian standing (or sitting for a short time or exposure)
6 – 8 m/s	Pedestrian walking
8 – 10 m/s	Business walking (objective walking from A to B or for cycling)
> 10 m/s	Uncomfortable
Distress/Safety (max. wind speed exceeded 0.022% of the time, twice per annum)	
<15 m/s	General access area
15 – 20 m/s	Acceptable only where able-bodied people would be expected; no frail people or cyclists expected
>20 m/s	Unacceptable
The wind speed is either an hourly 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 1.85.	

Table 2: Summary of wind effect on people, Penwarden (1973)

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

4 ENVIRONMENTAL WIND ASSESSMENT

The proposed development consists of two buildings: North Building (30 m) and South Building (79 m). The subject site is primarily surrounded by suburban low-rise buildings in most directions, except for the south quadrant, which consists of the mid- to high-rise developments of the North Sydney CBD. Additionally, a 4-tower development at 168 Walker Street is currently under construction to the immediate east of the subject site, with the four proposed towers rising to a similar elevation as the South Building. This new 4-tower development is adjacent to the existing Rydges hotel building, located to the east of the North Building. A moderate topographic gradient rising from the south and east will marginally accelerate flow for winds from these directions, though the wind conditions at the proposed development will be primarily determined by the surrounding built massing.

Winds in such surrounds can experience channelling along streets with many tall structures, along with local effects being dictated by exposed buildings and their relation to prevailing strong wind directions. Several wind flow mechanisms such as downwash and channelling flow are described in Appendix 1, and the effectiveness of some common wind mitigation measures are described in Appendix 2. Previous wind tunnel testing conducted by CPP in the surrounding areas has indicated that most street-level locations in the vicinity would be classified as Pedestrian Standing or Walking under the Lawson comfort criteria, and would not pass the North Sydney DCP requirement. The subject site is located on a block bounded by Miller Street to the west and McLaren Street to the south. A walkway on the eastern side of the proposed development provides a link between McLaren Street and Elliot Street.

Figure 5: Ground-level render of the proposed development, viewed from the south.

4.1 Winds from the north-east

Winds from the north-east quadrant will approach over the low-rise buildings of Neutral Bay, St. Leonards Park, and the Bradfield Highway. Though taller than most surrounding structures, the South Building is partially in the wake of the Rydges Hotel and the North Building. Given the alignment of the north-north-east winds and the walkway to the east of the development, marginally accelerated flow can be expected along the eastern frontages due to channelling between the proposed development and the high-rise massing to the east. North-east winds reaching the north-east apex of the proposed buildings will tend to move horizontally across the north and east façades, Figure 6, with the link connecting North and South Buildings restricting the flow through the gap. Some of the downwash flow generated on the east façade of the South Building will reach the ground-level creating slightly windier conditions along the east aspect of the South Building. An awning extending across the east façade of the South Building would assist in deflecting some of the vertical flow and shielding the South Building entries at the eastern frontages.

The North Building is of a similar height to the surrounding low to mid-rise massing, receiving some protection against winds from the north-east. As such only a small component of downwash is expected to be generated from the north and east façades of the North building, with some of this flow passing through the outdoor part of the childcare centre at the north end of the development, Figure 6. The undercroft region of the North Building and the retaining wall around the childcare centre will assist in improving the wind conditions at the ground level, though porous screens or dense foliage landscaping at the start/end of the walkway and local screening to any areas intended for seating or dining activation along the eastern side of the development, may be implemented if wind conditions for stationary or long-term activities are required. For winds from the north-east quadrant, the wind conditions at the southern and western entries are expected to remain calm and pass the safety/distress criterion.

Figure 6: North-east aerial view of the proposed development and the expected impact of north-east winds

4.2 Winds from the south

Winds from the south quadrant will pass over the mid- to high-rise buildings of the North Sydney CBD. The massing upstream of the project site are generally of a similar elevation to the subject development, and will provide significant shielding during winds from the south. Consequently, such winds are not expected to generate significant impacts as a result of interaction with the narrow south façade of the South Building, which subsequently provides shielding for the North Building. Wind conditions on the southern side of the site would be expected to remain mostly similar to existing during winds from this direction. Channelling flow along the walkway connecting McLaren Street to Elliot Street may be expected due to the alignment of the walkway with winds from the south quadrant, Figure 7, and the influence of the larger towers under construction at 168 Walker St, though the massing of current and future developments of the North Sydney CBD will somewhat limit the exposure of this area to direct strong winds from the south. A landscaping plan for this area that incorporates a mixture of solid and porous elements at a range of heights would be suggested for this area to promote a comfortable wind environment. As noted above, specific mitigation would be necessary for dedicated seating or dining areas.

4.3 Winds from the west

Winds from the west quadrant will pass over the low-rise buildings of suburban North Sydney before reaching the broad façades of the proposed development. Except for the minor shielding provided by the Victoria Cross station at the lower levels of the South Building, the west façade of the South Building is relatively exposed to the west and would be expected to generate significant downwash, Figure 7. As there are no setbacks on the western façade of either building, most of the downwash flow is expected to reach the ground-level unimpeded, with some flow dispersing over the rooftop of the Victoria Cross station entry. The vertical flow reaching the ground-level may create slightly stronger wind conditions near the steps up to the South Building, as downwash generated from the west façade is accelerated around the south-west corner of the tower and discharged along McLaren Street. The steps up the development are partially protected from existing channelling flow by the Victoria Cross Station massing during winds from the west. Addition of dense foliage landscaping will help maintain suitable wind conditions for pedestrian thoroughfare. At this stage, no major walkways or entrances are indicated on the western side of the South building. If this area is to be trafficable, it would be recommended to allow for an awning, or similar horizontal element, extending along the western boundary. On the north side of the development, any generated downwash from the exposed top levels of the North Building will partially flow through the outdoor part of the childcare centre. Perimeter landscaping or porous screens will assist in preventing this flow-through if calmer wind conditions are required.

The proposed development provides shielding from westerly winds to the eastern side of the site and to the neighbouring Rydges Hotel building, and would be expected to reduce wind speeds on Elliot Street and limit the overall downwash generated from the hotel. Similarly, the South Building will provide some shielding to the new development at 168 Walker Street, reducing downwash and accelerated flow along the walkway linking McLaren Street and Elliot Street. However, the addition of the South Building will contribute to the channelling flow initiated by the upstream massing along McLaren Street, during winds from the west. The addition of dense foliage landscaping along the footpaths of McLaren Street can be implemented to improve wind speeds in this location. In overview, from a pedestrian comfort and safety viewpoint, wind conditions at the site are expected to be increased slightly, particularly along the McLaren Street frontage.

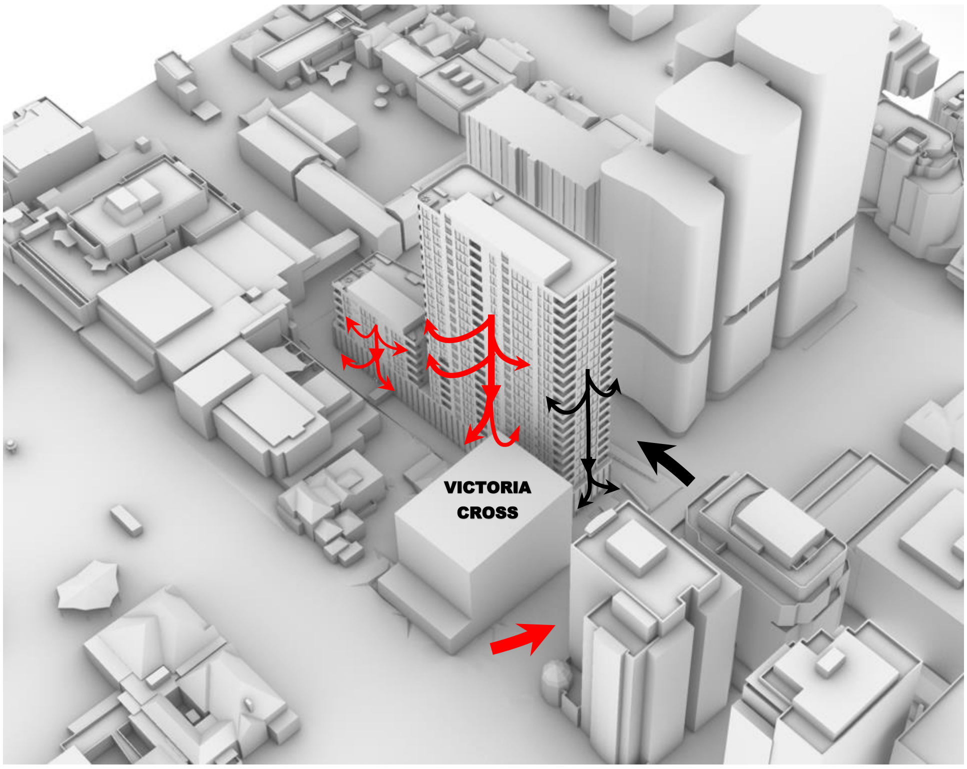

Figure 7: South-west aerial view of the proposed development and the expected impact of winds from the south and west quadrant

4.4 Summary

For most locations in the public domain, wind conditions within the proposed development site are expected to remain similar to the existing wind conditions. Based on previous wind tunnel studies in the region, the wind environment around the proposed development site is likely to be classified as acceptable for Pedestrian Standing or Walking under Lawson in most locations. These pedestrian comfort levels would be suitable for public accessways, and for stationary short-term exposure activities. Localised amelioration measures would be suggested if calmer areas are desired for particular locations. Additionally, a landscaping plan that includes a mix of solid and porous elements at varying heights would be recommended through the through-site link. Some areas are likely to experience increased wind velocities due to the interaction of the proposed buildings with prevailing winds. All locations would be expected to satisfy the safety/distress criterion. A wind tunnel study to quantify the wind conditions around the development is recommended at the detailed design stage.

4.5 Wind conditions within the development

The development includes communal rooftops on both buildings, exposed to all prevailing wind directions. The corner areas of the rooftops where seating areas have been indicated are particularly prone to cross-flows. The proposed porous canopies and planters are likely to improve wind conditions, though tall perimeter balustrades (>1.8 m) may be considered to allow suitable wind conditions for long-term stationary activities. Alternatively, localised screens may be considered for seating areas to provide regions of calm conditions.

Exposed corner balconies or larger terraces may be susceptible to strong cross-flows, potentially necessitating amelioration depending on the size and position of the space. In this case, balconies have been proposed on all corner of both buildings, except the north-east corner of the South Building. Adjustable screens or louvred elements may be considered to partially enclose the space and increase the proportion of time calm conditions are available. For residential balconies, occupants will tend manage and optimise the usage of the balconies over time.

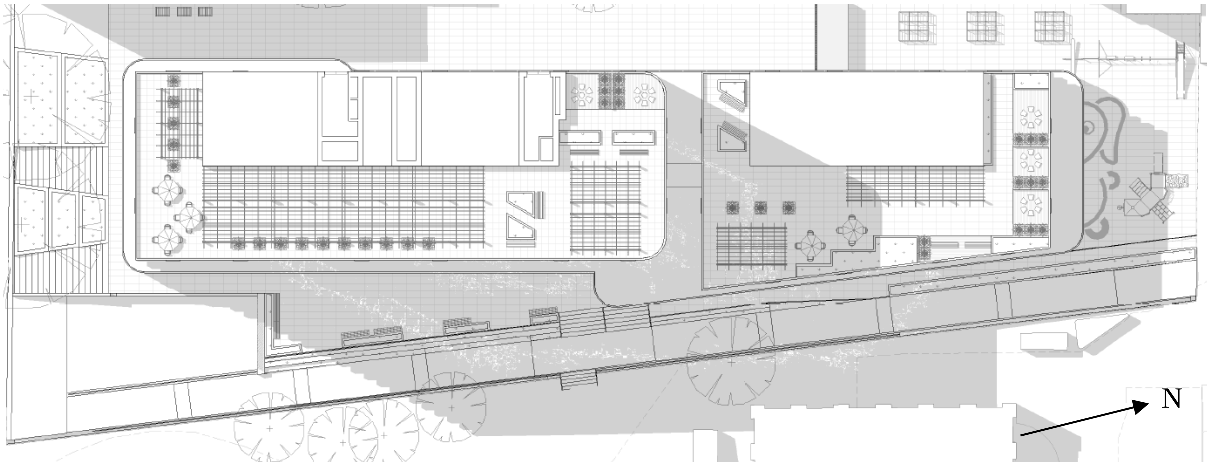

Figure 8: Rooftop plan view of the proposed development

5 CONCLUSION

Cermak Peterka Petersen Pty. Ltd. has provided a qualitative assessment of the impact of the proposed 52 McLaren Street project on the local wind environment in and around the development site. Being slightly larger than most surrounding structures, the proposed development will have some effect on the local wind environment. Wind conditions around the development are expected to be classified as acceptable for Pedestrian Standing or Walking from a Lawson comfort perspective and pass the distress/safety criterion, which is considered to be broadly in line with the intent of the North Sydney DCP. Local amelioration would likely be necessary for areas intended for long-term stationary or outdoor dining activities, particularly on the eastern sides of the development site. To quantify the wind conditions around the site, wind tunnel testing at the detailed design stage is recommended.

6 REFERENCES

Lawson, T.V. (1990), "The Determination of the Wind Environment of a Building Complex before Construction" Department of Aerospace Engineering, University of Bristol, Report Number TVL 9025.

Melbourne, W.H., 1978, Criteria for Environmental Wind Conditions, Journal of Wind Engineering and Industrial Aerodynamics, Vol.3, No.2-3, pp.241-249.

North Sydney Council (2013), "North Sydney Development Control Plan 2013"

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

Appendix 1: Wind flow mechanisms

When the wind hits a large isolated building, the wind is accelerated down and around the windward corners, Figure 9; this flow mechanism is called downwash and causes the windiest conditions at ground level on the windward corners and sides of the building. In Figure 9, 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.

Techniques to mitigate the effects of downwash winds on pedestrians include the provision of horizontal elements, the most effective being a podium to divert the flow away from pavements and building entrances. Awnings along street frontages perform a similar function, and the larger the horizontal element, the more effective it will be in diverting the flow.

Channelling occurs when the wind is accelerated between two buildings or along straight streets with buildings on either side.

Figure 10 shows the wind at mid and upper levels on a building being accelerated substantially around the corners of the building. When balconies are located on these corners, they are likely to be breezy, and will be used less by the owner due to the regularity of stronger winds. Owners quickly become familiar with when and how to use their balconies. If the corner balconies are deep enough, articulated, or have regular partition privacy fins, then local calmer conditions can exist.

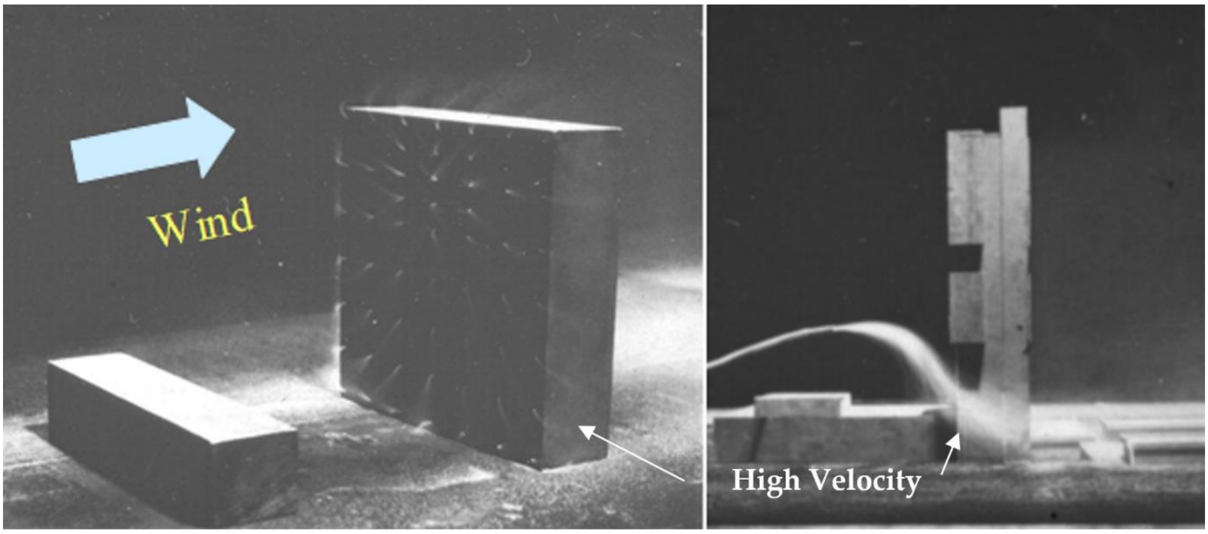

Figure 9: Flow visualisation around a tall building.

Figure 10: Visualisation through corner balconies (L) and channelling between buildings (R).

Appendix 2: 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 11. 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 large office buildings.

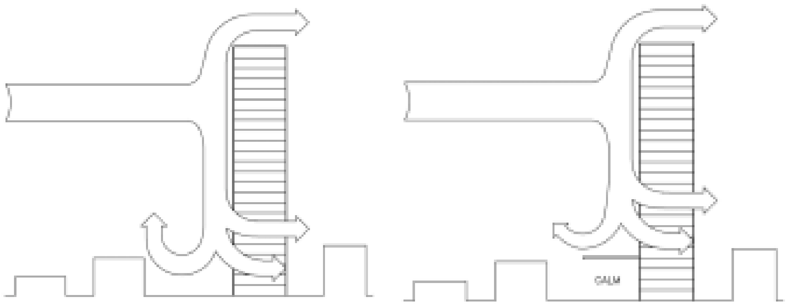

Figure 11: Canopy Windbreak Treatment. (L) Downwash to street level may generate windy conditions for pedestrians. This is particularly true for buildings much taller than the surrounding buildings. (R) A large canopy is a common solution to this pedestrian-wind problem at street level.

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 12. 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.

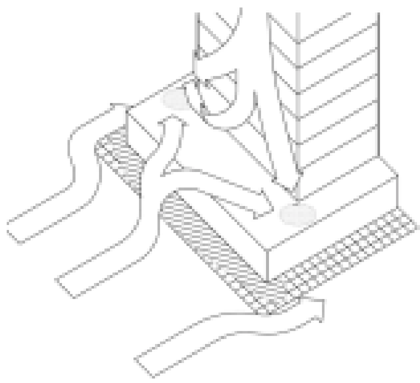

Figure 12: The tower-on-podium massing often results in reasonable conditions at ground level, but the podium may not be useable.

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 13. The uninvitingly windy nature of these open areas is a contributing reason behind the use of arcade airlock entrances (revolving or double sliding doors).

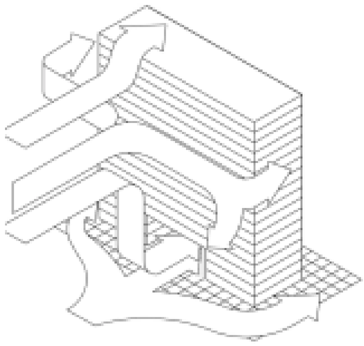

Figure 13: An arcade or open column plaza under a building frequently generates strong pedestrian wind condition.

Building form – Alcove

An entrance alcove behind the building line will generally produce a calmer entrance area at a mid-building location, Figure 14(L). 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 14(R), due to the accelerated flow mechanism described in Figure 9 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.

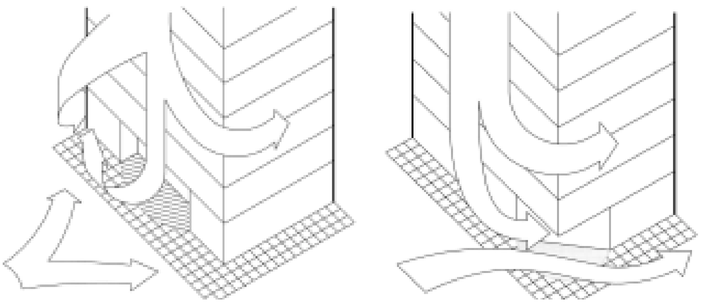

Figure 14: Alcove Windbreak Treatment. (L) A mid-building alcove entrance usually results in an inviting and calm location. (R) Accelerated corner flow from downwash often yields an unpleasant entrance area.

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 12. 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 10(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.

References

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