REDFERN WATERLOO AUTHORITY

North Eveleigh Rail Yard Site –Wind Effects Study

Report No. 30B-08-0281-TNT-424946-2

Vipac Engineers & Scientists Ltd

Melbourne VIC

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EXECUTIVE SUMMARY

Redfern Waterloo Authority commissioned Vipac Engineers and Scientists Ltd to prepare a statement of wind effects for the ground level areas adjacent to the proposed buildings on the former North Eveleigh Rail Yard Site, Sydney, NSW. This appraisal is based on Vipac's experience as a wind-engineering consultancy.

The environmental assessment carried out in this report was based on the Height and Floor space Ratio drawings, outlined in the North – Eveleigh Rail Yard Site Concept Plan, supplied by Redfern Waterloo Authority in September 2008.

The findings of this study can be summarised as follows:

- With the implementation of the recommendations outlined in this report Vipac does not expect the proposed Development to generate any wind conditions in excess of the criterion for sitting in public parklands.

- The proposed Development incorporates a number of wind mitigating features, such as slender façades exposed to strong wind conditions for medium to high rise buildings.

- With the implementation of the recommendations outlined in this report, including the provision of wind control measures for future development proposals, winds can be controlled to ensure the site is comfortable throughout the year.

- Vipac recommend a wind tunnel test be conducted when the architectural design is progressed to determine the type and scope of wind-break features that may be required to achieve acceptable wind conditions in adjacent ground level areas.

We provide the following major recommendations in regard to wind impact to assist with the proposed height/massing controls for the 16 storey residential buildings, 8 storey office buildings, open spaces/ parklands and residential buildings (C1-C3 and D1-D3).

- Curved edges to the towers assist in reducing corner acceleration flows and improve pedestrian comfort conditions.

- Canopies around the base of each medium to high rise building would be a distinct advantage.

- To abate winds in streets and park lands; we recommend the use of street planting in combination with the canopies.

The assessments provided in this report have been made based on experience with similar projects in Sydney and around the world. No wind tunnel test has been carried out at this stage, however it is recommended at the project application stage.

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1. INTRODUCTION

Vipac Engineers & Scientists Ltd was commissioned by Redfern Waterloo Authority to carry out an appraisal of the pedestrian level wind effects for the North Eveleigh Concept Plan, located at approximately 5 Kilometres to the south west of Sydney's CBD area.

The proposed mixed-use Development comprises residential, office and adaptive reuse buildings. The site of the proposed Development is bounded by Wilson Street to the North, Ivery's Lane to the West, Little Eveleigh Street to the East and by existing railway tracks to the south (see Figures 1 & 2).

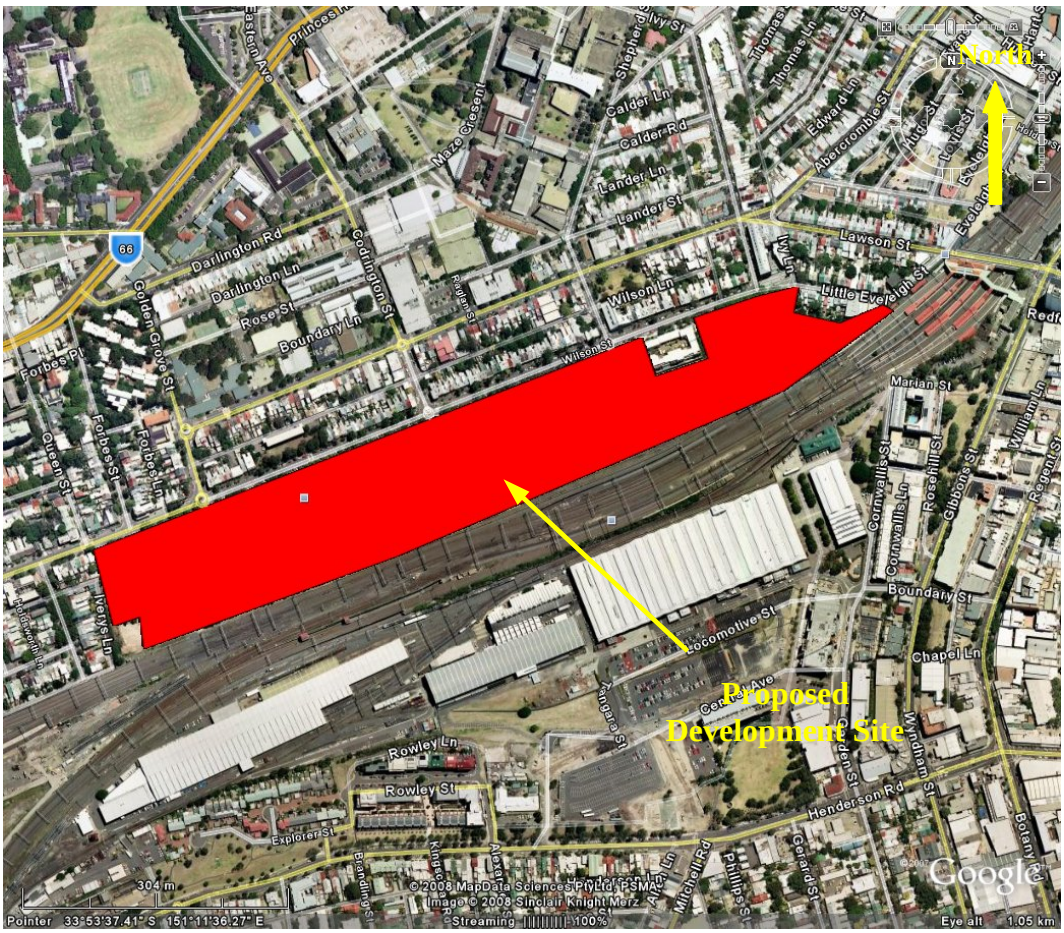


Figure 1- Satellite image of the site of the proposed North Eveleigh Concept Plan, Sydney, NSW.

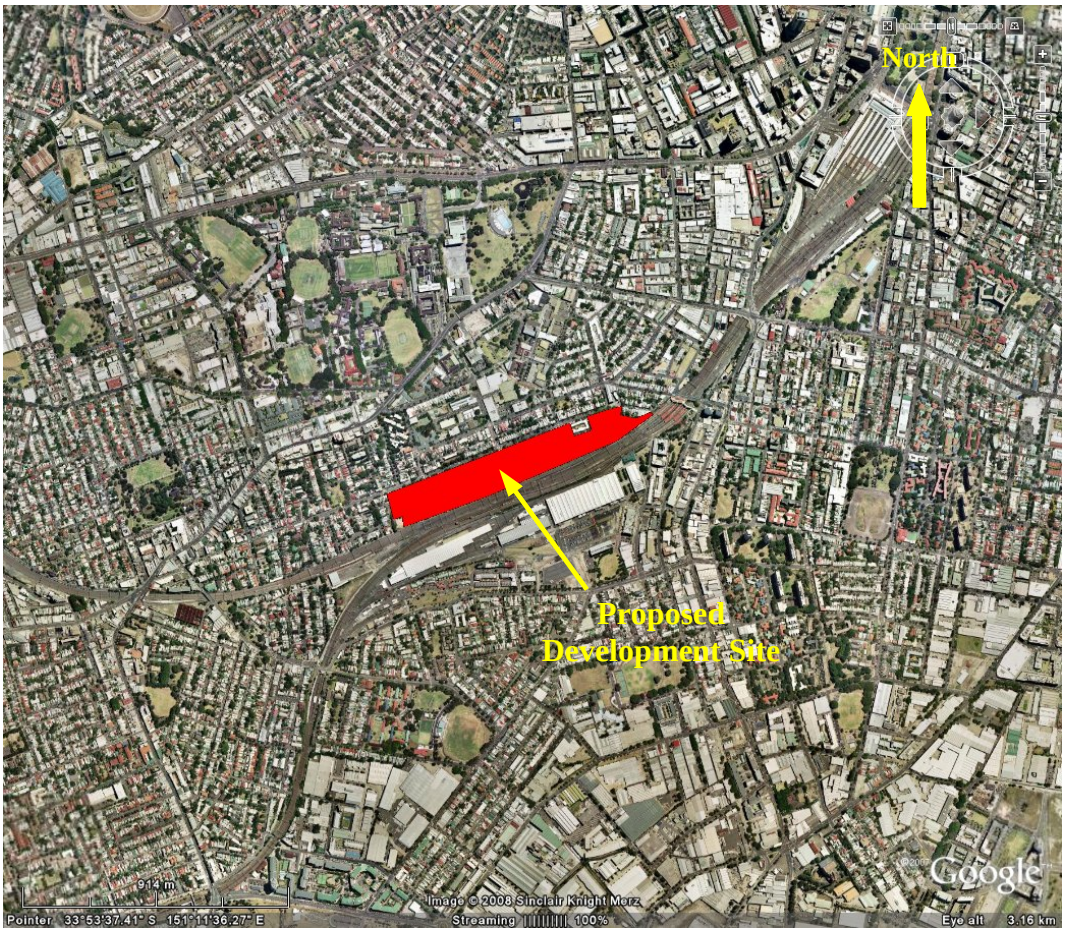


Figure 2 - Satellite image of the site of the proposed North Eveleigh Concept Plan Development, Sydney, NSW and surrounding terrain.

This report details the opinion of VIPAC as an experienced wind consultancy regarding the wind effects in ground level public areas and access-ways in and adjacent to the proposed buildings. No wind tunnel testing has been carried out at this stage. Wind tunnel testing is more appropriately undertaken when the architectural design of buildings is resolved.

The environmental assessment carried out in this report was based on the drawings outlined in the Redfern-Waterloo Authority's website supplied by Redfern Waterloo Authority. (http://www.redfernwaterloo.com.au/development_applications/north_eveleigh.htm)

2. ANALYSIS APPROACH

In assessing whether a proposed development is likely to generate adverse wind conditions in adjacent ground level areas, Vipac has considered five main points:

- The exposure of the proposed development to wind
- The regional wind climate
- The geometry and orientation of the proposed development
- The interaction of flows with adjacent developments
- The assessment criteria, determined by the intended use of the public areas affected by wind flows generated or augmented by the proposed development.

The pedestrian wind comfort at specific locations around a site may be assessed by predicting the worst annual 3-second wind gust expected at that location. The location may be deemed generally acceptable for its intended use if the annual 3-second gust is within the threshold values noted in Section 2.5. Where Vipac predicts that a location would not meet its appropriate comfort criterion, the use of wind control devices and/or local building geometry modifications to achieve the desired comfort rating may be recommended. For complex flow scenarios Vipac recommend scale model wind tunnel testing to determine the type and scope of the wind control measures required to achieve acceptable wind conditions.

2.1 SITE EXPOSURE

The proposed Development Site is located at approximately 5 Kilometres to the south west of Sydney's CBD area. The site of the proposed Development is located on terrain that rises towards north. Considering the immediate surroundings and terrain, the site of the proposed Development is assumed to be within a terrain Category 3 for all wind directions [1], see Figure 2.

2.2 REGIONAL WIND CLIMATE

The mean and gust wind speeds have been recorded in the Sydney area for over 30 years. This data has been analysed and the directional probability distribution of wind speeds have been determined. The directional distribution of hourly mean wind speed at the gradient height (≈500m), with a probability of occurring once per year (i.e. 1 year return period) is shown in Figure 3. The wind data at this free stream height is common to all Sydney city sites and may be used as a reference to assess ground level wind conditions at the Site.

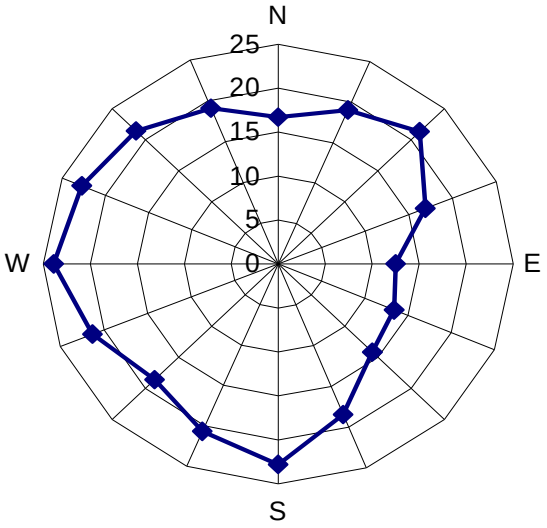


Figure 3 - Directional Distribution of Annual Return Period Mean Hourly Wind Velocities (ms-1) at Gradient Height of 500m for Sydney.

2.3 SITE GEOMETRY AND ORIENTATION

The site of the proposed Development comprises a mixture of office/ retail, residential and heritage adaptive re-use buildings. The height of the buildings within the proposed Development site varies from 2 stories (low rise) to 16 stories (high rise), with most of the buildings possessing a rectangular plan form. The building orientation for medium to high rise developments are between north-west and south-east directions. The low-rise buildings are oriented with their major axis running between north-east and south-west directions. Furthermore, most of the low-rise buildings are located towards the site's boundary on the north eastern side, along Wilsons Street, and also towards the centre of the site. See Figure 4 for building orientations.

a. North East Section

b. South West Section

Residential Office/ Retail Heritage – Adaptive re-use Public Open Space Private Open Space

Figure 4 - Plan-form view of the proposed Development.

2.4 FLOW INTERACTIONS WITH ADJACENT DEVELOPMENTS

The proposed Developments are not expected to cause any significant change in the wind conditions near most of the adjacent ground level areas. For northerly and north-north-easterly winds, turbulent wake flows dominate the adjacent ground level areas. The effects would be felt most near the footpath area between the 16 Storey residential tower and the 8 storey office buildings (caused by the 16 storey building). The resultant wind flows about the Development for these wind directions are likely to be of intermittent nature with low mean velocities.

Furthermore, considering the relative exposure of the facades of the 16 storey residential building, down wash flows could be experienced around the development for various approaching wind directions.

For winds approaching from the north west, west and south directions, the aerodynamic interactions with adjacent developments are predicted to affect the wind flows about the site. Furthermore the winds from these directions could also result in channelling flows near the pedestrian pathways between the buildings. Additionally, high velocity wind flows could also be experienced in balconies facing these wind directions (This could be addressed in detail with subsequent project applications).

2.5 ASSESSMENT CRITERIA

With some consensus of international opinion, pedestrian wind comfort is rated according to the suitability of certain activities at a site in relation to the expected annual peak 3-second gust velocity at that location for each wind direction. Each of the major areas around the site are characterised by the annual maximum gust wind speeds. Most patrons would consider a site generally unacceptable for its intended use if it were probable that during one annual wind event, a peak 3-second gust occurs which exceeds the established comfort threshold velocity. If that threshold is exceeded once per year then it is also likely that during moderate winds, noticeably unpleasant wind conditions would result, and the windiness of the location would be voted as unacceptable.

The threshold gust velocity criteria are:

Annual Maximum Gust Speed	Result on Perceived Pedestrian Comfort
>23m/s	Unsafe (frail pedestrians knocked over)
<16m/s	Acceptable for Walking (steady steps for most pedestrians)
<13m/s	Acceptable for Standing (window shopping, vehicle drop off, queuing)
<10m/s	Acceptable for Sitting (outdoor cafés, pool areas, gardens)

Table 1 – Recommended Wind Comfort and Safety Gust Criteria

In a similar manner, a set of hourly mean velocity criteria with a 1% probability of occurrence are also applicable to ground level areas in and adjacent to the proposed Development. An area should be within both the relevant mean and gust limits in order to satisfy the particular human comfort and safety criteria in question.

The threshold mean velocity criteria are:

Annual Maximum Mean Speed	Result on Perceived Pedestrian Comfort
>15m/s	Unsafe (frail pedestrians knocked over)
<10m/s	Acceptable for Walking (steady steps for most pedestrians)
<7m/s	Acceptable for Standing (window shopping, vehicle drop off, queuing)
<5m/s	Acceptable for Sitting (outdoor cafés, pool areas, gardens)

Table 2 – Recommended Wind Comfort and Safety Mean Criteria

Recommended Criteria

The following table lists the specific areas adjacent to the Development and the corresponding recommended criteria.

Area	Recommended Criteria
Public Footpaths	Acceptable for Walking
Building Entrances	Acceptable for Standing
Public Open Spaces	Acceptable for Sitting

Table 3 – Recommended application of criteria

3. PEDESTRIAN LEVEL WIND EFFECTS

3.1. PREDICTED WIND CONDITION AND RECOMMENDATIONS

North easterly winds

The strong north easterly winds are not expected to create any significant effects at most of the locations. However, the north easterly winds could potentially result in downwash flows around the ground level areas of the 16 storey residential building. Furthermore the resultant wind flows about the private open space to the south (between 8 storey office building) for these wind directions are likely to be of intermittent nature with low mean velocities.

Strategic planting of trees around the building (3m high at 4m spacing along with intermediate low rise plantation) and the addition of awnings or podiums to the 16 storey residential building will help to ameliorate these adverse wind conditions near the adjacent open space areas.

North westerly winds

The north westerly winds considered to be relatively strong in magnitude could result in channelling flows in the open space areas between the proposed eight storey office buildings (located on the north-east section, see Figure 4). Furthermore, considering the relative exposure of the 8 storey office buildings to these winds, down wash flows could also be expected at their northern ends.

Most of the public open space areas would not be affected by winds approaching from these directions. For the public open spaces to the south west section (near buildings A2, C1 and C4), Vipac recommends dense vegetation (trees 4m high at 3 m spacing and low rise plantations) with the required properties referred to in section 3.23 to ensure conditions achieve the criterion for sitting.

Vipac recognises that the proposed landscaping (as per the landscape master plan) around the 8 storey buildings could ameliorate most of the flow channelling effects. Recommendations on the type of vegetation required for amelioration are provided in section 3.2.3. With regards to the downwash flows, Vipac recommends the addition of awnings/ canopies to the northern facades of these office buildings.

Westerly winds

For strong winds approaching from a western direction, high velocity corner accelerated flows could be experienced at most of the building corners (western corners) particularly near the residential buildings (C1-C3 and D1-D3) located on the south-west section of the site, see Figure 4. Furthermore, the westerly winds could result in gusty wind conditions near the public open spaces/ parks.

In order to mitigate the corner accelerating flows low rise plantations or perforated wind screens (50% free area) could be used at building corners. Furthermore strategic plantation of medium rise plantations (3 –4m high at 3m spacing and dense low rise vegetation) along the boundaries of the public open space/ parks could ameliorate the gusty wind conditions in those areas.

Southerly winds

Considering the relatively flat facades of the residential buildings (C1-C3 and D1-D3) to the south western sections, the winds approaching from south could result in down wash flows near their adjacent ground level areas. Thus, as a result gusty wind conditions could be expected near the public open spaces on the south-western section, near buildings C1, C4 and A2. Additionally, the winds approaching from these directions could also result in corner accelerated flows and channelled flows on pedestrian walkways near the 8 storey office buildings located to the north eastern section of the site.

Addition of awnings/canopies to the building facades could ameliorate most of the down wash flows. Furthermore, the presence of vegetation (as per the landscape masterplan) around the 8 storey office buildings could ameliorate most of the corner acceleration and channelling flows. In regards to the public open spaces, Vipac recommends evergreen medium rise trees along with dense low-rise plantations around their boundaries for wind mitigation, especially for the public open space adjacent to buildings C1 and C4.

3.2. RECOMMENDATIONS

Vipac recommends a wind tunnel based assessment performed when the architectural design of the buildings is resolved. Recommendations regarding the various wind ameliorating devices for future development proposals are described below.

3.2.1. Tower Massing

- It is recommended that main entrances shall not be located near building corners.
- Curved edges to the towers would help reduce corner accelerating flows and improve pedestrian comfort conditions at ground level areas.

3.2.2. Use of Canopies/ Awnings

- Canopies around the base of each medium to high rise building would be a distinct advantage, since they assist to mitigate down wash flows.
- Canopies in combination with trees would provide both vertical and horizontal elements of protection especially for the 16 storey residential building.
- With regards to the downwash flows from tall buildings, set backs, such as podium canopies, are effective in wind amelioration.

3.2.3. Use of Trees as Wind breaks

For public open spaces/ park lands medium rise ever green trees (4m high at 3m spacing) are recommended throughout their boundaries. Furthermore, when planning wind breaks around the towers, note the following points for selection of trees:

- Choose an evergreen species with medium to heavy leaf density, this shall apply for all trees considered in the landscape plan.

- Foliage density should be maintained close to the outer periphery of the crown and extend as close to ground level as possible.

- Solid barriers produce a significant localised wind reduction but tend to displace the wind problem.

- Small flow accelerations should be expected around the trees or between gaps in a row of trees and hence spacing should be as close as possible.

- The height of the tree should be approximately twice the height of the area to be protected (e.g. twice pedestrian height).

- Height to width ratio should be around 2:1 or 3:1. Cylindrical shaped crowns are just as effective in absorbing wind energy as a square faced hedge.

- Many other considerations exist in choosing tree species such as water, light, salt levels in the air, use of planter boxes, soil, drainage, weather conditions and town planning regulations.

3.2.4. Architectural features

- The use of flags, fins and screens can be provided to abate wind flows around the site.

- Consider the use of porous artworks in public spaces in order to abate the wind. Porous screening devices within the garden areas and open public space areas could be incorporated into the design to control winds.

4. CONCLUSIONS

An assessment of the likely wind conditions for the proposed North Eveleigh Rail Yard Site development has been made.

The proposed Development site comprises Commercial/ Office building, Residential Buildings and Heritage adaptive re-use buildings, and is approximately 5 Km to the south west of Sydney's CBD area.

The environmental assessment carried out in this report was based on the concept plan drawings outlined in North Eveleigh Rail Yard Site Plans supplied by Redfern Waterloo Authority.

The findings of this study can be summarised as follows:

- With the implementation of the recommendations outlined in this report Vipac does not expect the proposed Development to generate any wind conditions in excess of the criterion for sitting in public parklands.

- The proposed Development incorporates a number of wind mitigating features, such as slender façades exposed to strong wind conditions for medium to high rise buildings.

- With the implementation of the recommendations outlined in this report, including the provision of wind control measures for future development proposals, winds can be controlled to ensure the site is comfortable throughout the year.

- Vipac recommend a wind tunnel test be conducted when the architectural design is progressed to determine the type and scope of wind-break features that may be required to achieve acceptable wind conditions in adjacent ground level areas.

The recommendations and assessments provided in this report have been made based on experience of similar situations in Sydney and around the world. As with any opinion, it is possible that an assessment of wind effects based on experience and without wind tunnel model testing may be in error.

This Report has been Prepared

For

Redfern Waterloo Authority

By

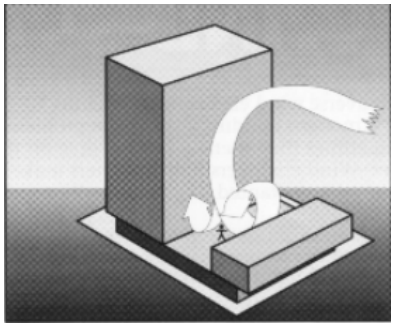
VIPAC ENGINEERS & SCIENTISTS LTD.

APPENDIX A - ENVIRONMENTAL WIND EFFECTS

Atmospheric Boundary Layer

As wind flows over the earth it encounters various roughness elements and terrain such as water, forests, houses and buildings. To varying degrees, these elements reduce the mean wind speed at low elevations and increase air turbulence. The wind above these obstructions travels with unattenuated velocity, driven by atmospheric pressure gradients. The resultant increase in wind speed with height above ground is known as a wind velocity profile. When this wind profile encounters a tall building, some of the fast moving wind at upper elevations is diverted down to ground level resulting in local adverse wind effects.

The terminology used to describe the wind flow patterns around the proposed Development is based on the aerodynamic mechanism, direction and nature of the wind flow.



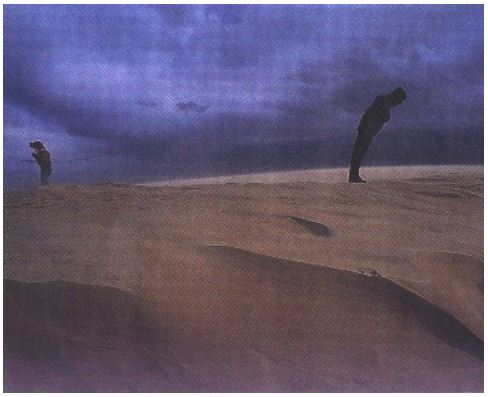
Downwash – refers to a flow of air down the exposed face of a tower. A tall tower can deflect a fast moving wind at higher elevations downwards.

Corner Accelerations – when wind flows around the corner of a building it tends to accelerate in a similar manner to airflow over the top of an aeroplane wing.

Flow separation – when wind flowing along a surface suddenly detaches from that surface and the resultant energy dissipation produces increased turbulence in the flow. Flow separation at a building corner or at a solid screen can result in gusty conditions.

Flow channelling – the well-known “street canyon” effect occurs when a large volume of air is funnelled through a constricted pathway. To maintain flow continuity the wind must speed up as it passes through the constriction. Examples of this might occur between two towers, in a narrowing street or under a bridge.

Direct Exposure – a location with little upstream shielding for a wind direction of interest. The location will be exposed to the unabated mean wind and gust velocity. Piers and open water frontage may have such exposure.



APPENDIX B - REFERENCES

[1] *Structural Design Actions, Part 2: Wind Actions*, Australian/New Zealand Standard 1170.2:2002

[2] *Wind Effects on Structures* E. Simiu, R Scanlan, Publisher: Wiley-Interscience

[3] *Architectural Aerodynamics* R. Aynsley, W. Melbourne, B. Vickery, Publisher: Applied Science Publishers