

APPENDIX 16 : WIND IMPACT ASSESSMENT



HEGGIES

REPORT 10-8304-R1

Revision 1

**6-16 Atchison Street, St Leonards
Proposed Residential Tower
Environmental Wind Tunnel Test**

PREPARED FOR

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6-16 Atchison Street, St Leonards

Proposed Residential Tower

Environmental Wind Tunnel Test

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Reference	Status	Date	Prepared	Checked	Authorised
10-8304-R1	Revision 1	21 June 2010	Sophie Wong Kai In	Dr Neihad Al-Khalidy	Dr Peter Georgiou
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EXECUTIVE SUMMARY

Introduction

Heggies Pty Ltd (Heggies) has been engaged by Bancor Pty Ltd (Bancor) to assess the local wind environment, via an Environmental Wind Tunnel Study, within and around the proposed Residential Development at 6-16 Atchison Street, St Leonards.

The development is bounded by Atchison Street to the south, Atchison Lane to the north, an existing 3-storey development to the east and an existing 17-storey mixed-use development to the west.

The proposed residential development will consist of the following features:

- A total of 34 levels
 - Entry lobby and café on ground floor;
 - Hotel apartment and gym with swimming pool on levels 2 to 5;
 - Residential apartment on levels 6 to 33.
- The entrances to the residential building are located on the east and west sides of the building underneath an large undercroft
- 5.5 levels of basement carparking

Sydney's Wind Climate

Sydney is affected by two primary wind seasons, namely summer and winter/early spring.

- Summer winds occur mainly from the northeast, south and southeast. While northeast winds are the more common *prevailing* wind direction (occurring typically as offshore land-sea breezes), southeast and south winds generally provide the strongest gusts during summer.
- Winter/Early spring winds occur mainly from the west and the south. West quadrant winds (southwest to northwest) provide the *strongest winds* during winter and in fact for the whole year.

Aspects of Interest with the Proposed Development Relevant to Wind Impact

To the northwest on the corner of Atchison Lane and Christie Street is a 13-storey building. From direct north around to northeast across Atchison Lane lie several 3-storey and 6-storey developments. Abutting the site to the east is a 3-storey building with a 5-storey development following further east.

To the southeast across Atchison Street is the 15-storey commercial IBM building. To the direct south lies a smaller 7-storey development, with an 11-storey building further around southwest of the proposed development. Abutting the west of the site is a 17-storey commercial/residential building, beyond which lie several other large developments, including a 12-storey development directly to the west, and the high-rise multi-building "Forum" development a little further to the west-southwest.



EXECUTIVE SUMMARY

Wind Effects Within and Around the Development

For the present study, a “Baseline” configuration was tested, representing the proposed development with *no windbreak features* such as trees, planting, etc. The following points summarise the wind environment around the proposed 6-16 Atchison Street Residential Development.

- There is potential for localised areas both at ground level to experience wind gusts exceeding criteria relevant to comfort conditions, eg walking, strolling, sitting, outdoor dining, etc.
- Locations on Atchison Street, at the end of the courtyard, experience higher wind speeds due to the northerly and southerly wind funnelling through the courtyards and in between buildings and impacting these locations
- The outdoor cafe area also attract higher winds (above the 10m/sec criterion) due to funnelling in between proposed development and the adjacent building, in this instance especially for north and southwest wind directions.
- Finally, the roof of the development will be exposed to potentially high winds of a mostly horizontal nature, requiring mostly vertical windbreak elements if it is foreseen to have a roof garden.

Many windbreak elements have already been proposed for the development such as the enclosed balconies to the apartment, the large undercroft for the cafe and sitting area reducing downwash impacts. Some additional windbreak features have been recommended as a result of the present round of testing, including:

- Landscaping for street footpath and internal lane areas. Dense landscaping on the north and south of the courtyards.
- 2 metres high vertical windbreak and horizontal canopies to the roof area if it is proposed to have a roof garden.

Windbreak recommendations are summarised graphically in **Figure 7**.

The wind mitigation recommendation will be refined during the detailed design stage of the development. It is therefore recommended that, as the building design progresses to the point of confirmed design approval, the wind mitigation treatments are also reviewed and refined, ie specific landscaping strategies or dimensions recommended for vertical screens, etc, to ensure that wind comfort conditions are achieved or existing wind environment is maintained while minimising wind mitigation impact on the public domain.



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APPENDIX A SYDNEY WIND ROSES



1 INTRODUCTION

Heggies Pty Ltd (Heggies) has been engaged by Bancor Pty Ltd (Bancor) to assess the local wind environment, via an Environmental Wind Tunnel Study, within and around the proposed Residential Development at 6-16 Atchison Street, St Leonards.

1.1 Development Site

The development is bounded by Atchison Street to the south, Atchison Lane to the north, an existing 3-storey development to the east and an existing 17-storey mixed-use development to the west (refer **Figure 1**).

Figure 1 Locality Map for the Proposed Residential Development

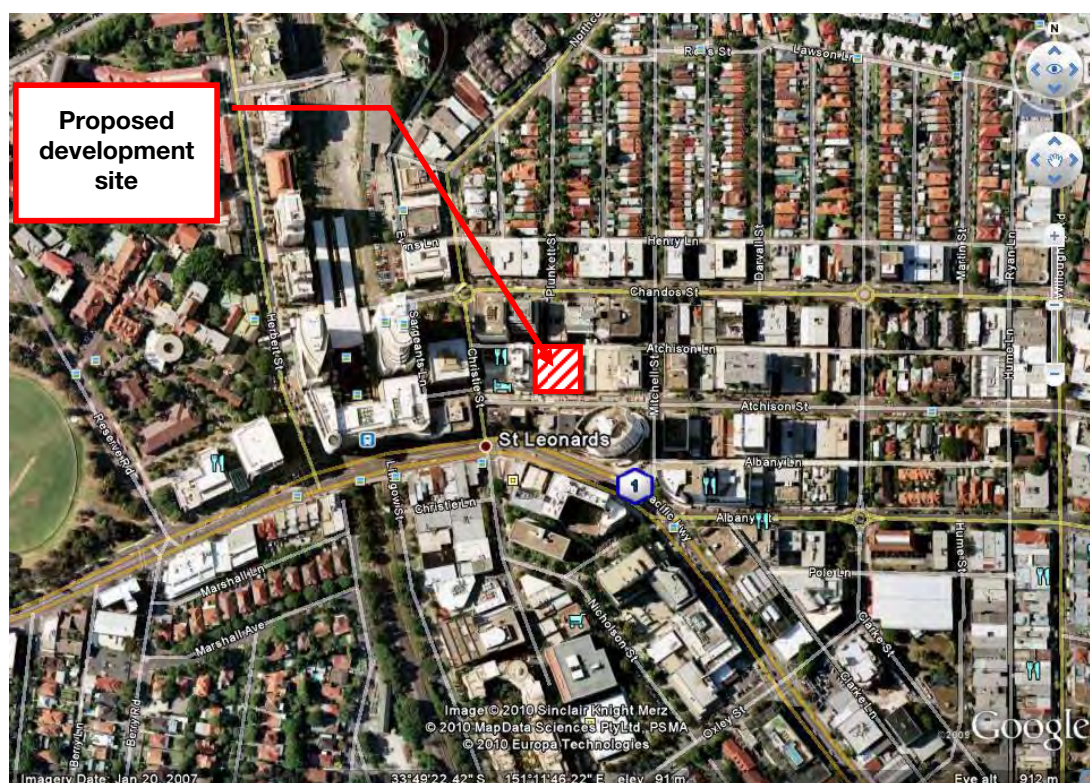


Image courtesy from GoogleEarth



1.2 Development Description

The proposed residential development will consist of the following features:

- A total of 33 levels
 - Entry lobby and café on ground floor;
 - Hotel apartment and gym with swimming pool on levels 2 to 3;
 - Residential apartment on levels 7 to 33.
- The entrances to the residential building are located on the east and west side of the building underneath an large undercroft
- 5 levels of basement carparking

1.1 Points of Interest with Respect to Wind

Immediately surrounding the site is a mix of commercial and residential developments including numerous similar height or even taller developments.

To the northwest on the corner of Atchison Lane and Christie Street is a 12-storey building. From direct north around to northeast across Atchison Lane lie several 3-storey and 6-storey developments. Abutting the site to the east is a 3-storey building with a 5-storey development following further east.

To the southeast across Atchison Street is the 16-storey commercial IBM building. To the direct south lies a smaller 7-storey development, with an 11-storey building further around southwest of the proposed development. Abutting the west of the site is a 17-storey commercial/residential building, beyond which lie several other large developments, including a 12-storey development directly to the west, and the high-rise multi-building “Forum” development a little further to the west-southwest.



2 SYDNEY'S WIND CLIMATE

2.1 General

The data of interest in this study are the annual extreme mean hourly wind speeds and largest gusts experienced throughout the year, how these winds vary with azimuth, and the seasonal break-up of winds into the two primary Sydney wind seasons.

2.2 Seasonal Winds

In relation to key characteristics of the Sydney Region Wind Climate (refer to Sydney Wind Rose in **Appendix A**) relevant to the wind impact assessment of the proposed development, we note that Sydney is affected by two primary wind seasons:

Summer winds occur mainly from the northeast, south and southeast.

- While northeast winds are the more common prevailing wind direction (occurring typically as offshore land-sea breezes), southeast and south winds generally provide the strongest gusts during summer.

Winter/Early spring winds occur mainly from the west and the south.

- West quadrant winds (southwest to northwest) provide the strongest winds during winter and in fact for the whole year.

2.3 Wind Exposure of the Site

Close to the ground at particular locations, the broad seasonal patterns described above are modified by the terrain, topography and effects of nearby buildings, giving rise to the “local” wind environment.

The site is located in St Leonards, approximately 3 km north of Sydney's North Sydney CBD precinct and is surrounded by a mix of medium-rise commercial and residential buildings, ranging in height up to the level of the proposed development. The site is somewhat more exposed to the southwest where the topography falls off towards Greenwich and Sydney Harbour.



3 PEDESTRIAN LEVEL WIND ACCEPTABILITY CRITERIA

3.1 Council Criteria

The wind acceptability criteria found in Central Sydney DCP 1996 Section 4.2 were developed from research on suitable criteria for evaluating the acceptability of particular ground level conditions. They are currently referenced by many Australian Local Government Development Control Plans (including North Sydney Council) and have been summarised in **Table 1**.

Table 1 Standard Local Government Wind Acceptability Criteria

Type of Criteria	Limiting Gust Wind Speed Occurring Once Per Year	Activity Concerned
Safety	24 m/s	Knockdown in Isolated Areas
	23 m/s	Knockdown in Public Access Areas
Comfort	16 m/s	Comfortable Walking
	13 m/s	Standing, Waiting, Window Shopping
	10 m/s	Dining in Outdoor Restaurant

The primary objectives relating to the above wind impact criteria are as follows:

- The general objective is for annual 3-second gust wind speeds to remain at or below the so-called 16 m/sec “*Walking Comfort*” criterion. Whilst this magnitude may appear somewhat arbitrary, its value represents a level of wind intensity which the majority of the population would find unacceptable for comfortable walking on a regular basis at any particular location.
- In many urban locations, either because of exposure to open water conditions or because of street “canyon” effects, etc, the 16 m/sec “*Walking Comfort*” level may already be currently exceeded. In such instances a new development should ideally not exacerbate existing adverse wind conditions and, wherever feasible and reasonable, ameliorate such conditions.

3.2 Application of Council Wind Criteria

The criteria provided in **Table 1** should not be viewed as “*hard*” numbers as the limiting values were generally derived from subjective assessments of wind acceptability. Such assessments have been found to vary with the height, strength, age, etc, of the pedestrian concerned.

A further factor for consideration is the extent of windy conditions, and some relaxation of the above criteria may be acceptable for small areas under investigation provided the general site satisfies the relevant criteria.

Finally, it is noted that the limiting wind speed criteria in **Table 1** are based on the maximum wind gust occurring (on average) once per year. Winds at all other times, ie monthly winds, weekly winds, etc, would be of lesser magnitude. So for example, a location with a maximum annual gust of 10 m/sec would experience winds throughout the year of a generally very mild nature, conducive to stationary activities (seating, dining, etc).



WIND TUNNEL TEST METHODOLOGY

4.1 Simulation of the Natural Wind

Similarity requirements between the wind tunnel model and prototype (ie full-scale) need to be fulfilled so that similitude in the flow conditions is satisfied. Usually all requirements cannot be satisfied and compromises need to be made. In this type of wind tunnel test it is possible to waive strict adherence to the full range of similarity parameters.

The wind tunnel test has been carried out using a geometric length scale of 1:400 for all dimensions and by scaling the boundary layer approach wind in the wind tunnel to the same scale as in the atmosphere.

The approach wind was modelled by matching Terrain Category conditions for all wind directions. In the wind tunnel, this is achieved by an upstream trip fence and a 15-metre fetch of appropriate roughness elements. For the present wind test, different upstream profile conditions were simulated as shown in **Table 2**.

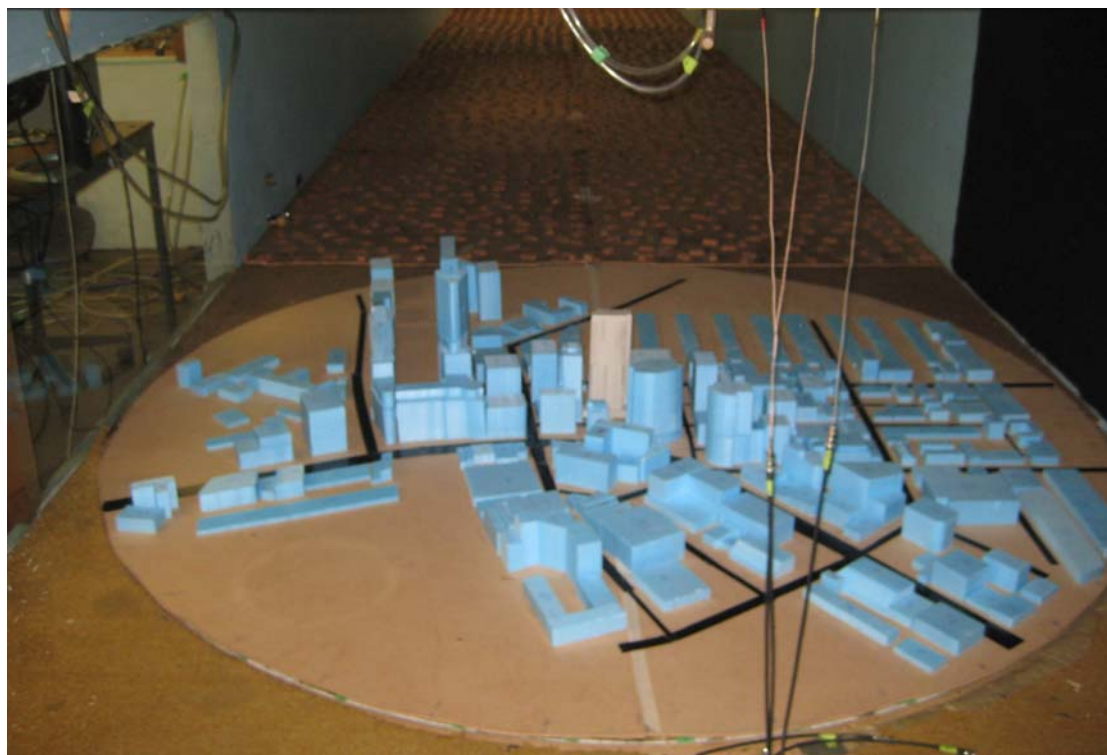
Table 2 Upstream Terrain Category Conditions Used for the Wind Tunnel Testing

Approach Wind Direction	Terrain Classification	Description
0° to 360°	Terrain Category 3	Suburban / Urban

4.2 The “Proximity” Model

To take into account the influence of the immediate surrounding physical environment, all neighbouring buildings and local topography within a 500 m radius around the project towers were included in the 1:400 scale “*proximity model*” used for the test as shown in **Figure 2**. The proximity model details included the existing built environment as of June 2010.

Figure 2 St Leonards Proximity Model in the Wind Tunnel



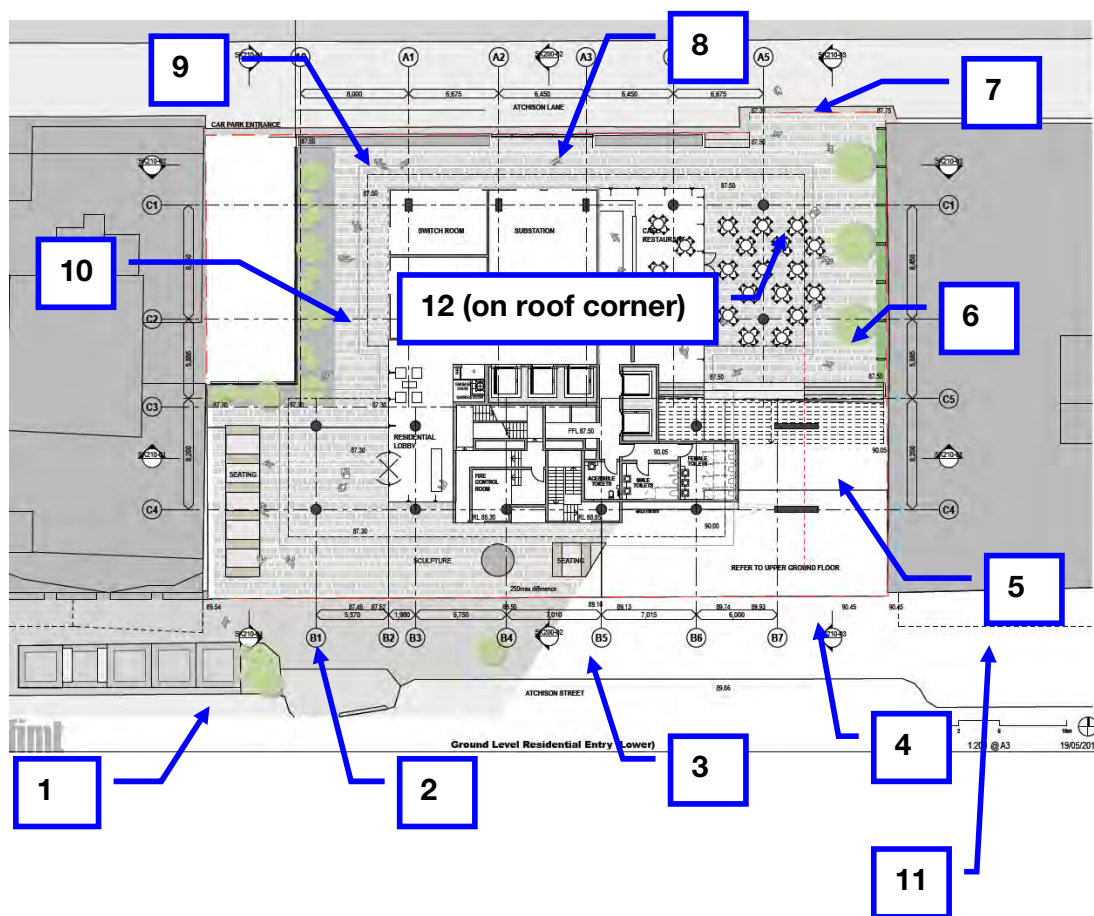


4.3 Test Method - Sensor Locations

In the wind tunnel testing, hot-wire wind sensors were positioned at the locations shown in **Figure 3**. These locations were chosen as potentially susceptible to adverse wind conditions, eg near building entrances, building corners, etc, and represent locations of interest throughout the development.



Figure 3 Wind Tunnel Test Sensor Locations





4.4 Data Processing

The wind speeds at the locations of interest are measured in the wind tunnel using hot wire sensors which are used to measure the fluctuating velocity corresponding to two to three-second gusts in full scale. Wind speeds are also averaged over time to determine the mean wind speed.

- Wind speeds in the wind tunnel are measured at a height corresponding to approximately *chest height* (1.5 metres) in full scale. The velocities are recorded as dimensionless ratios of the peak (2-3 second) gust and mean ground level velocity to mean gradient wind speed. The data is then processed using the directional wind speed information derived from Sydney's wind climate to yield ground level wind speeds as a function of annual return period and directional mean gradient wind speed.
- Wind speed measurements were taken at twenty-four wind directions (ie 15° intervals). The zero wind direction is from the north, with east at 90°, south at 180°, etc.

The ground level wind speeds thus incorporate both the building and topographical aspects of the location as well as the directional probability of wind speed for Sydney. The results have been computed on a one-year return period basis, ie the storm wind event which is equalled or exceeded once per year, on average, using Sydney statistical wind data.

4.5 Test Scenarios

Tests carried out for the present study:

- The "Baseline" configuration represents the proposed Atchison Street development without any windbreak options within or around the site.

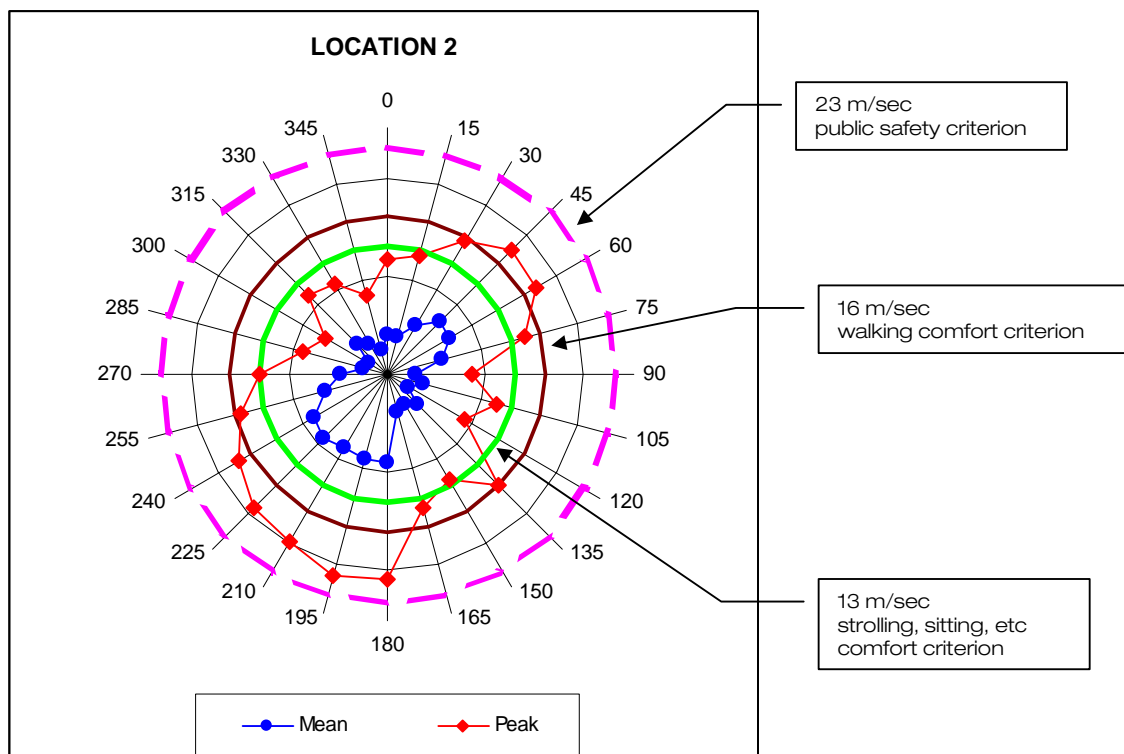
4.6 Sample Test Result

An example of the test results and interpretation of these results is shown in, illustrating the peak annual mean and gust wind speeds at:

Sensor:	No 2
Location:	Atchison Street, in line with southwest corner of building
Directions:	north is at 0°, east is at 90°, south is at 180°, etc.



Figure 4.6.1 Sample Test Result at Sensor No 2



The wind tunnel test results are plotted in polar form. The polar plot shows the variation of the *average* or “*mean*” wind speed exceeded once per year (inner data points, annotated using solid blue circles) as well as the *peak annual gust wind speed* (outer data points, annotated using solid red circles).

- It can be seen that the *average* winds are strongest from the northeast and southwest. From these directions, winds approach the site with moderate upstream blockage (especially from the southwest) and experience acceleration as they pass around the building’s northwest corner and channelling through the gap between the 17-storey building on the west and the proposed development. *Peak gust* winds are also strongest from the southwest and northeast, once again as a result of winds accelerating around the northeast corner of the development.

Finally, the polar diagram includes three circumferential lines representing the 23 m/sec (Public Safety), 16 m/sec (Walking Comfort) and 13 m/sec (Strolling, Sitting, etc, Comfort) Criteria levels. At Sensor Location 2, peak gust winds:

- Exceed the 16 m/sec walking comfort criterion from the southwest (180° to 240°) and almost from the northwest (45° to 60°).
- Exceed the 13 m/sec strolling, sitting, etc, comfort criterion from the northeast quadrant, southeast, and south clockwise through to west.

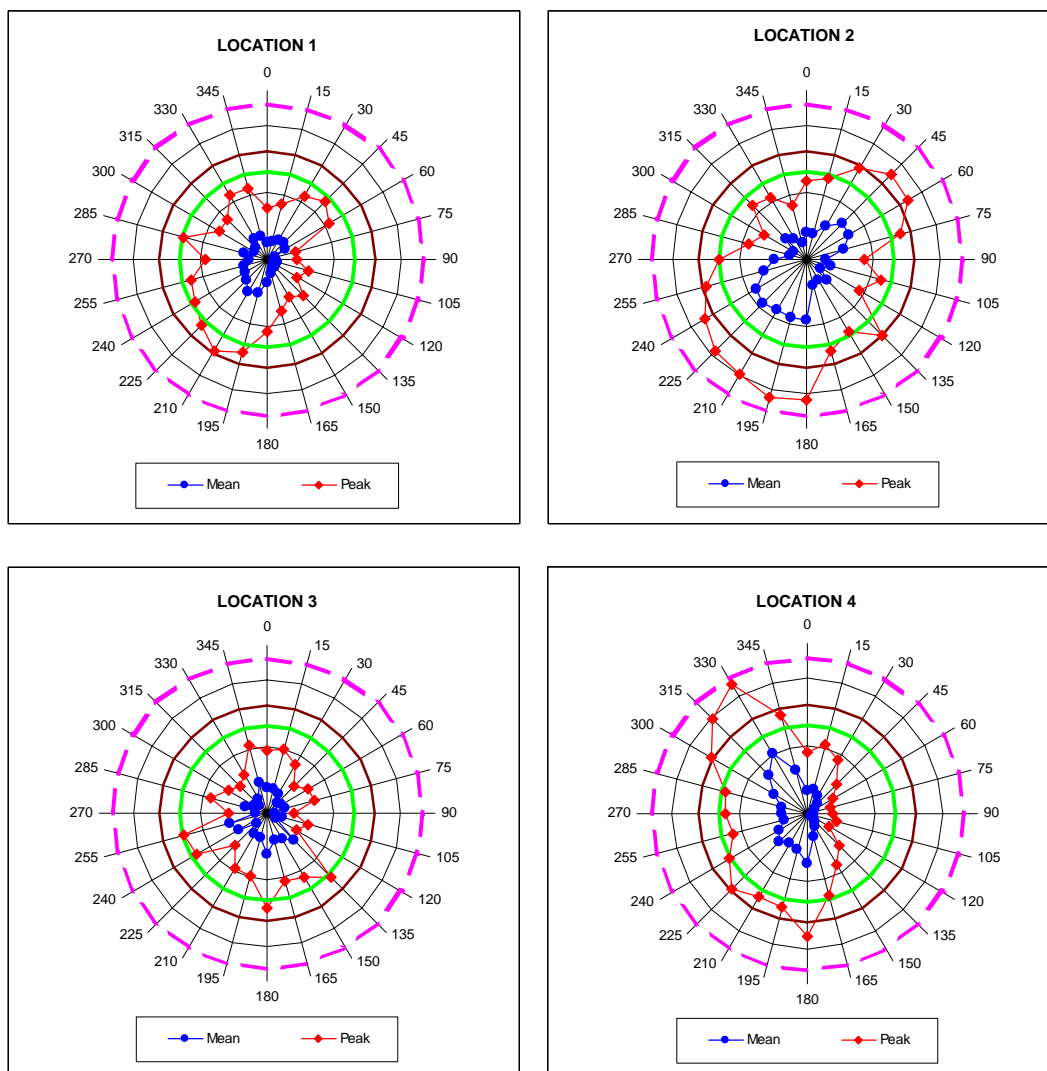


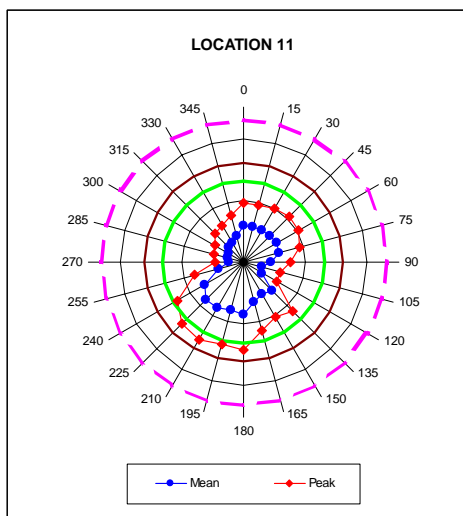
5 TEST RESULTS - EXTERNAL GROUND LOCATIONS

5.1 Atchison Street (Sensors 1, 2, 3, 4, 11)

The wind tunnel test results for Atchison Street locations in the “Baseline” configuration are shown in **Figure 5.1.1**.

Figure 4 Baseline Configuration Results for Atchison Street Sensor Locations





In the “Baseline” configuration:

- Wind speeds on Atchison Street are predicted to be moderate to high with Locations 2 and 4 south of the courtyards on both sides of the proposed development exceeding the 16 m/sec public safety criterion for northeast and southwest winds for Location 2 and south and northwest wind for Location 4.
- Wind speeds at Locations 1, 3 and 11 are all below the 16 m/sec walking comfort criterion level.

High winds at Location 2 occur due to a combination of channelling of northeast winds through the west courtyard of the proposed development and acceleration of winds around the western corners of the development. High winds from the southwest quadrant are due to the wind funnelling in between buildings south of the development site and impacting the site at Location 2 prior to passing by the development.

High winds at Location 4 occur due to a combination of channelling of northwest winds through along the east courtyard of the proposed development and acceleration of winds around the eastern corners of the development. High winds from the southwest quadrant are due to the wind funnelling in between the 16-storey IBM building and the 7-storey building directly south to the development site and impacting the site at Location 4 prior to passing by the development.

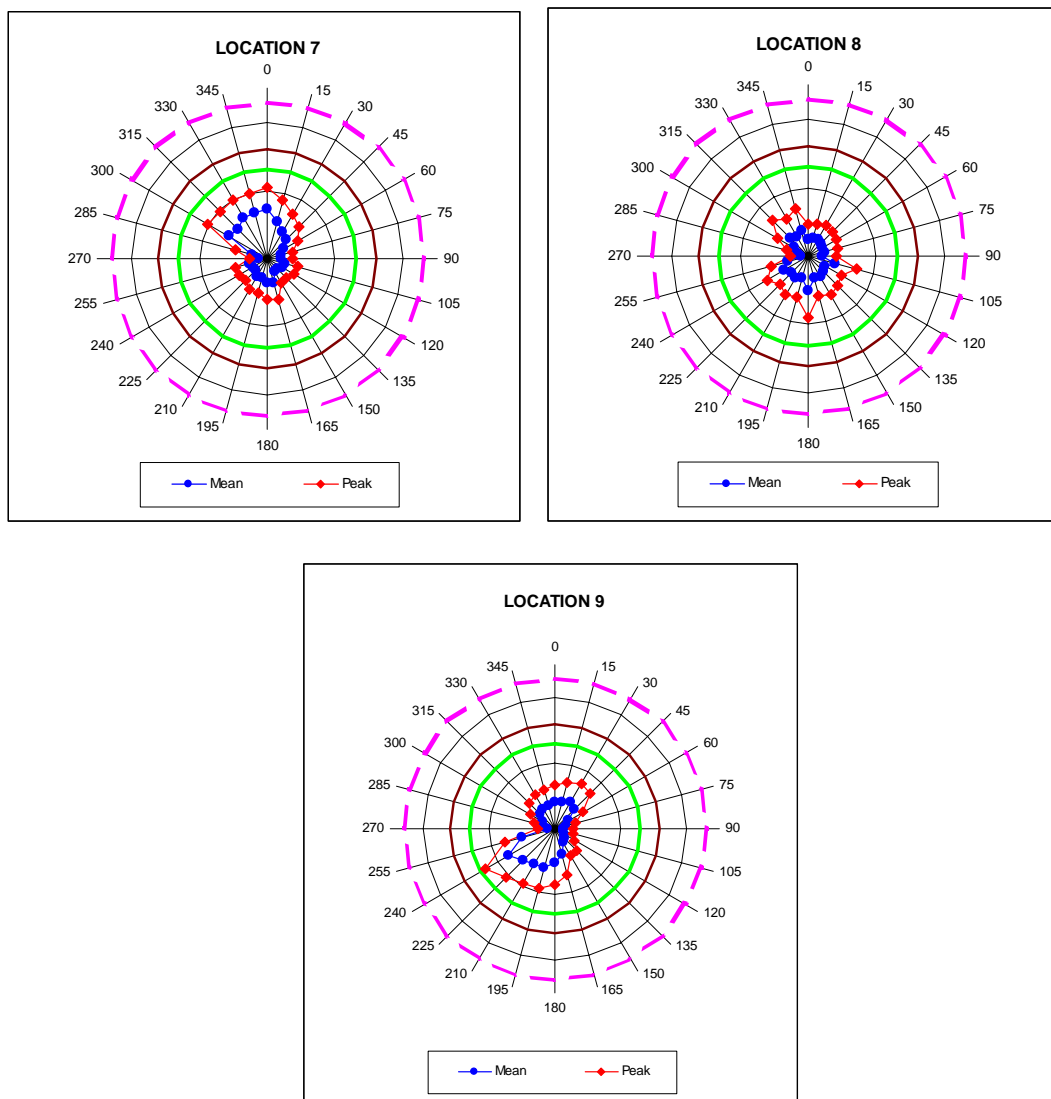
Wind speeds at Locations 1, 3 and 11 are below the 16 m/sec comfortable walking criterion due to shielding from surrounding buildings and the proposed development itself.

5.2 Atchison Lane (Sensors 7, 8, 9)

The wind tunnel test results for Atchison Lane locations in the “Baseline” configuration are shown in **Figure 5**.



Figure 5 Baseline Configuration Results for Atchison Lane Sensor Locations



In the “Baseline” configuration:

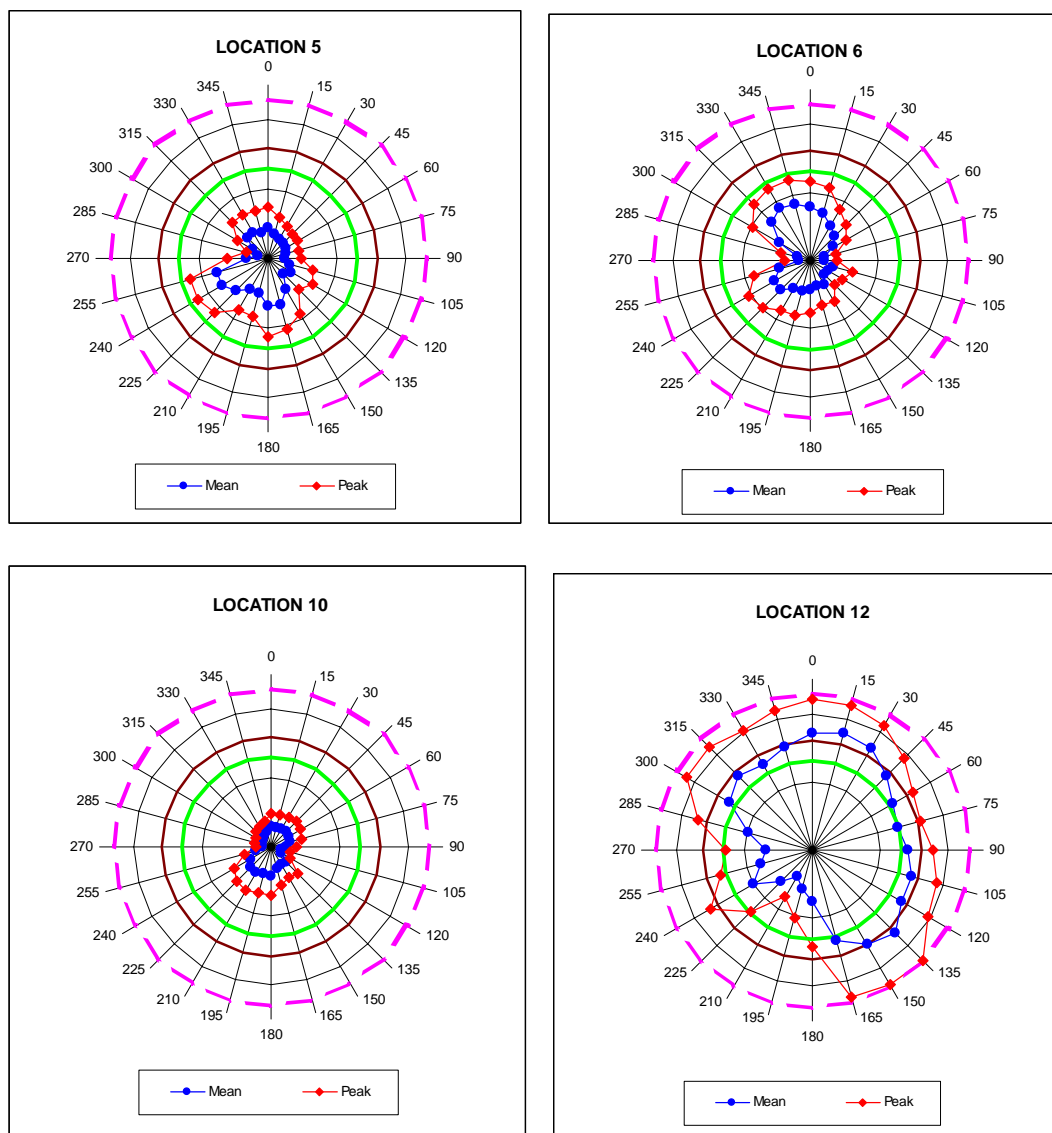
- Wind speeds on Atchison Lane are predicted to be moderately low with winds at Location 7 (northeast corner of proposed building), Location 8 (footpath north to proposed development) and Location 9 (at carpark entrance) just below the 13 m/sec criterion.



5.3 Courtyards (Locations 5, 6, 10) and Roof (Location 12)

The wind tunnel test results for courtyards locations in the “Baseline” configuration are shown in **Figure 6**.

Figure 6 Baseline Configuration Results for Courtyards Locations



In the “Baseline” configuration:

- Wind speeds along the east and west courtyards are predicted to be moderately low with peak wind speed at Locations 5 and 6 (east of proposed development) just below the 13 m/sec criterion and wind at Location 10 well below the 13 m/sec short-term stationary comfort level criterion.
- Winds over the roof, are predicted to be high with peak wind speed at Location 12 just below the 23 m/sec public safety criterion for northerly and southeasterly winds.



At Locations 5 and 6, higher wind speeds are observed for winds coming from the south and north as the wind flow accelerates through the gap between the proposed building and the commercial block on the east. Moreover it is seen that winds do not exceed the 13 m/sec short-term stationary comfort level for all wind directions, making these areas suitable for short-term stationary recreational activities expected to be conducted in the courtyard.

As it is proposed to have a cafe with outdoor dining area on the north part of the east courtyard (close to Location 6), it is of interest to check that the 10 m/sec outdoor dining criterion is not exceeded at Location 6. It is observed that the Location 6 peak winds exceed the 10 m/sec criterion for northerly winds (315° to 15° clockwise). Heggies recommends dense landscaping on the north side of the east courtyard so that the northerly winds are sufficiently dispersed to be below the 10 m/sec criterion for the outdoor cafe area.

Roof Level Winds

It is often stated winds over the roofs of taller buildings can be exposed to elevated wind speeds, especially if the building in question is not surrounded by similar height building.

Sensor Location 12 was located very close to the northeast corner of the building roof.

It can be seen that winds there are very high for all wind directions approaching from the north and east quadrants. Winds are much lower for winds approaching from the southwest, ie the opposite corner of the building roof.

While this result is of interest in an aerodynamic sense and provides confirmation of the potential for high roof level wind speeds, the roof is not a habitable area and wind speeds relative to human comfort criteria are not relevant.

SUMMARY AND RECOMMENDATIONS

The following points summarise the wind environment around the proposed 6-16 Atchison Street Residential Development.

- There is potential for localised areas both at ground level to experience wind gusts exceeding criteria relevant to comfort conditions, eg walking, strolling, sitting, outdoor dining, etc.
- Locations on Atchison Street, at the end of the courtyard, experience higher wind speeds due to the northerly and southerly wind funnelling through the courtyards and in between buildings and impacting these locations.
- Elevated wind conditions along Atchison Street associated with southerly winds are due to winds approaching the site through gaps in upstream buildings and not due to the development itself.
- Elevated wind conditions along Atchison Street associated with north quadrant winds (northeast and northwest) are due to winds funnelling in between the proposed development and adjacent buildings. At these locations, vertical windbreak elements, preferably landscaping, would reduce winds to well below walking comfort level.
- The outdoor cafe area also attracts higher relative winds (above the 10 m/s criterion) due to funnelling in between proposed development and the adjacent building, in this instance especially for north and southwest wind directions.
- Finally, the roof of the development will be exposed to potentially high winds of a mostly horizontal nature, requiring mostly vertical windbreak elements if it is foreseen to have a roof garden.



Many windbreak elements have already been proposed for the development such as the enclosed balconies to the apartment, the large undercroft for the cafe and sitting area reducing downwash impacts. Some additional windbreak features have been recommended as a result of the present round of testing, including:

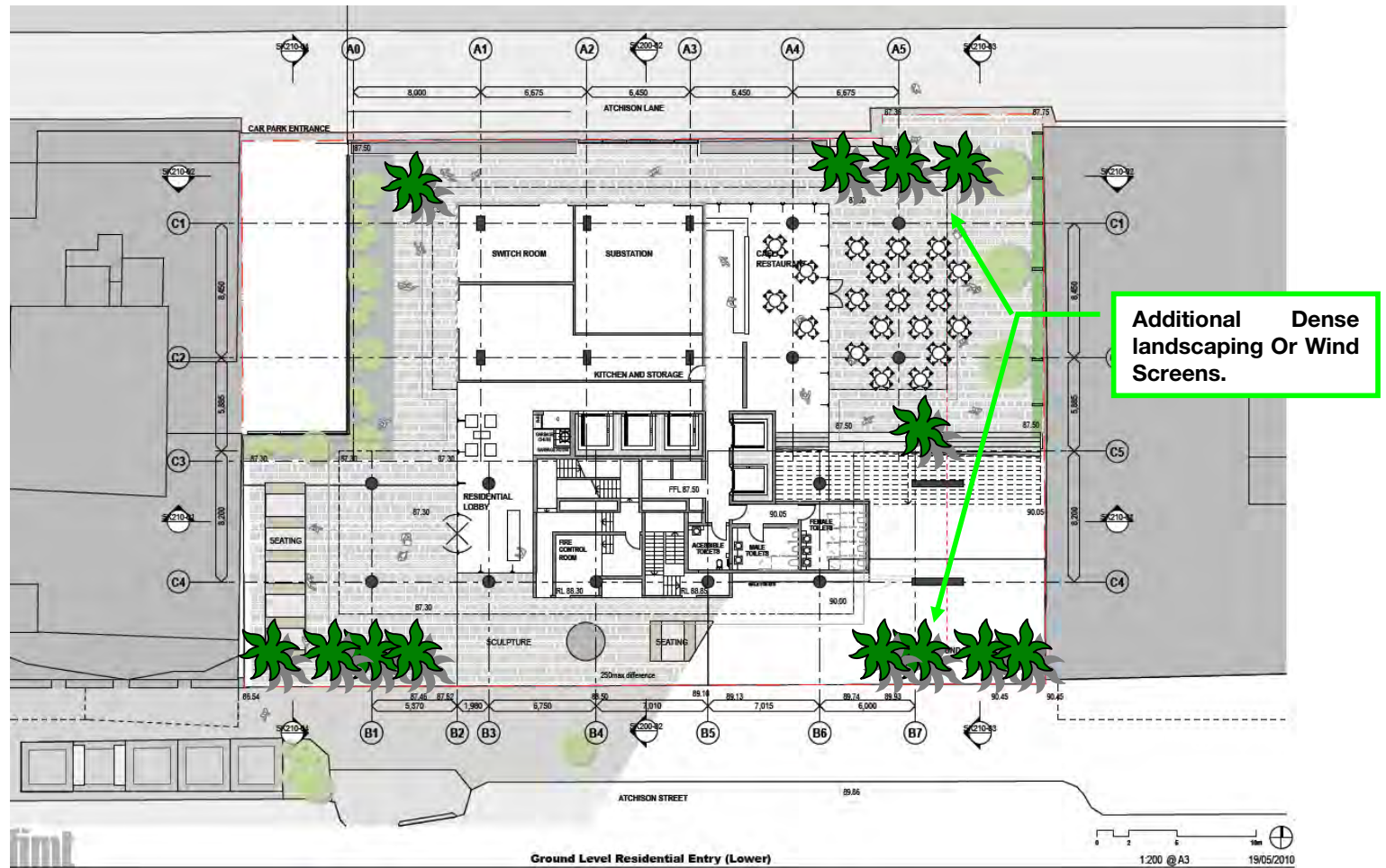
- Landscaping or wind screens for street footpath and internal lane areas. Dense landscaping or wind screens on the north and south of the courtyards.

Windbreak recommendations are summarised graphically in **Figure 7**.

The wind mitigation recommendation will be refined during the detailed design stage of the development. It is therefore recommended that, as the building design progresses to the point of confirmed design approval, the wind mitigation treatments are also reviewed and refined, ie specific landscaping strategies or dimensions recommended for vertical screens, etc, to ensure that wind comfort conditions are achieved or existing wind environment is maintained while minimising wind mitigation impact on the public domain.



Figure 7 Ground Floor - Recommended Wind Treatments



Appendix A

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SYDNEY WIND ROSES

