APPENDIX 8.
WIND EFFECTS STATEMENT

Wind Effects Statement

for the proposed modification
to the approved Concept Plan for

Barangaroo, Sydney

June 19, 2008

Report Reference No. WA078-02F03(rev1)- WS Report

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1.0 Executive Summary

A modification to the approved Concept Plan has been developed for the Barangaroo site in Sydney. This site is bounded by Hickson Road to the east, Darling Harbour to the west, Walsh Bay to the north and the King Street Wharf development to the south.

This report presents a preliminary assessment of the existing wind environment within the Barangaroo precinct of Sydney. Comments regarding the potential impact of the proposed building massing are also presented in this report. No specific recommendations are made in this report as the aim is to highlight potential areas of concern rather than prescribe specific solutions. However, some general suggestions have been made to assist in the future design process.

The site is currently subject to strong southerly and westerly wind effects. The changes on the site proposed by the Concept Plan modification are not expected to result in a worsening of the existing conditions. However, due to the proposed change of use, it is important that the design of any areas for outdoor passive recreational use be subjected to wind tunnel modelling to confirm the effectiveness of any proposed ameliorative measures for wind effects, subject to the following;

- Wind tunnel testing methodology must comply with the Australasian Wind Engineering Society AWES-QAM-1-2001.
- Comfort under wind conditions should be assessed based on the applicable criteria for the weekly maximum Gust Equivalent Mean. The criteria by Davenport (1972) are preferred, although the Lawson (1975) criteria may also be used.
- Not-withstanding the above criteria, all public outdoor spaces will also need to satisfy the safety limit of 23m/s annual maximum gust suggested by Melbourne (1978).
- The appropriate criterion should be selected for the type of activity intended for the area in question. For example, all seating areas must comply with the short exposure criterion, whereas outdoor dining areas should aim to comply with the long exposure criterion.

The use of strategic planting and localised screens are effective in providing protection to the outdoor areas designated for passive recreational use. However, the form of the buildings also plays a significant role. The gradual increase in building heights towards the south is helpful in minimising the impact of the north-westerly winds.

The planting of densely foliating trees along the Hickson Road boundary of the precinct and along the east-west streets within the precinct is important in minimising the impact of the southerly and westerly winds on pedestrians.

2.0 Introduction

A modification to the approved Concept Plan has been developed for Barangaroo. The site is bounded by Hickson Road to the east, Darling Harbour to the west, Walsh Bay to the north and the King Street Wharf development to the south.

This report presents a preliminary assessment of the existing wind environment within the Barangaroo precinct, Sydney. Comments regarding the potential impact of the proposed building massing are also presented in this report. No specific recommendations are made in this report as the aim is to highlight potential areas of concern rather than prescribe specific solutions. However, some general suggestions have been made to assist in the future design process.

3.0 Statement of Commitments

This report presents a preliminary assessment of the wind environment within and around the proposed Barangaroo East Darling Harbour precinct. The report aims to highlight potential areas of concern rather than prescribe specific solutions. Therefore the commitments to be made by the proponent can remain as:

1. That wind tunnel modelling be undertaken at future design stages to obtain a reliable prediction of the likely wind environment effects and to test the recommended treatment options.
2. That the wind tunnel modelling referred to in 1 be carried out in accordance with the procedures outlined in an industry recognised guidelines such as the Australasian Wind Engineering Society Quality Assurance Manual, AWES-QAM-1-2001.

4.0 Local Wind Climate

Three principal wind directions potentially affect the precinct. These winds prevail from the north-east, south and west, Table 1 is a summary of the principal time of occurrence of these winds. This summary is based on data obtained by the Bureau of Meteorology from Sydney Airport, between 1939 and 1992. Table 1 presents a summary of the principal time of occurrence of these winds.

Table 1: Principal Time of Occurrence of Winds – Sydney Region

Month	Wind Direction		
	North-Easterly	Southerly	Westerly
January	X	X	
February	X	X	
March	X	X	
April		X	X
May			X
June			X
July			X
August			X
September		X	X
October	X	X	
November	X	X	
December	X	X	

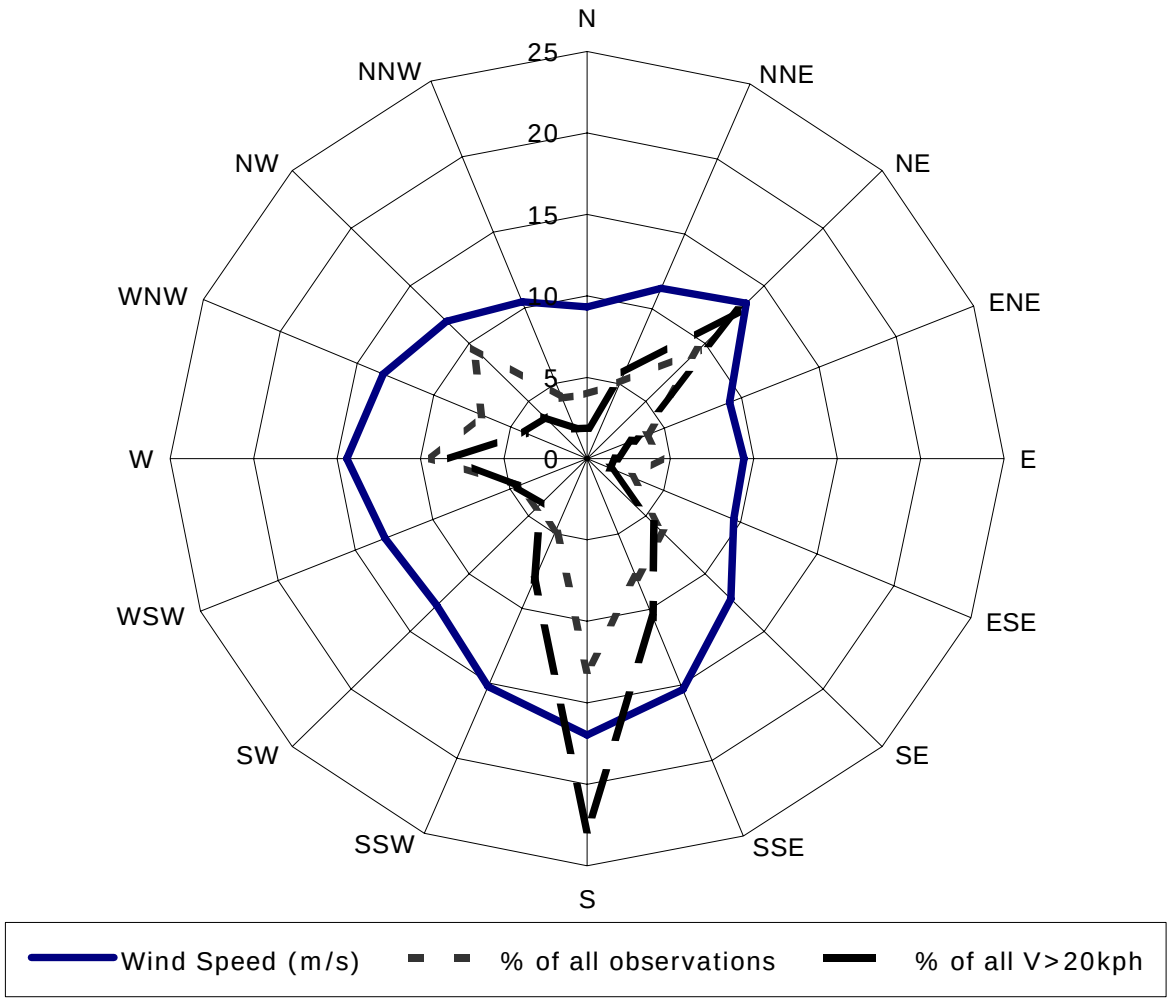

Figure 1: Basic Mean Wind Speed Data for Sydney, 1932-1992 (in metres per second, based on 3 hourly mean wind speeds, at 10m height at Kingsford Smith Airport)

5.0 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.

The following table, developed by Penwarden (1975), is a modified version of the Beaufort Scale, and describes the effects of various wind intensities on people. Note that the applicability column related to wind conditions occurring frequently (exceeded approximately once per week on average). Higher ranges of wind speeds can be tolerated for rarer events.

Table 2: Summary of Wind Effects on People (after Penwarden, 1975)

Type of Winds	Beaufort Number	Gust Speed (m/s)	Effects	Applicability
Calm, light air	1	0 - 1.5	Calm, no noticeable wind	Generally acceptable for Stationary, long exposure activities such as in outdoor restaurants, landscaped gardens and open air theatres.
Light breeze	2	1.6 - 3.3	Wind felt on face	
Gentle breeze	3	3.4 - 5.4	Hair is disturbed, Clothing flaps	
Moderate breeze	4	5.5 - 7.9	Raises dust, dry soil and loose paper - Hair disarranged	Generally acceptable for walking & stationary, short exposure activities such as window shopping, standing or sitting in plazas.
Fresh breeze	5	8.0 - 10.7	Force of wind felt on body	Acceptable as a main pedestrian thoroughfare
Strong breeze	6	10.8 - 13.8	Umbrellas used with difficulty, Hair blown straight, Difficult to walk steadily, Wind noise on ears unpleasant.	Acceptable for areas where there is little pedestrian activity or for fast walking.
Near Gale	7	13.9 - 17.1	Inconvenience felt when walking.	
Gale	8	17.2 -20.7	Generally impedes progress, Great difficulty with balance.	Unacceptable as a public accessway.
Strong gale	9	20.8 - 24.4	People blown over by gusts.	Completely unacceptable.

6.0 Description of the Concept Plan Modification

It is proposed to create a large public recreational area along the western (waterfront) portion of the precinct.

It is proposed to gradually increase the heights of the buildings towards the southern end of the precinct. Buildings will increase in height from low-rise at the northern part of the site to maximum heights of approximately 40 levels at the southern end of the site. It is proposed to gradually vary the development mix from predominantly residential at the northern end to predominantly commercial at the southern end. Ground level areas on the southern half of the precinct will involve retail activities. The east-west streets will be generally aligned with the existing streets to the east of the site.

Figure 2 below shows a perspective sketch of the potential tower component of the modified Concept Plan. The heights are also indicated in this figure. A plan image of the entire precinct is shown in Figure 3, with the basic proposed building outlines also indicated. An aerial image of the existing site is shown in Figure 4.

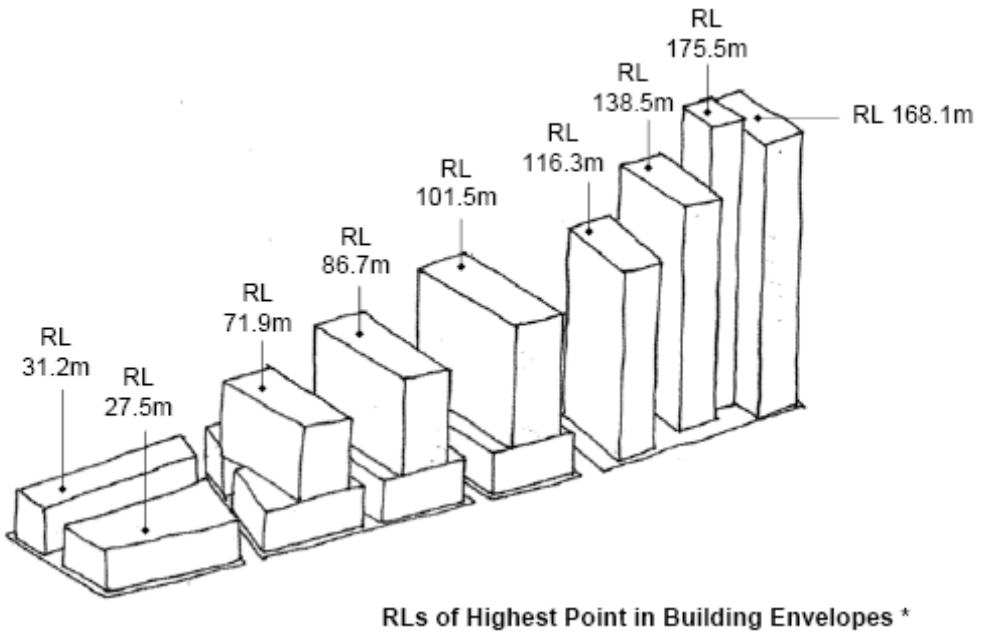

Figure 2: Perspective Sketch of the Potential Tower Component of the Modified Barangaroo Concept Plan (view from the north-west)

Figure 3: Site Plan

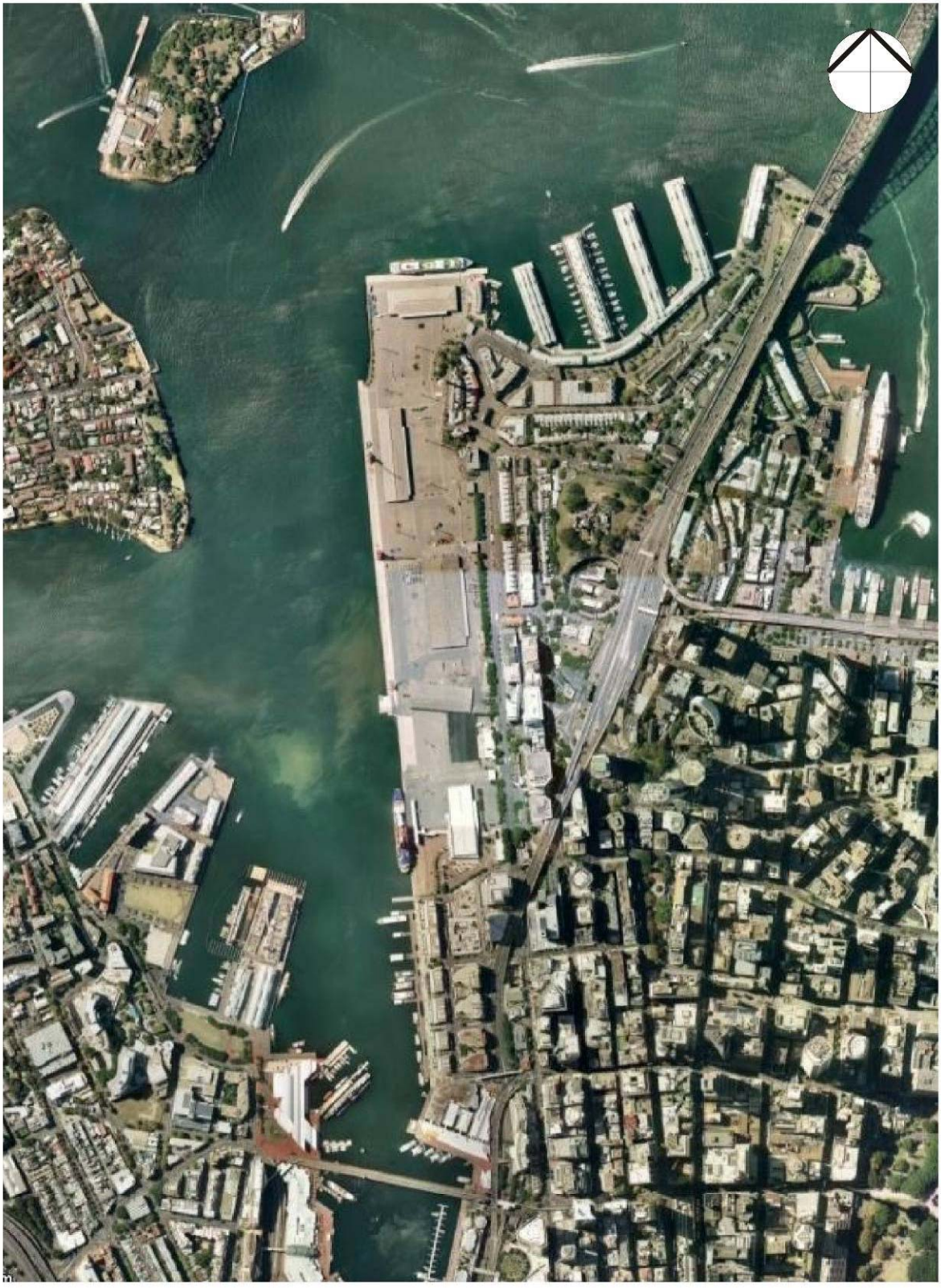

Figure 4: Aerial Image of the Existing Site

7.0 Results

The various wind effects are assessed in respect of the local wind climate (described in Section 4 of this report) and the level of exposure of the site. The impact of wind will differ depending on the type of activity intended for the outdoor space (refer to Section 5 of this report).

7.1 Assessment of Existing Conditions

Figure 1 below illustrates the main impacts of the three principle wind directions in Sydney.

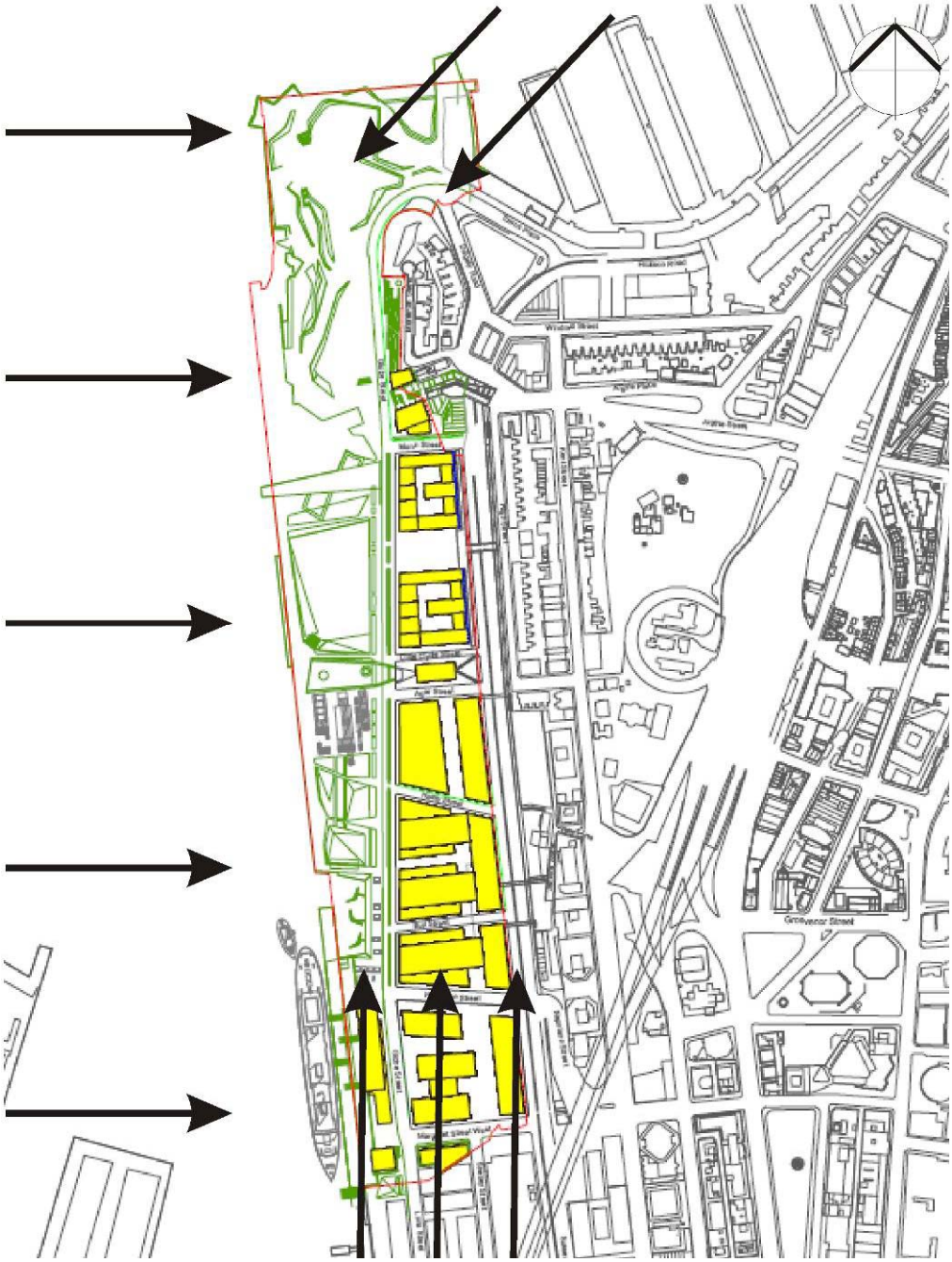

Figure 5: Main Impacts of the Three Principle Wind Directions for Sydney

7.1.1 North-Easterly Winds

North Easterly winds are generally not as strong or frequent as the other prevailing winds. Furthermore, as they tend to occur during the summer months they are likely to have a positive environmental effect.

However, it is important to ensure that the proposed building morphology will not result in accelerated flows at the ground level to the point where the north-easterly winds will tend to cause discomfort. The present conditions at the area north and west of Merriman Street are expected to be consistently windy due to its exposure to these winds. The effect of the north-easterly winds on the remainder of the site is not expected to be significant due to the effect of the substantial escarpment along the eastern side of Hickson Road and the shielding provided by the row of tall buildings adjacent to the southern half of the precinct.

7.1.2 Southerly Winds

The southerly winds currently have a significant impact on the local wind environment. The Western Distributor is expected to direct strong southerly winds onto the southern part of the site. The alignment of the north-south roads in the Sydney CBD tend to have a funneling effect at ground level for strong southerly wind events.

At present, south to south-westerly winds are expected to result in strong wind conditions along the foreshore area.

7.1.3 Westerly Winds

The west to north-westerly winds will have the greatest impact on the site due to the exposure of the site to these winds (refer to Figure 5). This is compounded by the fact that these tend to be the dominant winds during the colder winter months, when people tend to be more sensitive to the wind.

The Barangaroo precinct is not alone with regards to the exposure to the westerly winds. Other areas experiencing a similar problem are the Observatory Park, the top of the Hickson Road cliff-face (particularly where there are no tall buildings behind to stagnate the westerly winds, such as along High Street and Gas Lane), and along certain areas of Darling Harbour and King Street Wharf.

Wind conditions within the Clyne Reserve are expected to be tolerable due to the effect of the existing vegetation. However, conditions are expected to be particularly windy in areas immediately north or west of that area.

7.2 Assessment of Future Conditions (based on the modified Concept Plan)

It is proposed to create a large public recreational area along the western (waterfront) portion of the site.

It is proposed to gradually increase the heights of the buildings towards the south of the site. Buildings will increase in height from low-rise at the northern part of the site to maximum heights of approximately 40 levels at the southern end of the site. It is proposed to gradually vary the development mix from predominantly residential at the northern end to predominantly commercial at the southern end. Ground level areas on the southern half of the precinct will involve retail activities.

The east-west streets will be generally aligned with the existing streets to the east of the site.

7.2.1 North-Easterly Winds

North-easterly winds are generally not critical. However, care should be taken with regard to the potential use and protection of those using the northern end of the precinct, particularly the northern half of Headland Park. The escarpment that otherwise protects the site from the north-easterly winds is likely to funnel the north-easterly winds into this northern area. This effect can be ameliorated by means of strategic planting in the form of densely foliating trees throughout this area, although the exact locations are subject to future detailed design. It is expected that any areas within this part of Headland Park that involve seating or other stationery activities will require substantial protection. Techniques such as earth mounds or strategic planting could be considered, although densely foliating trees may be capable of ameliorating this wind effect alone if placed strategically.

7.2.2 Southerly Winds

Any proposal to have tall buildings at the southern end of the site with minimal or no podium setbacks is likely to result in substantial side-streaming and funnelling of the southerly winds onto Hickson Road (along the eastern side of the site) and along the waterfront area (along the western side of the site). A primary method of amelioration in this scenario would be significant street tree planting along the eastern and western boundaries of the site, particularly the section of Sussex Street between Napoleon and Margaret Streets. The selected species will need to be of a large density foliating type, with wide canopies. The use of strategic planting of trees is considered the most effective in this particular situation. However, alternative measures may be adopted provided that it can demonstrated, using wind tunnel modelling techniques, that they are as effective.

Downwash effects are likely on Margaret Street West and care should be taken in the detailed design stage to account for this. If no podium setback is to be provided from the southern aspects of the towers then alternative techniques should be investigated such as one or two

permeable floors near the base of the towers, or impermeable awnings/canopies over the pedestrian footpaths that can capture and deflect downwashed winds. Alternative measures can involve an aerodynamic form of the towers themselves to facilitate the horizontal movement of the wind and to minimise downwash.

South to south-westerly winds are likely to have an adverse impact on the wind environment west of Globe Street, including Globe Street itself. As mentioned in the case of the north-easterly winds, localised protection is the most effective means of protecting areas intended for seating or other stationary activities. The method of treating these direct ground-level wind effects will depend on the design and use of the area.

Wind tunnel modelling should be undertaken at a more detailed design stage for the components of the precinct located south of Agar Street. This is to obtain a reliable prediction of the likely wind environment effects and to test any recommended treatment options.

7.2.3 Westerly Winds

The westerly to north-westerly winds will have the greatest impact on the wind conditions within the open spaces on the western edge of the site west of Globe Street. In addition, the wind conditions on Globe Street and adjacent streets that are oriented east-west will be substantially affected by these direct ground level winds. Funnelling effects are also likely to occur at the southern portion of the site, particularly along Healy, Bull, Napoleon and Margaret Streets. It is expected that densely foliating vegetation in the form of trees will be necessary along the pedestrian footpaths of these streets to ameliorate the potentially adverse effects of these winds. However, in the case of Margaret Street, it is understood that it is intended to maintain this street as a view corridor to Darling Harbour. This will require careful design of wind mitigation device(s) for Margaret St, in conjunction with the design of the southernmost components of the Barangaroo precinct.

The southernmost tower of the proposed draft Concept Plan has a plan shape which features a recessed step-in. It is expected that this recess in the building form will provide effective stagnation to westerly winds on this aspect of the building, and limit the amount of potentially adverse side-streamed of winds around this building. However, it is expected that localised wind ameliorating devices such as screens and/or canopies/awnings will be necessary to treat adverse direct wind effects along the pedestrian footpaths of Margaret Street West.

It is expected that areas along the public reserve, west of Globe Street intended for seating or other passive recreational activities, will require localised protection. The method of treating these direct ground-level wind effects can be determined at a more detailed design stage since such treatments will depend on the design and use of the area. It is recommended that wind tunnel modelling be undertaken at

a more detailed design stage to obtain a reliable prediction of the likely wind environment effects and to test any recommended treatment options to verify their effectiveness.

8.0 Conclusions

A general overview of the key wind environment issues has been presented in this report. It is recommended that at a more detailed design stage that wind tunnel modelling and verification of proposed treatments be carried out due to the significant exposure of the site to the southerly and westerly winds.

Any development proposal for the southern portion of the site, where the taller building components are proposed (south of Agar Street) should be subjected to a wind tunnel study, carried out in accordance with the procedures outlined in the Australasian Wind Engineering Society Quality Assurance Manual, AWES-QAM-1-2001. The criteria to be applied for areas involving pedestrian and seating activity should be based on the weekly maximum Gust Equivalent Mean. It is preferable that such criteria be based on those recommended by Davenport (1972). Melbourne's (1978) safety limit of 23m/s for the annual maximum gust should be satisfied for all outdoor areas.

References

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Davenport, A.G., 1972, "An approach to human comfort criteria for environmental conditions", Colloquium on Building Climatology, Stockholm.

Lawson, T.V., 1973, "The wind environment of buildings: a logical approach to the establishment of criteria", Bristol University, Department of Aeronautical Engineering.

Lawson, T.V., 1975, "The determination of the wind environment of a building complex before construction", Bristol University, Department of Aeronautical Engineering.

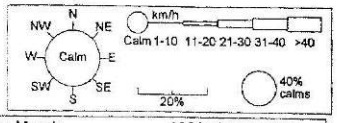
Melbourne, W.H., 1978, "Criteria for Environmental Wind Conditions", Journal of Wind Engineering and Industrial Aerodynamics, vol.3, pp.241-249.

Appendix

Wind Roses for Kingsford Smith (Sydney) Airport, 1939-2000

Wind Roses using available data between 1939 and 2000 for SYDNEY AIRPORT AMO

Site Number 066037 • Locality: SYDNEY AIRPORT • Opened Jan 1929 • Still Open
Latitude 33°56'28"S • Longitude 151°10'21"E • Elevation 6m



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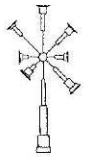
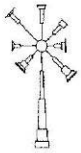
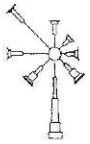
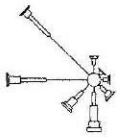
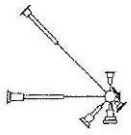
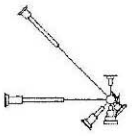
		
9 am April 1834 observations	**9 am May 1866 observations**	**9 am June 1806 observations**
		
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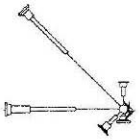	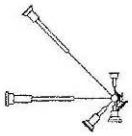	
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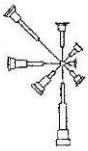
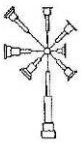
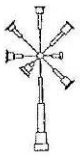
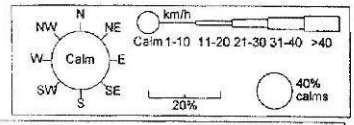
		

Wind Roses using available data between 1939 and 2000 for SYDNEY AIRPORT AMO

Site Number 066037 • Locality: SYDNEY AIRPORT • Opened Jan 1929 • Still Open
Latitude 33°56'28"S • Longitude 151°10'21"E • Elevation 6m



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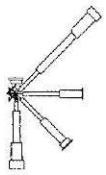

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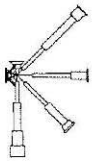

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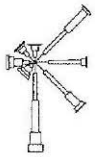

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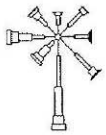

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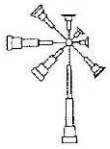

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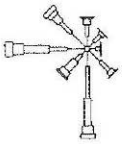

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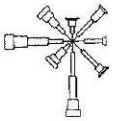

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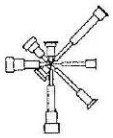

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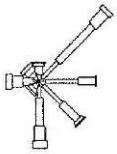

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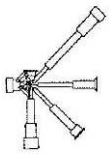

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