WIND IMPACT ASSESSMENT REPORT

APPENDIX M

Sydney Metro City & South West: Victoria Cross Over Station Development:

Wind impact assessment report

Applicable to:	Sydney Metro City & Southwest
Author:	AECOM Australia Pty Ltd
Owner	Transport for NSW
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1.0 Introduction

1.1 Purpose of this report

This report supports a concept State Significant Development Application (concept SSD Application) submitted to the Department of Planning and Environment (DP&E) 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.

Transport for NSW (TfNSW) is seeking to secure concept approval for a commercial office tower above the Victoria Cross Station, otherwise known as the over station development (OSD). The concept SSD Application seeks consent for a building envelope and its use as a commercial premises (office, business and retail), maximum building height, maximum gross floor area, pedestrian and vehicular access, circulation arrangements and associated car parking, future subdivision (if required) and the strategies and design parameters for the future detailed design of development.

TfNSW proposes to procure the construction of 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 DP&E on 9 January 2017.

As the development is within a rail corridor, is associated with railway infrastructure and is for commercial premises with a Capital Investment Value of more than $30 million, the project is identified as State Significant Development (SSD) pursuant to Schedule 1, 19(2)(a) of the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP).

This report has been prepared to outline the findings of a wind impact assessment and specifically respond to the Secretary's Environmental Assessment Requirements (SEARs) issued for the concept SSD Application on 30th November 2017 which states that the Environmental Impact Statement (EIS) is to address the following requirements:

- Wind analysis outlining the impacts and any proposed measures to address pedestrian amenity
- Wind impact assessment (including a wind tunnel study).

Refer to **Section 2.0** for further detail regarding the scope of this 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 (Stage 1), which is due for completion in 2019 and Sydney Metro City & Southwest (Stage 2), which is due for completion in 2024 (Refer to **Figure 1**).

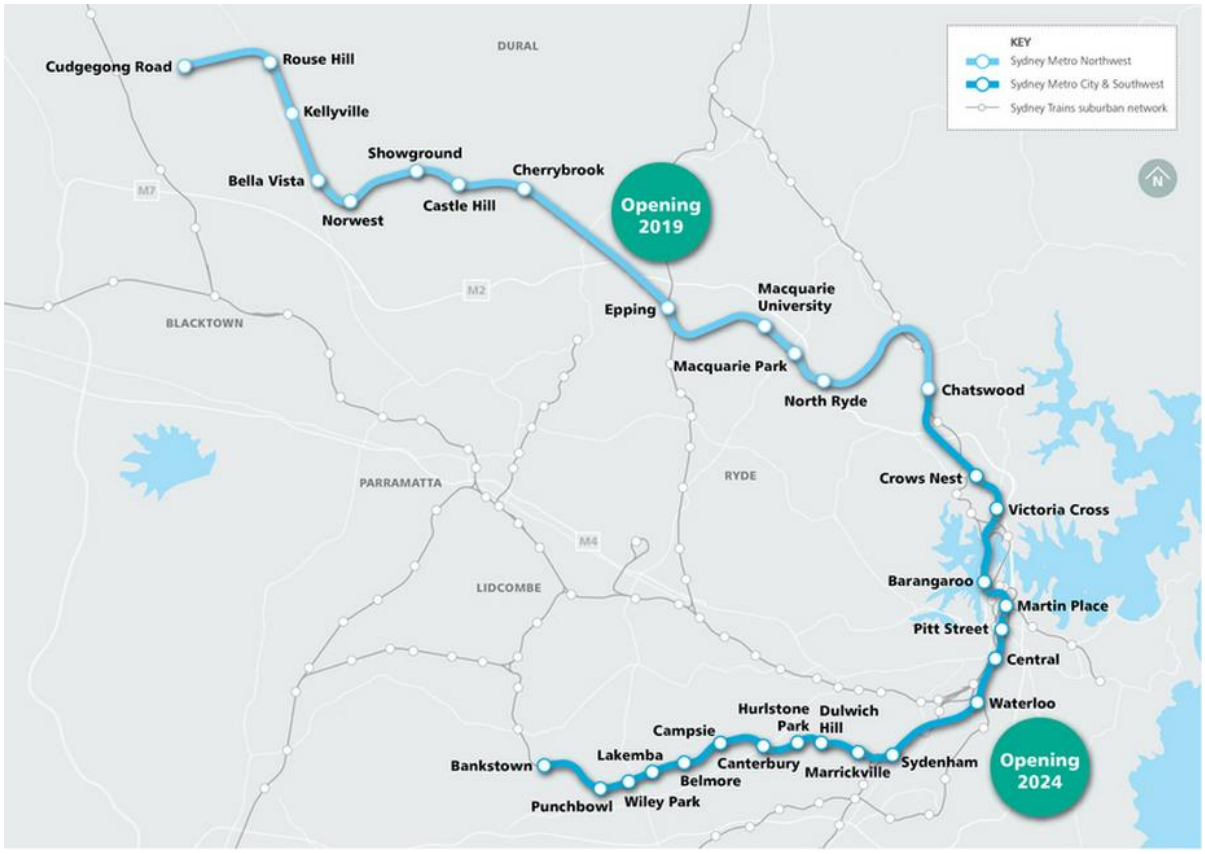

Figure 1: Sydney Metro alignment map
Source: Sydney Metro

Stage 2 of Sydney Metro 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 (7) new metro stations, including at North Sydney. 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 lodged by TfNSW 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 OSD (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 OSD to be more efficiently built and appropriately integrated into the metro station structure.

The EIS for the Chatswood to Sydenham component of the 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 with DP&E 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 original station design remains approved. This modification application was approved on 22 March 2018.
- Modification 4 - Sydenham Station and Sydney Metro Trains Facility South which incorporates 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 Stage 2 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 part of the project, referred to as the Sydenham to Bankstown Upgrade, is the subject of a separate CSSI Application (Application No. SSI 17_8256) which is currently being assessed by the DP&E.

1.3 Planning relationship between Victoria Cross Station and the OSD

While the Victoria Cross Station and OSD will form an Integrated Station Development, the planning pathways defined under the *Environmental Planning & 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 include the construction of below and above ground structures necessary for delivering the station and also enabling construction of the integrated OSD. This includes 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
- Pedestrian through-site link
- 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 Victoria Cross is defined by RL 82), above which would sit the OSD. This delineation is illustrated in **Figure 2**.

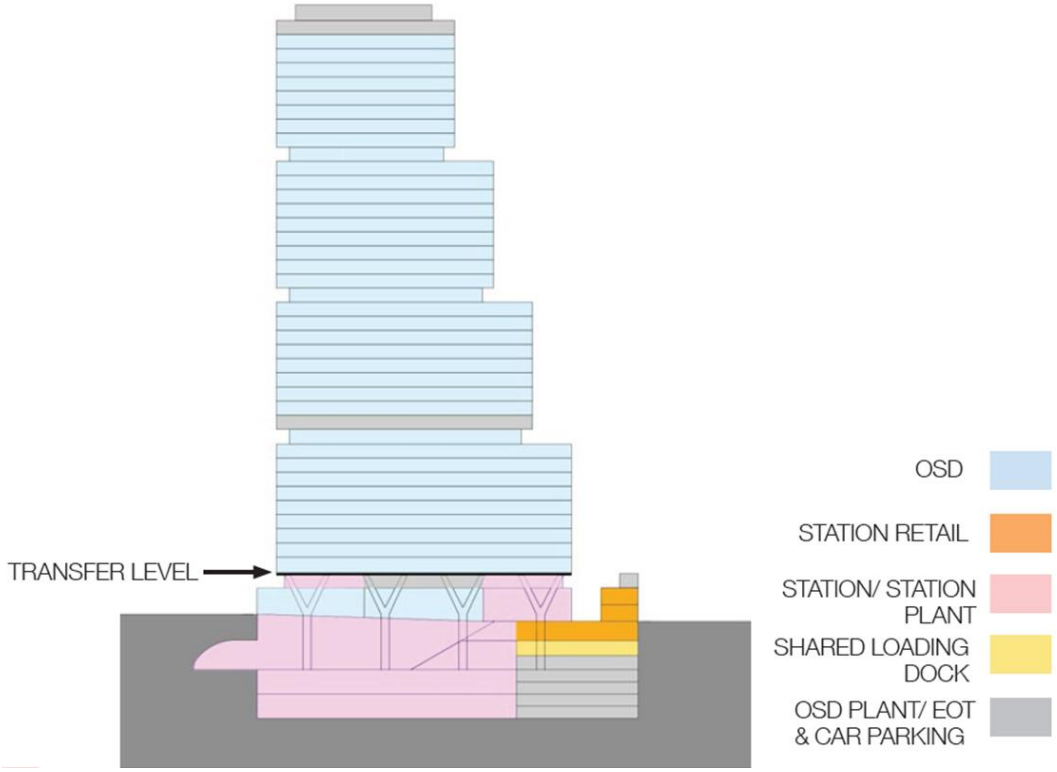

Figure 2: Delineation between the Metro station and OSD

The CSSI Approval also establishes the general concept for the ground plane of Victoria Cross Station including access strategies for commuters, pedestrians and workers. In this regard, pedestrian access to the station would be from Miller and Denison Streets and the commercial lobby would be accessed from Miller Street. Retail uses (approved under the CSSI Approval) would be located on the ground floor of the development at both the Miller Street and Denison Street levels activating the through-site link. Separate consent would be sought in the future for the fit-out and specific use of this retail space.

Since the issue of the CSSI Approval, TfNSW 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 Victoria Cross 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 Victoria Cross OSD site is located at the southeast corner of the intersection of Miller and Berry Streets, North Sydney, above the southern portal of the future Victoria Cross Station (refer to **Figure 3**). The site is located in North Sydney CBD, which is identified as part of Sydney's "Harbour CBD" (along with Sydney CBD) in the *Greater Sydney Region Plan (2018).* It is the third largest office market in Sydney and is a key component of Sydney's Global Economic Corridor.

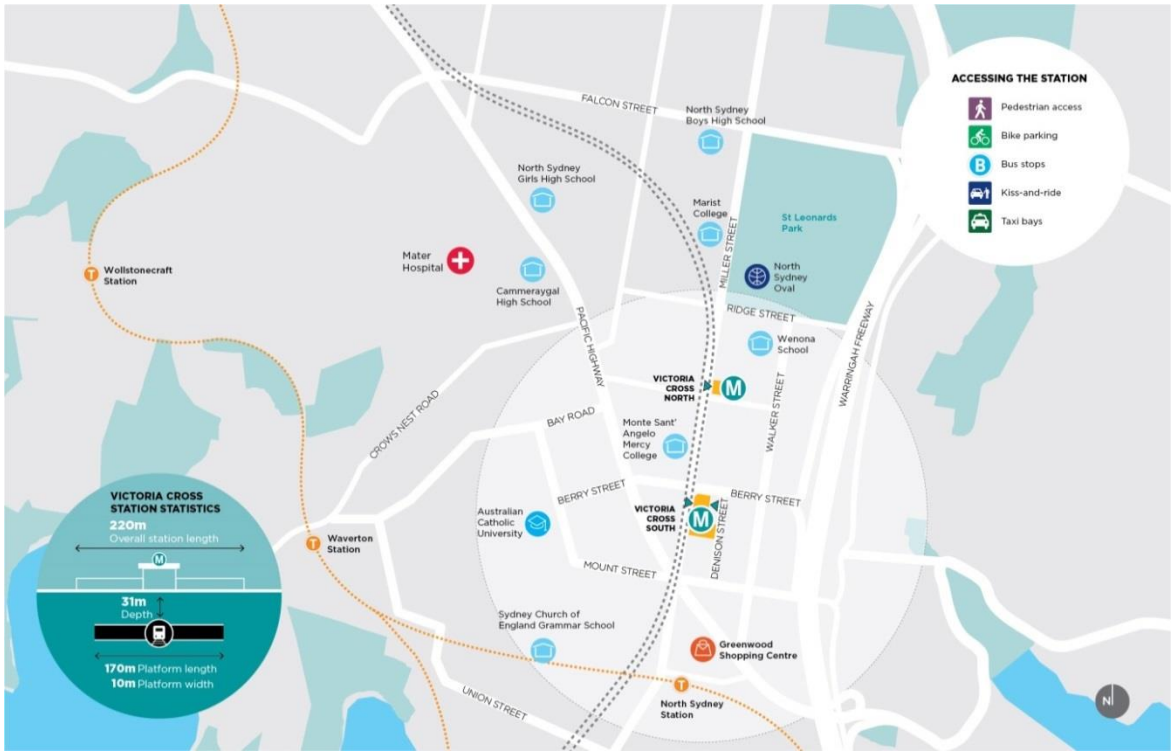

Figure 3: Victoria Cross Station location plan

The site is located in the North Sydney Local Government Area approximately 3km north of Sydney CBD, 5km southeast of Chatswood and 2km southeast of St Leonards.

The site (refer to **Figure 4**) is irregular in shape, has a total area of approximately 4,815 square metres and has street frontages of approximately 37 metres to Berry Street, 34 metres to Denison Street and 102 metres to Miller Street.

The site comprises the following properties:

- 155–167 Miller Street — SP 35644 (formerly Tower Square)
- 181 Miller Street — Lot 15 in DP 69345, Lot 1 & Lot 2 DP 123056 and Lot 10 in DP 70667
- 187 Miller Street — Lot A in DP 160018
- 189 Miller Street — Lot 1 in DP 633088
- Formerly part 65 Berry Street — Lot 1 in DP 1230458

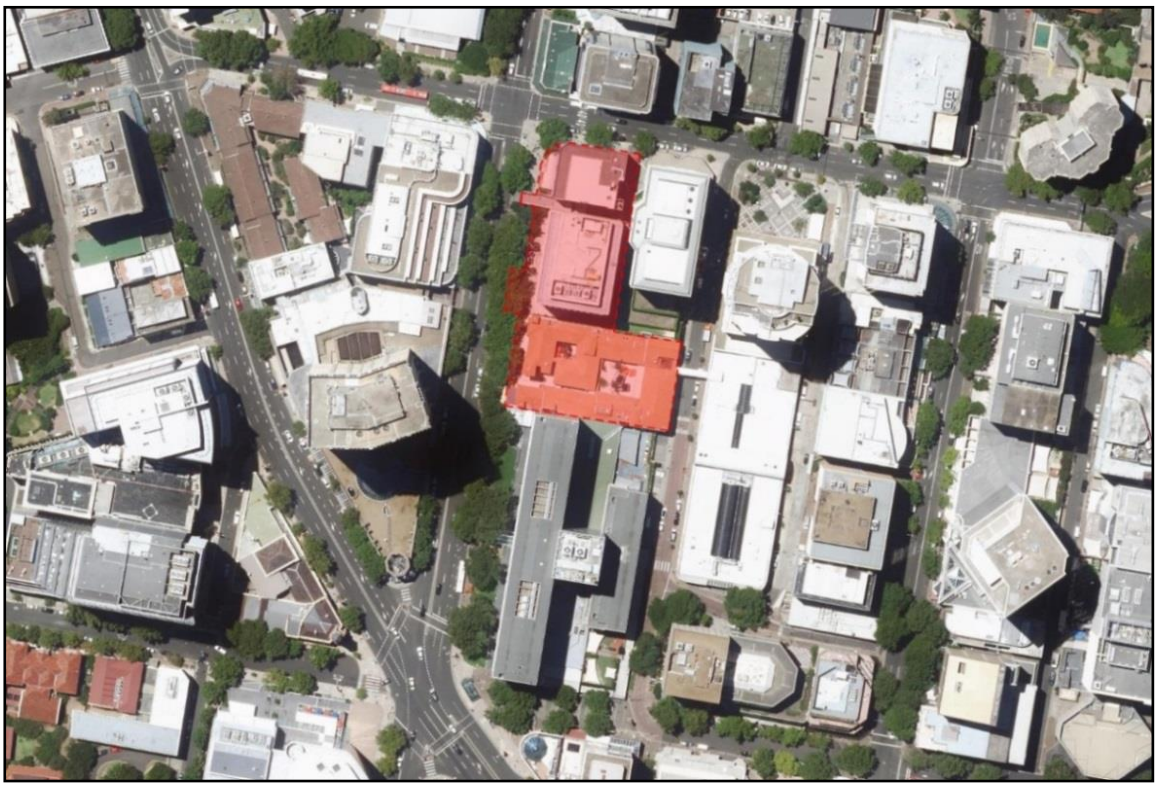

Figure 4: The Site

1.5 Overview of the proposed development

This concept SSD Application comprises the first stage of the Victoria Cross OSD project. It will be followed by a detailed SSD Application for the design and construction of the OSD to be lodged by the successful contractor who is awarded the contract to deliver the Integrated Station Development.

This concept SSD Application seeks approval for the planning and development framework and strategies to inform the future detailed design of the OSD. It specifically seeks approval for the following:

- A building envelope as illustrated in **Figure 5**
- A maximum building height of RL 230 or 168 metres (approximately 42 storeys, compromising 40 commercial storeys and 2 additional storeys for the roof top plant) for the high rise portion of building envelope and RL 118 or 55 metres (approximately 13 storeys) for the lower rise eastern portion of the building envelope
- A maximum gross floor area (GFA) of 60,000 square metres for the OSD component, which is equivalent to a floor space ratio of 12.46:1
- Use of the building envelope area for commercial premises including commercial office, retail and business premises

- Use of the conceptual OSD space provisioning within the footprint of the CSSI Approval (both above and below ground), including the OSD lobby and associated retail space, basement parking, end-of-trip facilities, services and back-of-house facilities
- Car parking for a maximum of 150 parking spaces over four basement levels with an additional 11 parking spaces allocated to the station retail approved under the terms of the CSSI Approval
- Loading, vehicle and pedestrian access arrangements from Denison Street
- Strategies for utility and services 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).

The total GFA for the Integrated Station Development including the station GFA (i.e. retail, station circulation and associated facilities) and the OSD GFA is 67,000 square metres and is equivalent to a FSR of 13.9:1.

A drawing illustrating the proposed building envelope is provided in **Figure 5**. The concept SSD Application includes an indicative design for the OSD to demonstrate one potential design solution within the proposed building envelope (refer to **Figure 6**).

Victoria Cross Station is to be a key station on the future Sydney Metro network, providing access to the growing North Sydney Central Business District (CBD). The proposal combines the Metro station with a significant commercial office tower, contributing to the North Sydney skyline. The OSD would assist in strengthening the role of North Sydney as a key component of Sydney's global economic arc and would contribute to the diversity, amenity and commercial sustainability of the CBD.

It is noted that Victoria Cross services building and new station entrance at Victoria Cross North do not form part of the concept SSD Application.

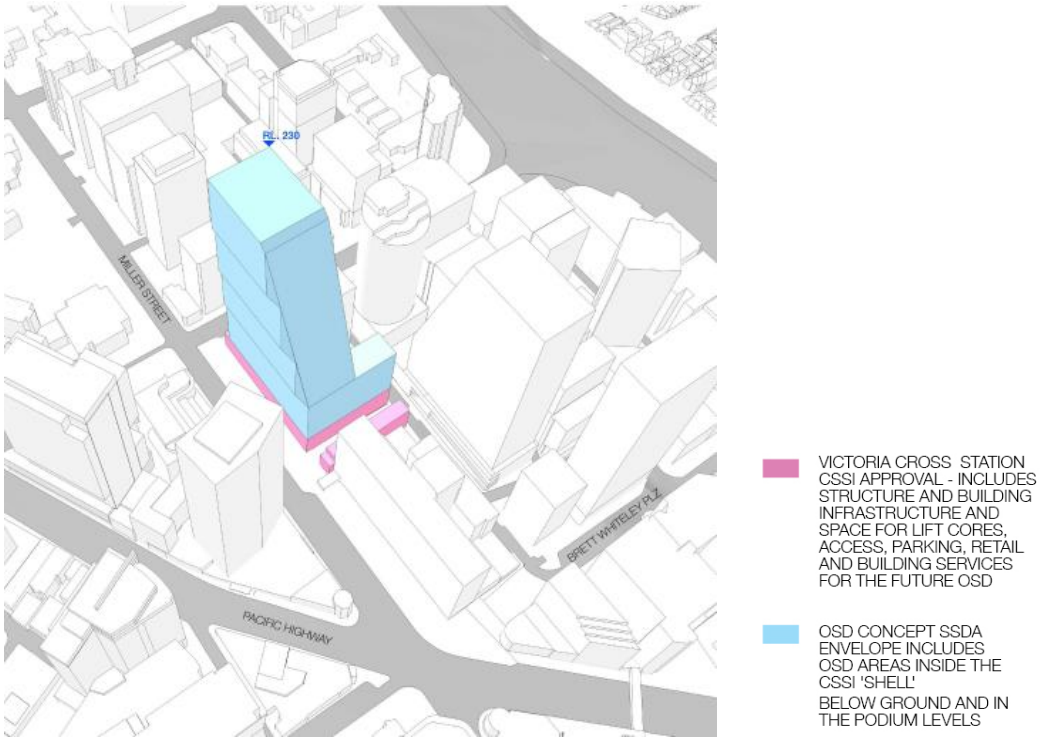

Figure 5: Proposed Victoria Cross OSD building envelope

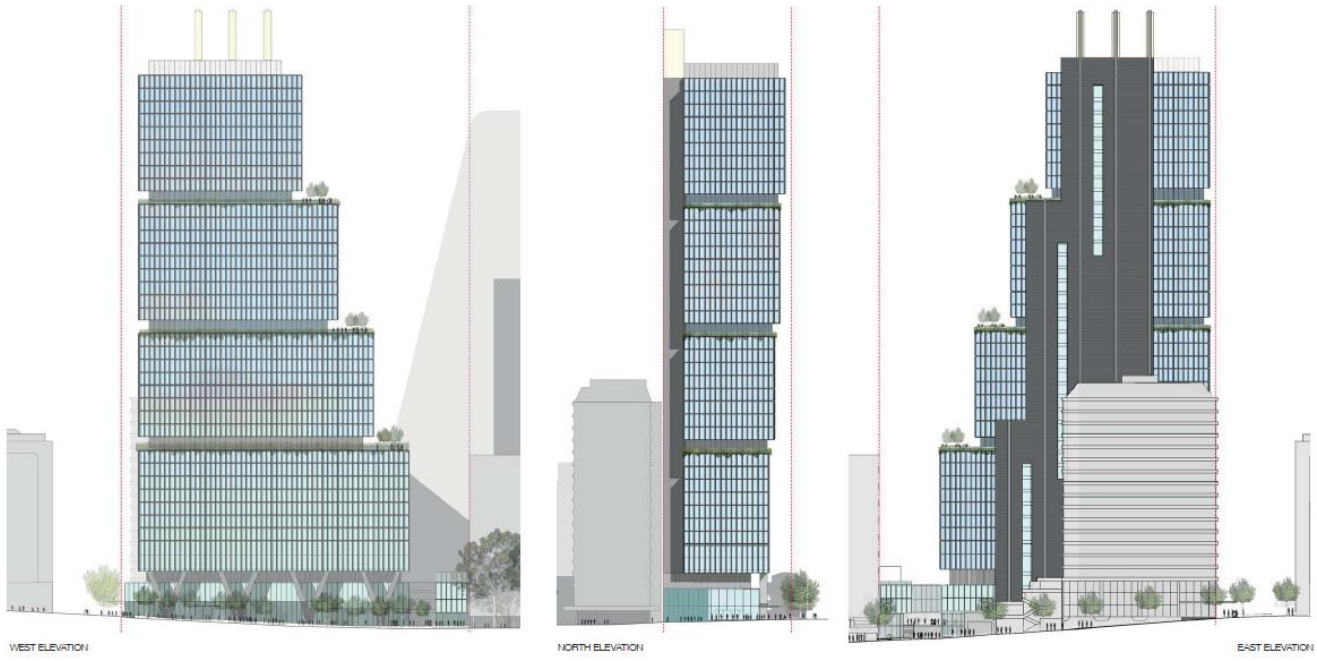

Figure 6: Victoria Cross indicative OSD design

2.0 Scope and methodology of assessment

It is somewhat inevitable that, with the construction of a new development, the wind microclimate in the vicinity would be changed. Where new buildings are significantly different in size and form, orientation or height from those in the immediate vicinity, winds can be introduced which may cause discomfort to pedestrians. The design of a development should therefore consider the provision of a quality outdoor environment, which is appropriate for its designated use for the majority of the year. Due to the height and layout of the proposed OSD above the new Victoria Cross Station, a number of potentially adverse wind effects may be created and require careful design mitigation strategies to ensure comfort conditions are achievable.

The building articulation, façade design, awning locations and extents of the Integrated Station Development would have a material impact on the nature and extent of any adverse wind effects created. Given the potential for these aspects to significantly change as a result of the procurement process adopted by TfNSW for the Integrated Station Development, detailed wind tunnel testing for the OSD component of the development involving detailed physical models and accurate calculations is proposed to be deferred to the detailed SSD Application stage.

For the purposes of this concept SSD Application, a high level desktop study of the likely wind conditions around the proposed OSD building envelope and surrounding streets has been undertaken. This study is an experience based qualitative review of the pedestrian level wind environment around the proposed OSD which would sit over, and integrated with the new Victoria Cross Station. The assessment of wind conditions is based upon experience with other similar schemes and knowledge of the interaction of the wind with the built environment. The wind conditions around the proposed OSD commercial tower in relation to planned pedestrian activities have been considered and an assessment of the potential impact that the proposed development may have on the surrounding area's wind microclimate is provided. Areas where wind is likely to be accelerated by geometrical features are highlighted and ways to mitigate these effects are recommended.

This report provides an indication of potential impacts which may have comfort implications. These are based on historical wind data and measured against commonly available wind effects criteria using accepted estimated methods.

Greater certainty that the proposed OSD building envelope and indicative design scheme would not adversely impact upon safety and comfort in the public realm would be available from detailed wind tunnel testing at detailed SSD Application stage. This assessment would consider rare high-wind events such as severe storms and future changes in wind climate due to global warming.

The amelioration of wind impacts at the ground plane and pedestrian links would require design collaboration between the station and OSD design teams. This aligns with the

Integrated Station Development model. Treatments such as awnings on the station's Miller St façade would be considered so as to improve comfort and safety at the indicative OSD design entrances and outdoor dining areas.

2.1 Planning context

The *North Sydney Development Control Plan 2013* (NSDCP2013), Part B Section 2.3.3 discusses wind speeds around commercial and mixed use developments:

> *Objectives*
>
> *O1 To ensure pedestrian comfort is not adversely affected by wind when walking along public streets or sitting down in public spaces.*
>
> *Provisions*
>
> *P1 Buildings should be designed to reduce wind velocity at footpaths and public outdoor spaces.*
>
> *P2 Development should not result in the wind speed exceeding 13m/s at footpaths and accessible outdoor spaces.*
>
> *P3 A Wind Impact Report, prepared by an appropriately qualified person, must be submitted with any application where the proposal results in the building exceeding 33m in height.*

This report provides an indication of likely conditions that pedestrians would experience, consistent with the limitations of a qualitative assessment. Confirmation that compliance with the relevant planning controls can be achieved would be provided by the wind tunnel testing at the detailed SSD Application stage.

3.0 Assessment criteria

3.1 Basis

Wind speed and gustiness are the primary measurable factors affecting people's comfort. Other factors such as air temperature and humidity, clothing, sun exposure, etc. are also significant, but these can often be addressed by a modification of effective wind speeds (Twidell, 2006).

Wind speed is understood to mean the average wind speed taken over a time of approximately one hour. Gustiness refers to the rate of change of wind speed, usually identified with the turbulent intensity defined by ratio of the standard deviation of the mean wind speed to the mean itself. The important wind gusts are those lasting 2–3 seconds, being the time taken to perform a simple act such as a few walking steps, opening a door etc.

Gustiness is a difficult factor to assess on the urban micro-scale. Fortunately, the implied turbulent intensity may be related to the underlying means in order to recast gustiness criteria in terms of mean wind speed (Twidell, 2006), (Melbourne, 1978), (ASHRAE, 2001), (Blocken, 2004). Estimates of turbulent intensity in urban situations range from 15% to 30% (Twidell, 2006), implying that gust wind speeds are generally 1.5–2.0 times greater than mean wind speeds.

3.2 Comfort

In general, comfort criteria relate to both the thermal effects of wind on people and the mechanical effects of wind on their activities.

The comfort criteria used in this study is the Lawson criteria (Lawson, 1978), based on certain mean wind speeds not being exceeded for more than 5% of the time. These criteria are presented in **Table 1**.

Table 1: The Lawson wind comfort criteria

Threshold wind speed (m/s)	Activity
4	Uncomfortable for pedestrians in the vicinity of entrance doors or sitting outside for long periods of time, such as outdoor cafes.
6	Uncomfortable for pedestrians standing or sitting for shorter periods of time, such as queuing or talking.
8	Uncomfortable for pedestrians 'leisure walking' e.g. strolling, window shopping and sightseeing.
10	Uncomfortable for pedestrians walking quickly e.g. walking to a destination, and cycling.

4.0 The local wind climate

4.1 Meteorological data

Given that the specific site address has not been used historically for recording weather data, suitable data for analysis of wind conditions must be acquired from nearby weather monitoring sites. The wind data used for the assessment was acquired from the Bureau of Meteorology for the automatic weather station at Fort Denison[1], which is located within Sydney Harbour, just under 3km to the south east of the new Victoria Cross Station.

The wind speed data was rescaled to account for the difference in land surface structure between the meteorological station and the development site, and the height difference between the anemometer and the level at which people are affected (assumed to be 1.5m above ground level). The rescaling was accomplished using a logarithmic-law approximation to a neutrally stable atmospheric boundary layer profile (Pasquill-Gifford Class D) (Oke, 2006) using the equation:

$$u_z = \frac{u_*}{\kappa} \ln \frac{z}{z_0}$$

In which u_z is the wind speed at height z (1.5m for pedestrian height), u_* is the friction velocity which is based on the reference wind speed from Fort Denison, κ is von Karman's constant ($\cong 0.4$) ans z_0 is the roughness height (taken as 2m for this site to account for physical obstructions such as cars).

Wind speeds below 0.5 m/s are registered by the anemometer as zero (calm).

4.2 Summary statistics

The wind data was analysed to assess the likelihood of uncomfortable winds, without allowing for the presence of the development. Local wind effects due to the development will be discussed in the next section.

The analysis was carried out using:

- Wind data for the nearest available location of Fort Denison
- The entire data set, representing wind conditions 24 hours a day; and
- A subset restricted to the hours of 7am to 7pm (business hours) when outdoor areas would be most active.

4.2.1 Wind speed

Based on weather data collected at Fort Denison, calm conditions occur rarely (2%) during business hours. Wind speeds at pedestrian height are low compared to the comfort criteria (**Figure 7**). Excluding potential impacts from the built form in North Sydney development,

[1] Station number 066022. The data consisted of hourly wind speed and direction, maximum gust speed, temperature and other variables from 13/8/1990 to 20/6/2016. After quality checks, there were a total of 212,148 suitable records.

recorded wind speeds at the weather station are likely to be comfortable for long term sedentary activities for the majority of the time. The detailed wind tunnel testing at detailed SSD stage will verify any exceptions to this assumption.

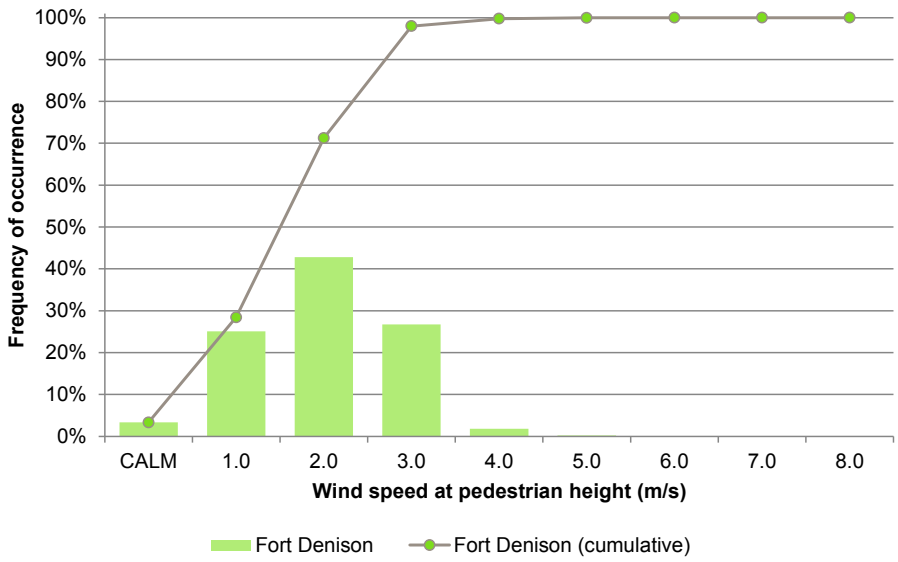

Figure 7: Distribution of wind speeds by band (bars) and cumulatively (line).

4.2.2 Wind direction

Based on weather data collected at Fort Denison, **Figure 8** shows the frequency of winds from each direction (divided in to 10° increments) for all hours and seasons (top left), divided by season for all times of the day (top right) and divided by season during business hours (bottom). Predominant winds are from the west, especially during the winter, which is likely to be when pedestrians are most impacted by wind. Easterly winds also occur, mostly during business hours, however as these occur in spring and summer, they are less likely to cause discomfort. This represents an analysis of the weather data collected at the nearest weather station to the site at Fort Denison and does not reflect the conditions presented by North Sydney urban development.

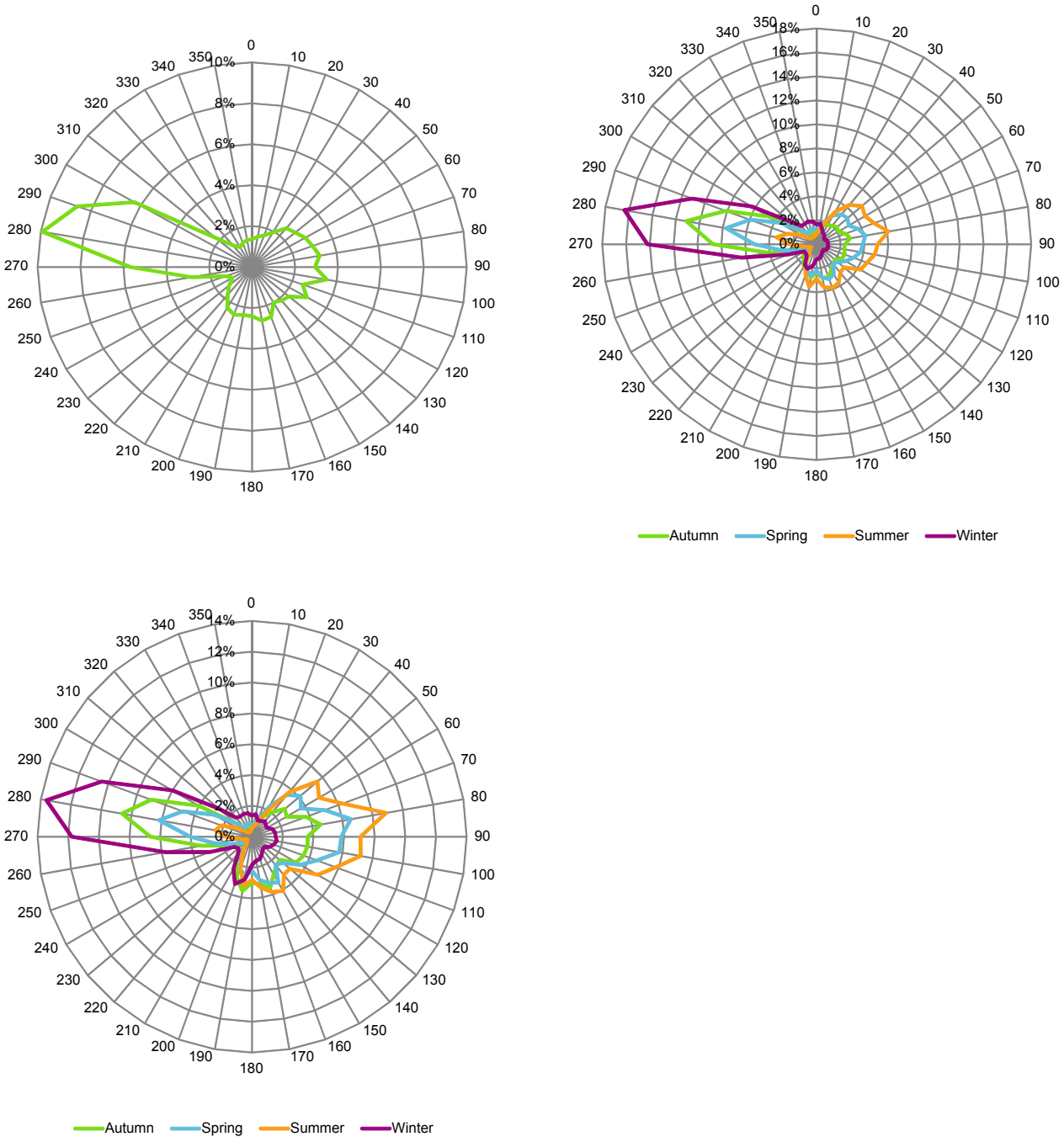

Figure 8: Distribution of wind heading for all times and seasons (top left), all times divided by season (top right), and by season during business hours (bottom).

5.0 Comfort assessment

5.1 Wind-sensitive locations

Figure 9, Figure 10 and **Figure 11** identify the locations that are potentially sensitive to wind flows, both within the site boundary and on adjacent streets (where a building may have an impact). Each location is discussed in the followings sections. Note this is based on the indicative OSD building design which may differ from the eventual scheme developed for the station and OSD commercial tower.

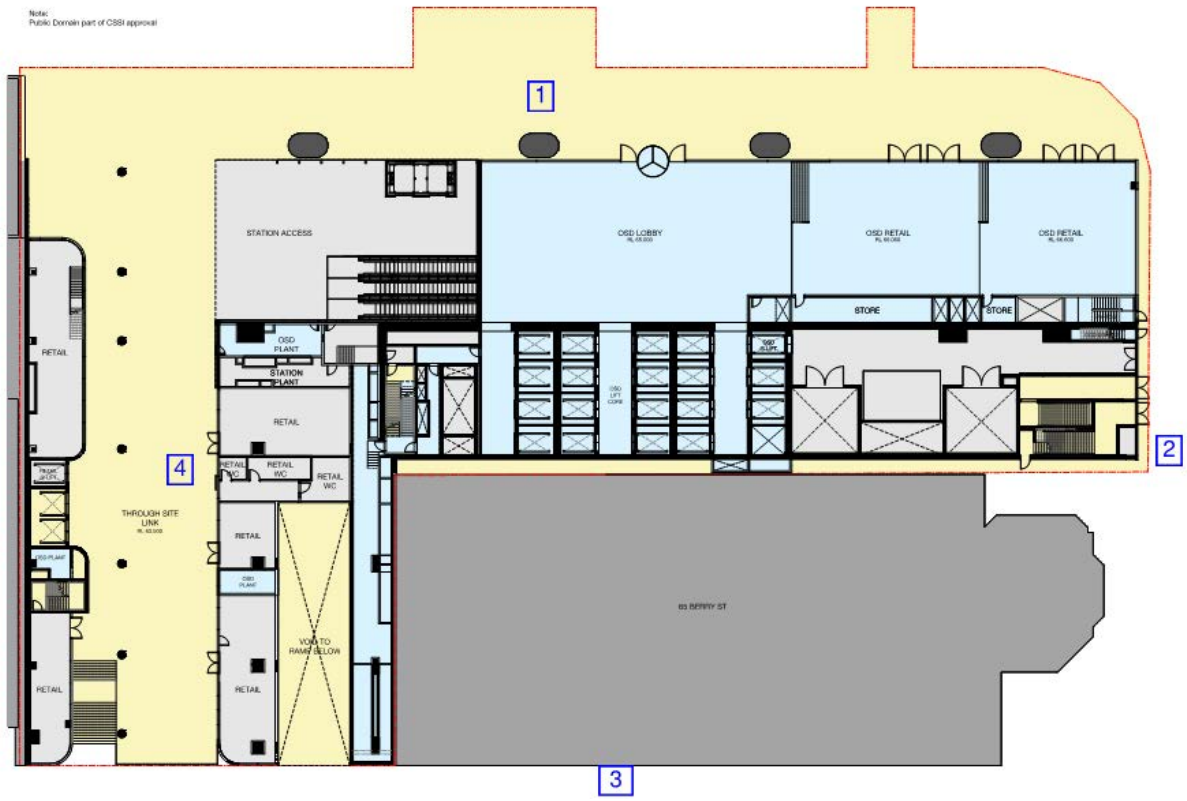

Figure 9: Ground Floor Plan

1. Along Miller Street
2. Along Berry Street
3. Along Denison Street
4. Undercover walkway between Miller and Denison Street
5. Level 4 Roof Terrace
6. Lower mid-rise, upper mid-rise and high-rise roof terraces

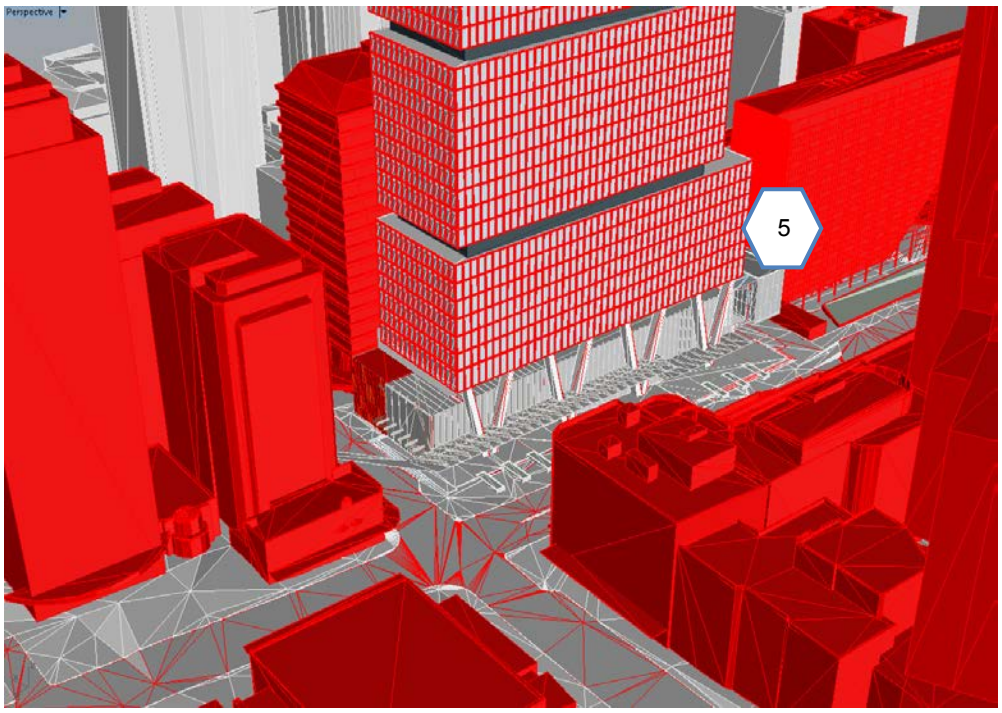

Figure 10: View towards main entrance

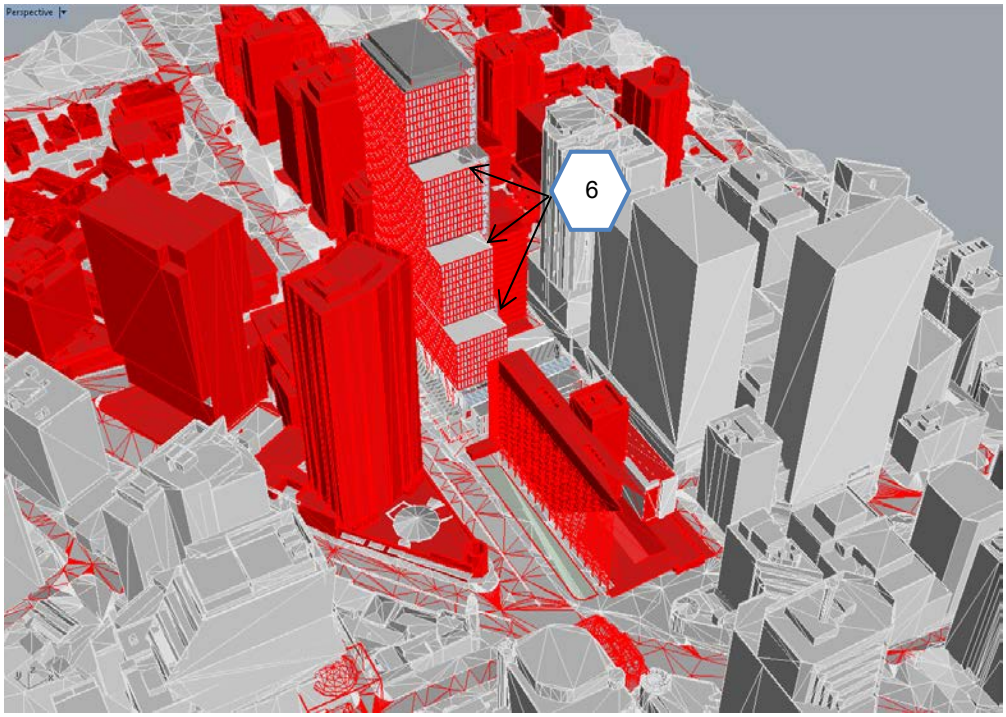

Figure 11: Upper terraces

5.1.1 Along Miller Street

Conditions along Miller Street should be suitable for leisure walking as a minimum, with the area directly out the front of the building suitable for short periods of sitting or standing.

Prevailing westerly winds are likely to result in downwash on the western façade of the proposed building, accelerating air down to ground level. Although some protection is offered by the buildings to the west of the site (namely 177 Pacific Highway and 100 Miller Street), these buildings are likely to accelerate winds on to the façade of the proposed Victoria Cross Integrated Station Development, increasing wind speeds further in some areas.

The indicative OSD design has recessed floors at level 03, 13, 22 and 32 that would help to deflect winds around the tower; however it is recommended that awnings at low level are included to protect pedestrians from downwash effects. This would need to be considered in the design development of the station as part of the CSSI Approval.

Tall trees with relatively large canopies (greater than 4-5m) would also provide overhead protection, however the effectiveness would be dependent on the species selected, as well as maturity.

Southerly and northerly winds are likely to channel along Miller Street with relatively few obstructions present to divert winds. The construction of the proposed building is unlikely to exacerbate these winds significantly, although trees and low level planting are recommended to provide some protection.

5.1.2 Along Berry Street

Conditions along Berry Street should be suitable for leisure walking as a minimum, with lower wind speeds desirable around building entrances.

Westerly winds are likely to be deflected around the western facade of the proposed OSD development, resulting in accelerated wind speeds along Berry Street. A full computational assessment is recommended during the next design stage to assess whether these wind speeds are likely to exceed the threshold for pedestrian comfort and investigation of potential mitigation strategies.

5.1.3 Along Denison Street

Conditions along Denison Street should be suitable for leisure walking.

The proposed building is unlikely to significantly accelerate wind speeds along Denison Street and so conditions are likely to be similar to those currently experienced.

5.1.4 Through Site Link between Miller and Denison Street

Conditions through the walkway should be suitable for long periods of sitting or standing, the most stringent category in the Lawson Comfort Criteria. This is due to the retail and outdoor dining spaces proposed for this location.

The entrance to the through site link on Miller Street is likely to be relatively well sheltered by the buildings to the west of the site; however, there is a risk that westerly winds would be deflected by taller buildings (177 Pacific Highway and 100 Miller Street) and channel via the through site link causing discomfort. A computational analysis would be able to identify the likelihood of this occurring, and whether further mitigation is required and effectiveness of potential mitigation strategies such as operable doors or partial obstructions. This should be undertaken to inform the final detailed design.

5.1.5 Level 3 roof terrace

The Level 3 Roof Terrace should be suitable for shorter periods of sitting or standing if this is required, however exposure is generally considered to be by choice and easily avoidable.
Like the undercover walkway, the terrace is relatively sheltered, however is also at risk from winds deflected and channelled between 177 Pacific Highway and 100 Miller Street. Balustrades of at least 1.6m (and potentially taller) are recommended to provide protection to users.

5.1.6 Lower mid-rise, upper mid-rise and high-rise roof terraces

As with the Level 3 Terrace, the higher roof terraces should be suitable for shorter periods of sitting or standing. Again, exposure is generally considered to be by choice and easily avoidable.

The higher terraces are generally more exposed than the lower Level 3 Terrace, and therefore conditions are likely to be comfortable less frequently. Balustrades of at least 1.6m (and potentially taller) are recommended to provide protection to users, and these areas are also recommended for assessment using computational analysis.

6.0 Conclusion

6.1 Likelihood of discomfort

A high level desktop study of likely wind conditions around the proposed OSD and surrounding streets has been undertaken. Prevailing westerly winds are likely to result in elevated wind speeds along Miller Street, with the potential for winds to be channelled via the through-site link between Miller and Denison Streets. Large awnings at low level on Miller Street are likely to provide some shelter, and the use of trees is recommended along Miller Street to further dissipate the effects of uncomfortable winds.

The inclusion of outdoor terraces in the future building is likely to be exposed to winds from all directions. Although balustrades provide some protection, additional local mitigation measures such as solid and semi porous structures, or planting may be required.

The Concept SSD Application seeks approval for a building envelope as opposed to an articulated building. The building articulation, façade design, awning locations and extents for the Integrated Station Development would have a material impact on the wind tunnel test results. A detailed level of design resolution would be required to produce accurate wind tunnel test results. As such, wind tunnel testing will be carried out at detailed SSD Application stage. For the purposes of this concept SSD Application, a high level desktop study of the likely wind conditions around the proposed OSD and surrounding streets has been undertaken.

A detailed computational analysis is recommended during the next design stage to quantify expected wind speeds and demonstrate compliance with the Lawson comfort criteria. This would allow a refined mitigation scheme to be developed, targeting the cause of any uncomfortable wind conditions at pedestrian level and nearby surrounding public domain.

6.2 Mitigation and verification

Effects of wind in and around buildings, such as downwash and wind tunnel effects, can be somewhat mitigated through measures such as articulation of façade, inclusion of external solar shading louvres, landscaping at the ground plane with large canopy trees and planters, and addition of building awnings.

These strategies have not necessarily been included or adopted in the proposed design at this stage as it is a concept only. Further design development would need to address the need for mitigation measures and the need to be validated through quantitative modelling such as numerical analysis using computational fluid dynamics (CFD). Numerical analysis should aim to assess the suitability of mitigation measures in accordance with the Lawson wind comfort criteria and ensure that the development meets the proposed needs for outdoor food and beverage sitting areas.

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