



PEDESTRIAN WIND ENVIRONMENT STATEMENT

DGL AT NORWEST STATION

WE446-01F02(REV4)- WS REPORT

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Prepared for:

Landcom

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DOCUMENT CONTROL

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EXECUTIVE SUMMARY

This report is in relation to the Developable Government Land (DGL) development located adjacent Norwest Station in Norwest and presents an opinion on the likely impact of the proposed design on the local wind environment on the critical outdoor areas within and around the subject development as well as comment on the impact of the development on the passage of cooling wind flows through the precinct.

The effect of wind activity is examined for the three predominant wind directions for the Greater Sydney region; namely those which prevail from the north-east, south-east to south, and west. The analysis of the wind effects relating to the proposed development was carried out in the context of the local wind climate, building morphology and land topography.

The conclusions of this report are drawn from our extensive experience in this field and are based on an examination of the latest architectural drawings. No wind tunnel testing has been undertaken for the subject development, and hence this report addresses only the general wind effects and any localised effects that are identifiable by visual inspection. Any recommendations in this report are made only in-principle and are based on our extensive experience in the study of wind environment effects.

The results of this assessment indicate that the development is relatively exposed with minimal shielding from the easterly and westerly prevailing wind directions. As a result, there are expected adverse wind effects within certain areas of the development. It is expected that suitable wind conditions can be achieved through all trafficable areas within and around the site with the treatments recommended in this report, which are summarised below:

- Retain the proposed vegetation around the ground levels,
- Include awnings around podia at the Ground Level along Brookhollow Avenue,
- Include additional vegetation around Brookhollow Avenue,
- Include additional vegetation around entrances to the pedestrian thoroughfare,
- Include vegetation through the thoroughfare and potentially baffle screens to slow funnelling south-easterly winds,
- Retain proposed awnings along plaza,
- Retain vegetation on the Roof Garden Of The 1 Storey Building,
- Retain the proposed vegetation of the Podium Roof Gardens,
- Include additional vegetation on the Podium Roof Garden along the south-eastern end of the Site B Building,
- Include a 1.5m high impermeable parapet around the Podium Roof Gardens,

- Include a 2m high impermeable parapet around the Roof Garden of the Site A Building,
- Include a 1.5m high impermeable parapet around the Roof Garden of B1,
- Retain the proposed vegetation of the Roof Gardens for both Site A and B,
- Include additional vegetation for the Roof Garden of the Site A Building, and
- Retain horizontal sunshade fins on the Site B Buildings.

It should be noted that for any tree planting and landscaping to be effective as a wind ameliorative device, the species selected should be of an evergreen variety and densely foliating. Trees should be planted in clusters with interlocking canopies to help absorb the wind as a tree in isolation can be impacted by stronger wind conditions.

With regards to the obstruction of the summer breezes through the precinct, the positioning and orientation of the buildings was considered with respect to the prevailing winds of the Greater Sydney region.

- The alignment of the developments will allow the prevailing north-easterly winds to travel along Norwest Boulevard which will assist in cooling the pedestrian areas around the north-west of the development along Norwest Boulevard as well as on the north-east of the site.
- The south-easterly winds are aligned with the pedestrian thoroughfare that links Brookhollow Avenue to the Plaza, and hence south-easterly breezes will be permitted to travel through the plaza.

Due to the height and exposure of the development, a wind tunnel study must be undertaken to verify the outcomes of this desktop assessment. This will provide a quantitative analysis of the wind conditions and determine the extent of the abovementioned wind mitigation treatments to ensure suitable wind conditions are achieved.

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1 INTRODUCTION

An opinion on the likely impact of the proposed design on the local wind environment affecting pedestrians within the critical outdoor areas within and around the subject development is presented in this report. The analysis of wind effects relating to the subject development has been carried out in the context of the predominant wind directions for the region, building morphology of the development and nearby buildings, and local land topography. The conclusions of this report are drawn from our extensive experience in the field of wind engineering and studies of wind environment effects.

No wind tunnel testing has been undertaken for this assessment. Hence this report addresses only the general wind effects and any localised effects that are identifiable by visual inspection, and any recommendations in this report are made only in-principle.

2 DESCRIPTION OF THE DEVELOPMENT AND SURROUNDINGS

The proposed Developable Government Land (DGL) development is located in Norwest. Immediately surrounding the site are a mid-rise commercial building to the north-east, Brookhollow Avenue to the east, south and south-west, and Norwest Boulevard to the north-west. Further from the site to the north is a large shopping mall with mid-rise buildings followed by Norwest Lake and the Castle Hill Country Club Golf Course. Further from the site to the east are mid-rise commercial buildings. Further from the site to the south are low-rise residential buildings. Further from the site to the west are a mix of mid-rise commercial buildings and low-rise residential buildings.

A number of additional future buildings are likely to be constructed to the north of the site on the other side of Norwest Boulevard.

A survey of the land topography indicates there are no major elevation changes in the region surrounding the site. An aerial image of the subject site and the local surroundings is shown in Figure 1.

The subject development is a mixed used development comprised of 3 main building forms split into Site A (A) and Site B (B). The development may be constructed in stages, with Site A first and Site B second. An image of the stages is shown in Figure 2 and a render of the development is shown in Figure 3.

Site A encompasses the south-west of the site and consists of a single commercial building of 11 floors with a large roof garden and podium roof garden on the 2nd Floor. The canopy-covered pedestrian entry of Norwest Station at the corner of Brookhollow Avenue and Norwest Boulevard is situated on the western end of the site next to the Site A building.

Site B encompasses the north-east of the site and consists of 2 towers: a 25 floor building of hotel and commercial offices with a roof garden / communal area on the 12th Floor (B1), and a 21 floor building of commercial offices (B2). The towers of Site B share a communal podium roof garden on the roof area between the towers on the 2nd Level.

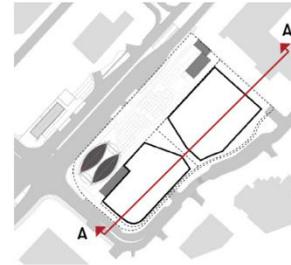
Between the towers of A and B is a pedestrian thoroughfare and a large open plaza area with shop entrances and café dining areas. In the open communal area is a single storey building with a roof garden that extends from the building of A adjacent to the open pedestrian thoroughfare/ open communal area.

The critical trafficable areas associated with the proposed development, which are the focus of this assessment with regards to wind effects, are detailed as follows:

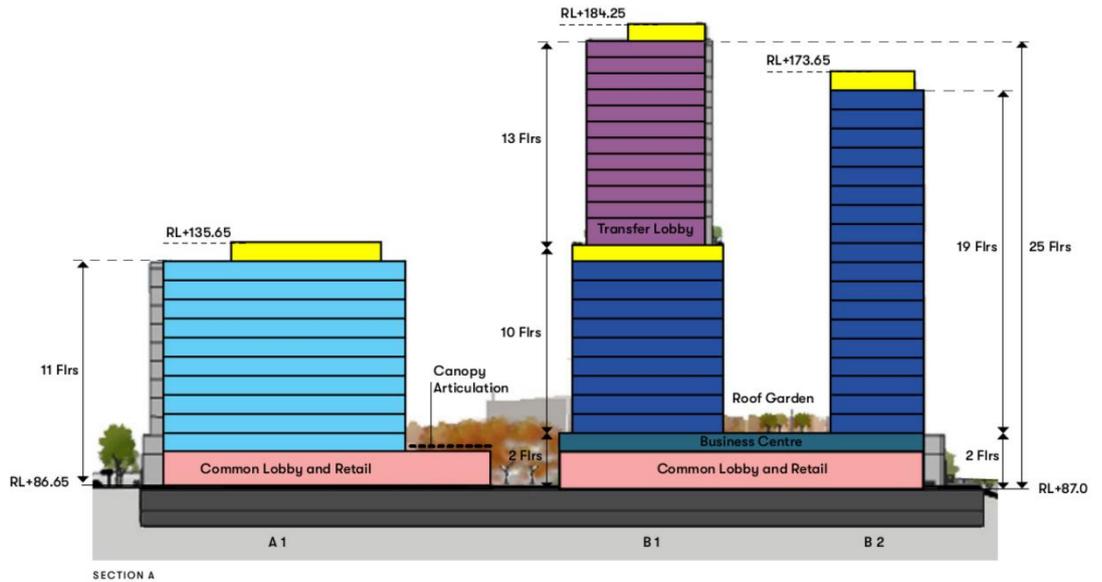
- Pedestrian footpaths and trafficable areas around the site on the Ground Level,
- Pedestrian thoroughfare and plaza areas between the buildings of A and B,
- Podium Roof Garden of the 1 storey building between the buildings of A and B,
- Podium Roof Gardens of the A and B buildings, and
- Roof gardens of the buildings of A and the B1 Tower of B.



Figure 1: Aerial Image of the Site Location



KEY PLAN



Assumptions for Floor Heights:

Commercial Offices Floor Height: 3.8m	Lift Overrun and Plant Room: 4m
Ground Floor Retail: min 5m	Basement Car Parking: 3m
Short term Accommodation: 3.2m	Basement Service Area: 4.5m



Figure 2: Southern section view indicating A and B



Figure 3: Rendered image of the development viewed from North

3 REGIONAL WIND

The Greater Sydney region is governed by three principal wind directions, and these can potentially affect the subject development. These winds prevail from the north-east, south-east to south, and west. These wind directions were determined from an analysis undertaken by Windtech Consultants of recorded directional wind speeds obtained at the meteorological station located at Bankstown Airport by the Bureau of Meteorology. The data has been collected from this station from 1993 to 2016 and corrected so that it represents winds over standard open terrain at a height of 10m above ground level. Figure 4 shows a summary of this analysis in the form of a directional plot of the annual and 5% exceedance mean winds for the region. The frequency of occurrence of these winds is also determined and shown in Figure 4.

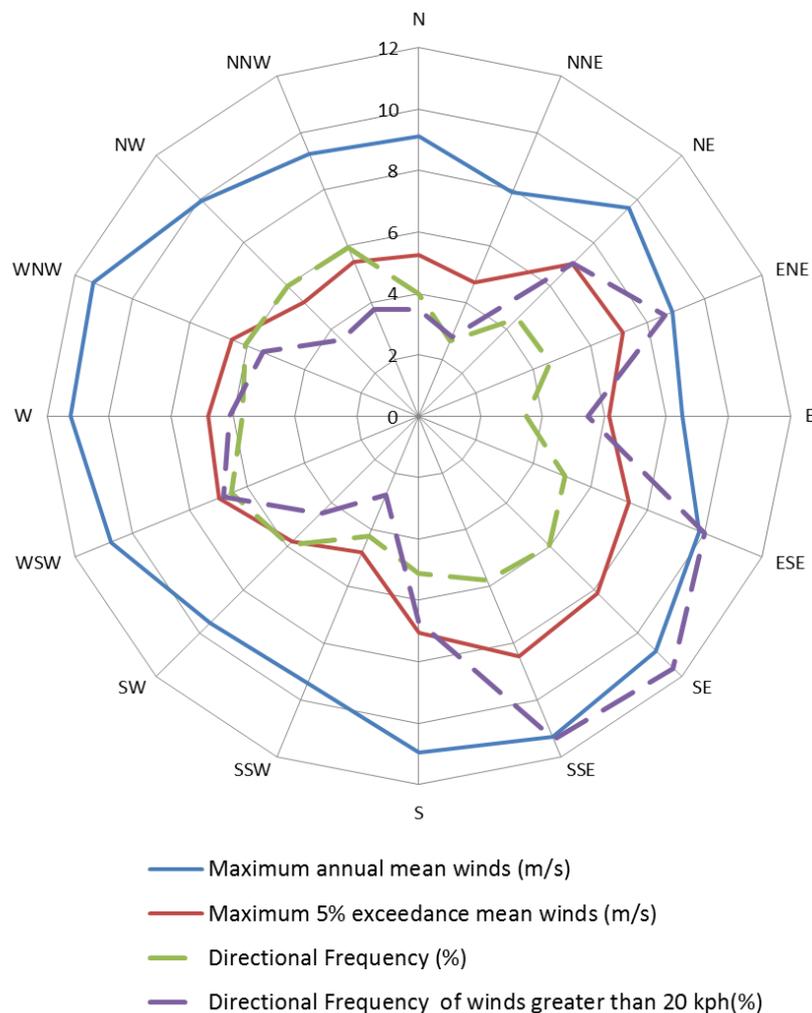


Figure 4: Annual and 5% Exceedance Hourly Mean Wind Speeds, and Frequencies of Occurrence, for the Greater Sydney Region (referenced to 10m above ground in standard open terrain)

4 WIND EFFECTS ON PEOPLE

The acceptability of wind in any area is dependent upon its use. For example, people walking or window-shopping will tolerate higher wind speeds than those seated at an outdoor restaurant. Various other researchers, such as A.G. Davenport, T.V. Lawson, W.H. Melbourne, and A.D. Penwarden, have published criteria for pedestrian comfort for pedestrians in outdoor spaces for various types of activities. Some Councils and Local Government Authorities have adopted elements of some of these into their planning control requirements.

For example, A.D. Penwarden (1973) developed a modified version of the Beaufort scale which describes the effects of various wind intensities on people. Table 1 presents the modified Beaufort scale. Note that the effects listed in this table refers to wind conditions occurring frequently over the averaging time (a probability of occurrence exceeding 5%). Higher ranges of wind speeds can be tolerated for rarer events.

Table 1: Summary of Wind Effects on People (A.D. Penwarden, 1973)

Type of Winds	Beaufort Number	Mean Wind Speed (m/s)	Effects
Calm	0	Less than 0.3	Negligible.
Calm, light air	1	0.3 – 1.6	No noticeable wind.
Light breeze	2	1.6 – 3.4	Wind felt on face.
Gentle breeze	3	3.4 – 5.5	Hair is disturbed, clothing flaps, newspapers difficult to read.
Moderate breeze	4	5.5 – 8.0	Raises dust, dry soil and loose paper, hair disarranged.
Fresh breeze	5	8.0 – 10.8	Force of wind felt on body, danger of stumbling
Strong breeze	6	10.8 – 13.9	Umbrellas used with difficulty, hair blown straight, difficult to walk steadily, wind noise on ears unpleasant.
Near gale	7	13.9 – 17.2	Inconvenience felt when walking.
Gale	8	17.2 – 20.8	Generally impedes progress, difficulty balancing in gusts.
Strong gale	9	Greater than 20.8	People blown over.

It should be noted that wind speeds can only be accurately quantified with a wind tunnel study. This assessment addresses only the general wind effects and any localised effects that are identifiable by visual inspection and the acceptability of the conditions for outdoor areas are determined based on their intended use (rather than referencing specific wind speeds). Any recommendations in this report are made only in-principle and are based on our extensive experience in the study of wind environment effects.

5 RESULTS AND DISCUSSION

The expected wind conditions are discussed in the following sub-sections of this report for the various outdoor areas within and around the subject development. The interaction between the wind and the building morphology in the area is considered and important features considered including the distances between the surrounding buildings and the proposed building form, as well as the surrounding landform. Note that only the potentially critical wind effects are discussed in this report.

The potential future buildings to the north of the site on the other side of Norwest Boulevard are not aligned with the prevailing wind directions and hence are not expected to be critical with regards to the wind conditions of the site. There is the potential for the prevailing north-easterly winds to be redirected from these buildings toward the DGL site, creating adverse wind conditions on the north-end of the site. If these developments are to be completed after the DGL it is expected that the future developments will undertake independent analyses of their building forms to determine the impact of their developments on the surrounding developments including the pedestrian areas around the DGL development.

It should be noted that for any tree planting and landscaping to be effective as a wind ameliorative device, the species selected should be of an evergreen variety and densely foliating. Trees should be planted in clusters with interlocking canopies to help absorb the wind as a tree in isolation can be impacted by stronger wind conditions.

5.1 Pedestrian Footpaths and Ground Level Areas

The pedestrian footpaths, site entrances and public open spaces around the site are exposed to the prevailing winds from the south-east, west and north-east.

The pedestrian areas along Brookhollow Avenue are exposed to the prevailing south-easterly winds both as direct winds and winds that downwash off the façade of the main towers, as well as north-easterly winds that travel along Brookhollow Avenue. The street front benefits from the proposed vegetation however, it is recommended to include additional vegetation in these areas along Brookhollow Avenue to slow the direct winds, particularly around the corners. It may be required to include an awning on the podia to deflect downwash. The area near the entrance to the pedestrian thoroughfare on Brookhollow Avenue may be exposed to adverse wind conditions caused by funnelling between the two buildings. It is recommended to include additional vegetation in this area to slow down the funnelling winds as they enter the thoroughfare.

The pedestrian areas near the entrance to Norwest Station are exposed to the prevailing westerlies side streaming off the corner of A and funnelling between the canopy covered pedestrian entry of Norwest Station and A. This area will benefit from the proposed trees along Brookhollow Avenue. It is noted that this area is outside of the boundary of this development,

however this area may experience adverse wind conditions. Wind tunnel testing is recommended to determine the extent of this wind effect.

The pedestrian areas along Norwest Boulevard are aligned with the prevailing north-easterly winds and area also exposed to the prevailing westerly winds. The proposed vegetation is expected to assist in slowing the prevailing winds. It is recommended to retain this proposed vegetation and to include additional vegetation to slow the prevailing winds.

With regards to the first stage of a staged construction, with only A, the pedestrian areas around the development along Brookhollow Avenue that would normally be shielded by B will be more exposed to the prevailing westerly winds. This however is expected to be similar to the existing conditions of the site. There may be increased wind flows further downstream as a result of the westerly winds side-streaming off the façade of A and onto Brookhollow Avenue, however the magnitude of this impact is not expected to cause significant additional discomfort.

5.2 Pedestrian Thoroughfares and Plaza Areas

The pedestrian thoroughfares area exposed to the prevailing south-easterly winds funnelling between the buildings. It is recommended to include additional landscaping throughout these area particularly at the end points. It may be required to include screening in this area to baffle the funnelling wind flows.

The plaza area is exposed to the direct prevailing westerly winds. The plaza will benefit from the proposed trees and planter boxes north of the plaza which will help slow down the direct flows from the prevailing westerly winds. It is recommended to retain this vegetation.

The plaza area is also exposed to the prevailing westerly winds that hit the western aspect of B and deflect downward toward the plaza in the form of downwash. The plaza area will benefit from the set-back podium of B which is expected to break up the downwash flows before they hit the ground. The downwash will also be further broken up by the horizontal sunshade elements of the tower façade. It is recommended to retain these sunshades. Furthermore, the plaza area will benefit from awnings above the ground floor along the western aspect. It is recommended to retain the proposed awnings along the western aspect of the ground level and it may be required to extend these awnings further along the aspect.

The plaza area is also exposed to the prevailing south-easterly winds that funnel through the pedestrian thoroughfare. The plaza will benefit from the proposed trees and planter boxes north of the plaza which will help inhibit funnelling through the plaza and thoroughfare. It may be required to include additional vegetation throughout and around the thoroughfare to help slow any funnelling. Furthermore, temporary screening maybe required to further enhance wind conditions in café seating areas. This funnelling should be further investigated by undertaking a wind tunnel study.

With regards to the first stage of a staged construction with only A, the plaza area is expected to be more exposed to the direct prevailing north-easterly winds, but also less exposed to the aforementioned funnelling of the prevailing south-easterly winds. It is recommended to use

topically placed temporary screening around the café seating areas to help mitigate the direct north-easterly winds as necessary.

5.3 Roof Garden Of The 1 Storey Building

The podium roof garden is exposed to the prevailing south-easterly winds funnelling through the towers of A and B. The podium roof garden will benefit from proposed vegetation which will help slow the prevailing winds. The area will also benefit from a large canopy, which will help stagnate wind flows and reduce any potential downwash from above. It is recommended to retain the proposed vegetation throughout this area.

With regards to the first stage of a staged construction with only A, the Roof Garden of the 1 Storey Building is expected to be exposed more to the prevailing north-easterly winds. This area is expected to benefit from the proposed planting throughout the area and hence, as mentioned above, it is recommended to retain the proposed vegetation throughout this area.

5.4 Podium Roof Gardens of A and B

The podium roof garden of A is aligned to the prevailing south-easterly winds. The area however benefits from some extensive landscaping and vegetation which will help slow the prevailing winds. It is recommended to retain the proposed vegetation and to include a 1.5m impermeable parapet around the roof garden.

The podium roof garden of B is aligned to the prevailing south-easterly winds and the positioning of the two towers will lead to winds funnelling between the two towers. The area however, similar to A, benefits from some extensive landscaping and vegetation which will help slow the prevailing winds. It is recommended to retain the proposed vegetation and provide additional vegetation along the south-eastern edge of the podium perimeter. It is recommended to include a 1.5m impermeable parapet around the roof garden. The proposed horizontal sunshade fins are also expected to assist in breaking up prevailing winds that impact the tower façade and downwash onto the roof garden area. It is recommended to retain these features in the final design.

With regards to the first stage of a staged construction with only A, the podium rooftop garden of A is expected to be more exposed to the prevailing north-easterly winds. These conditions are expected to be similar to the conditions of the second stage and hence the above treatments are recommended.

5.5 Roof Gardens of A and B1

The Roof Garden of the building of A is exposed to the prevailing winds of the Greater Sydney region. The area will benefit from extensive vegetation around the area which will act to slow the prevailing winds. It is recommended to retain the extensive vegetation, and to provide additional vegetation to further slow the prevailing winds. It is recommended to include a 2m high impermeable screen around the perimeter of the garden to deflect the prevailing winds.

The open garden of central tower of the site (the 25 floor tower of B, labelled B1 in Figure 2) is exposed to the prevailing winds of the Greater Sydney Region. The area will benefit from the proposed vegetation which will help slow the prevailing winds. It is recommended to include a 1.5m impermeable parapet around the garden to deflect the prevailing winds and to retain the proposed vegetation.

With regards to the first stage of a staged construction with only A, similarly to the podium rooftop garden, the rooftop garden of A is expected to be more exposed to the prevailing north-easterly winds. These north-easterly winds are expected to be similar to the conditions described above for B and hence the above treatments are recommended.

5.6 Cooling Summer Breezes Throughout the Precinct

With regards to the obstruction of the summer breezes through the precinct, the positioning and orientation of the buildings was considered with respect to the prevailing winds of the Greater Sydney region.

- The alignment of the buildings of the development will allow the prevailing north-easterly winds to travel along Norwest Boulevard which will assist in cooling the pedestrian areas around the north-west of the development along Norwest Boulevard as well as on the north-east of the site.
- The prevailing south-easterly winds are aligned with the pedestrian thoroughfare that links Brookhollow Avenue to the Plaza, and hence south-easterly breezes will be permitted to travel through the plaza.

With regards to the first stage of a staged construction with only A, the overall site is more exposed to the prevailing north-easterly winds. This is expected to increase wind conditions and hence increase the potential for cooling summer breezes through the development as a whole.

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