Final Report

Qualitative Wind Assessment for:

525 George Street
Sydney, Australia

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1 INTRODUCTION

Cermak Peterka Petersen Pty. Ltd. has been engaged by Event to provide a qualitative assessment of the impact of the proposed 525 George Street development on the wind conditions in the surrounding areas.

The proposed development is located in the southern part of the Sydney CBD, surrounded by mid- to high-rise developments, Figure 1. The proposed development will comprise of a single prismatic tower, reaching a maximum height of about 150 m above ground level including a podium of approximately 25 m height above ground, Figure 2. The impact of the proposed development on the local wind conditions are discussed in this report.

Figure 1: Aerial view of the proposed development site (Eagle View, 2018).
Figure 2: East elevation of the proposed development and surrounding buildings (Candalepas Associates, 2019).
2 SYDNEY WIND CLIMATE

The proposed development lies approximately 9 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 2017 have been used in this analysis. The wind rose for Sydney Airport is shown in Figure 3 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.

Winds from the north-east tend to be summer sea breezes and bring welcome relief on summer days, 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 breeze. Winds from the south are associated with large synoptic frontal systems and generally provide the strongest gusts during summer. Winds from the west are the strongest of the year and are associated with large weather patterns and thunderstorm activity. These winds occur throughout the year and can be cold or warm depending on the inland conditions.

![Wind rose for Sydney Airport](image)

Figure 3: 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 City of Sydney DCP (2012) specifies wind effects are not to exceed 10 m/s for ‘active frontages’, which includes the portion of George Street bordering the subject site (Kent Street and Albion Lane are not listed as active frontage). From discussions with Council, the 10 m/s threshold is intended to be interpreted as a once per annum gust wind speed, to be used in the assessment of pedestrian comfort rather than safety. There are few locations in Sydney that would satisfy this criterion without local shielding.

The wind speed criteria in the DCP are based on the work of Melbourne (1978). The Melbourne criteria are based on an infrequent gust event, which may not adequately characterise the general conditions at a site throughout the year. The wind assessment criteria that will be used in this study are based upon the criteria of Lawson (1990), which 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.
Table 1: Pedestrian comfort criteria for various activities.

<table>
<thead>
<tr>
<th>Comfort (max. wind speed exceeded 5% of the time)</th>
<th>Outdoor dining</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2 m/s</td>
<td></td>
</tr>
<tr>
<td>2 - 4 m/s</td>
<td>Pedestrian sitting (considered to be of long duration)</td>
</tr>
<tr>
<td>4 - 6 m/s</td>
<td>Pedestrian standing (or sitting for a short time or exposure)</td>
</tr>
<tr>
<td>6 - 8 m/s</td>
<td>Pedestrian walking</td>
</tr>
<tr>
<td>8 - 10 m/s</td>
<td>Business walking (objective walking from A to B or for cycling)</td>
</tr>
<tr>
<td>&gt; 10 m/s</td>
<td>Uncomfortable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distress/Safety (max. wind speed exceeded 0.022% of the time, twice per annum)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15 m/s</td>
<td>General access area</td>
</tr>
<tr>
<td>15 - 20 m/s</td>
<td>Acceptable only where able-bodied people would be expected; no frail people or cyclists expected</td>
</tr>
<tr>
<td>&gt;20 m/s</td>
<td>Unacceptable</td>
</tr>
</tbody>
</table>

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.
4 ENVIRONMENTAL WIND ASSESSMENT

The development site is surrounded in most directions by medium- to high-rise buildings of the Sydney CBD, with a region of parkland to the east. From a wind perspective the topography surrounding the site drops slightly to the south and west. Winds in such surrounds with many tall buildings tend to be channelled along the street corridors with local effects being dictated by exposed large buildings and local topography. Several wind flow mechanisms such as downwash and channeling flow are described in Appendix 1, and the effectiveness of some common wind mitigation measures are described in Appendix 2.

The subject site is located on a block bounded by Kent Street to the west and George Street to the east. The proposed development comprises a single prismatic tower up to 150 m high above ground level, including a podium of approximately 25 m above ground level. Floor plans of lower ground and ground levels are shown in Figure 4.

Figure 4: Lower Ground (T) and Ground floor plan (B) of the proposed development (Candalepas Associates, 2019).
Existing environmental conditions in this section of the city are known to be relatively windy along George Street, particularly for winds from the south, which are accelerated up the slope and combined with the downwash generated by the upwind large buildings. Using the Lawson criteria these areas would be expected to be classified for ‘pedestrian standing’ or ‘pedestrian walking’ and pass the distress criterion. It is considered unlikely that the existing wind conditions would meet the City of Sydney (2012) DCP requirements for the once per annum maximum gust to not exceed 10 m/s along George Street.

4.1 Winds from the north-east

Winds from the north-east quadrant will approach over the high-density massing of the Sydney CBD prior to reaching the subject site. The proposed development is reasonably well protected from winds from the north-east crossing Sydney Harbour, The Domain and Hyde Park. The general wind flow pattern in this area is governed by the larger buildings in the neighbouring blocks to the north-east combined with the open nature of Hyde Park. It is expected that the proposed building will have little impact on the wind conditions along George or Kent Streets as the tower is in the wake of the Lumiere Tower (101 Bathurst Street), Century Tower (343-357 Pitt Street), and 580 George Street, as well as the approved 240 m tall tower at 505 George Street directly adjacent to the site during winds from the north-east quadrant. The tower setback at podium level to the north and east further minimises the impact on any remaining downwash flow on the ground plane. Kent Street and Albion Place are well shielded and will experience calm conditions. As detailed information on the interface between tower and ground for the proposed 505 George Street is not yet available, it is assumed the design will address pedestrian comfort without adversely affecting the subject site. For winds from the north-east quadrant, the wind conditions around the proposed development site are expected to remain similar to the existing wind conditions.

4.2 Winds from the south

Winds from the south quadrant are currently channelled by the taller buildings along George Street. As Kent Street only extends to Liverpool Street to the south, there is insufficient distance for channelling flow to develop along this corridor. The large residential tower at 569-581 George Street will largely prevent flow from entering Kent Street, also encouraging calmer conditions. Winds from the south quadrant will impinge on the upper part of the adjacent Meriton Tower, which is likely to direct the wind flow horizontally around the tower at height and would provide shielding for most of the proposed development for winds from these directions. Some amount of downwash off the south façade of the proposed development would be anticipated close to the windward building corners. The tower setback at podium level would provide protection for the ground plane from the downwash flow, as the wind would be deflected into George and Kent Streets at height. For winds from the south quadrant, the wind
conditions around the proposed development site are expected to remain similar to the existing wind conditions.

4.3 Winds from the west

Winds from the west are channelled up Liverpool and Bathurst Streets by the upstream buildings. The proposed tower is located in the centre of the block, however, and the west façade is rather narrow with a width of approximately 13 m. These features will limit the influence of the building on local conditions. The 6 m tower setback at podium height will deflect any remaining downwash at height, further minimising the impact on the ground plane. George Street is mostly shielded for winds from the west quadrant. Albion Place is oriented in the east-west direction, however the tower setback and the narrow extent of the laneway would limit the amount of downwash and channelling flow in this area. The wind conditions around the proposed development are expected to remain similar to existing conditions for winds from the west quadrant.

4.4 Summary

For most locations, wind conditions within the proposed development site are expected to remain similar to the existing wind conditions, as the proposed development is reasonably protected from most prevailing wind directions by the massing of the high-rise buildings of the CBD. From a pedestrian comfort perspective, the wind environment around the proposed development site is likely to be classified as acceptable for pedestrian standing or walking under Lawson. 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. All locations would be expected to satisfy the safety/distress criterion.

4.5 Wind conditions within the development

Some locations within the development may experience higher wind velocities at times, which may necessitate local amelioration depending on how these areas are to be used. The tower setback at the podium level deflects vertical flow preventing it from reaching ground level but would cause windy conditions on the podium roof, which features terraces on the Kent Street and George Street side including a pool in the south-west corner, Figure 5 (T). Wind channelling along George Street particularly may cause windy conditions on the eastern terrace. During winds from the south and west quadrants, some direct and downwash flow reaching the podium terrace would be expected to cause windy conditions in the pool area. The approved neighbouring development at 505 George Street will also direct some winds onto the podium spaces. A high balustrade near the building corners, and/or incorporating a horizontal canopy over some of the terrace and pool area would help to improve wind conditions. Local mitigation in the form of landscaping, umbrellas, or vertical screens can be used to improve wind conditions in the seating areas if desired.
Private balconies are located on the residential levels in the top third of the proposed development, Figure 5 (M). It is understood that these balconies will be fully enclosed as winter gardens, so wind conditions will not be a concern in these spaces.

The rooftop is to be activated as an outdoor terrace, Figure 5 (B). At this elevation, there is potential for frequent strong winds, however the full-height perimeter balustrade and shielding provided by the adjacent plant level will allow reasonable conditions. In addition, it would be suggested to incorporate overhead protection to seating areas such as an awning or umbrellas.

Figure 5: Podium Level (T), typical residential floor plan (M), and Rooftop (B) of the proposed development (Candalepas Associates, 2019).
5 CONCLUSION

Cermak Peterka Petersen Pty. Ltd. has provided a qualitative assessment of the impact of the proposed 525 George Street project on the local wind environment in and around the development site. The proposed development is well shielded for most wind directions and features setbacks at podium level which will further assist in protecting the ground plane. The building would not be expected to significantly affect ground level wind conditions in the area from the perspective of pedestrian comfort or safety. 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.

To quantify the wind conditions around the site, a wind-tunnel test would be recommended during detailed design.
6 REFERENCES

Candalepas Associates (2019) 525 George Street Architectural Drawings Issue A. 21.06.19
Appendix 1: Wind flow mechanisms

When the wind hits a large isolated building, the wind is accelerated down and around the windward corners, Figure 6; 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 6, 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 7 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.

![Flow visualisation around a tall building.](image-url)
Figure 7: 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 8. 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 8: 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.](image)

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 9. 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 9: The tower-on-podium massing often results in reasonable conditions at ground level, but the podium may not be useable.](image)
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 10. 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 10: 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 11(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 11(R), due to the accelerated flow mechanism described in Figure 6 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 11: 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 9. 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 7(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