QUALITATIVE WIND ASSESSMENT

APPENDIX M

Sydney Metro City & Southwest Pitt Street North Over Station Development:

Qualitative Wind Assessment

Applicable to:	Sydney Metro City & Southwest
Author:	CPP Wind Engineering
Owner	Sydney Metro
Status:	Final
Version:	#5
Date of issue:	August 2018

CPP Project: 12213

DOCUMENT VERIFICATION

Date	Revision	Prepared by	Checked by	Approved by
14/03/18	Draft report	TXE	MG	MG
16/05/18	Minor amendments	TXE		TXE
15/06/18	Minor amendments	TXE		TXE
26/06/18	Minor amendments	TXE		TXE

Table of Contents

1. Purpose of this report

1.1 Background

This report supports a concept State Significant Development application (concept SSD Application) submitted to the Department of Planning and Environment (DPE) pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The concept SSD Application is made under section 4.22 of the EP&A Act.

Sydney Metro is seeking to secure concept approval for a mixed use tower above the northern portal of Pitt Street Station, otherwise known as the over station development (OSD). The concept SSD Application seeks consent for a building envelope and its use for residential accommodation, visitor accommodation and commercial premises, maximum gross floor area (GFA), pedestrian and vehicular access, circulation arrangements and associated car parking as well as the strategies and design parameters for the future detailed design of development.

Sydney Metro proposes to construct the OSD as part of an integrated station development package, which would result in the combined delivery of the station, OSD and public domain improvements. The station and public domain elements form part of a separate planning approval for Critical State Significant Infrastructure (CSSI) approved by the Minister for Planning on 9 January 2017.

As the development is within a rail corridor, is associated with railway infrastructure and is for the purposes of residential or commercial premises with a Capital Investment Value of more than $30 million, the project is State Significant Development (SSD) pursuant to Schedule 1, clause 19(2)(a) of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP). The full extent of the proposed development is also State Significant Development by virtue of clause 8(2) of the SRD SEPP.

This report has been prepared to respond to the Secretary's Environmental Assessment Requirements (SEARs) issued for the concept SSD Application for Pitt Street North on 30th November 2017 which state that the Environmental Impact Statement (EIS) is to address the following requirement:

> *Plans & Documents: wind impact assessment*

1.2 Overview of the Sydney Metro in its context

The New South Wales (NSW) Government is implementing *Sydney's Rail Future*, a plan to transform and modernise Sydney's rail network so that it can grow with the city's population and meet the needs of customers in the future (Transport for NSW, 2012). Sydney Metro is a new standalone rail network identified in *Sydney's Rail Future*.

Sydney Metro is Australia's biggest public transport project, consisting of Sydney Metro Northwest, which is scheduled for completion in 2019 and Sydney Metro City & Southwest, which is scheduled for completion in 2024.

Sydney Metro West is expected to be operational in the late 2020s. (Refer to **Figure 1**).

Figure 1: Sydney Metro alignment map

Sydney Metro City & Southwest includes the construction and operation of a new metro rail line from Chatswood, under Sydney Harbour through Sydney's CBD to Sydenham and on to Bankstown through the conversion of the existing line to metro standards.

The project also involves the delivery of seven new metro stations, including at Pitt Street. Once completed, Sydney Metro will have the ultimate capacity for 30 trains an hour (one every two minutes) through the CBD in each direction - a level of service never seen before in Sydney.

On 9 January 2017, the Minister for Planning approved the Sydney Metro City & Southwest - Chatswood to Sydenham application as a Critical State Significant Infrastructure project (reference SSI 15_7400), hereafter referred to as the CSSI Approval.

The CSSI Approval includes all physical work required to construct the CSSI, including the demolition of existing buildings and structures on each site. Importantly, the CSSI Approval also includes provision for the construction of below and above-ground structures and other components of the future ISD (including building infrastructure and space for future lift cores, plant rooms, access, parking and building services, as relevant to each site). The rationale for this delivery approach, as identified within the CSSI Application, is to enable the ISD to be more efficiently built and appropriately integrated into the metro station structure.

The EIS for the Chatswood to Sydenham component of the Sydney Metro City & Southwest project identified that the OSD would be subject to a separate assessment process.

Since the CSSI Approval was issued, Sydney Metro has lodged four modification applications to amend the CSSI Approval as outlined below:

- Modification 1- Victoria Cross and Artarmon Substation which involves relocation of the Victoria Cross northern services building from 194-196A Miller Street to 50 McLaren Street together with inclusion of a new station entrance at this location referred to as Victoria Cross North. 52 McLaren Street would also be used to support construction of these works. The modification also involves the relocation of the substation at Artarmon from Butchers Lane to 98 – 104 Reserve Road. This modification application was approved on 18 October 2017.
- Modification 2- Central Walk which involves additional works at Central Railway Station including construction of a new eastern concourse, a new eastern entry, and upgrades to suburban platforms. This modification application was approved on 21 December 2017.
- Modification 3 - Martin Place Station which involves changes to the Sydney Metro Martin Place Station to align with the Unsolicited Proposal by Macquarie Group Limited (Macquarie) for the development of the station precinct. The proposed modification involves a larger reconfigured station layout, provision of a new unpaid concourse link and retention of the existing MLC pedestrian link and works to connect into the Sydney Metro Martin Place Station. It is noted that if the Macquarie proposal does not proceed, the modification (if approved) would be surrendered. This modification application was approved on 22 March 2018.
- Modification 4 - Sydenham Station and Sydney Metro Trains Facility South which incorporated Sydenham Station and precinct works, the Sydney Metro Trains Facility South, works to Sydney Water's Sydenham Pit and Drainage Pumping Station and ancillary infrastructure and track and signalling works into the approved project. This modification application was approved on 13 December 2017.

Given the modifications, the CSSI Approval is now approved to operate to Sydenham Station and also includes the upgrade of Sydenham Station.

The remainder of the City & Southwest project (Sydenham to Bankstown) proposes the conversion of the existing heavy rail line and the upgrade of the existing railway stations along this alignment to metro standards. This portion of the project, referred to as the Sydenham to Bankstown Upgrade, is the subject of a separate CSSI Application (No. SSI 17_8256) for which an Environmental Impact Statement was exhibited between September and November 2017 and a Response to Submissions and Preferred Infrastructure Report was submitted to the NSW Department of Planning & Environment (DPE) in June 2018 for further exhibition and assessment.

1.3 Planning relationship between Pitt Street Station and the OSD

While the northern portal of Pitt Street Station and the OSD will form an Integrated Station Development, the planning pathways defined under the *Environmental Planning and Assessment Act 1979* require separate approval for each component of the development. In this regard, the approved station works (CSSI Approval) are subject to the provisions of Part 5.1 of the EP&A Act (now referred to as Division 5.2) and the OSD component is subject to the provisions of Part 4 of the EP&A Act.

For clarity, the approved station works under the CSSI Approval included the construction of below and above ground structures necessary for delivering the station and also enabling construction of the integrated OSD. This included but is not limited to:

- demolition of existing development
- excavation
- station structure including concourse and platforms
- lobbies
- retail spaces within the station building
- public domain improvements
- station portal link (between the northern and southern portals of Pitt Street Station)
- access arrangements including vertical transport such as escalators and lifts
- structural and service elements and the relevant space provisioning necessary for constructing OSD, such as columns and beams, space for lift cores, plant rooms, access, parking, retail and building services.

The vertical extent of the approved station works above ground level is defined by the 'transfer slab' level (which for Pitt Street North is defined by RL 48.00), above which would sit the OSD. This delineation is illustrated in **Figure 2** below.

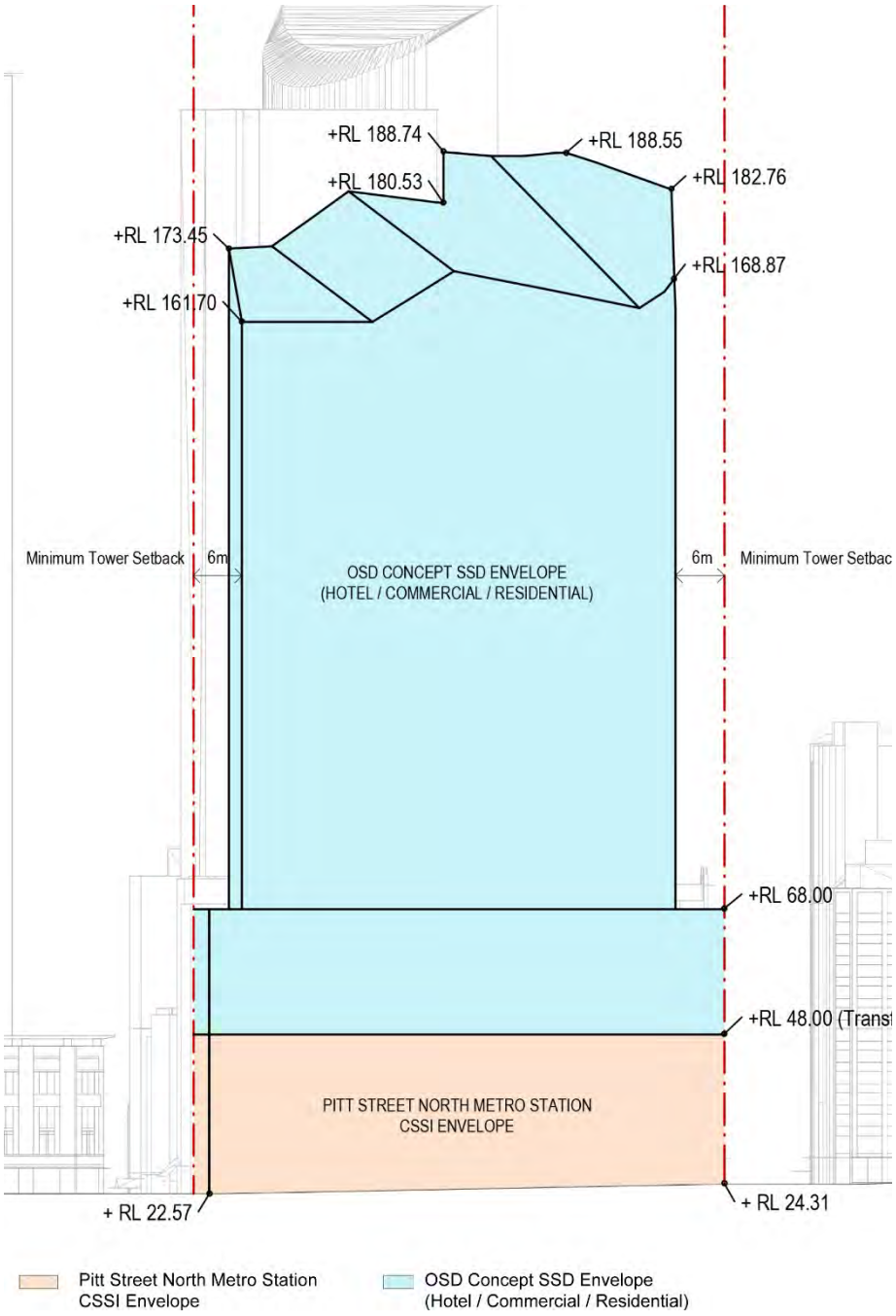

Figure 2: Delineation between station and OSD

The CSSI Approval also establishes the general concept for the ground plane of Pitt Street Station including access strategies for commuters, pedestrians and workers. In this regard, pedestrian access to the station would be from Park Street and the OSD lobbies would be accessed from Pitt Street, Park Street and Castlereagh Street.

Since the issue of the CSSI Approval, Sydney Metro has undertaken sufficient design work to determine the space planning and general layout for the station and identification of those spaces within the station area that would be available for the OSD. In addition, design work has been undertaken to determine the technical requirements for the structural integration of

the OSD with the station. This level of design work has informed the concept proposal for the OSD. It is noted that ongoing design development of the works to be delivered under the CSSI Approval would continue with a view to developing an Interchange Access Plan (IAP) and Station Design Precinct Plan (SDPP) for Pitt Street Station to satisfy Conditions E92 and E101 of the CSSI Approval.

The public domain improvement works around the site would be delivered as part of the CSSI Approval.

1.4 The Site

The Pitt Street North OSD site is located at the southern portion of the Sydney CBD block bounded by Pitt Street, Park Street and Castlereagh Street, above the northern portal of the future Pitt Street Station (refer to **Figure 3** below).

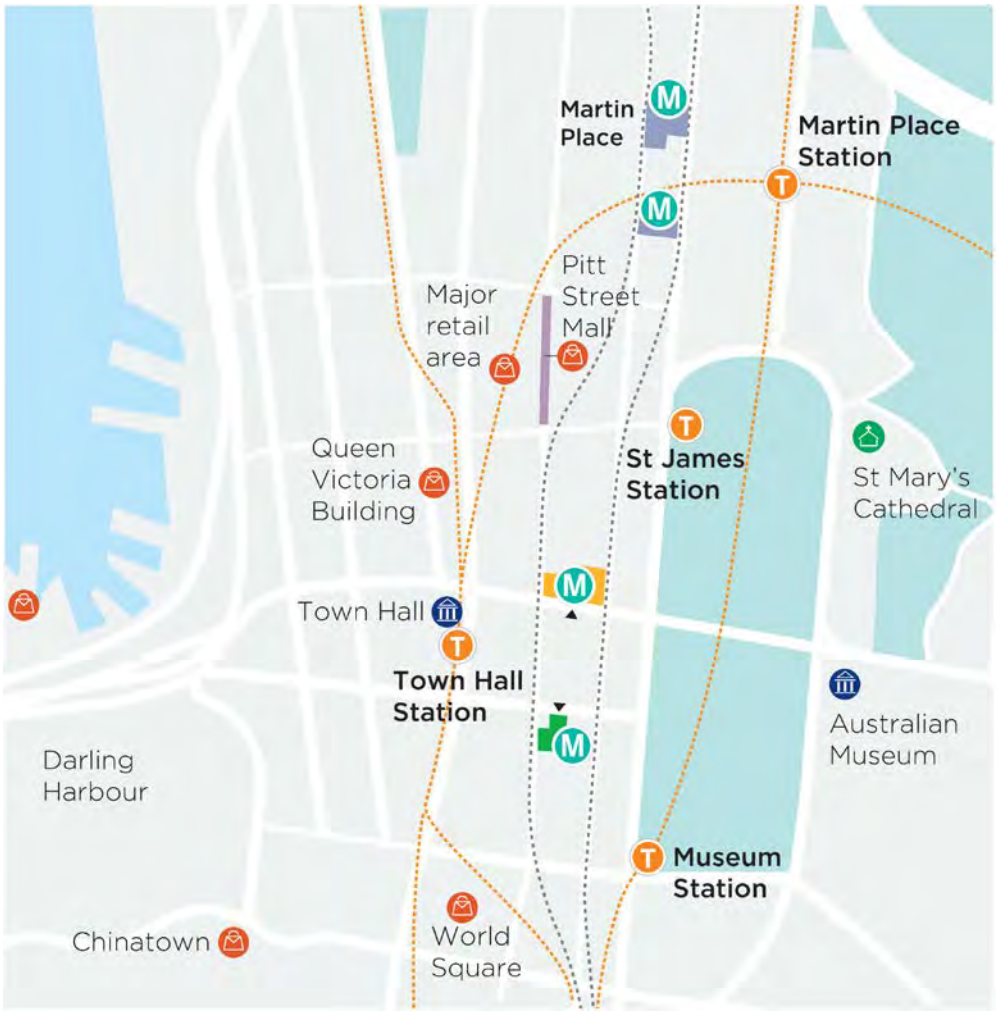

Figure 3: Pitt Street Station location plan

The site is located in the City of Sydney Local Government Area. The site (refer to **Figure 4** below) is irregular in shape, has a total area of approximately 3,150 square metres and has street frontages of approximately 28 metres to Pitt Street, 81 metres to Park Street and 48 metres to Castlereagh Street.

The site address is 175-183 Castlereagh Street, Sydney and comprises the following properties:

- Lot 3 in DP 74952
- Lot 1 in DP 229365
- Lot 2 in DP 900055
- Lot 1 in DP 596474
- Lot 17 in DP 1095869
- Lot 2 in DP 509677
- Lot 1 in DP 982663
- Lot 2 in DP 982663
- Lot 3 in DP 61187
- Lot 1 in DP 74367

Figure 4: Aerial photo of Pitt Street North

1.5 Overview of the proposed development

The concept SSD Application seeks concept approval in accordance with section 4.22 of the EP&A Act for the OSD above the approved Pitt Street Station (northern portal). This application establishes the planning framework and strategies to inform the detailed design of the future OSD and specifically seeks planning approval for:

- a building envelope as illustrated at Figure 5
- a maximum building height of approximately Relative Level (RL) 189 which equates to approximately 43 storeys including a podium height of RL68 (approximately 45m), which equates to approximately 12 storeys above ground
- a maximum GFA of 49,120 square metres for the OSD component, which equates to a Floor Space Ratio (FSR) of 15.59:1, resulting in a total maximum GFA at the site (including station floorspace) of 50,309 square metres and a total maximum FSR of 15.97:1, including flexibility to enable a change in the composition of land uses within the maximum FSR sought
- conceptual use of the building envelope for a range of uses including commercial office space, visitor accommodation and residential accommodation
- use of the conceptual OSD space provisioning within the footprint of the CSSI Approval (both above and below ground), including the OSD lobby areas, podium car parking, storage facilities, services and back-of-house facilities
- car parking for approximately 50 spaces located across five levels of the podium
- loading and vehicular access arrangements from Pitt Street
- pedestrian access from Pitt Street, Park Street and Castlereagh Street
- strategies for utilities and service provision
- strategies for the management of stormwater and drainage
- a strategy for the achievement of ecologically sustainable development
- indicative signage zones
- a strategy for public art
- a design excellence framework
- the future subdivision of parts of the OSD footprint (if required)

As this concept SSD Application is a staged development pursuant to section 4.22 of the EP&A Act, future approval would be sought for detailed design and construction of the OSD. A concept indicative design, showing a potential building form outcome at the site, has been provided as part of this concept SSD Application at Appendix E.

Pitt Street Station is to be a key station on the future Sydney Metro network, providing access to the Sydney Central Business District (CBD). The proposal combines the metro station with a significant mixed use tower, contributing to the Sydney skyline. The OSD would assist in strengthening the role of Central Sydney as the key centre of business in Australia and would contribute to the diversity, amenity and sustainability of the CBD.

It is noted that Pitt Street Station southern portal OSD has been subject to a separate application, and does not form part of this concept SSD Application.

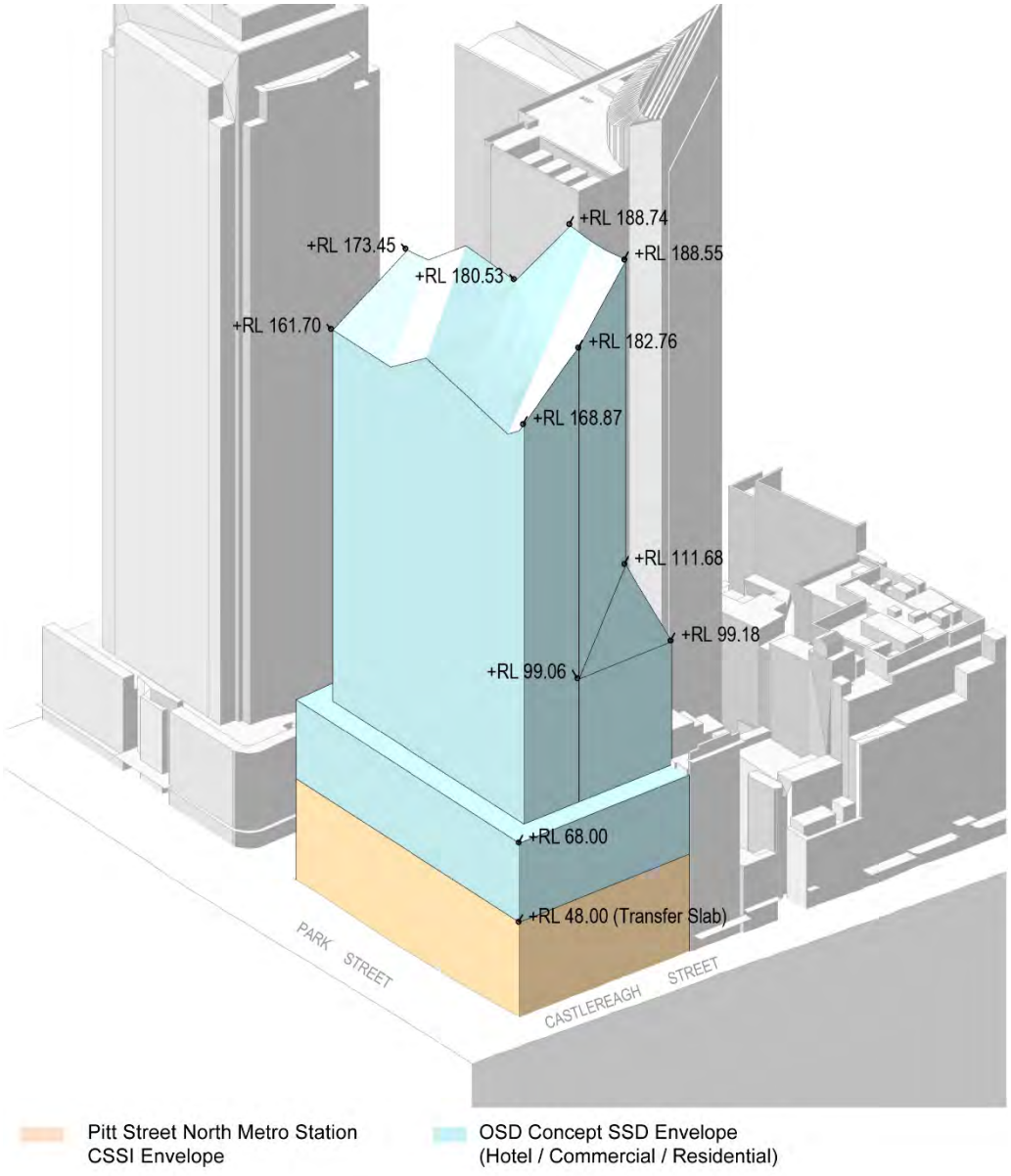

Figure 5: Pitt Street North OSD building, including OSD components (orange) and station box (grey)

Figure 6: Pitt Street North OSD indicative design, as seen from eastern, southern and western elevations

1.6 Staging and framework for managing environmental impacts

Sydney Metro proposes to procure the delivery of the Pitt Street North integrated station development in one single package, which would entail the following works:

- station structure
- station fit-out, including mechanical and electrical
- OSD structure
- OSD fit-out, including mechanical and electrical.

Separate delivery packages are also proposed by Sydney Metro to deliver the excavation of the station boxes/shafts ahead of the ISD delivery package, and line-wide systems (e.g. track, power, ventilation) and operational readiness works prior to the Sydney Metro City & Southwest metro system being able to operate.

Three possible staging scenarios have been identified for delivery of the Integrated Station Development:

1. Scenario 1 – the station and OSD are constructed concurrently by constructing the transfer slab first and then building in both directions. Both the station and OSD would be completed in 2024.

2. Scenario 2 – the station is constructed first and ready for operation in 2024. OSD construction may still be incomplete or soon ready to commence after station construction is completed. This means that some or all OSD construction is likely to still be underway upon opening of the station in 2024.
3. Scenario 3 – the station is constructed first and ready for operation in 2024. The OSD is built at a later stage, with timing yet to be determined. This creates two distinct construction periods for the station and OSD.

Scenario 1 represents Sydney Metro's preferred option as it would provide for completion of the full integrated station development and therefore the optimum public benefit at the site at the earliest date possible (i.e. on or near 2024 when the station is operational). However, given the delivery of the OSD could be influenced by property market forces, Scenarios 2 or 3 could also occur, where there is a lag between completion of the station component of the ISD (station open and operational), and a subsequent development.

The final staging for the delivery of the OSD would be resolved as part of the detailed SSD application(s).

For the purposes of providing a high level assessment of the potential environmental impacts associated with construction, the following have been considered:

- Impacts directly associated with the OSD, the subject of this SSD application
- Cumulative impacts of the construction of the OSD at the same time as the station works (subject of the CSSI Approval).

Given the integration of the delivery of the Sydney Metro City & Southwest metro station with an OSD development, Sydney Metro proposes the framework detailed in

Figure 7 to manage the design and environmental impacts, consistent with the framework adopted for the CSSI Approval, which includes:

- project design – measures which are inherent in the design of the project to avoid and minimise impacts
- mitigation measures – additional to the project design which are identified through the environmental impact assessment
- construction environmental management framework – details the management processes and documentation for the project
- construction noise and vibration strategy – identifies measures to manage construction noise and vibration
- design guidelines – provides an assurance of end-state quality
- environmental performance outcomes – establishes intended outcomes which would be achieved by the project

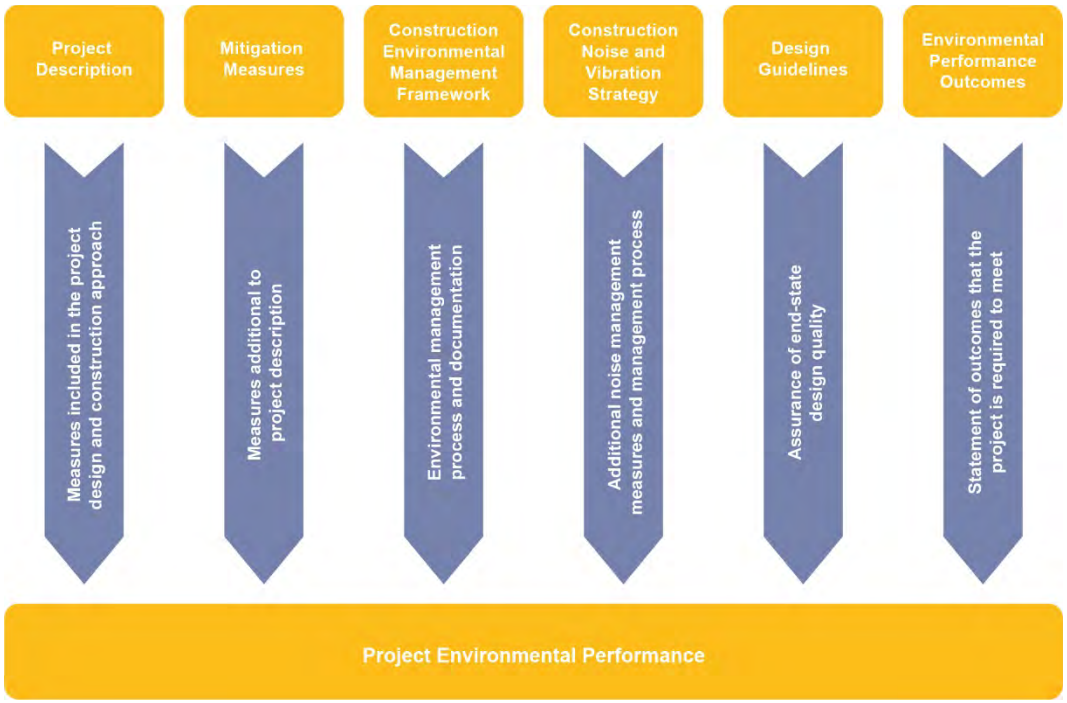

Figure 7: Project approach to environmental mitigation and management

Sydney Metro proposes to implement a similar environmental management framework where the integrated delivery of the CSSI station works and the OSD occur concurrently. This would ensure a consistent approach to management of design interface and construction-related issues.

Sydney Metro proposes this environmental management framework would apply to the OSD until completion of the station and public domain components of the integrated station development delivery contract (i.e. those works under the CSSI Approval). Should the OSD be constructed beyond the practical completion and opening of the section, standard practices for managing construction related environmental impacts would apply in accordance with the relevant guidelines and Conditions of Approval for the detailed SSD application(s).

2. Introduction

Cermak Peterka Petersen Pty. Ltd. has been engaged by Architectus to provide a qualitative assessment of the impact of the proposed Pitt Street North OSD development on local pedestrian-level wind conditions.

The proposed development is located in the southern section of the Sydney CBD, on a block bounded by Park Street to the south, Castlereagh Street to the east, and Pitt Street to the west, Figure 8. The indicative design for the proposed development is comprised of two medium-rise towers over a common podium, Figure 9. The extent to which the addition of the proposed development to this site will impact ground level wind speeds is broadly discussed in this report.

Figure 8 – Aerial view of the proposed development site *Google Earth (2017)*

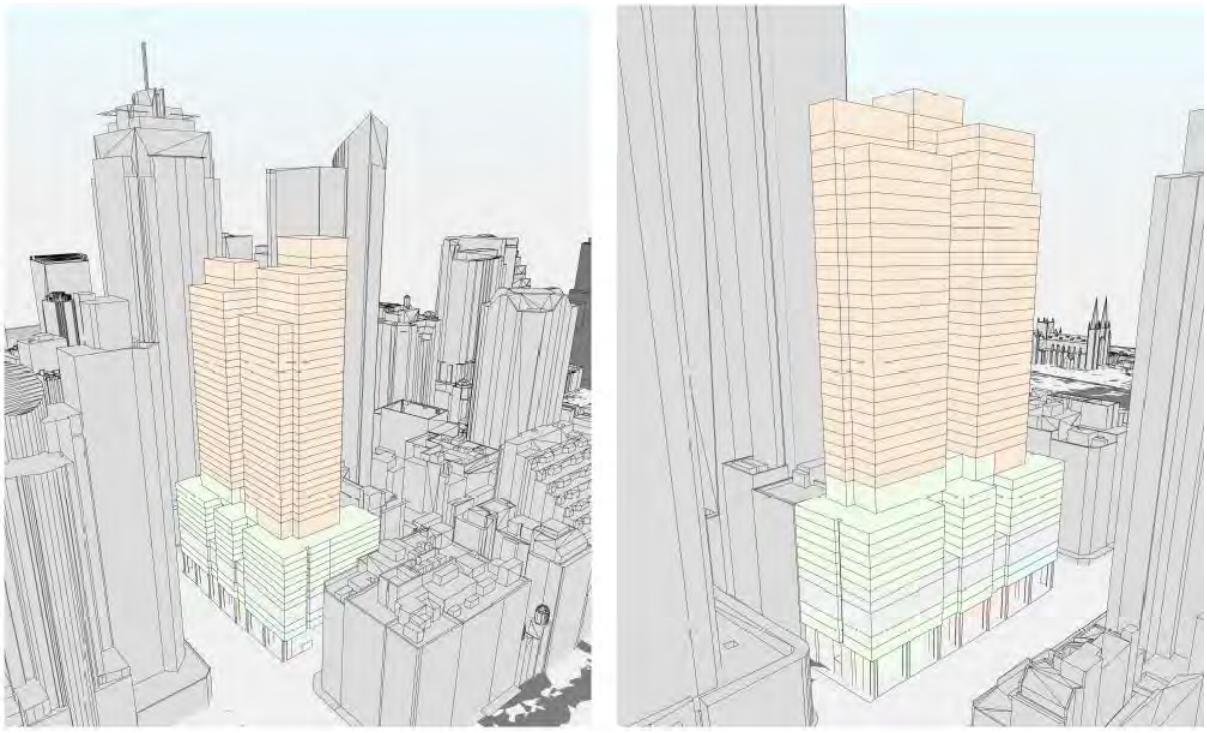

Figure 9 – : South-east (L) and south-west (R) perspective views of the proposed development

3. Sydney Wind Climate

The proposed development lies approximately 8 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 this anemometer from 1995 to 2015 have been used in this analysis. The wind rose for Sydney is shown in Figure 10 and is considered to be representative of prevailing winds at the site. It is noted from Figure 10 that strong prevailing winds typically originate from the 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. Winds from the south occur throughout the year and tend to be cold, generally associated with frontal systems that can last several days. 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.

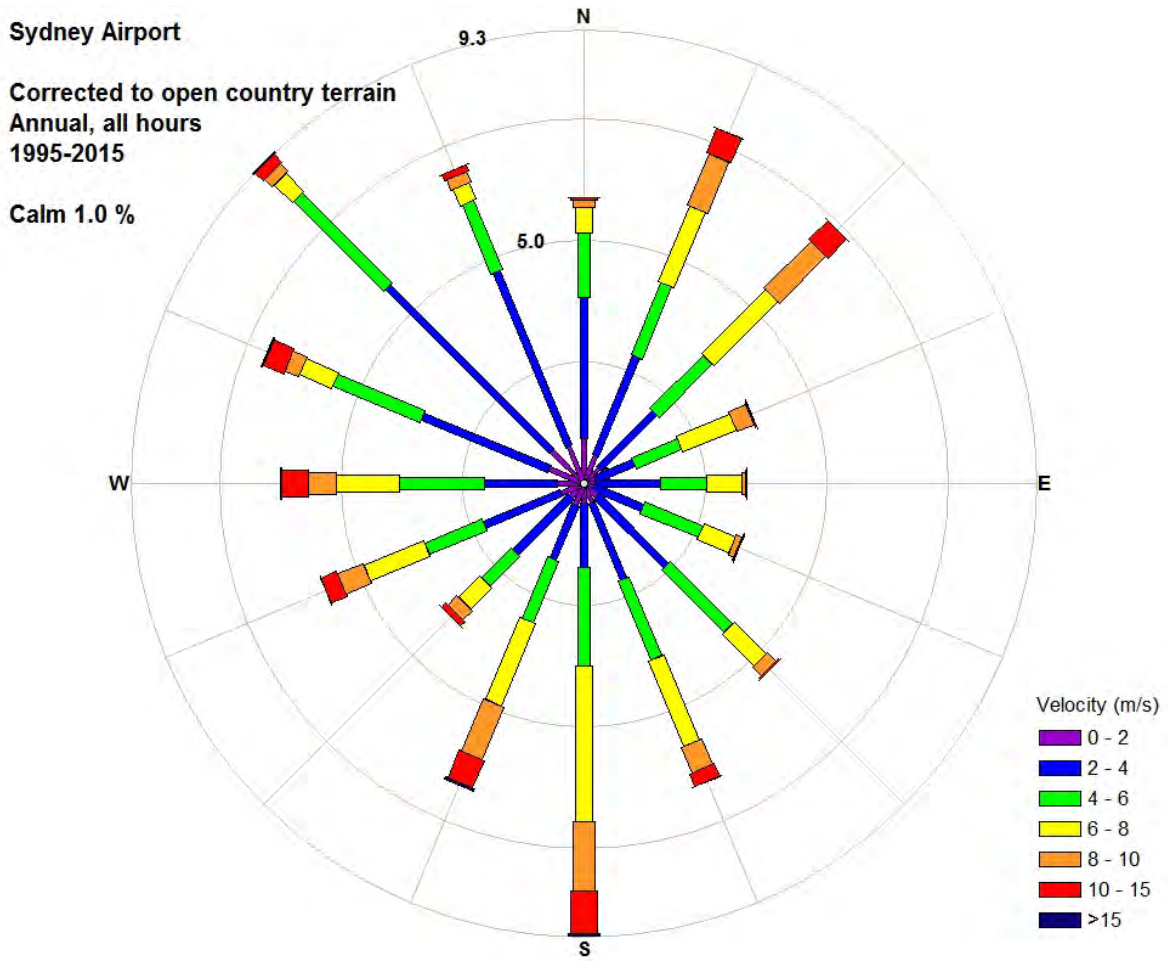

Figure 10 – :Wind Rose of strength and direction at Sydney Airport

4. 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) (DCP) specifies wind effects are not to exceed 10 m/s for 'active frontages', which includes the portions of Park, Castlereagh, and Pitt Streets bordering the subject site. 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 criteria 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. To address this limitation, the current study is based upon the criteria of Lawson (1990), which are described in Table 1. The Lawson criteria have categories for both comfort and distress/safety. The 5% of the time event is considered an appropriate comfort threshold for a precinct to develop a reputation from the general public. The limiting criteria wind speeds include consideration of both a mean and gust equivalent mean (GEM) 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.

Table 1 – :Lawson pedestrian comfort criteria

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.

5. Environmental Wind Assessment

The development site is located on the central ‘spine’ of the Sydney CBD massing, surrounded in most directions by medium to high-rise structures. To the east is the relatively open region of Hyde Park, which will allow for stronger breezes from this direction. Topography surrounding the site is relatively flat from a wind perspective and unlikely to significantly affect the wind climate at the site. Ground level conditions in areas such as this are particularly affected by channelling flows between tall buildings. The surrounding streets are roughly aligned on a north-south and east-west grid, which will encourage channelled flows for winds from these directions. Taller exposed buildings nearby will also affect pedestrian level conditions at some locations. Wind flow mechanisms including downwash and channelling flow are described in Appendix 1 of this document, and the effectiveness of some common wind mitigation measures are described in Appendix 2.

The indicative design for the development consists of two towers (labelled east and west) of generally rectangular planform over a shared 11-storey podium. A ground floor plan and elevation are shown in Figure 11. This assessment will also include consideration of a planning envelope scheme (“envelope design”) shown in Figure 12.

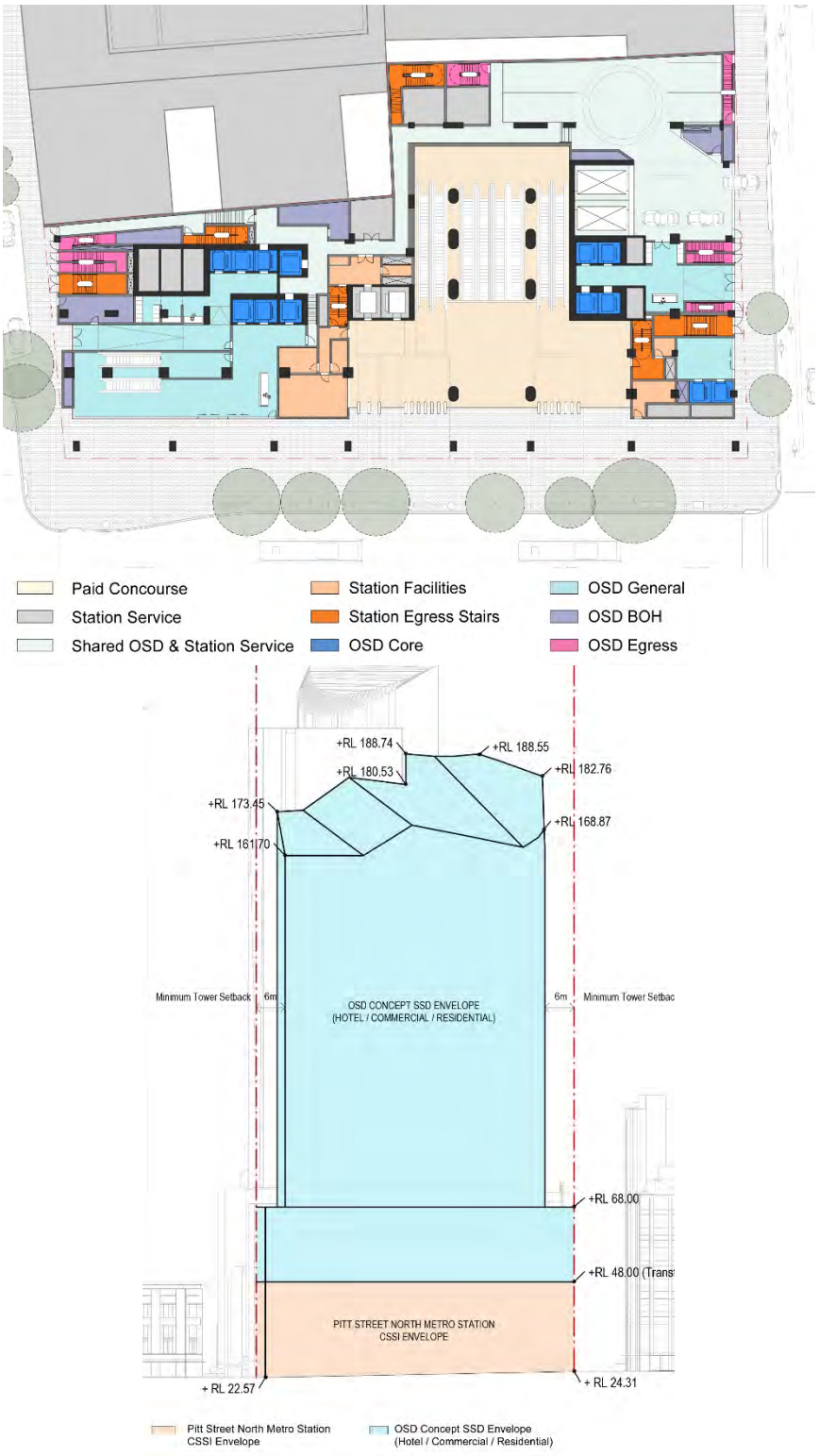

Figure 11 – : Ground floor (T) and south elevation (B) of the indicative design for the proposed development

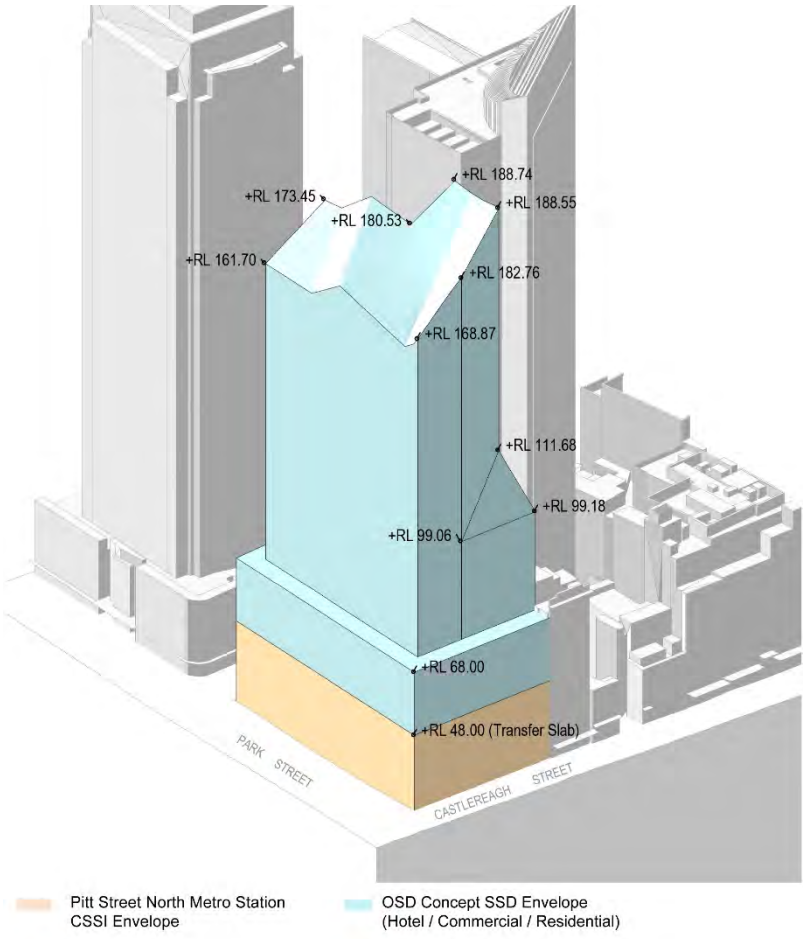

Figure 12– : Perspective view of planning envelope design

5.1. Winds from the north-east

Winds from the north-east approach over the Botanic Gardens and Hyde Park, and will be diverted towards the south by the general Sydney CBD massing. Most of the surrounding pedestrian areas are shielded from direct winds by adjacent developments, allowing for mostly calm conditions. The oblique orientation of the towers relative to the incoming wind from this direction and the podium setback will limit the amount of downwash affecting pedestrians.

Some channelled flow would be expected along Castlereagh and Pitt streets during winds from the north-east, and the addition of the indicative design will contribute to this mechanism by directing some flow onto Castlereagh Street. A modest increase in wind speeds relative to the existing would be anticipated on this frontage, with the strongest conditions occurring at the south-east corner of the site. No significant difference between the indicative design and envelope design massing would be expected for this wind direction.

5.2. Winds from the south

Winds from the south will be channelled along the corridors formed by Pitt and Castlereagh Streets. The addition of the indicative design would be expected to provide a marginal contribution to this effect relative to the existing massing, as would the envelope design.

The neighbouring towers to the south are of a similar size to the proposed development, and will provide shielding from southerly winds, particularly for pedestrian locations along Park Street. Some downwash effects would be expected from the exposed portions of the towers, however the setback of the towers from the podium will limit effects at ground level by redirecting flow horizontally at podium level.

The ground-level Park Street colonnade in the indicative design will also provide a sheltered area for pedestrians at the station entrance, allowing an improvement in conditions relative to the envelope design. Overall, the addition of the proposed development is not expected to strongly affect the pedestrian environment during winds from the south relative to existing conditions, and similar conditions would be expected for both the indicative and envelope designs for this wind direction.

5.3. Winds from the west

The intensity of winds from the west will be attenuated by the densely built ‘spine’ of the Sydney CBD. In particular, the neighbouring tower to the immediate west of the site will dictate conditions to a significant extent, meaning the relative impact of the proposed development will be minor. Relatively strong channelled flow would be expected along Park Street during winds from this direction. The addition of the proposed development would be expected to slightly exacerbate this effect by narrowing the channel, however the impact on pedestrian comfort is likely to be negligible and conditions will remain similar to the existing.

Calm conditions would be anticipated on Castlereagh and Pitt Streets during winds from the west due to the compound massing of surrounding structures. The colonnade along Park Street is likely to create a slightly calmer area, being set back from the Park Street corridor and protected from overhead.

5.4. Summary

The pedestrian wind environment in this area of the city is largely determined by the combined massing of larger structures and the resulting channelled flows along street grids. Downwash from taller exposed facades may also affect ground level conditions. Wind tunnel testing conducted by CPP at nearby locations has indicated that most areas are rated as suitable for Pedestrian Walking under Lawson, with more sheltered locations such as those under the colonnade being rated as suitable for Pedestrian Standing. Due to the size of the proposed development relative to its surrounds and the setback of the towers from the podium, the impact on ground level winds is expected to be minor compared to the existing configuration. Overall, the wind environment will remain similar to the existing with most locations suitable for Pedestrian Walking under Lawson. Some locations may experience a modest increase in wind speeds relative to the existing, while others will become calmer. Windier areas are likely to be found close to the south-east corner of the site as well as along Castlereagh Street, while locations under the southern colonnade are likely to be mostly calm. All locations would be expected to satisfy the Lawson distress criterion. No significant differences between the indicative design and envelope design are likely.

5.5. Wind conditions within the development

The indicative design for the development features outdoor terrace areas on the podium rooftop and tower rooftops, as well as smaller balconies. Elevated outdoor spaces such as these tend to experience stronger wind conditions, having greater exposure to strong winds and the influence of immediately adjacent towers. They are also affected by local accelerations in the flow near façade and roof edges. It is understood that the assessed design is indicative only, and as such the following advice should be considered generic.

5.5.1. Residential balconies

Private balconies are distributed across both towers. A typical level is shown in Figure 13. In general, the balconies are well located from a wind perspective, being recessed from the façade line. Their depth to width ratio will also benefit wind conditions. Strong winds may be experienced, particularly on the larger corner balconies. High balustrades or privacy screens could be used to improve conditions at these locations.

Figure 13– Level 30-34 (T) and Level 12 (B) general arrangement plans

5.5.2. Podium terrace

On the podium roof (Figure 14), the eastern side of the terrace is somewhat exposed to the effects of north-easterly winds. Downwash from the eastern tower will affect this area, with strongest conditions expected at the south-eastern corner of the tower. Winds from the south and west will also affect all three sides of the podium terrace, with strongest conditions occurring near the tower bases and at the corners. Most of the podium terrace is likely to be suitable for transient or short-term stationary activity without additional mitigation measures. The northern section of the podium roof (residential pool area) would be expected to be mostly calm.

Horizontal awnings or canopies would be suggested around the tower bases to mitigate the effects of downwash. A fence or high balustrade around the perimeter of the terrace areas could be combined with planting as marked on architectural drawings to provide shielding from strong winds moving across the podium. Additionally, local screening in the form of

vertical barriers, umbrellas, or cabanas could be used to provide smaller areas of calm. (noting typically high wind loads on these elements.)

5.5.3. Rooftop terraces

The rooftop terraces may also experience windy conditions for significant periods. The west tower rooftop terrace will be shielded from some wind directions by the higher levels to the north. The L-shaped layout and privacy screen will allow at least some of the area to remain relatively calm for most wind directions. The smaller size of the adjacent private terrace will promote slightly calmer conditions here. High (>1.5 m) balustrades would be recommended to provide further amelioration.

The rooftop terraces on the east tower are expected to experience strong conditions for significant portions of the time. These areas are exposed to prevailing winds from multiple directions, which will be accelerated over the edges of the tower. Conditions will be strongest near the perimeter and corners of each terrace and calmer towards the recessed areas.

Detailed wind amelioration strategies may be developed in subsequent design stages and verified during wind tunnel testing.

Figure 14– : Level 38 (T) and Level 41 (B) general arrangement plans

6. Conclusion

Cermak Peterka Petersen Pty. Ltd. has provided a qualitative assessment of the impact of the proposed Pitt Street North OSD project on the local wind environment in and around the development site. The site is located in a densely developed section of the city, where conditions are largely determined by the combined massing of larger structures. As the addition of the proposed development will provide only a minor modification to this global massing, its impact on ground level wind speeds is expected to be small. Wind conditions around the development are likely to be classified as acceptable for Pedestrian Walking from a Lawson comfort perspective and pass the Lawson distress/safety criterion. Most locations would not be expected to satisfy the conservative 10 m/s threshold from the DCP. As with most locations in Sydney, additional amelioration would likely be necessary if any areas are intended for long-term stationary or outdoor dining activities. General guidance on improving conditions on terraces in the interests of patron comfort has been provided.

Wind tunnel testing to verify the findings of this study has been undertaken. The findings are summarised in a separate report.

7. 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.

Standards Australia (2011), Australian/New Zealand Standard, Structural Design Actions, Part 2: Wind Actions (AS/NZS1170 Pt.2).

Appendix 1: Wind Flow Mechanisms

When the wind hits a large isolated building, the wind is accelerated down and around the windward corners, Figure 8; 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 8, 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 9 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.

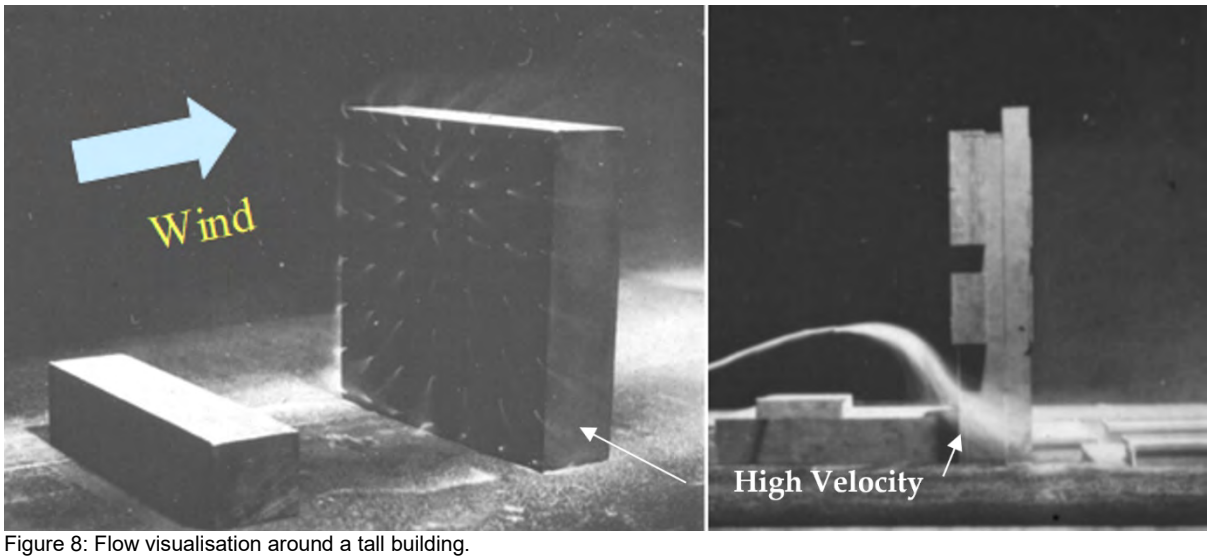

Figure 8: Flow visualisation around a tall building.

Figure 9: 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 10. 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.

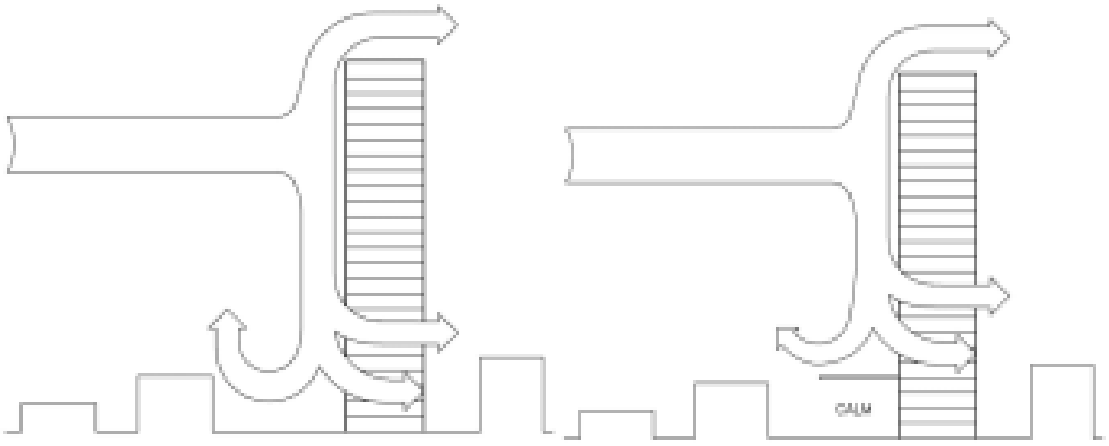

Figure 10: Canopy Windbreak Treatment. (L) Downwash to street level may generate windy conditions for pedestrians. This is particularly true for buildings much taller than the surrounding buildings. (R) A large canopy is a common solution to this pedestrian-wind problem at street level.

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 11. 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.

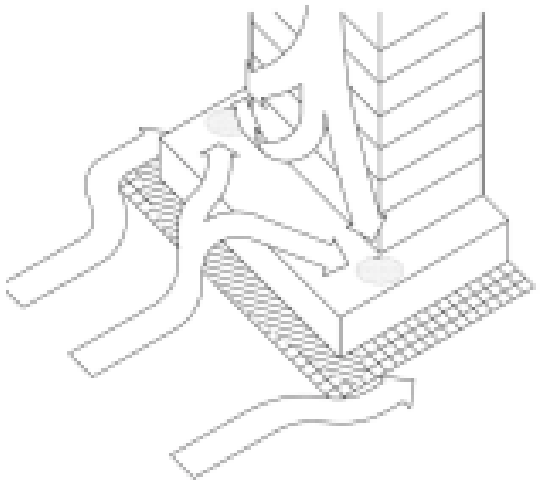

Figure 11: The tower-on-podium massing often results in reasonable conditions at ground level, but the podium may not be useable.

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

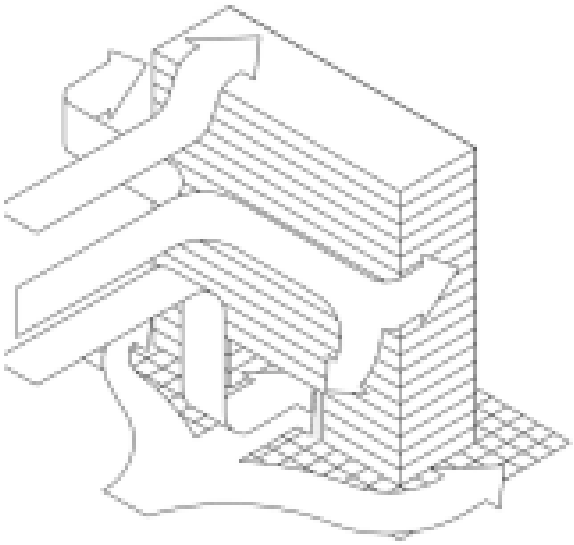

Figure 12: An arcade or open column plaza under a building frequently generates strong pedestrian wind condition.

Building form – Alcove

An entrance alcove behind the building line will generally produce a calmer entrance area at a mid-building location, Figure 13 (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 13 (R), due to the accelerated flow mechanism described in Figure 8 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.

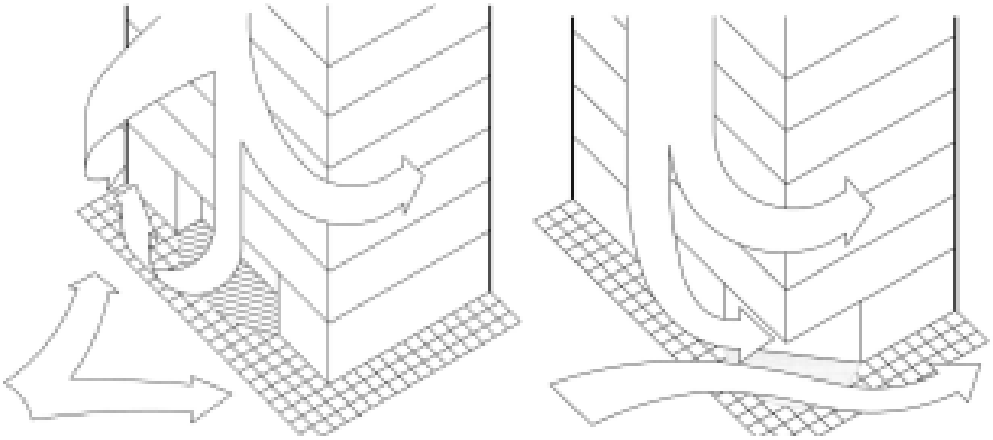

Figure 13: Alcove Windbreak Treatment. (L) A mid-building alcove entrance usually results in an inviting and calm location. (R) Accelerated corner flow from downwash often yields an unpleasant entrance area.

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 11. 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 9 (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.