# Wind Environment Assessment: A case study in the Brisbane CBD.

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**Abstract**

Continuous full scale wind speed measurements at two locations on inner city footpaths are being undertaken in order to evaluate wind tunnel methods for predicting street level wind environment. Three years of data have been collected and analysed. This paper presents comparisons with predictions from wind tunnel tests.

## 1. Introduction

The construction of exposed or tall buildings significantly alters the street level wind environment and many city authorities require wind tunnel testing of new developments to assess their impact on the local wind environment. Street level wind speeds are of concern for two reasons. Firstly, high gust wind speeds unbalance pedestrians which may lead to serious injury or death. Secondly, persistent lower strength winds causing a wind environment that is perceived as unpleasant can result in social and economic losses as people will avoid such areas. This particularly relevant in outdoor entertainment, shopping or eating areas.

The standard procedure for wind environment assessment combines the local wind climate information and an atmospheric boundary layer model to predict a reference wind speed for each global wind direction. Drawing on similarity, wind tunnel tests are then undertaken to establish ratios of street level winds to this reference wind speed for each global wind direction. The probability distribution of street level winds can then be predicted by integration over all wind directions. An assessment of the local wind environment can then be made using various criteria, eg. as suggested by Melbourne[1].

This paper describes a project that has been underway for approximately three years which specifically aims to obtain long-term street level wind data with the ultimate goal being to evaluate the performance of the current method of assessing the local wind environment. A preliminary report on this project is found in [2], since then significantly more full scale data has been analysed. In addition, 1:400 scale wind tunnel tests hve been undertaken and this paper specifically presents comparisons between model and full scale.

## 2. Present study

Two locations within the heart of the Brisbane CBD have been instrumented with anemometers, wind vanes, data loggers and modems. Figure 1 gives an aerial schematic of the CBD showing the instrumented sites in George and Eagle Streets. These two sites were chosen to reflect the quite different wind conditions experienced in the city during summer and winter. The George Street site being exposed to winter westerlies and the Eagle Street site to summer northerlies and south-easterlies.

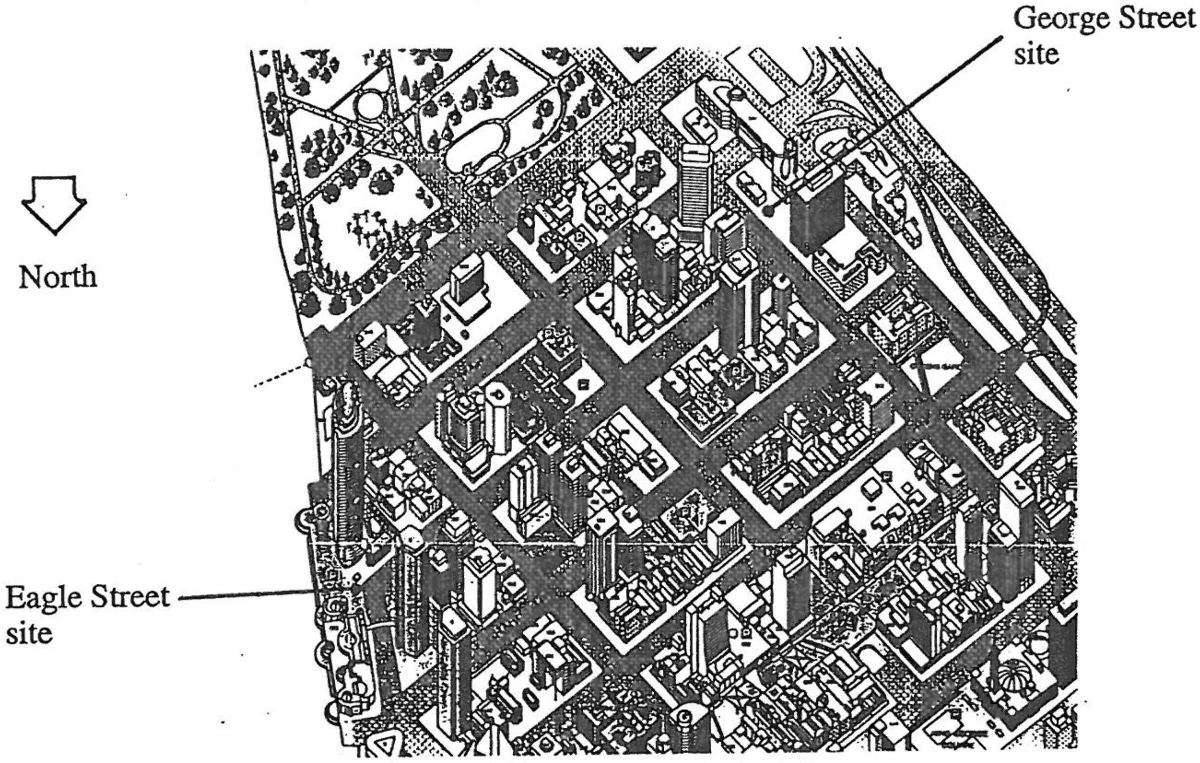


Figure 1. Aerial schematic of the Brisbane CBD showing the instrumented sites. (from JLW Metroscan)

Instrumentation and data acquisition details may be found in [2]. For each 10 minute period of the day the mean wind speed and direction were recorded together with the largest gust in that period and its direction. At the George Street site recording commenced in April 1990 and at the Eagle Street site in November 1990. Data has been analysed up to April 1993 and for the George Street site the down time amounted to 6% while for Eagle Street it was 10%. The maximum gust speeds measured to date have been 61km/hr (twice) in George Street and 71km/hr in Eagle Street, neither was associated with a thunderstorm.

The 10 minute mean wind speed and direction, at 10m height, recorded at half hourly intervals at the Brisbane Airport Meteorology Station have been digitized for correlation with the inner city sites. The meteorology station is located adjacent to Moreton Bay some 10km to the north-east of the CBD. Half hourly observations have been taken at Brisbane Airport since the 1950's and a specific period from May 1961 until November 1987, employing the same anemometer, has been used to establish the long term wind climate of the region. Figure 2 shows the predicted 10 minute mean half hourly wind speed at Brisbane Airport with a probability of exceedance of 0.001. The prevailing northerlies, south easterlies and westerlies are in evidence.

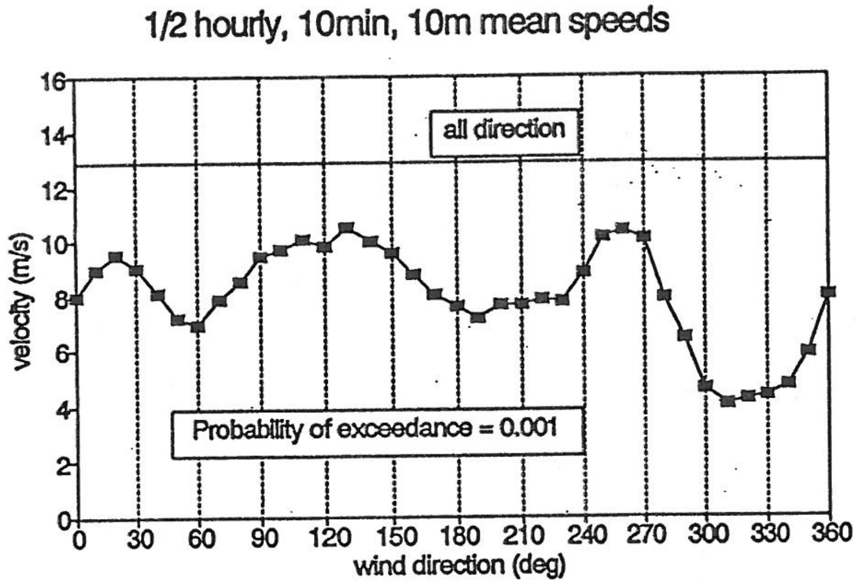


Figure 2. Brisbane Airport wind climate

### 3. Wind tunnel model tests

Wind tunnel model studies of the two locations were undertaken in the Department of Civil Engineering's boundary layer wind tunnel at a model scale of 1:400. The wind tunnel has a cross section of 2m by 3m and a working section of 12m for developing Atmospheric Boundary Layer simulations. A suitable simulation of an AS1170.2 [3] terrain category 3, $z_0$ = 0.2m, ABL was obtained with excellent matching of mean velocity and turbulence intensity profiles as well as the spectrum of the longitudinal component of velocity. Detailed modelling of the inner city for a radius of 550m from each site was situated on the wind tunnel turntable.

Street level velocity measurements were made with Irwin tubes [4] with some additional measurements made with DISA hot wire probes. The Irwin tubes were calibrated against a hot wire anemometer. During the experiment, the Irwin tube pressure measurements were non-dimensionalized by the mean dynamic pressure at 1.7m height in the wind tunnel away from the influence of the model. Final presentation of results were in the form of a ratio of street level wind speed to a wind speed located at 1.0m above the wind tunnel turntable centre without the model in place. By similarity this ratio would represent the full scale ratio of street level wind speed to that wind speed at 400m within a terrain category 3 boundary layer. Measurements were taken for 30° sectors and tests were undertaken with and without vegetation modelling to examine the effect of the screening.

## 4. Results

The practically simultaneous 10minute mean wind speeds recorded at the airport and the city sites have been correlated to produce mean speed ratios for each 10° airport wind direction. Figure 3 shows these measured ratios for the Eagle Street site for two conditions of mean airport wind speed; all winds, ie. $V_{airport} > 0.0$m/s and only stronger winds, ie. $V_{airport} > 5.0$m/s. Also shown on Figure 3 are the predicted ratios from the 1:400 scale model test with vegetation. Somewhat incongruously, the measured ratios are sustained for both light and strong winds from the east while the stronger winds produce lower ratios for westerly winds. This is unusual because the more variable winds would be expected to be the easterly on-shore breezes whereas the westerly winds are generally stronger and more sustained. Smaller numbers of observations from the west may be masking the comparison.

The model test combined with the atmospheric boundary layer model in [3] lead to an overprediction of the city/airport ratios, particularly for easterly and south-westerly winds. These ratios were much larger when vegetation modelling was not included and thus emphasize the shielding that can be achieved.

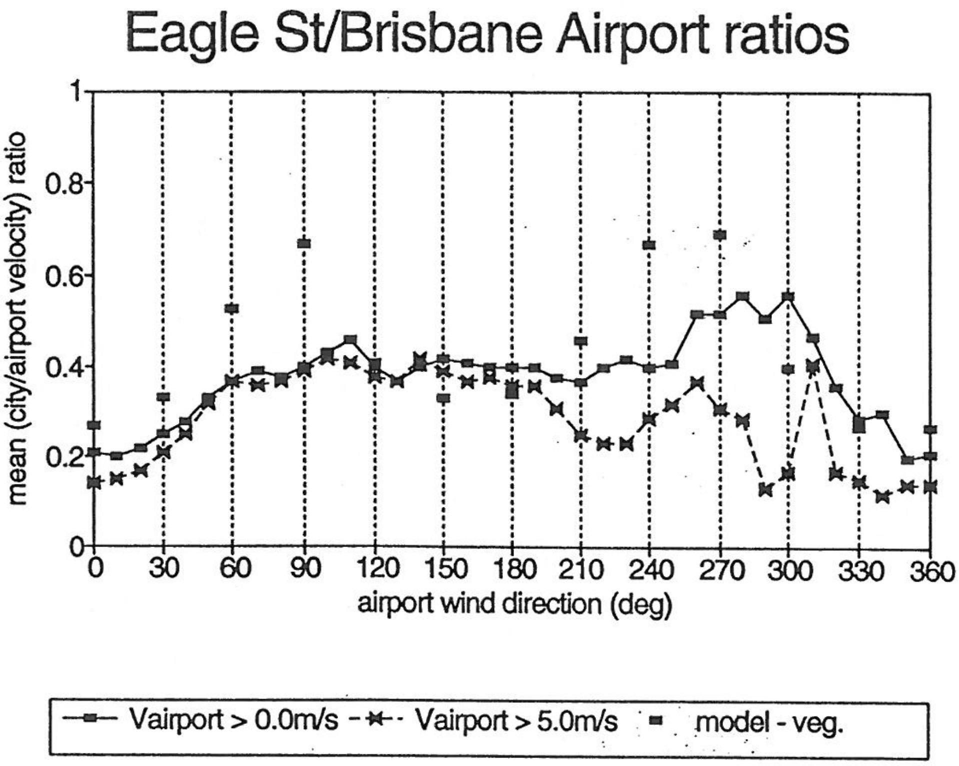


Figure 3. Measured and predicted mean (city/airport) velocity ratios at Eagle Street.

Figure 4 shows the measured all direction probability distribution of mean wind speed at the Eagle Street site compared with predictions obtained from a 1:400 scale model test. The full scale data points have been fitted to a Weibull probability distribution. As can be seen, the predicted wind speeds are significantly higher for a given probability, ie. a conservative result, which increases with mean wind speed. This overestimation is largely due to the larger ratios for the easterly and southwesterly directions shown in Figure 3. The effect of vegetation modelling is also clearly evident.

Possible reasons for the overprediction may include (1) inaccurate simulation of the street level environment, (2) the assumption of a neutrally stable atmospheric boundary layer for tranlating the airport wind climate some 10km inland to the city and (3) insufficient full scale data. The last point is unlikely to be the case as Williams and Wardlaw [5] suggest as little as 2800 hours of recording are needed to achieve stable street level to reference location speed ratios.

Figure 5 shows similar results for the 1:400 scale model test of the George Street site. However there is much better agreement between measured and predicted wind speed probability distributions in this case. Again the effect of modelling vegetation is significant.

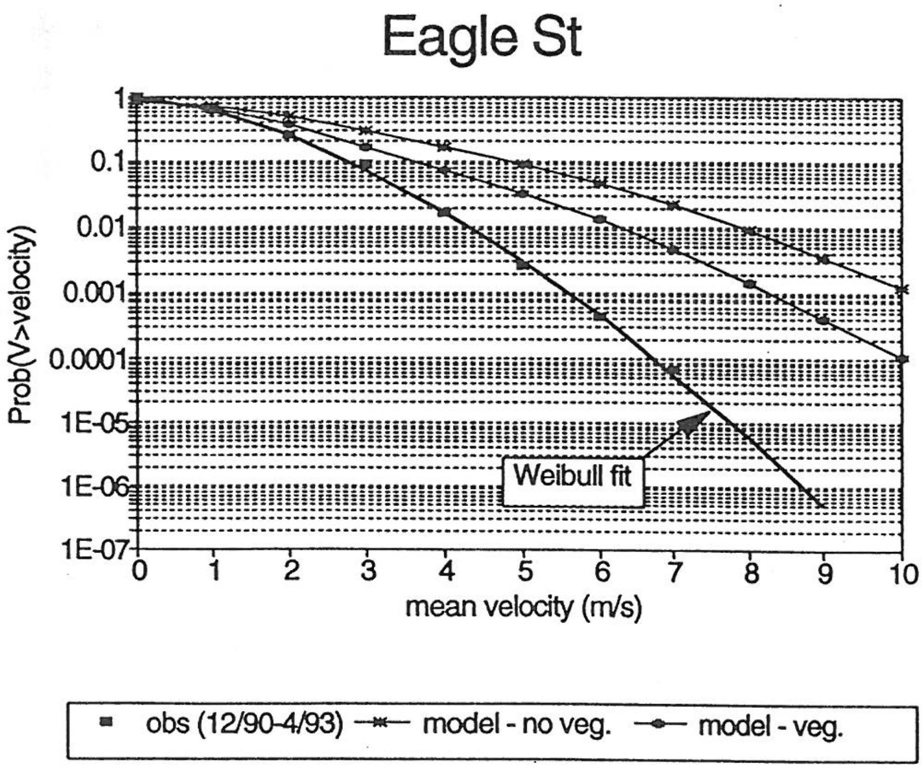


Figure 4. Comparison of measured and predicted (1:400 scale model) probability distribution of mean wind speed in Eagle Street, Brisbane.

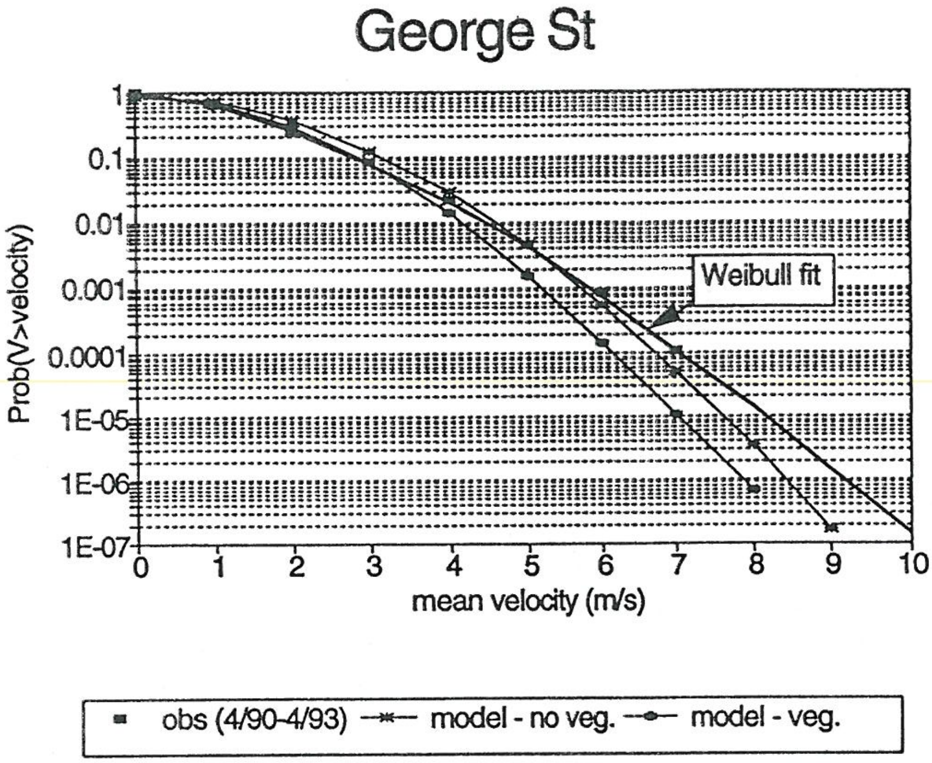


Figure 5. Comparison of measured and predicted (1:400 scale model) probability distribution of mean wind speed in George Street, Brisbane.

**5. Conclusions**

Three years of full scale wind speed data at two locations on inner city footpaths have been analysed and compared with predictions from 1:400 scale model tests. The results are inconsistent with the model test overpredicting the measured probability distribution at one site, while producing a good match at the other. Further analysis of the full scale data is underway and the model tests will be repeated with different measuring techniques to ascertain where the differences might lie.

**6. Acknowledgements**

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**7. References**

1. W.H. Melbourne, Criteria for environmental wind conditions, J. Wind Engng. & Ind. Aerodyn., 3 (1978) 241-249.
2. C.W. Letchford and L.T. Isaacs, Full scale measurements of wind speed in an inner city, J. Wind Engng. & Ind. Aerodyn., 44 (1992) 2331-2341.
3. Australian Standards, SAA Loading Code Part 2: Wind Loads AS1170.2 (1989)
4. H.P.A.H Irwin, A simple omni-directional sensor for wind tunnel studies of pedestrian winds, J. Wind Engng. & Ind. Aerodyn., 7 (1981) 219-239.
5. C.D. Williams and R.L. Wardlaw, Determination of the pedestrian wind environment in the City of Ottawa using wind tunnel and field measurements, J. Wind Engng. & Ind. Aerodyn., 41 (1992) 255-266.