Attachment B26(a)

Pedestrian Wind Environment Study Part 1 – Waterloo Estate (South) – Land and Housing Corporation

WATERLOO SOUTH MASTERPLAN

PEDESTRIAN WIND ENVIRONMENT STUDY

WD510-10F02(REV3) - WE REPORT

MARCH 25, 2020

Prepared for:

Land and Housing Corporation

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DOCUMENT CONTROL

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EXECUTIVE SUMMARY

This report presents the results of a detailed investigation into the wind environment impact of the proposed Waterloo South masterplan. Testing was performed at Windtech's boundary layer wind tunnel facility. The wind tunnel has a 3.0m wide working section and a fetch length of 14m, and measurements were taken from 16 wind directions at 22.5 degree increments. Testing was carried out using a 1:400 detailed scale model of the development. The effects of nearby buildings and land topography have been accounted for through the use of a proximity model which represents an area with a radius of 600m. The existing site conditions and proposed massing of Waterloo South were tested and are detailed within this report.

Peak gust and mean wind speeds were measured at selected critical outdoor trafficable locations within and around the subject development. Wind velocity coefficients representing the local wind speeds are derived from the wind tunnel and are combined with a statistical model of the regional wind climate (which accounts for the directional strength and frequency of occurrence of the prevailing regional winds) to provide the equivalent full-scale wind speeds at the site. The wind speed measurements are compared with criteria for pedestrian comfort and safety, based on Gust-Equivalent Mean (GEM) and annual maximum gust winds, respectively.

Wind tunnel testing of the existing site wind conditions allowed for a baseline case for the proposed development precinct to be established, taking into account the prevailing wind directions for the area, as well as the local topographical effects of the terrain and the surrounding buildings of the proposed site. An assessment of the wind conditions has been made to identify the wind conditions and patterns, with the information used to coordinate a massing model.

Wind tunnel testing of the proposed Waterloo South masterplan was undertaken, based on the drawing package by the project architect Turner, received February 2020. The results of the study indicate that wind conditions for the majority of trafficable outdoor locations within and around the development will be suitable for their intended uses. For areas where the comfort and/or safety criteria were exceeded additional treatments have been incorporated into the design. The recommended treatments, which have been tested in the wind tunnel are summarised as follows:

- Recommended wrap around awning on western and southern aspects of Building Q1.
- Recommended wrap around awning on western and southern aspects of Building U2.
- Recommended wrap around awning on western and southern aspects of Building Y1.
- Recommended chamfering of south-east building corner on Building Z5.
- Recommended wrap around awning on eastern and southern aspects of Building Z5.
- Recommended porous screen at north-west corner of Building U4.

- Retention of trees as noted in tree retention plan (No.: 17018, Dwg.: 710.3, dated: 18.2.20)

Comparison between the existing site wind conditions and the proposed Waterloo South indicate that a majority of areas are similar to the existing site conditions. The proposed building and tower forms, podium setbacks, and Lot layouts combined with the recommended treatments demonstrates that the ground level wind conditions satisfy both the comfort and safety criteria.

Further wind tunnel testing of the ground level and elevated areas within the proposed Waterloo South masterplan is recommended to be investigated during the detailed design development stages to further verify the suitability of areas for their intended purpose.

Number	Study Requirements	Addressed at Section No.
19.1	Provide a complete understanding of the existing wind characteristics of the precinct. Consider the wind climate of Sydney, local characteristics such as topography that modify this wind climate for the precinct and the impact of existing buildings, in particular, the tower and slab blocks, on wind conditions.	6
19.2	Identify significant locations for wind sensitivity within the public domain, including bus stops, public plazas and other public domain areas for the purpose of modelling wind impacts of the proposed development.	7.2
19.3	Ensure early consideration of potential wind impacts and amelioration approaches through the layout and arrangement of the public domain and the built form.	7, 8
19.4	Advise on measures to ensure the suitability of areas for their intended use with regard to the impact of wind on comfort and safety. In particular, this is to focus on the public space areas intended to be used for seating (i.e. the park, outdoor dining areas on footpaths and public plazas) and standing (i.e. building entries); and, also for outdoor private recreation areas to be suitable for sitting (e.g. balconies, decks and outdoor communal private open space). Advise on the placement, orientation, shape and external design of buildings, and relevant wind mitigation devices.	8, 9
19.5	Any advice on landscaping of public space must accord with the City of Sydney Public Design Manual and the Public Domain design. In general landscaping can only be used for wind mitigation if it is already in place.	8.2
19.6	Include areas surrounding the precinct that may be wind affected as a result of the proposal.	7.2, 8.1
19.7	Undertake an assessment to demonstrate that subject to any recommended measures, wind will not have an unacceptable impact on the proposal, and the proposal will not generate unacceptable wind impacts.	8
19.8	Wind tunnel testing is required	6, 7, 8

CONTENTS

1 INTRODUCTION

The Greater Sydney Region Plan and Eastern City District Plan seek to align growth with infrastructure, including transport, social and green infrastructure. With the catalyst of Waterloo Metro Station, there is an opportunity to deliver urban renewal to Waterloo Estate that will create great spaces and places for people to live, work and visit.

The proposed rezoning of Waterloo Estate is to be staged over the next 20 years to enable a coordinated renewal approach that minimises disruption for existing tenants and allows for the up-front delivery of key public domain elements such as public open space. Aligned to this staged approach, Waterloo Estate comprises three separate, but adjoining and inter-related stages:

- Waterloo South;
- Waterloo Central; and
- Waterloo North.

Waterloo South has been identified as the first stage for renewal. The lower number and density social housing dwellings spread over a relatively large area, makes Waterloo South ideal as a first sub-precinct, as new housing can be provided with the least disruption for existing tenants and early delivery of key public domain elements, such as public open space.

A planning proposal for Waterloo South is being led by NSW Land and Housing Corporation (LAHC). This will set out the strategic justification for the proposal and provide an assessment of the relevant strategic plans, state environmental planning policies, ministerial directions and the environmental, social and economic impacts of the proposed amendment. The outcome of this planning proposal will be a revised planning framework that will enable future development applications for the redevelopment of Waterloo South. The proposed planning framework that is subject of this planning proposal, includes:

- Amendments to the Sydney Local Environmental Plan 2012 – This will include amendments to the zoning and development standards (i.e. maximum building heights and floor space ratio) applied to Waterloo South. Precinct-specific local provisions may also be included.
- A Development Control Plan (DCP) – This will be a new part inserted into 'Section 5: Specific Areas' of the Sydney DCP 2012 and include detailed controls to inform future development of Waterloo South.
- An infrastructure framework – in depth needs analysis of the infrastructure required to service the needs of the future community including open space, community facilities and servicing infrastructure.

1.1 Waterloo Estate

Waterloo Estate is located approximately 3.3km south-south-west of the Sydney CBD in the suburb of Waterloo (refer to Figure 1). It is located entirely within the City of Sydney local government area (LGA). Waterloo Estate is situated approximately 0.6km from Redfern train station and 0.5km from Australia Technology Park. The precinct adjoins the new Waterloo Metro Station, scheduled to open in 2024. The Waterloo Metro Quarter adjoins Waterloo Estate and includes the station and over station development, and was rezoned in 2019. Waterloo Estate comprises land bounded by Cope, Phillip, Pitt and McEvoy Street, including an additional area bounded by Wellington, Gibson, Kellick and Pitt Streets. It has an approximate gross site area of 18.98 hectares (14.4 hectares excluding roads). Waterloo Estate currently comprises 2,012 social housing dwellings owned by LAHC, 125 private dwellings, a small group of shops and community uses on the corner of Wellington and George Streets, and commercial properties on the south-east corner of Cope and Wellington Streets.

A map of Waterloo Estate and relevant boundaries is illustrated in Figure 2.

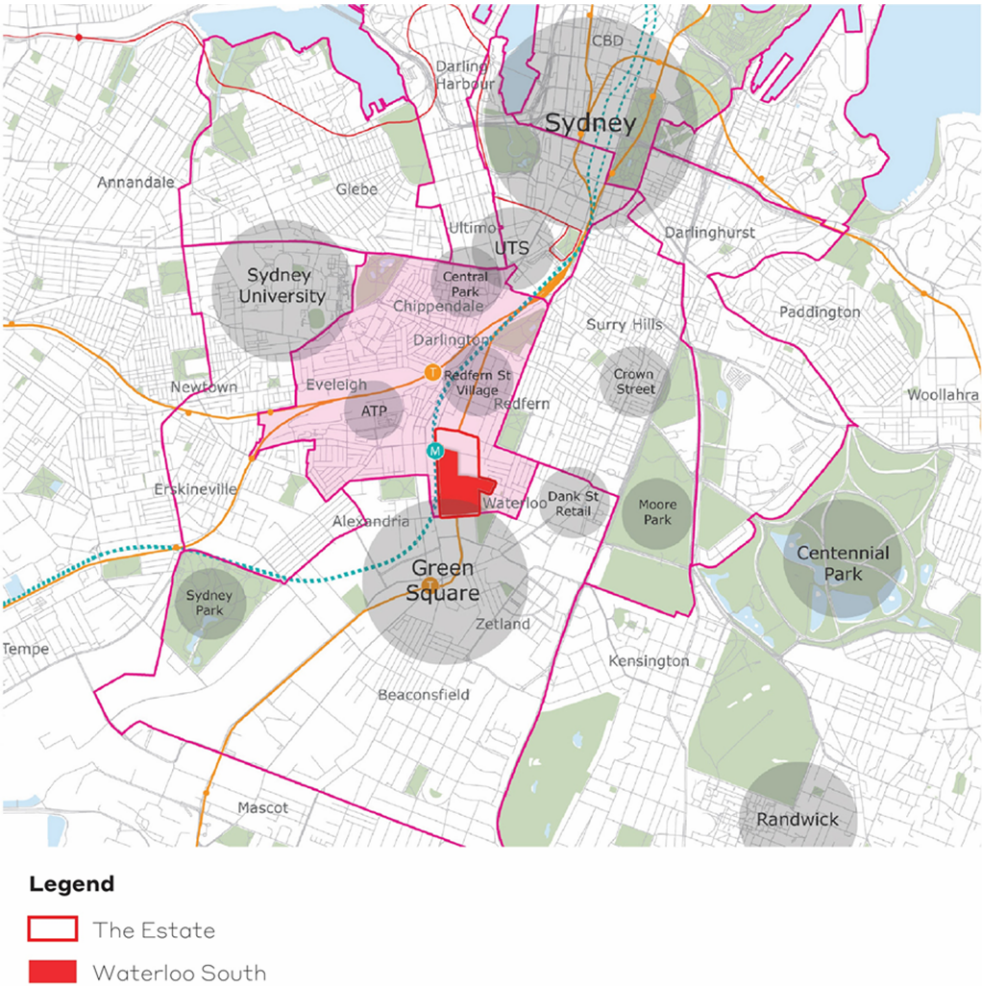

Figure 1: Location plan of Waterloo Estate and Waterloo South (Source: Turner Studio)

1.2 Waterloo South

Waterloo South includes land bounded by Cope, Raglan, George, Wellington, Gibson, Kellick, Pitt and McEvoy Streets, and has an approximate gross site area of 12.32 hectares (approximately 65% of the total Estate).

Waterloo South currently comprises 749 social housing dwellings owned by LAHC, 125 private dwellings, and commercial properties on the south-east corner of Cope and Wellington Streets. Existing social housing within Waterloo South is predominantly walk up flat buildings constructed in the 1950s and '60s, and mid-rise residential flat buildings (Drysdale, Dobell & 76 Wellington Street) constructed in the 1980s. Listed Heritage Items within Waterloo South include the Duke of Wellington Hotel, Electricity Substation 174 on the corner of George and McEvoy Streets, the terrace houses at 229-231 Cope Street and the Former Waterloo Pre-School at 225-227 Cope Street. The State Heritage listed 'Potts Hill to Waterloo Pressure Tunnel and Shafts' passes underneath the precinct.

A map of Waterloo South and relevant boundaries is illustrated in Figure 2.

Figure 2: Waterloo Precinct (Source: Ethos Urban)

1.3 Redevelopment Vision

The transition of Waterloo Estate will occur over a 20-year timeframe, replacing and providing fit for purpose social (affordable rental) housing as well as private housing to create a new integrated and inclusive mixed-tenure community.

This aligns with Future Directions for Social Housing in NSW – the NSW Government's vision for social housing. It also aligns with LAHC's Communities Plus program, which is tasked with achieving three key objectives:

1. Provide more social housing
2. Provide a better social housing experience
3. Provide more opportunities and support for social housing tenants

The following is LAHC's Redevelopment Vision for Waterloo Estate, which was derived from extensive consultation and technical studies:

Source: Let's Talk Waterloo: Waterloo Redevelopment (Elton Consulting, 2019)

Culture and Heritage

- Recognise and celebrate the significance of Waterloo's Aboriginal history and heritage across the built and natural environments.
- Make Waterloo an affordable place for more Aboriginal people to live and work.
- Foster connection to culture by supporting authentic storytelling and recognition of artistic, cultural and sporting achievements.

Communal and Open Space

- Create high quality, accessible and safe open spaces that connect people to nature and cater to different needs, purposes and age groups.
- Create open spaces that bring people together and contribute to community cohesion and wellbeing.

Movement and Connectivity

- Make public transport, walking and cycling the preferred choice with accessible, reliable and safe connections and amenities.
- Make Waterloo a desired destination with the new Waterloo Station at the heart of the Precinct's transport network – serving as the gateway to a welcoming, safe and active community.

Character of Waterloo

- Strengthen the diversity, inclusiveness and community spirit of Waterloo.
- Reflect the current character of Waterloo in the new built environment by mixing old and new.

Local Employment Opportunities

- Encourage a broad mix of businesses and social enterprise in the area that provides choice for residents and creates local job opportunities.

Community Services, Including Support for Those Who Are Vulnerable

- Ensure that social and human services support an increased population and meet the diverse needs of the community, including the most vulnerable residents.

- Provide flexible communal spaces to support cultural events, festivals and activities that strengthen community spirit.

Accessible Services

- Deliver improved and affordable services that support the everyday needs of the community, such as health and wellbeing, grocery and retail options.

Design Excellence

- Ensure architectural design excellence so that buildings and surrounds reflect community diversity, are environmentally sustainable & people friendly – contributing to lively, attractive and safe neighbourhoods.
- Recognise and celebrate Waterloo's history and culture in the built environment through artistic and creative expression.
- Create an integrated, inclusive community where existing residents and newcomers feel welcome, through a thoughtfully designed mix of private, and social (affordable rental) housing.

1.4 Purpose of this Report

This report relates to the Waterloo South planning proposal. While it provides comprehensive baseline investigations for Waterloo Estate, it only assesses the proposed planning framework amendments and Indicative Concept Proposal for Waterloo South.

The key matters addressed as part of this study, include:

- Preparation of a scale model of the development, including surrounding buildings and land topography.
- Wind tunnel testing to be performed so that measurements are taken from 16 wind directions at 22.5 degree increments and configured to the appropriate boundary layer wind profile.
- Wind tunnel study to assess existing site ground level wind conditions.
- Wind tunnel study to assess ground level wind conditions at selected critical outdoor trafficable areas within and around Waterloo South masterplan.
- Identify key areas that do not satisfy the relevant pedestrian comfort and safety criterion.
- Implement and test treatment strategies to ameliorate the measured wind conditions of the proposed Waterloo South masterplan.
- Provide a detail outline of the recommended treatment strategies that result in compliance with the pedestrian comfort and safety criteria.

1.5 Waterloo South Planning Proposal

The planning proposal will establish new land use planning controls for Waterloo South, including zoning and development standards to be included in Sydney LEP 2012, a new section in Part 5 of DCP 2012, and an infrastructure framework. Turner Studio and Turf has prepared an Urban Design and Public Domain Study which establishes an Indicative Concept Proposal presenting an indicative renewal outcome for Waterloo South. The Urban Design and Public Domain Study provides a comprehensive urban design vision and strategy to guide future development of Waterloo South and has informed the proposed planning framework. The Indicative Concept Proposal has also been used as the basis for testing, understanding and communicating the potential development outcomes of the proposed planning framework.

The Indicative Concept Proposal comprises:

- Approximately 2.57 hectares of public open space representing 17.8% of the total Estate (Gross Estate area - existing roads) proposed to be dedicated to the City of Sydney Council, comprising:
    - Village Green – a 2.25 hectare park located next to the Waterloo Metro Station; and
    - Waterloo Common and adjacent – 0.32 hectares located in the heart of the Waterloo South precinct.
    - The 2.57 hectares all fall within the Waterloo South Planning Proposal representing 32.3% of public open space (Gross Waterloo South area – proposed roads).
- Retention of 52% of existing high and moderate value trees (including existing fig trees) and the planting of three trees to replace each high and moderate value tree removed.
- Coverage of 30% of Waterloo South by tree canopy.
- Approximately 257,000 sqm of GFA on the LAHC land, comprising:
    - Approximately 239,100 sqm GFA of residential accommodation, providing for approximately 3,048 dwellings comprising a mix of market and social (affordable rental) housing dwellings;
    - Approximately 11,200 sqm of GFA for commercial premises, including, but not limited to, supermarkets, shops, food & drink premises and health facilities; and
    - Approximately 6,700 sqm of community facilities and early education and child care facilities.

The key features of the Indicative Concept Proposal are:

- It is a design and open space led approach.
- Creation of two large parks of high amenity by ensuring good sunlight access.
- Creation of a pedestrian priority precinct with new open spaces and a network of roads, lanes and pedestrian links.
- Conversion of George Street into a landscaped pedestrian and cycle friendly boulevard and creation of a walkable loop designed to cater to the needs of all ages.
- A new local retail hub located centrally within Waterloo South to serve the needs of the local community.
- A target of 80% of dwellings to have local retail services and open space within 200m of their building entry.
- Achievement of a 6 Star Green Star Communities rating, with minimum 5-star Green Star – Design & As-Built (Design Review certified).
- A range of Water Sensitive Urban Design (WSUD) features.

The proposed land allocation for the Waterloo South precinct is described in Table 1 below.

Table 1: Breakdown of allocation of land within the Waterloo South

Land allocation	Existing	Proposed
Roads	3.12ha / 25.3%	4.38ha / 35.5%
Developed area (Private sites)	0.86ha / 6.98%	0.86ha / 7%
Developed area (LAHC property)	8.28ha / 67.2%	4.26ha / 34.6%
Public open space (proposed to be dedicated to the City of Sydney)	Nil / 0%	2.57ha / 20.9% (32.3% excluding roads)
Other publicly accessible open space (Including former roads and private/LAHC land)	0.06ha / 0.5%	0.25ha / 2%
TOTAL	12.32ha	12.32ha

The Indicative Concept Proposal for the Waterloo South is illustrated in Figure 3 below.

Figure 3: Indicative Concept Proposal (Source: Turner Studio)

2 WIND TUNNEL TESTING

A wind tunnel study has been undertaken to assess the ground level wind speeds at selected critical outdoor trafficable areas within and around Waterloo South. The test procedures followed for this wind tunnel study were based on the guidelines set out in the Australasian Wind Engineering Society Quality Assurance Manual (AWES-QAM-1-2019), ASCE 7-16 (Chapter C31), and CTBUH (2013).

A scale model of the development was prepared, including the surrounding buildings and land topography. Testing was performed at Windtech's boundary layer wind tunnel facility. The wind tunnel has a 3.0m wide working section and a fetch length of 14m, and measurements were taken from 16 wind directions at 22.5 degree increments. The wind tunnel was configured to the appropriate boundary layer wind profile for each wind direction. Wind speeds were measured using Dantec hot-wire probe anemometers, positioned to monitor wind conditions at critical outdoor trafficable areas of the development.

The model was tested in the wind tunnel without the effect of any forms of wind ameliorating devices such as screens, balustrades, etc., which are not already shown in the architectural drawings. The wind speeds measured during testing were combined with a statistical model of the regional wind climate to provide the equivalent full-scale wind speeds at the site. The measured wind speeds were compared against appropriate criteria for pedestrian comfort and safety. Treatments have been recommended and tested for any area which was exposed to strong winds. These treatments could be in the form of retaining vegetation that is already proposed for the site, or including screens, awnings, etc.

3 BOUNDARY LAYER WIND PROFILES AT THE SITE

The roughness of the surface of the earth has the effect of slowing down the wind near the ground. This effect is observed up to the boundary layer height, which can range between 500m to 3km above the earth's surface depending on the roughness of the surface (ie: oceans, open farmland, etc). Within this range the prevailing wind forms a boundary layer wind profile.

Various wind codes and standards and other publications classify various types of boundary layer wind flows depending on the surface roughness z_0. Descriptions of typical boundary layer wind profiles, based on Deaves & Harris (1978), are summarised as follows:

- Flat terrain (0.002m < z_0 < 0.003m). Examples include inland water bodies such as lakes, dams, rivers, etc, and the open ocean.
- Semi-open terrain (0.006m < z_0 < 0.01m). Examples include flat deserts and plains.
- Open terrain (0.02m < z_0 < 0.03m). Examples include grassy fields, semi-flat plains, and open farmland (without buildings or trees).
- Semi-suburban/semi-forest terrain (0.06m < z_0 < 0.1m). Examples include farmland with scattered trees and buildings and very low-density suburban areas.
- Suburban/forest terrain (0.2m < z_0 < 0.3m). Examples include suburban areas of towns and areas with dense vegetation such as forests, bushland, etc.
- Semi-urban terrain (0.6m < z_0 < 1.0m). Examples include centres of small cities, industrial parks, etc.
- Urban terrain (2.0m < z_0 < 3.0m). Examples include centres of large cities with many high-rise towers, and also areas with many closely-spaced mid-rise buildings.

The boundary layer wind profile does not change instantly due to changes in the terrain roughness. It can take many kilometres (at least 100km) of a constant surface roughness for the boundary layer wind profile to achieve a state of equilibrium. Hence an analysis of the effect of changes in the upwind terrain roughness is necessary to determine an accurate boundary layer wind profile at the development site location.

For this study this has been undertaken based on the method given in AS/NZS1170.2:2011, which uses a "fetch" length of 60 times the study reference height. However, it should be noted that this "fetch" commences *beyond* a "lag distance" area, which has a length of 20 times the study reference height (in accordance with AS/NZS1170.2:2011), so the actual "fetch" of terrain analysed is the area between 20 and 60 times the study reference height away from the site. The proximity model accounts for the effect of the near field topographic effects as well as the influence of the local built forms.

An aerial image showing the surrounding terrain is presented in Figure 4 for a range of 2.7km from the edge of the proximity model used for the wind tunnel study. The resulting mean and gust terrain and height multipliers at the site location are presented in Table 2. The terrain and height multipliers are referenced to the study reference height (approximately half of the height of the subject development since typically we are most interested in the wind effects at the ground plane). Details of the boundary layer wind profiles at the site are combined with the regional wind model (see Section 4) to determine the site wind speeds.

Table 2: Approaching Boundary Layer Wind Profile Analysis Summary (at the study reference height)

Wind Sector (degrees)	Terrain and Height Multiplier			Turbulence Intensity	Equivalent Terrain Category
	$k_{tr,T=1hr}$ *(hourly)*	$k_{tr,T=10min}$ *(10min)*	$k_{tr,T=3s}$ *(3sec)*	I_v	*(AS/NZS1170.2:2011 naming convention)*
0	0.56	0.61	1.02	0.271	3.5
30	0.56	0.61	1.02	0.271	3.5
60	0.70	0.74	1.12	0.200	2.8
90	0.75	0.79	1.15	0.177	2.5
120	0.70	0.74	1.12	0.200	2.8
150	0.68	0.72	1.10	0.209	3.0
180	0.64	0.68	1.07	0.232	3.2
210	0.56	0.61	1.02	0.271	3.5
240	0.67	0.71	1.10	0.212	3.0
270	0.67	0.71	1.10	0.212	3.0
300	0.61	0.65	1.05	0.248	3.3
330	0.72	0.76	1.13	0.190	2.7

For each of the 16 wind directions tested in this study, the approaching boundary layer wind profiles modelled in the wind tunnel closely matched the profiles listed in Table 2. Plots of the boundary layer wind profiles used for the wind tunnel testing are presented in Appendix B of this report.

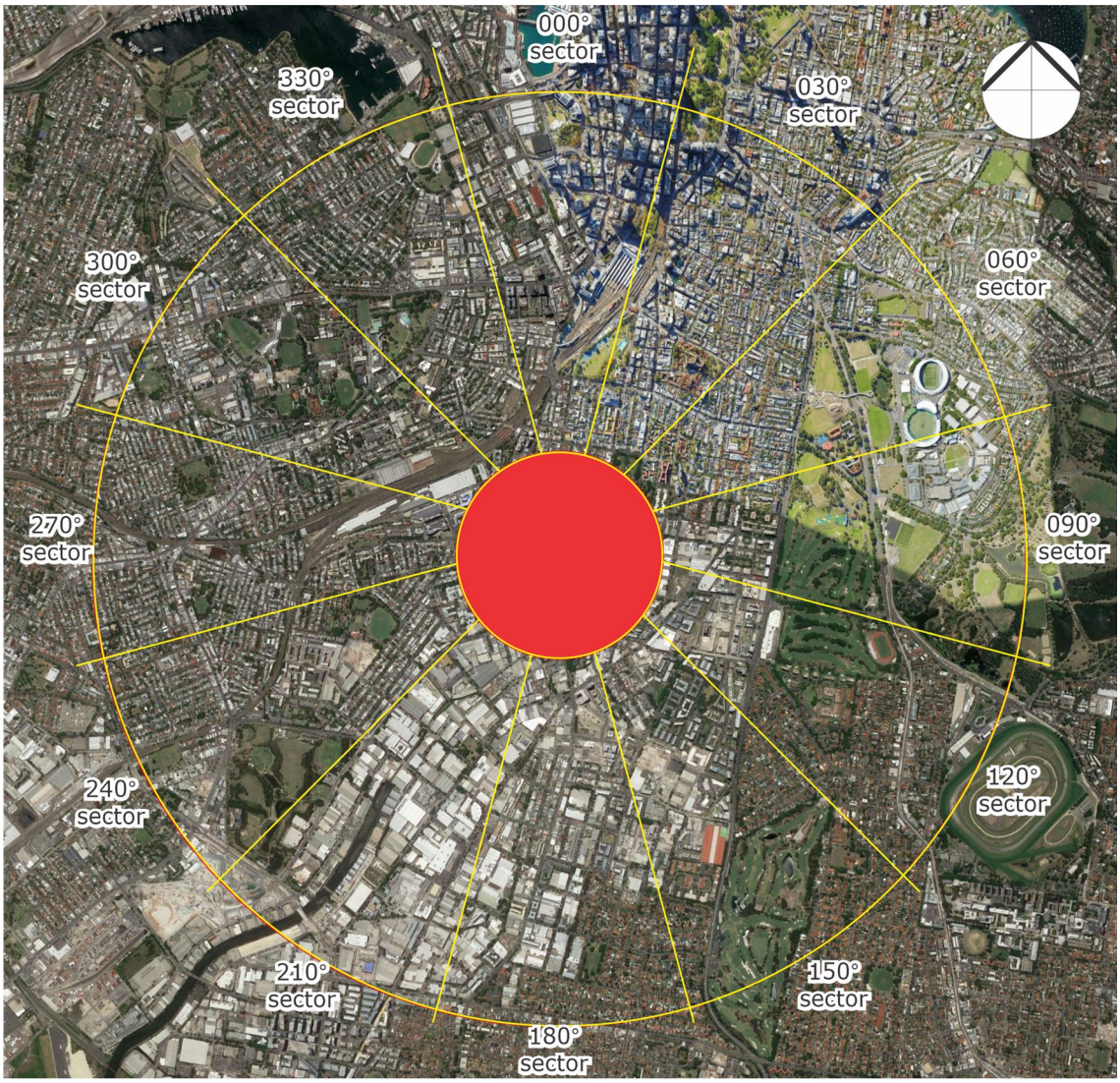

Figure 4: Aerial Image of the Surrounding Terrain
(radius of 2.7km from the edge of the proximity model, which is coloured red)

4 REGIONAL WIND MODEL

The regional wind model used in this study was determined from an analysis of measured directional mean wind speeds obtained at the meteorological recording station located at Kingsford Smith Airport (Sydney Airport). Data was collected from 1995 to 2016 between 6am to 10pm and corrected so that it represents wind speeds over standard open terrain at a height of 10m above ground for each wind direction. From this analysis, directional probabilities of exceedance and directional wind speeds for the region are determined. The directional wind speeds are summarised in Table 3. The directional wind speeds and corresponding directional frequencies of occurrence are presented in Figure 5.

The data indicates that the southerly winds are by far the most frequent winds for the Sydney region, and are also the strongest. The westerly winds occur most frequently during the winter season for the Sydney region, and although they are typically not as strong as the southerly winds, they are usually a cold wind and hence can be a cause for discomfort for outdoor areas. North-easterly winds occur most frequently occur during the warmer months of the year for the Sydney region, and hence are usually welcomed within outdoor areas since they are typically not as strong as the southerly or westerly winds.

The recurrence intervals examined in this study are for exceedances of 5% (per 90 degree sector) for the pedestrian comfort criteria using Gust-Equivalent Mean (GEM) wind speeds, and annual maximum wind speeds (per 22.5 degree sector) for the pedestrian safety criterion. Note that the 5% probability wind speeds presented in Table 3 are only used for the directional plot presented in Figure 5 and are not used for the integration of the probabilities.

Table 3: Directional Wind Speeds (m/s)
(hourly means, referenced to 10m above ground in standard open terrain)

Wind Direction	5% Exceedance	Annual Maximum
N	5.9	9.9
NNE	9.9	12.9
NE	9.7	12.3
ENE	7.5	10.0
E	6.3	9.3
ESE	6.2	9.1
SE	7.0	10.1
SSE	8.5	12.2
S	10.3	13.9
SSW	10.0	14.1
SW	6.9	11.9
WSW	9.3	13.6
W	9.8	14.4
WNW	8.8	14.3
NW	6.7	12.6
NNW	5.5	10.7

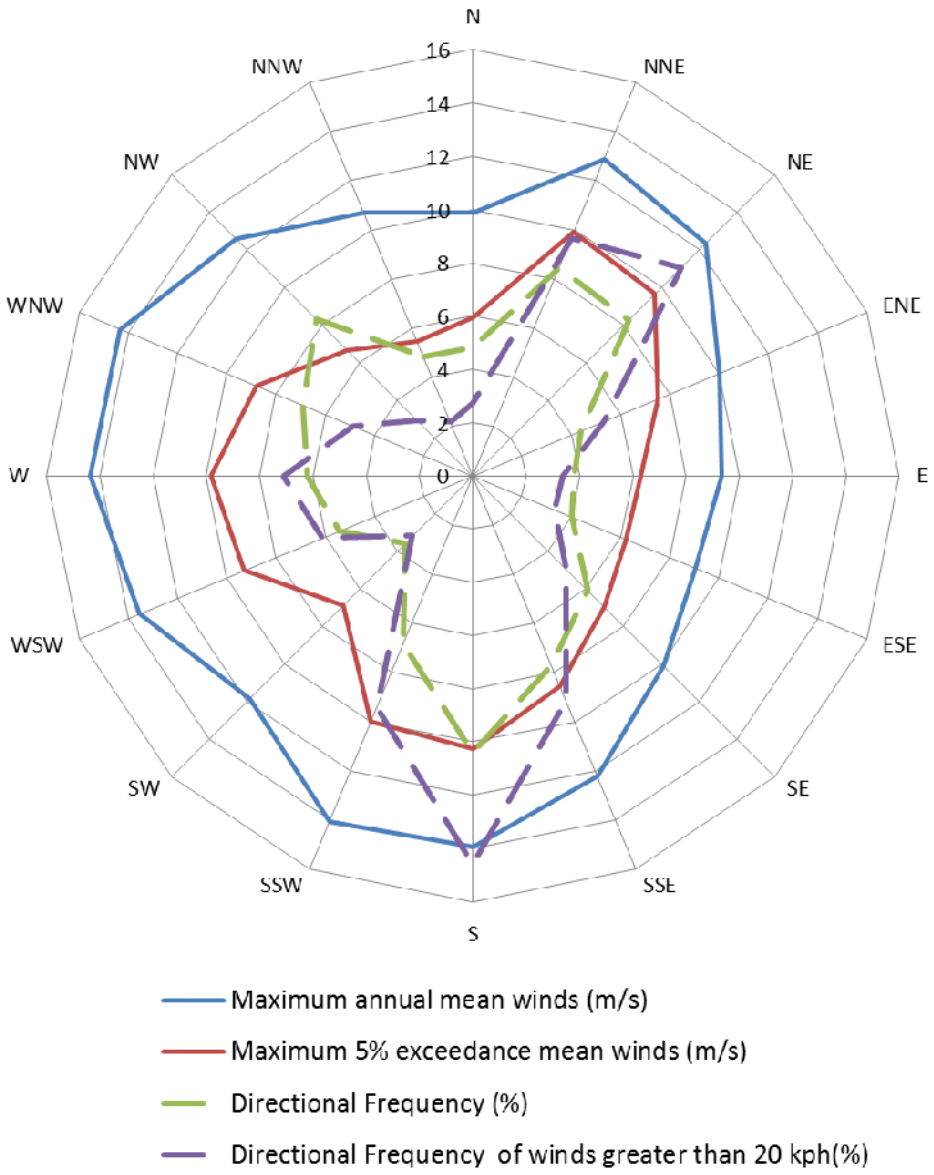

Figure 5: Annual and 5% Exceedance Hourly Mean Wind Speeds, and Frequencies of Occurrence, for the Sydney Region (referenced to 10m above ground in standard open terrain)