Project Number: 5-29P84.00

Wind tunnel study of Parliamentary precinct development, Wellington

1 September 2022

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150 YEARS IN AOTEAROA

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Document Details:

Date:	1 September 2022
Reference:	5-29P84.00
Status:	Final

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Document History and Status

Revision	Date	Author	Reviewed by	Approved by	Status
1.0	16 September 2021	Nick Locke	Neil Jamieson	Peter Cenek	Draft
2.0	6 October 2021	Nick Locke	Neil Jamieson	Peter Cenek	Final
3.0	1 September 2022	Nick Locke	Peter Cenek	Peter Cenek	Final

Revision Details

Revision	Details
1.0	Draft report
2.0	Final report – incorporating feedback from design team
3.0	Report updated to incorporate amendments to Parliamentary FAS development

Contents

Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for Parliamentary Service ('**Client**') in relation to a wind tunnel investigation of wind effects of a proposed development for the Parliamentary Precinct, Wellington ('**Purpose**') and in accordance with the Short Form Agreement with the Client dated 10 May 2021. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

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1 Introduction

This report presents the results of a wind tunnel study of pedestrian wind conditions around a proposed development for the Parliamentary precinct in Wellington, including the results of wind mitigation tests. The development proposal that was wind tunnel tested comprises two new buildings on Parliament grounds and an alteration to the Executive Wing (commonly known as the Beehive). These proposed buildings are referred to and abbreviated as follows:

- MUS: Museum Street Building
- BAL: Ballantrae Place Building
- MIN: Ministerial Building

The objectives of the wind tunnel study are (1) to quantify the extent and magnitude of wind effects of the proposed development on pedestrian level wind conditions in the surrounding public areas, and (2) to compare the wind conditions at a number of potential locations for relocating the Museum Street oak tree.

This study is intended to meet the reporting requirements of the Wind Standard in the Wellington City Operative District Plan and the Proposed District Plan. *Wellington City Council notified its Proposed District Plan on 18 July 2022, which contains wind standards for new buildings that are essentially the same as the wind standards in the Operative Plan. Given that this application was lodged in May 2022, the development proposal is assessed against the Operative District Plan (refer Appendix B) in this report,*

1.1 Revised Parliamentary FAS development

Since the wind tunnel study was completed, the consent application has been revised to only include the MUS and BAL buildings. The larger replacement of the existing Press Gallery portion of the Executive Wing (MIN) is now removed from the resource consent application. The effects of retaining the existing Press Gallery in the same or similar form are discussed in section 10 of this report. No wind tunnel measurements have been taken for the revised development proposal (ie only the MUS and BAL buildings) as it was not considered necessary, given the minimal wind effects of the MIN building measured in the wind tunnel study.

A request for information on the wind effects of the original development was received during the initial resource consent application. The response to this request is provided in Appendix H as the information requested is still relevant to the wind effects of the revised development proposal.

2 The proposed development and surrounding area

The development site sits within Parliament grounds, between Bowen Street and Hill Street, as shown in Figure 1. The site is relatively flat and is currently used as open carparking.

The surrounding area slopes up to the north and west. The Bowen State Building (36m high) and Charles Fergusson Tower (52m high) are large office buildings that lie immediately to the west of the development site, while Parliament House and the Executive Wing sit immediately to the east. Large office buildings extend to the south beyond Bowen Street, and smaller low and mid-rise buildings extend north beyond Hill Street.

Two large office building developments are under construction at 40 and 44 Bowen Street have been included in the wind tunnel modelling (these developments are partially visible in the foreground of Figure 2b)

Overall, the site is partially sheltered by the topography and large buildings in the surrounding area, although pedestrian level wind conditions are dominated by wind flowing off the large buildings adjacent to the site.

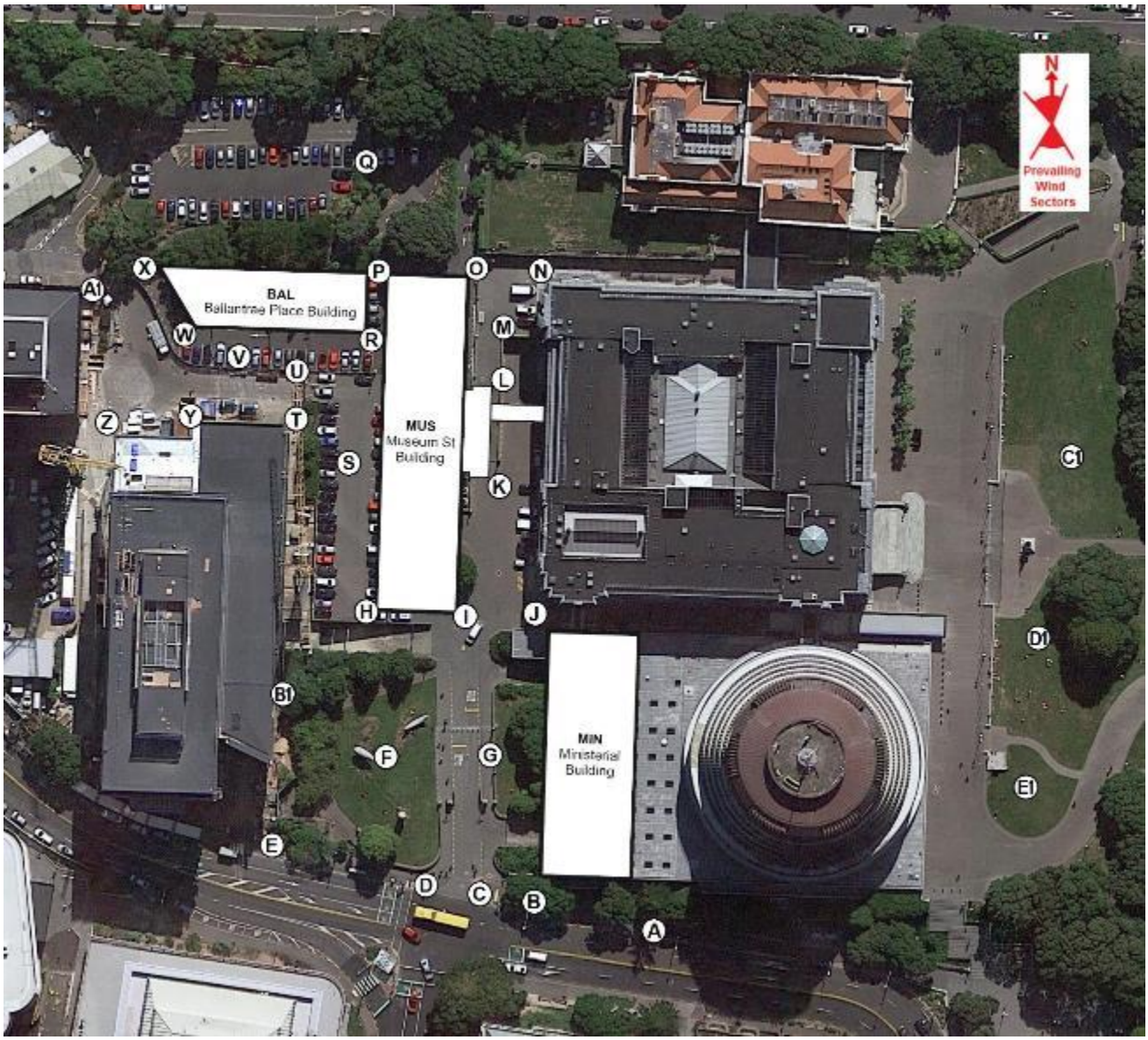


Figure 1: Aerial photo of the Parliamentary precinct with the proposed buildings outlined in white and black. Locations where wind speeds have been measured in the wind tunnel are marked alphabetically.

2.1 Proposed development

The development proposal that was wind tunnel tested comprises two new buildings, the Museum Street Building and Ballantrae Place Building, on Parliament grounds, an addition to the Executive Wing, the Ministerial Building, and relocating the Museum Street oak tree.

2.1.1 Museum Street Building, MUS

The proposed Museum Street Building is a new 6-storey office building that is rectangular in planform and is 28 metres high. The building runs north-south, as shown in Figure 1. A two-storey entry pavilion extends from the east face of the building. This incorporates an elevated walkway / bridge link above Museum Street from the second storey, connecting the building with Parliament House. The façade of the Museum Street Building is glazed and flat.

Figures 2a and 2b shows views of the wind tunnel model of the Museum Street Building and the immediate surroundings.

2.1.1 Ballantrae Place Building, BAL

The proposed Ballantrae Place Building is a two-storey service building, approximately 8m high, that has a rectangular planform except at the west end of the building which is angled to match Ballantrae Place. The building runs east-west, as shown in Figure 1, and is relatively sheltered by the upwind terrain to the north and west. A large canopy extends out from the south face of the building, above a vehicle entrance off Ballantrae Place.

Figures 2a and 2b shows views of the wind tunnel model of the proposed Ballantrae Place Building and the immediate surroundings.

2.1.1 Ministerial Building, MIN

The proposed Ministerial Building was a three-storey alteration to the western end of the Executive Wing, which would have replaced the existing Press Gallery. The alteration increases the height of the western end of the Executive Wing to around 17 metres above the ground. It is rectangular in shape, as shown in Figures 1 and 2, and connects to Parliament House via an elevated walkway / bridge link at its northern end. The façade of the Ministerial Building is glazed and has vertical fins extending from its east and west faces.

The MIN alteration is no longer part of the current consent application, but is included in the wind tunnel testing and results.

Figures 2a and 2b shows views of the wind tunnel model of the Ministerial Building and the immediate surroundings.

2.1.1 Museum Street Oak Tree Relocation, OAK

The Museum Street oak tree relocation involves transplanting an existing oak tree that is in Museum Street, where the proposed Museum Street Building is to be sited. A number of potential new locations for the oak tree have been identified. Wind conditions at a number of these sites have been compared in this wind tunnel study.

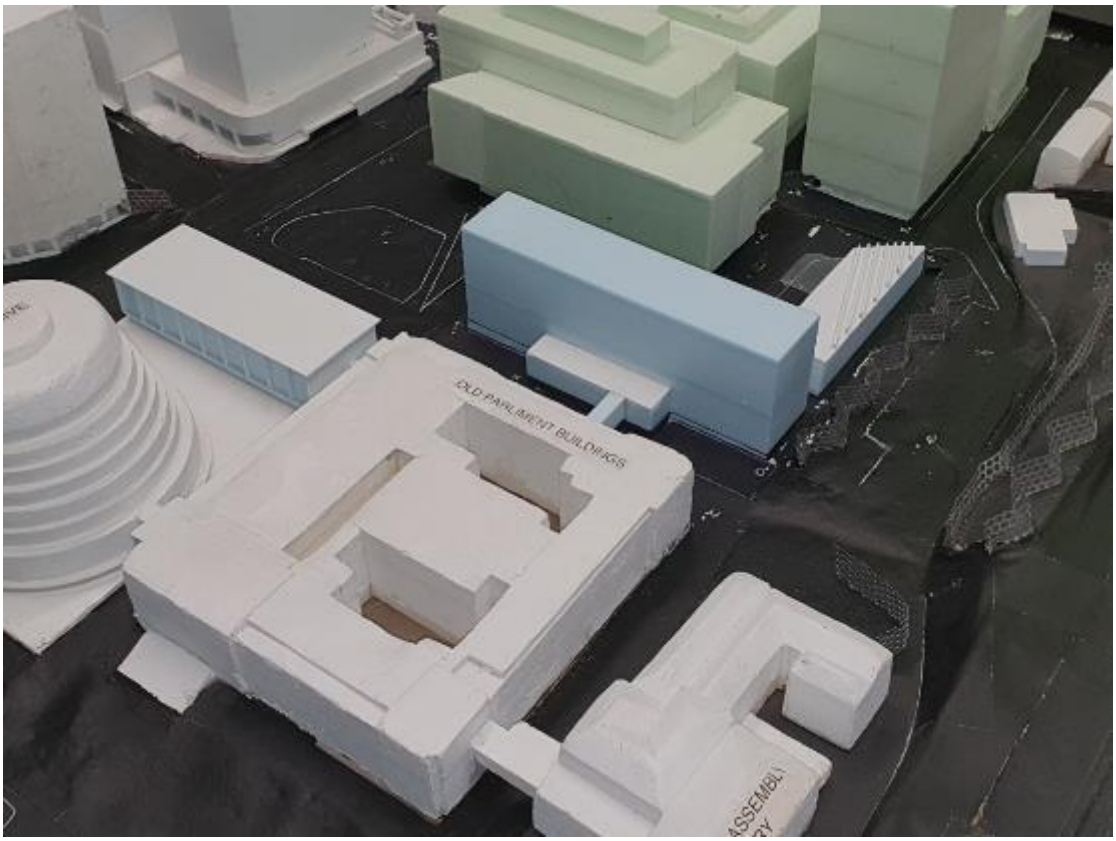


Figure 2(a): Wind tunnel model of the development proposal that was wind tunnel tested, viewed from the north-east.

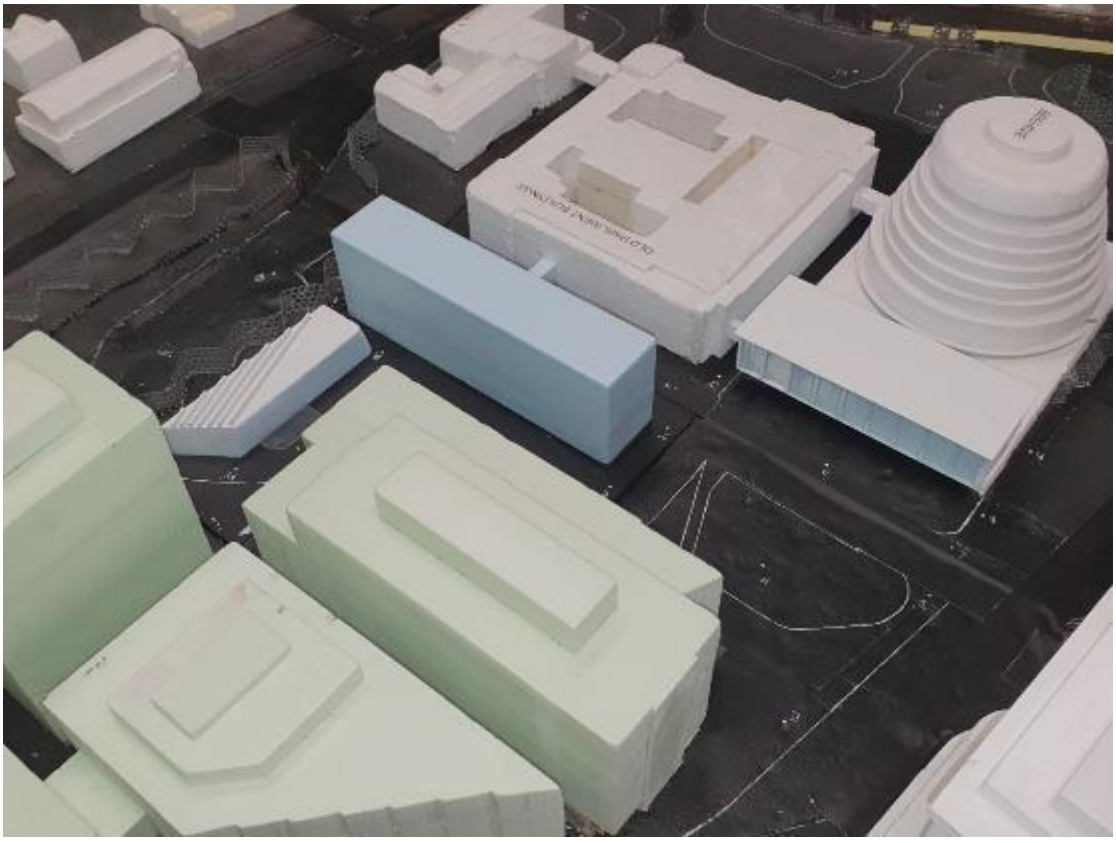


Figure 2(b): Wind tunnel model of the development proposal that was wind tunnel tested, viewed from the southeast.

3 Wind tunnel test procedures

3.1 General

Testing was performed in the WSP Research and Innovation Centre re-circulating wind tunnel, using a 1:264 scale model of the proposed development and the surrounding area of Wellington. The model of the development was positioned approximately at the centre of the wind tunnel turntable, with the surrounding area modelled to a full-scale radius of approximately 300-400m. The wind tunnel boundary layer was set up to reproduce conditions for Terrain Category 3, as defined in Appendix D, for all the wind directions.

Flow visualisation and hot-film anemometry were used in this study.

3.2 Flow visualisation

Flow visualisation provides a means of quickly identifying the areas of highest relative wind speed on the surface of the model. The test method involves sprinkling a thin layer of small bran flakes on the model surface and then running the wind tunnel at increasing speeds. A camera mounted directly above the model is used to record the erosion patterns as the test proceeds. The areas cleared first are assumed to be the windiest. Details of the test method are given in Appendix E. Flow visualisation tests were carried out for the four wind directions, 170˚, 210˚, 320˚ and 360˚, which are representative of the prevailing wind directions for Wellington City (refer Appendix C). These tests were carried out for the existing configuration and for the proposed development.

3.3 Wind speed measurements

Wind speed measurements made with a hot-film anemometer involve measuring the ratio of the wind speeds at a location on the model (at a scale height of 2 metres) to a reference wind speed (at a scale height of 150 metres). Using these measurements and relating them to full-scale meteorological wind data, it is possible to estimate the wind speeds that will be experienced at a location and therefore classify the wind performance of the area by measuring speeds at many locations (refer Appendix A). The wind speed measurements were made using a hot-film anemometer for the eight wind directions 150˚, 170˚, 190˚, 210˚, 320˚, 340˚, 360˚ and 020˚. These measurements were carried out for the existing configuration and the proposed development.

The measured wind speed data is processed to give 1) the maximum gust wind speeds that are expected to occur and 2) the number of days each year where winds equal or exceed an hourly mean value of 2.5 m/s and 3.5 m/s.

1 The mean wind speed and the corresponding standard deviation in the wind speed are combined to provide a “calculated gust speed”, V_c.

V_c, is defined as: $V_c = V_{mean} + 3.7\ V_{rms}$

where V_{mean} is the maximum annual hourly mean wind speed
V_{rms} is the corresponding standard deviation

The calculated gust speeds represent the maximum 3-second gust wind speed and are compatible with the Safety Criteria for wind specified in the Wellington City District Plan (refer Appendix B).

2 The mean wind speeds for each location and for each wind direction are divided by the directional mean reference wind speed to provide a mean velocity ratio. These ratios are then used to scale the Wellington City wind climate data listed in Appendix C and calculate the number of days where the winds are expected to equal or exceed a mean speed of 2.5m/s and 3.5m/s on average each year.

4 Flow visualisation

Photographic records of each flow visualisation test have been processed to give contour images that show the relative degree of windiness in the area around the development. These images are shown in Figures 3 to 6. The images in each figure (as described in Appendix E) show the wind patterns for the existing situation and then those with the proposed development. All the photographs are orientated so that the wind flow is from the right side of the page. The development site is located approximately in the centre of the photographs.

4.1 Northerly winds

The main observations from the flow visualisation studies for northerly winds are:

(a) Currently, the development site is relatively sheltered from northerly winds (360°) by the upwind terrain, but the large buildings to the west, Bowen State Building and Charles Fergusson Tower, deflect northerly winds down into Ballantrae Street and the northeast area of the site. During northwest winds (320°) the site is substantially windier, as Bowen State Building and Charles Fergusson Tower deflect wind down into Ballantrae Street and across the open carparking area and Museum Street onto Parliament House and the Ministerial Building. Similar wind effects are apparent in Bowen Street and the Terrace as large office buildings that line these streets deflect north and northwest winds down to ground level.

(b) The proposed development does not appear to affect wind conditions during northerly winds, other than (1) in a localised area around the northern end of the Museum Street Building, where conditions become windier from downwash off the northern face, and (2) at the southwest end of the Museum Street Building, where some channelling of existing wind flows off Bowen State Building is apparent. The low height of Ballantrae Place Building and the north-south orientation of the taller, more exposed, Museum Street Building and Ministerial Building are the main reasons for the small effect on wind conditions that is observed.

(c) During northwest winds the proposed development has a significant effect on strong winds that flow across Museum Street and the adjacent open carpark area. The Ballantrae Place Building and Museum Street Building channel the existing ground level wind flows off Bowen State Building and Charles Fergusson Tower, redirecting the wind flow through the plaza area between the Museum Street Building and the Bowen State Building. This channelling effect also shelters Museum Street, Parliament House and the Ministerial Building to the east of the Museum Street Building.

4.1 Southerly winds

The main observations from the flow visualisation studies for southerly winds are:

(a) The site is sheltered from southerly winds (170°) by the upwind terrain and the large buildings along Bowen Street and The Terrace. During southwest winds (210°) the site is windier, as wind flows along The Terrace and off Bowen State Building blow across Bowen Street and along Museum Street. A localised windy area to the north of Bowen State Building is also visible, as the southwest winds are channelled between Bowen State Building, Charles Fergusson Tower and 40 Bowen Street. The Ministerial Building appears to be most exposed during southwest winds.

(b) The proposed development has little effect on southerly wind conditions. The only changes observed are over a localised area near the southern end of the Museum Street Building, where downwash winds off the south face of the building flow to ground level, and at the north end of the plaza (formed between MUS, BAL and the Bowen State Building) where winds are channelled between the buildings. There are no significant changes in the erosion patterns evident elsewhere.

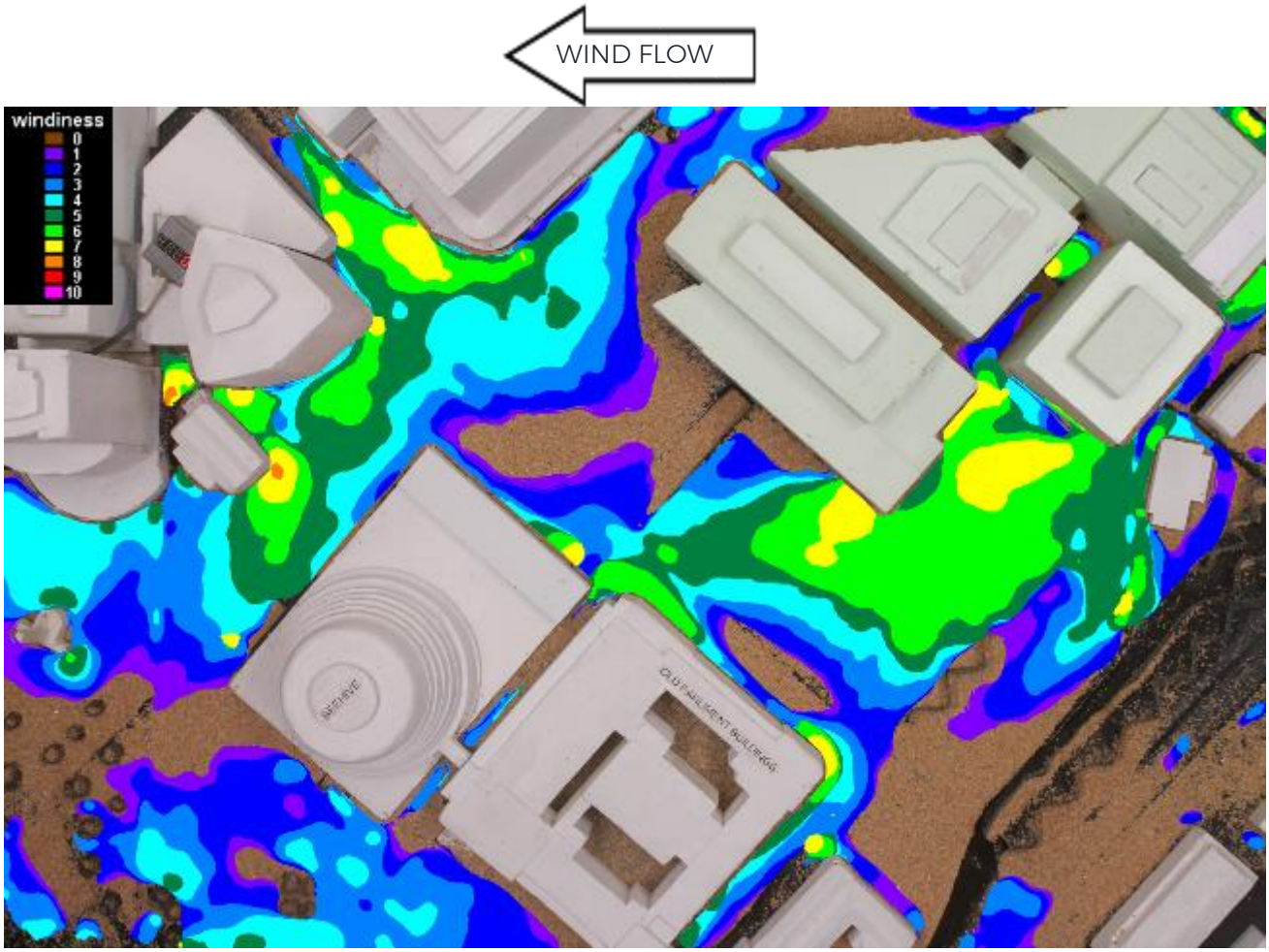


Figure 3 (a): Relative windiness – Existing configuration – wind from 320˚

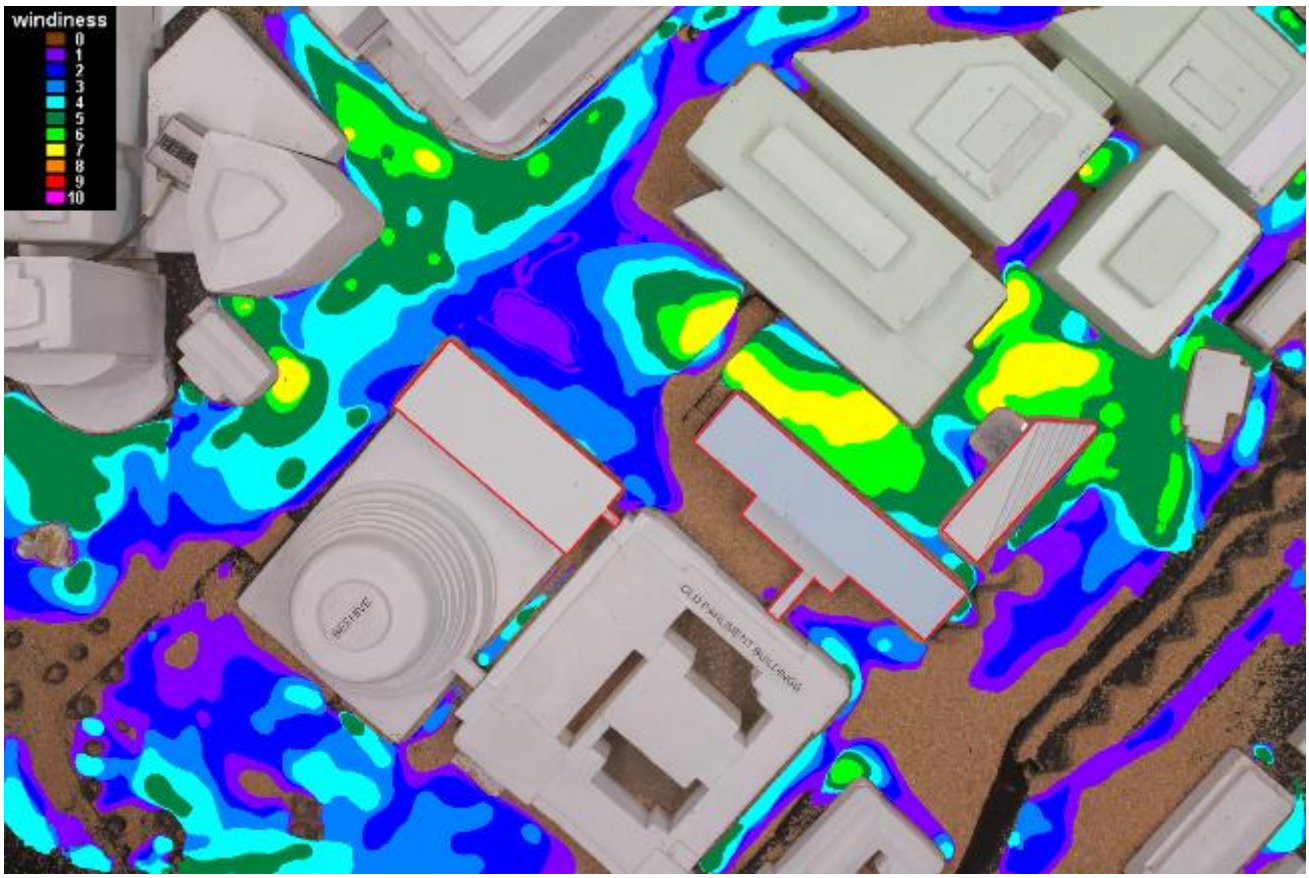


Figure 3 (b): Relative windiness – Proposed development (outlined red) – wind from 320˚

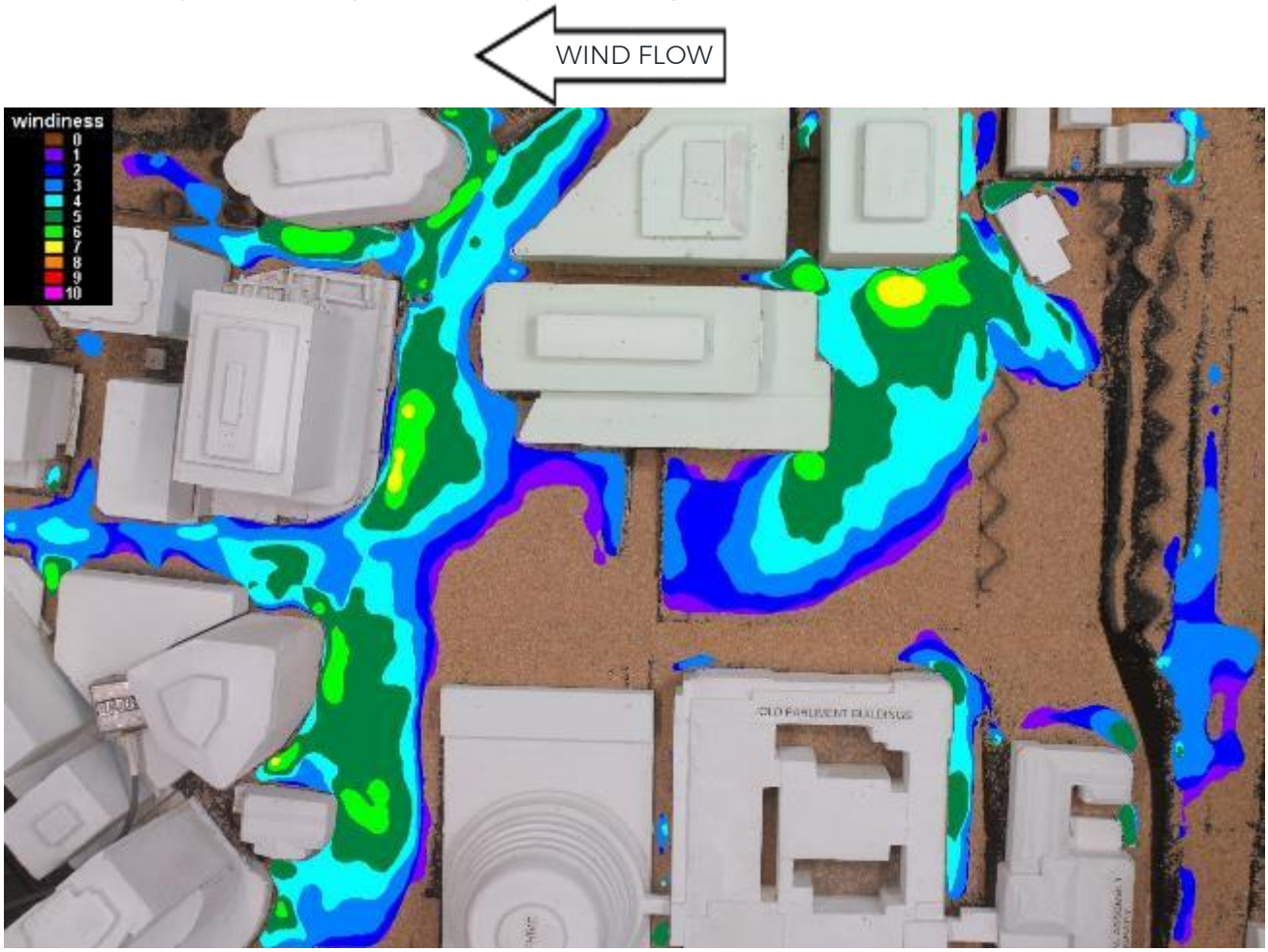


Figure 4 (a): Relative windiness – Existing configuration – wind from 360˚

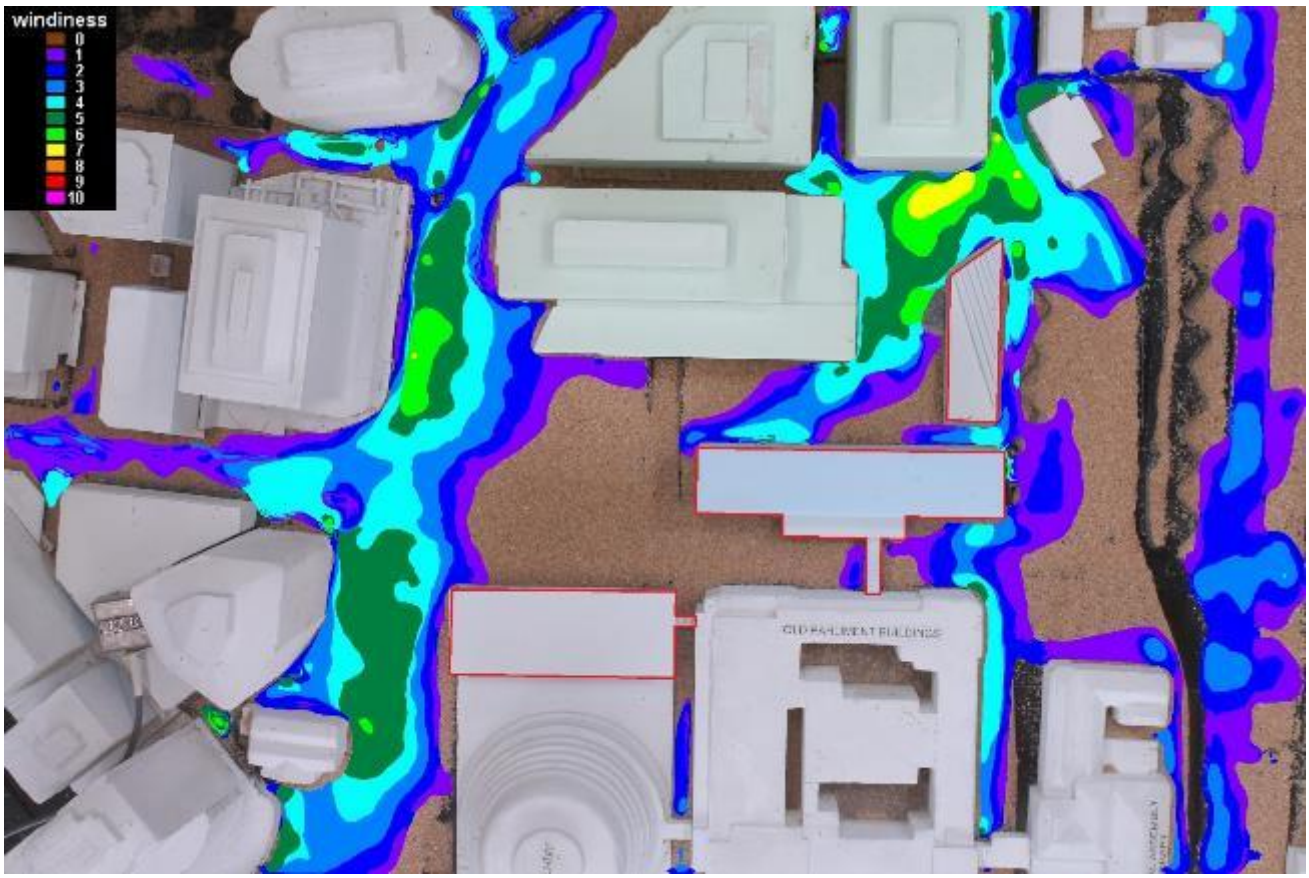


Figure 4 (b): Relative windiness – Proposed development (outlined red) – wind from 360˚

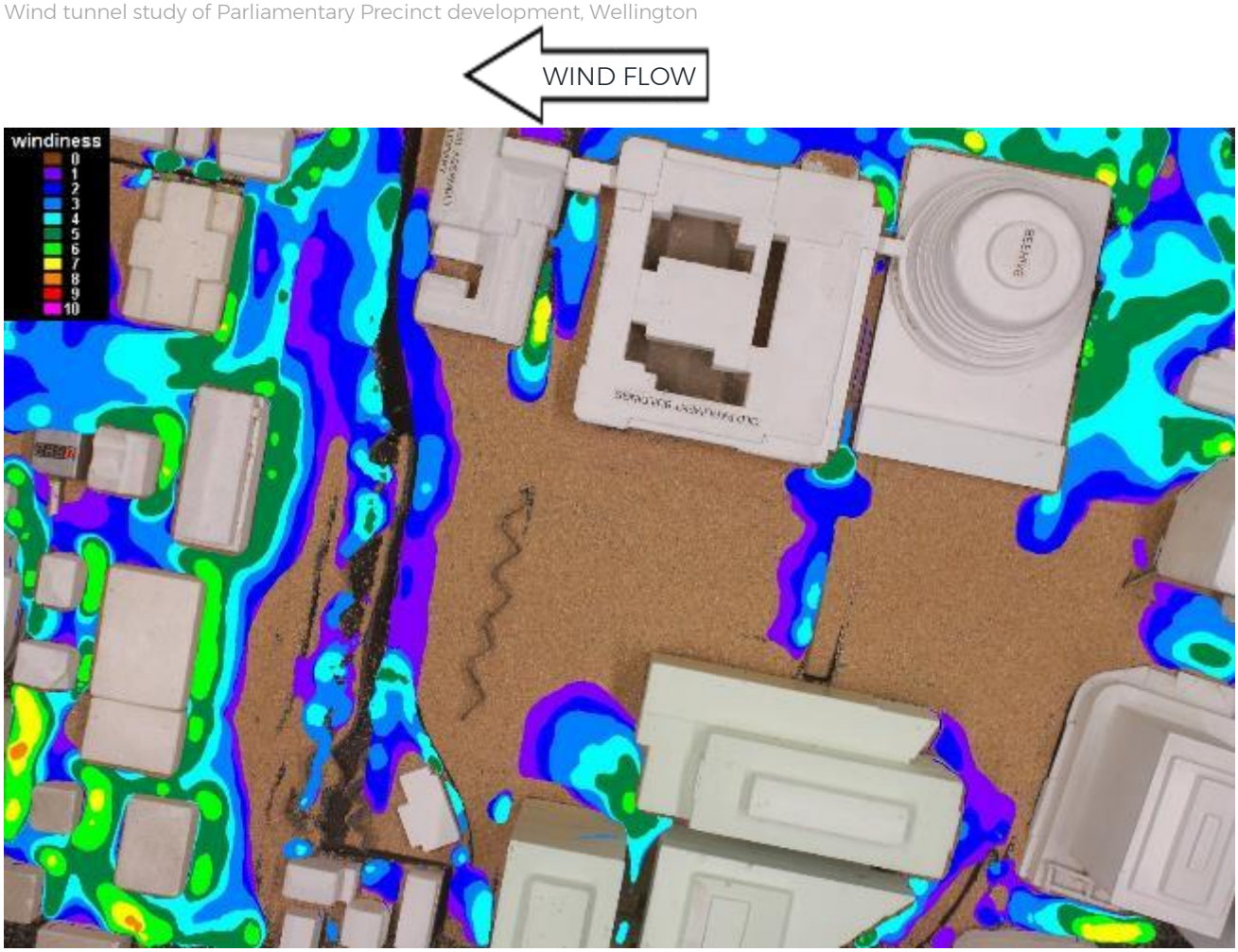


Figure 5 (a): Relative windiness – Existing configuration – wind from 170°

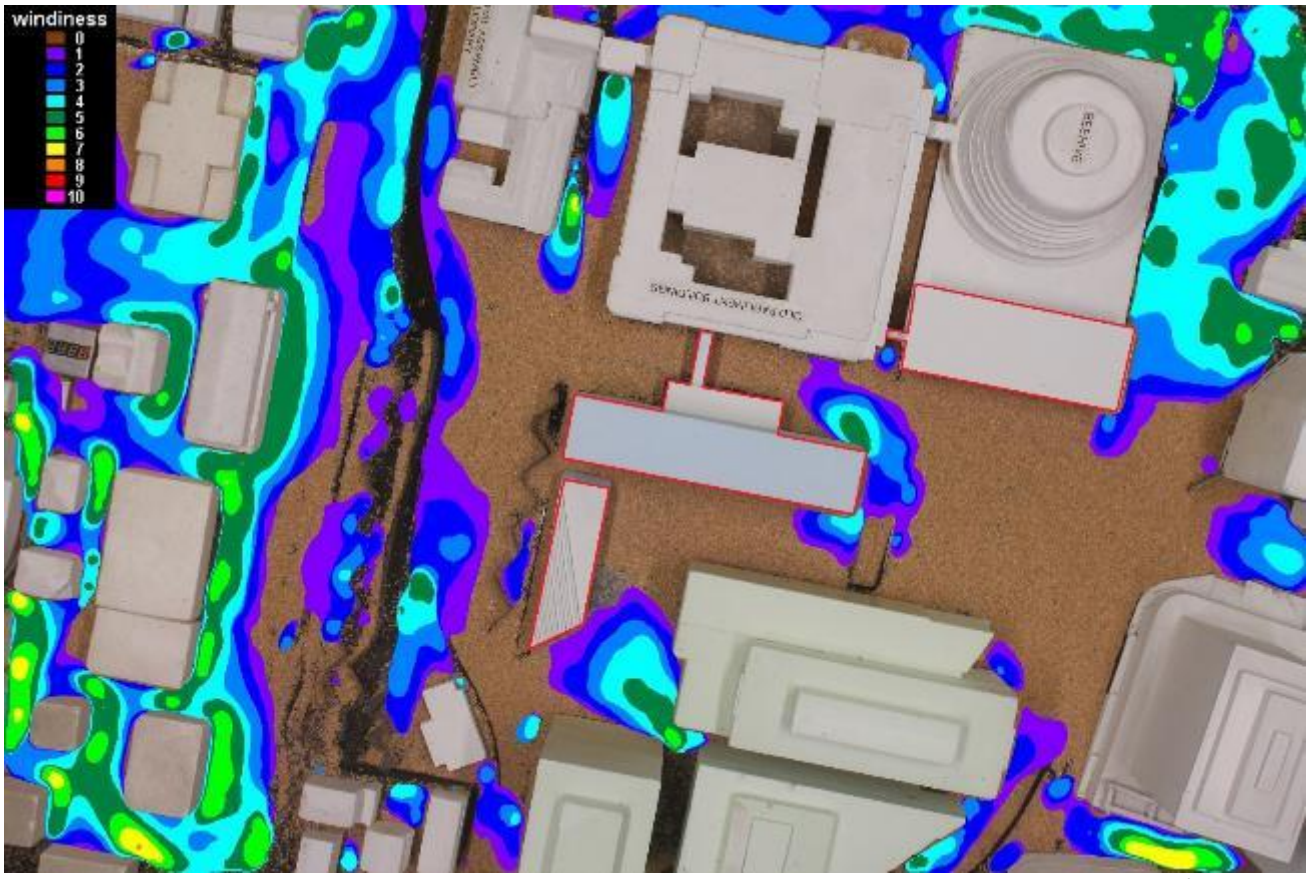


Figure 5 (b): Relative windiness – Proposed development (outlined red) – wind from 170°

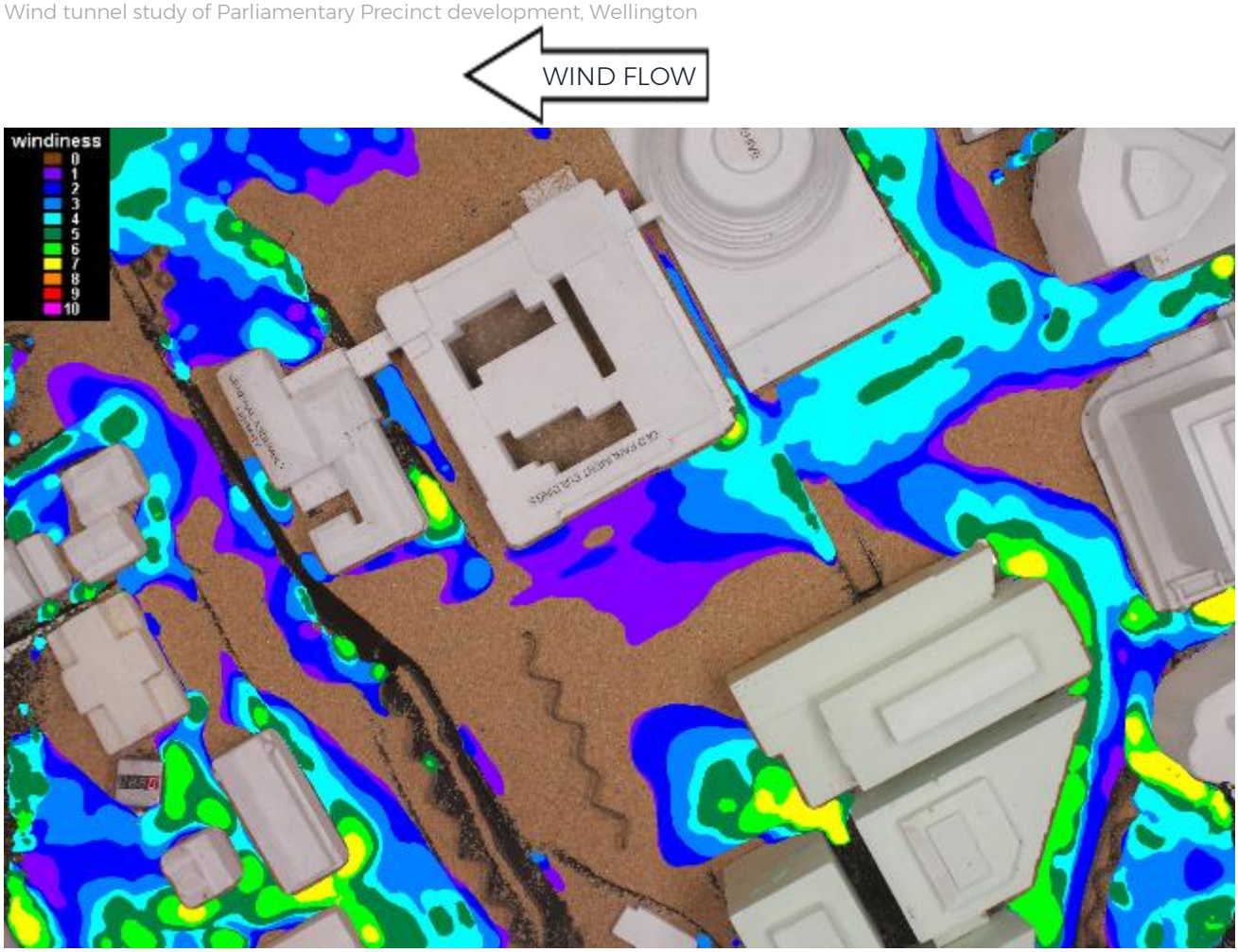


Figure 6 (a): Relative windiness – Existing configuration – wind from 210°

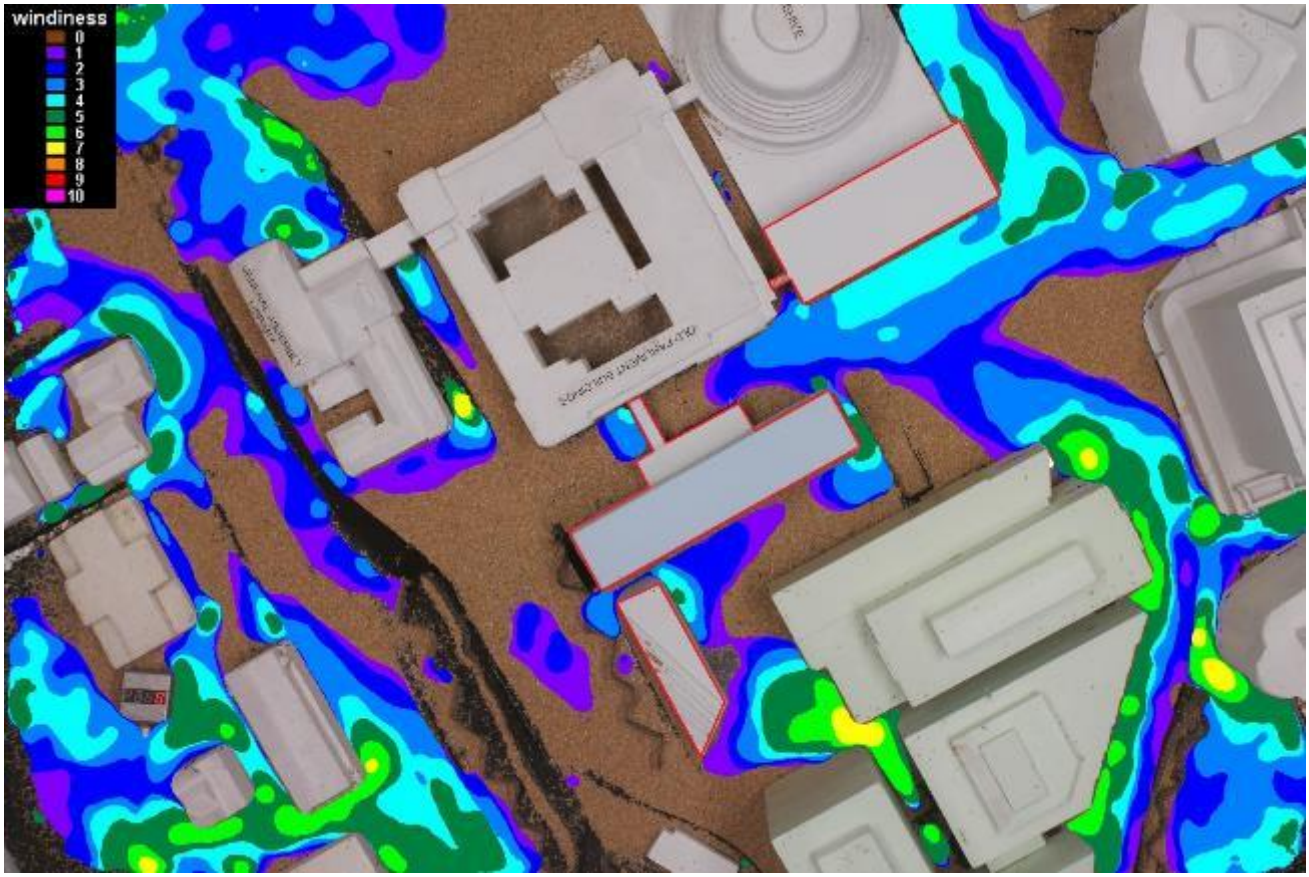


Figure 6 (b): Relative windiness – Proposed development (outlined red) – wind from 210°

5 Gust wind speeds

Wind speeds were measured for the existing configuration and the proposed development for the eight wind directions described in Section 3. The maximum gust wind speeds at each location out of the eight wind directions are listed in Table 1, with the maximum gust speeds for individual directions listed in Appendix F. These gust speeds can be compared with the District Plan safety threshold of 20m/s. A change of 1 m/s in the gust speed is not considered significant within the limitations of the test method.

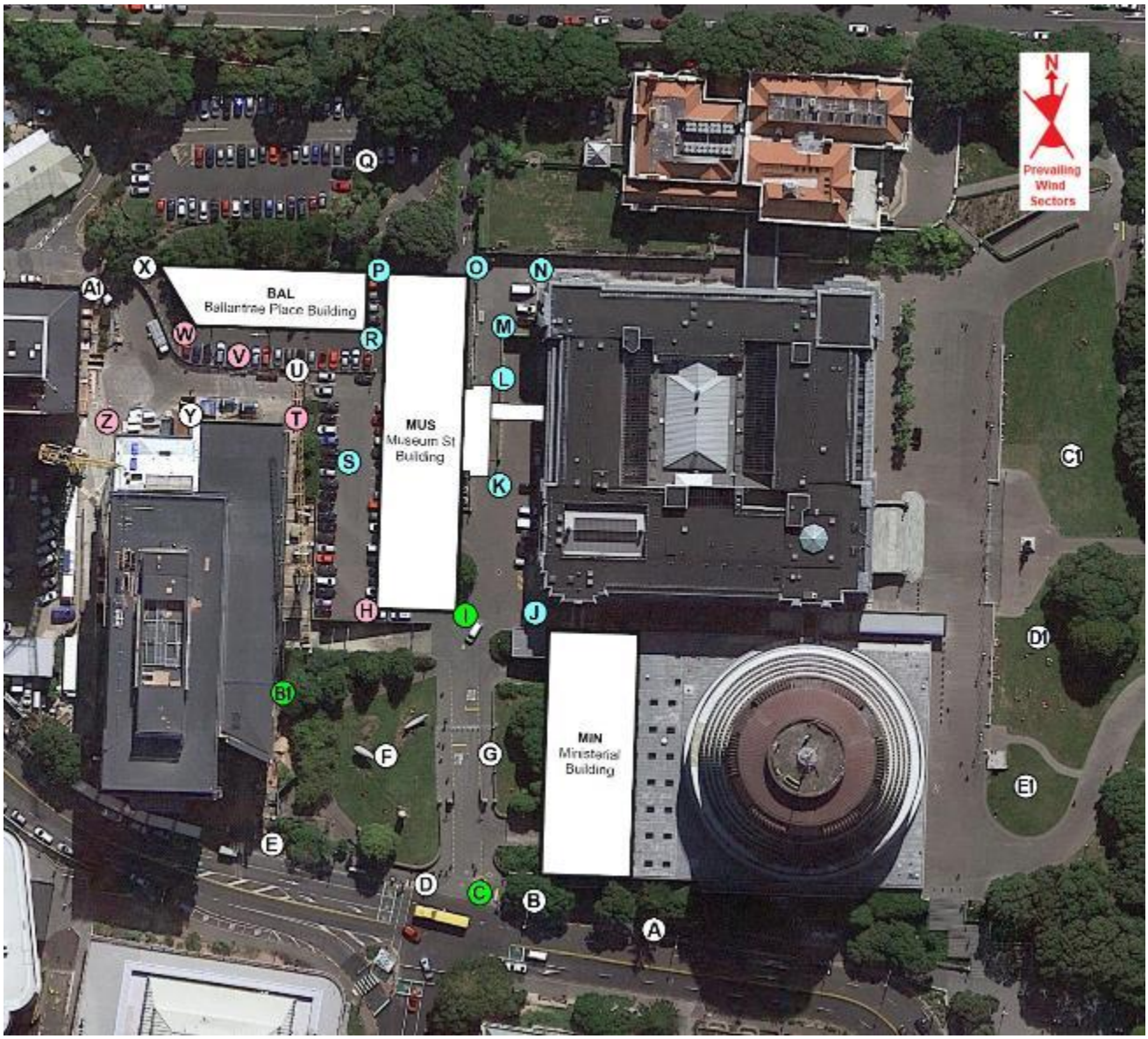
Figure 7 shows those locations where the proposed development has either (1) increased or decreased the gust speed by 2 m/s or more, or (2) increased the gust speed above the 20m/s Safety Criteria.

Table 1. Maximum gust speed, V_c (m/s).

location	exg		new
A	22		23
B	21		21
C	24	▽	22
D	21		21
E	25		25
F	22		22
G	25		25
H	20	▲	27
I	24	▽	21
J	24	▽	20
K	24	▽	18
L	22	▽	18
M	21	▽	18
N	21	▽	15
O	22	▽	18
P	24	▽	18
Q	15		15
R	24	▽	19
S	28	▽	23
T	27	▲	30
U	24		25
V	23	▲	27
W	24	▲	26
X	24		24
Y	21		21
Z	24	▲	27
A1	25		26
B1	17	▽	14
C1	18		-
D1	16		-
E1	19		-

Notes:

exg = existing configuration
new = with proposed development
= gust speed > 20m/s safety threshold
- = not measured
▲ = increase of 2 m/s or more
▽ = decrease of 2 m/s or more



	decrease >2m/s and reduce to 20m/s or below		decrease > 2m/s		increase > 2m/s		increase >2m/s and increase above 20m/s		no change

Figure 7: Significant changes in the maximum gust speed

6 Frequency of winds

The wind speeds measured in the wind tunnel have also been analysed to give the number of days per year that mean wind speeds of 2.5m/s and 3.5m/s (i.e. thresholds specified in the District Plan cumulative effect criteria) will be equalled or exceeded. This analysis does not change the underlying data, but simply changes the variable from gust speed to days per year. Note, a day is defined as a cumulative duration of 24 hours, which may be spread over several calendar days and different wind directions.

Tables 2 and 3 list the total number of days per year that mean speeds of 2.5m/s and 3.5m/s are equalled or exceeded respectively, for the existing configuration and for the proposed development. An increase of 20 days/year is the maximum increase that is acceptable in the Wind Standard.

Figure 8 shows the differences in the number of days for which the Cumulative Effect threshold of 2.5m/s is exceeded between the existing situation and the proposed development. A diagram for the 3.5 m/s Cumulative Effect threshold is not shown as the locations of the changes and the general trends in the data are similar to those for the 2.5m/s threshold.

Table 2. Days per year that a mean wind speed of 2.5m/s is equalled or exceeded.

location	exg	new	Δ
A	82	56	-26
B	82	92	10
C	67	38	-29
D	53	52	-1
E	139	125	-14
F	54	55	1
G	46	12	-34
H	31	93	62
I	80	15	-65
J	76	25	-51
K	99	11	-88
L	64	19	-45
M	70	13	-57
N	42	11	-31
O	68	32	-36
P	101	38	-63
Q	18	22	4
R	123	41	-82
S	131	107	-24
T	152	138	-14
U	150	106	-44
V	135	120	-15
W	141	133	-8
X	147	117	-30
Y	53	37	-16
Z	205	196	-9
A1	147	140	-7
B1	30	2	-28
C1	80		-
D1	63		-
E1	82		-

Notes:

exg = existing configuration

new = with proposed development

Δ = difference between days for the new and existing configuration

\- = not measured

= increase in occurrence > 20days

= decrease in occurrence > 20days

Table 3. Days per year that a mean wind speed of 3.5m/s is equalled or exceeded.

location	exg	new	Δ
A	29	16	-13
B	27	31	4
C	22	15	-7
D	14	16	2
E	68	57	-11
F	21	22	1
G	14	7	-7
H	6	67	61
I	42	6	-36
J	55	7	-48
K	63	5	-58
L	41	2	-39
M	39	5	-34
N	16	1	-15
O	38	10	-28
P	63	8	-55
Q	4	5	1
R	73	15	-58
S	83	66	-17
T	94	88	-6
U	87	56	-31
V	72	72	0
W	85	90	6
X	94	69	-25
Y	16	14	-2
Z	130	123	-7
A1	105	101	-4
B1	6	0	-6
C1	30		-
D1	23		-
E1	32		-

Notes:

exg = existing configuration

new = with proposed development

Δ = difference between days for the new and existing configuration

\- = not measured

= increase in occurrence > 20days

= decrease in occurrence > 20days

Figure 8: Change in the number of days a mean wind speed of 2.5m/s is exceeded (the development site outlined in red)

7 Museum Street oak tree relocation

Wind speeds were measured at the existing site of the Museum Street oak tree (Location L) and six potential new locations (Locations D, Q, S, C1, D1 and E1) as shown in Figure 9. The results of these measurement are listed in Table 4.

The gust wind speeds correspond to the maximum speed the tree would experience, on average, each year, and so could relate to damage (for example, broken branches). The gust speed is experienced for a very short duration, but enough to blow people over or to damage trees and structures if it is strong enough. The days per year that an indicated speed is equalled or exceeded provides an all-round indication of wind conditions that will occur throughout the year, and account for all wind directions. It gives a better indication of the wind conditions people will experience at a given location.

The measurements show the existing location of the Museum Street oak tree is relatively windy, only surpassed by location 10 (S) in terms of strong winds (both gust and hours that strong winds occur).

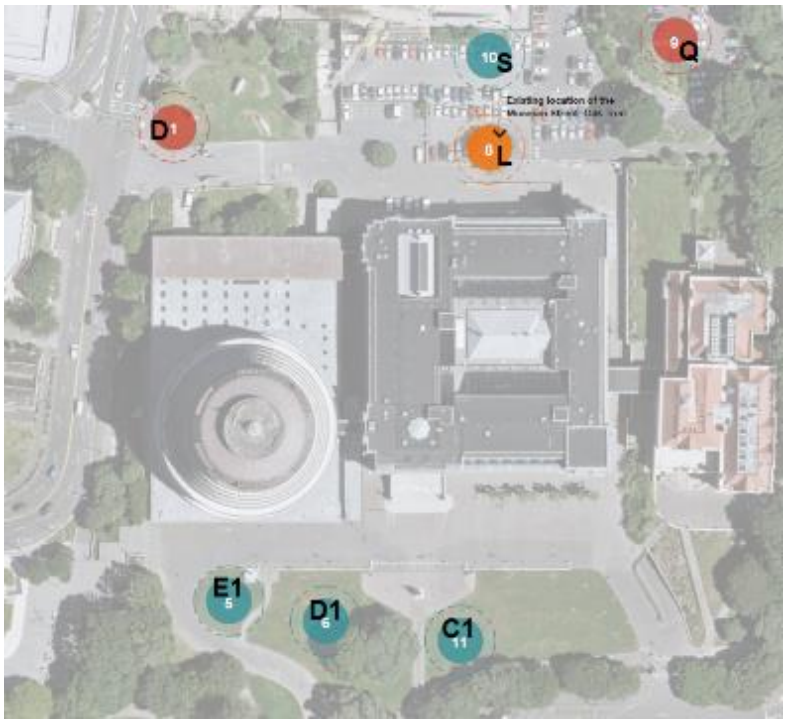


Figure 9: Locations of wind speed measurements for the Museum Street oak tree relocation.

Table 4. Gust speeds, V_c (m/s), for the alternative design at selected wind directions and locations.

Oak tree location	measurement location	days per year that 2.5m/s is equalled or exceeded	days per year that 3.5m/s is equalled or exceeded	maximum gust speed
9	Q	22	5	15
1	D	52	16	21
6	D1	63	23	16
11	C1	80	30	18
5	E1	82	32	19
8 (existing)	L	64	41	22
10	S	107	66	23

8 Wind mitigation

Wind mitigation was developed and tested to address some very high gust speeds that occur at some locations near the Bowen State Building and the Museum Street Building during northwest (340°) winds. Because the very high gust speeds occur only for the 340° wind direction, the effect of the wind mitigation has been evaluated for only this direction (the directional wind effects can be seen in Appendix F, Table F1).

Wind speeds were measured at a limited number of locations where high wind speeds had been previously measured. Two additional locations, F1 and G1, were also included to provide a more detailed understanding of the wind effects of the proposed design and of the proposed wind mitigation. Locations where wind speeds have been measured for the wind mitigation testing are shown in Figure 10.

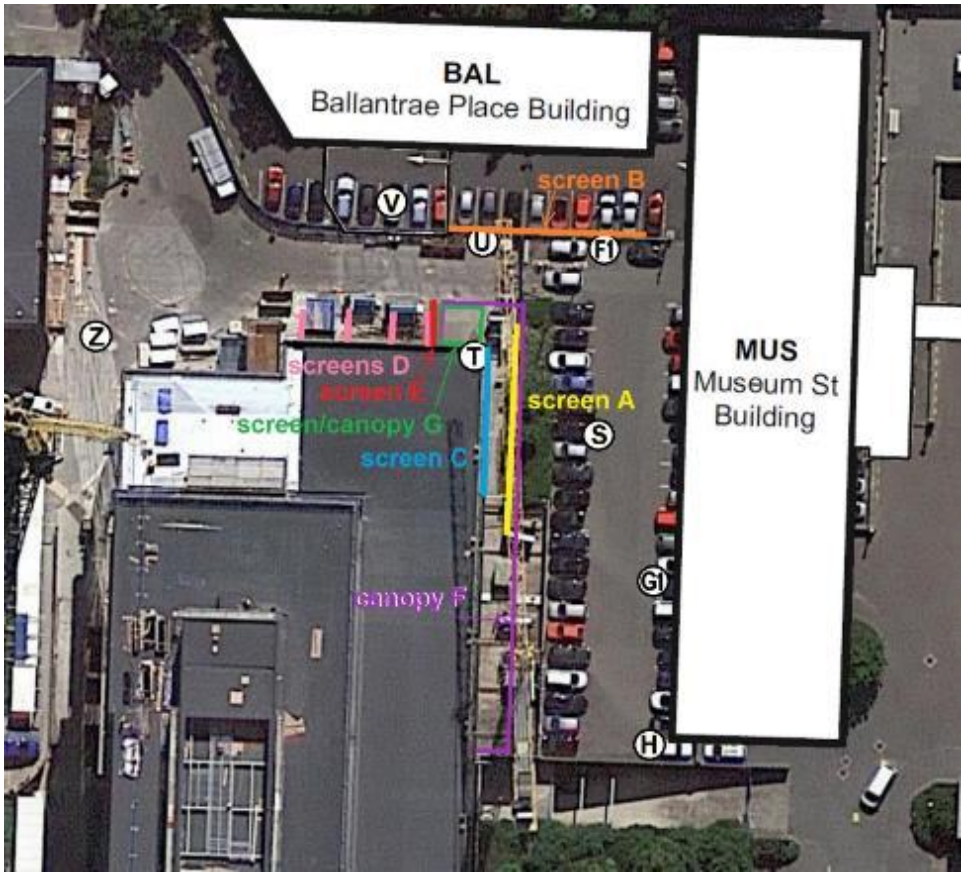


Figure 10: Location of wind mitigation options and wind speed measurements.

8.1 Wind mitigation options

The wind mitigation design configurations that were tested are described as follows:

Option 1 Option 1 comprises screen A, screen B and screen C, as shown in Figure 10. Each screen is 3 metres high at full scale and is porous.

Option 2 Option 2 comprises screen A and screen B, as shown in Figure 10. Each screen is 3 metres high at full scale and is porous.

Option 3 Option 3 comprises a large horizontal canopy F, as shown in Figure 10. The canopy extends around the northeast corner and along the east face of the Bowen State Building, approximately 3 metres (at full scale) above ground level.

Option 4 Option 4 comprises screen A, as shown in Figure 10. The screen is 3 metres high at full scale and is porous.

Option 5 Option 5 comprises screen B, as shown in Figure 10. The screen is 3 metres high at full scale and is porous.

Option 6 Option 6 comprises screen B and screen D, as shown in Figure 10. Each screen is 3 metres high at full scale and is porous.

Option 7 Option 7 comprises screen E, as shown in Figure 10. The screen is 3 metres high at full scale and is porous.

Option 8 Option 8 comprises screens on either side of a canopy that extends over a vehicle ramp into the Bowen State Building, shown as screens/canopy G in Figure 10. The screens are approximately 3 metres high at full scale and are porous. The canopy extends horizontally 3m above the vehicle ramp and connects the screens either side.

8.2 Wind mitigation results

Each of the wind mitigation options described in section 8.1 was tested separately from any of the other options.

The gust speeds measured for each option are listed in Table 5. A change of 1 m/s in the gust speed is not considered significant within the limitations of the test method.

Table 5. Gust speeds (m/s) for wind mitigation options, for the wind direction 340°.

	exg	new	op1	op2	op3	op4	op5	op6	op7	op8
H	15	26	26	26	26	25	26			
S	28	22	21	21	20	21	22	21	21	22
T	27	29	20	29	29	27	29	28	21	13
U	24	24	22	22	23	23	23	23		24
V	22	26	24							
F1	29	17	18	18	16	18	17	17		
G1	23	23	22	22	24	22	22	22		

Notes:
- exg = existing configuration
- new = with proposed development
- option 1-8 = wind mitigation option included with proposed development
- \- = not measured
- ▲ = increase of 2 m/s or more compared to 'new'
- ▽ = decrease of 2 m/s or more compared to 'new'

9 Discussion of results

9.1 Existing local wind environment

The existing pedestrian level wind environment in the area around the development site is determined primarily by the surrounding topography and the influence of large office buildings nearby (particularly the Bowen State Building) on the prevailing wind flows.

Existing wind speeds around the site range from very low to extremely high, with the overall strength of wind conditions being sensitive to wind direction. Northwest and southwest winds penetrate down into the area, producing the windiest conditions at pedestrian level.

The windiest direction is 340˚ where a gust speed of 28 m/s occurs at the northeast corner of the Bowen State Building, and where most of the gust speeds over the northern end of the development site exceed the 20 m/s safety threshold specified in the Wellington District Plan. For 340˚, strong wind flows are generated across the development site by the large Bowen State Building and the Charles Fergusson Tower, which deflect wind down to ground level and eastward across the site. The open carpark area on the site and Museum Street allow these winds to flow unobstructed on to Parliament House and the Executive Building, which channel the wind flow out onto Bowen Street.

During southerly winds the large buildings on the southern side of Bowen Street shelter the site, producing relatively benign wind conditions. The exception is the 210˚ wind direction where prevailing winds flow around the southern end of the Bowen State Building and exhaust across the southern end of the site towards the Ministerial Building and Parliament House. Gust speeds up to 25 m/s occur for winds from 210˚ direction, with much of the southern part of the site having gust speeds that exceeding the 20 m/s safety threshold specified in the Wellington District Plan.

The frequency of winds shows the windiest areas throughout the year (i.e over a broader range of wind directions and wind speeds than the single maximum gust speed) are near the northern and southern ends of the Bowen State Building (refer Tables 2 and 3, locations E, T, U and Z). It is useful to emphasise that the number of days reported in the frequency of wind results do not represent specific days, but rather the cumulative number of 24 hour periods when winds will exceed the given thresholds of 2.5 m/s (corresponding to moderate wind conditions) and 3.5 m/s (corresponding to strong wind conditions). Therefore, windy conditions will occur across a greater number of different calendar days than the frequency results show.

9.2 Effect of the proposed development on gust wind speeds

The overall effect of the development on gust wind speeds is neutral, with increases in speeds approximately balanced by decreases elsewhere. The maximum gust wind speed increases with the development from 28m/s (measured at location S for 340˚ wind direction) to 30 m/s (measured at location T for 340˚ wind direction).

The development produces the greatest changes in gust speeds for winds from the 340˚ direction. Wind flows are channelled by the proposed Museum Street Building, deflecting wind down the western side of the site (increasing speeds at locations H) and sheltering the eastern part of the site (decreasing speeds at locations C, G, I, J, K, L, M, N and O). Wind speeds also generally increase around the northern end of the Bowen State Building (see locations T, V, W and Z) and decrease in the plaza area to the east (see locations R and S). This effect is likely to be caused by the Museum Street Building changing the pressure field (and pressure gradients) around the Bowen State Building, which affects wind flows off this building.

Similar wind effects caused by the development occur for other northerly wind directions, with small differences to those occurring for 340˚ that reflect changes in building exposure from the particular wind direction.

During southerly winds the Museum Street Building appears to slightly choke wind flow through the site, producing a slight decrease overall in the gust speeds. The maximum gust wind speed that occurs during southerly winds is unchanged by the development, being 25 m/s at locations E and G.

9.3 Effect of the development on frequency of winds

The proposed development has a beneficial effect on the surrounding wind conditions, reducing or maintaining the frequency of winds that exceed 2.5m/s and 3.5m/s at all but one of the measurement locations.

The changes in the number of days that winds exceed 2.5m/s and 3.5m/s are similar to the changes observed in the gust speeds during northerly winds, where the development reduces the number days exceeded over the east of the site (refer Table 2, Table 3 and Appendix G, locations I, J, K, L, M and O) and increases the number of days exceeded at location H (refer Table 2, Table 3 and Appendix G).

The largest (and only significant) increases in the number of days wind speeds exceed 2.5m/s and 3.5m/s are 62 and 61 days respectively, measured at location H. This is comparable to the largest decreases in the number of days wind speeds exceed 2.5m/s and 3.5m/s, being 88 and 58 days respectively, measured at location K. This similarity in the magnitude of the change reflects the effect of the development during northerly winds, where existing wind flows are redistributed from the east to the west of the site, but no significant wind flow is added at pedestrian level.

The changes in the frequency of winds show a greater overall improvement with the development than the changes in the maximum gust speeds suggest because the frequency of winds account for all wind directions and are less affected by one particular wind direction. This highlights the localised and directional nature of the changes in the wind environment with the proposed development.

9.4 Effect of wind mitigation on gust wind speeds

Gust speeds measured for a number of different wind mitigation options (see section 8) in the plaza between the Bowen State Building and the Museum Street Building showed small reductions in localised areas, but no change over wider areas (see Table 5).

Large decreases in the gust speed were measured immediately downstream of 3 metre high screening designed to shelter the northeast pedestrian access to the Bowen State Building (see Table 5, location T for mitigation options 1, 7 and 8), but little or no change was measured nearby, showing the strength of the wind flows through the area.

The placement of wind mitigation screens is limited by vehicle and pedestrian access (for example, Ballantrae Place) and by property ownership (i.e high gust speeds occur on the Bowen State Building property). These restrictions limit the effectiveness of the screens, which ideally need to span uninterrupted across the pedestrian-level winds, at right-angles to the flow. The strength of wind flowing through the plaza during northwest winds also makes it likely that many sequential screens would be needed to reduce gust speeds substantially throughout the plaza.

Additional measurements at locations F1 and G1 (see Figure 10) confirm that the increases in gust speeds produced by the development (primarily by the Museum Street Building) are relatively localised (i.e. location G1 shows no change in gust speed with the development), and that the existing gust speeds over the northern part of the site are very high (28m/s is measured at location F1 for the existing configuration).

9.5 Overall assessment of building design

Overall, the proposed development has a small beneficial effect on pedestrian level wind conditions. The primary effect of the development arises from the proposed Museum Street Building which blocks northwest and southwest winds that currently flow unimpeded across the site, sheltering some areas and channelling the existing wind flows across other areas. The Ballantrae Place Building and the formerly proposed Ministerial Building have little overall effect on existing wind conditions. The maximum gust speed increases from 28m/s to 30m/s with the development, while the frequency of winds exceeding 2.5m/s and 3.5m/s decreases overall.

The north-south alignment of the Museum Street Building and the Ministerial Building (both with relatively long slender planforms) are the most beneficial design features for minimising the effect of the development on the surrounding wind conditions. These proposed buildings present a relatively small barrier to the prevailing winds, which help to minimise the downwash wind flows they generate. The Ballantrae Place Building is sufficiently low in height to have a minimal effect on the surrounding wind speeds.

Northwest winds that flow off the Bowen State Building cause the windiest conditions for both the existing configuration and the proposed development. Northwest wind flowing off the Bowen State Building currently spreads out across the site as it flows east and southeast toward Parliament House and The Executive Wing. The proposed Museum Street Building blocks this eastward flow and deflects the wind to the south and above its roof. It is illustrative that wind speeds in the plaza, between the Bowen State Building and the Museum Street Building, do not increase compared to the existing configuration given the strength and breadth of the existing winds flowing across the northern end of the site. This indicates that the pressure field around the Museum Street Building limits wind flows near ground level, particularly at the northern end of the plaza.

There is little that can practically be done to reduce the very high wind speeds measured for both the existing configuration and with the development, whilst maintaining vehicle and pedestrian access. Some localised improvements are possible where screens or dense planting can be installed at right-angles to the ground levels wind flows. Unfortunately, Museum Street and Ballantrae Place are aligned with the wind that flows through those areas, making screening or planting relatively ineffective. Localised screening of building entrances may be possible but will be limited by competing requirements for pedestrian access/egress.

9.6 Further wind assessment in response to a section 92 request

An earlier version of this wind report, dated 6 October 2021, was submitted as part of a resource consent application in early 2022. A request for further information was received in relation to the report and the wind effects of the development. As the questions and the responses are believed to be relevant to the revised development proposal, they are provided in Appendix H for completeness.

10 Wind effects of the revised development

Since the wind tunnel study was completed, the resource consent application has been revised to only include the MUS and BAL buildings. The larger replacement of the existing Press Gallery portion of the Executive Wing (MIN) is no longer part of the application for resource consent.

The wind effects of this revised development are not expected to be significantly different to the original proposal tested in the wind tunnel, except in Bowen Street at the southern end of the MIN building. In this area, the MIN Building improved wind conditions slightly in southerly winds, while the revised development is not expected to change the existing wind conditions.

During southerly winds the MIN addition would have slightly improved wind conditions adjacent to the building in Bowen Street and in Museum Street. Often a taller building will deflect downwash into surrounding areas increasing wind speeds at ground level, but in this instance the MIN building would generally increase the blockage to wind flowing through the site and therefore reduce wind speeds in localised areas nearby.

During northly winds the MIN addition appears to induce slightly higher wind speeds at its southwest corner (ie location B), most likely because of a lower wake pressure generated by the taller MIN building, which draws wind flows down Bowen Street. This wind effect is expected to disappear without the MIN proposal being included in the resource consent application.

Overall, the primary effect of removing the MIN building from the application is expected to be that existing wind speeds in Bowen Street adjacent to the Ministerial Wing (ie locations A, B and C) will not change with the development (whereas with MIN wind speeds would likely have changed in that area). Wind conditions elsewhere on the development site and surrounding streets are expected to change as described in this report.

11 Conclusions

1. Existing wind conditions near the development site range from very low to extremely high, with wind conditions being influenced by wind direction and the effects of large office buildings in the vicinity. The windiest directions at the site are for winds from the northwest (320°) and the southwest (210°).

2. Existing gust speeds over much of the site exceed the safety threshold of 20m/s specified in the District Plan (both the Operative and Proposed District Plans), and with a maximum gust speed of 28m/s measured during northwest winds.

3. Maximum gust speeds with the proposed development are similar to those for the existing configuration. Gust speeds both increase and decrease with the development, with no significant change to the gust speeds overall. The safety threshold of 20m/s is exceeded over much of the site, essentially unchanged from the existing situation.

4. The overall frequency that winds equal or exceed the cumulative effect thresholds (i.e. mean speeds of 2.5 m/s and 3.5 m/s) decrease with the proposed development. The improvement in wind conditions is widespread and occurs over the north and east of the site, which is sheltered by the Museum Street Building during northerly winds. The only area where wind conditions deteriorate with the development is around the southwest corner of the Museum Street Building.

5. Taken overall, wind conditions are improved with the proposed development, but existing unsafe wind speeds are unaffected overall.

6. Wind mitigation options, comprising large screens (3m high and 50m long at full-scale) or a canopy, are ineffective at reducing gust wind speeds over significant areas, although localised areas are improved when the screens are orientated at right angles across the ground level wind flows.

7. The site constraints, particularly the need to maintain vehicle and pedestrian access through areas that are windy, limit practical design alternatives to improve pedestrian level wind conditions with the proposed development.

Appendix A
Wind effects on people

One of the primary parameters in any assessment of how wind affects people are the peak gust speeds and the associated rates of change of the wind speed. Table A1 gives a summary of the typical effects of 3-second gust speeds on people in an urban environment (after Penwarden).

Table A1: Typical effects of a 3-second gust on pedestrians.

Wind Description	Gust Speed (m/s)	Effects
Moderate breeze	5 – 8	Raises dust, dry soil and loose paper; hair disarranged.
Fresh breeze	8 – 11	Force of wind felt on body; limit of agreeable wind.
Strong breeze	11 - 14	Walking irregular; hair blown straight; umbrellas used with difficulty.
Near gale	14 - 17	Walking difficult to control; wind noise unpleasant; body leans into wind.
Gale	17 - 21	Great difficulty with balance; body blown sideways; dangerous for elderly people.
Strong gale	21 - 24	People blown over by gusts.
Storm	24 - 28	Impossible to stand up; necessary to crouch and hold onto a support.
Violent Storm	>28	Unlikely to be ever experienced.

The wind performance of an urban area may be classified in a number of different ways, but one of the simplest and widely accepted is in terms of the "annual maximum 3 second gust". The criteria used (after Melbourne (1978)) have been established internationally for some time and are given in the Table A2. A location which experiences a maximum annual gust speed within a certain category in Table A2 will typically also experience a range of wind conditions throughout the year, which result in the criteria being appropriate.

The expression "annual maximum 3 second gust" is shorthand for a description of the probability of occurrence of a certain level of wind speed, given that both weather conditions and wind turbulence vary in an unpredictable manner. It should be noted that the expression describes a wind speed which is in fact a little less than the highest wind speed that one would be likely to record if an anemometer were mounted in a city street for a year.

Table A2: Pedestrian level gust speed criteria.

Category	Annual Maximum 3 Second Gust (m/s)	
A	23 and above	Dangerous. Completely unacceptable in a main public area.
B	16 to 23	Undesirable in a main public area.
C	Less than 16	Generally acceptable for walking.
D	Less than 13	Generally acceptable for stationary short exposure activities (e.g. window shopping, standing or sitting in plazas).
E	Less than 10	Generally acceptable for stationary long exposure activities (e.g. outdoor restaurants).

Wellington wind tunnel studies

For Wellington wind tunnel studies, we calculate a gust speed corresponding to the annual maximum hourly mean speed for a particular wind direction. This is based on the wind conditions which are equalled or exceeded during 6 hours per year, within a 20° sector centred on a particular wind direction. The gust speed is calculated using the mean wind speed and the corresponding standard deviation of the wind speed multiplied by the peak factor defined in the Wellington District Plan.

The Wellington District Plan specifies a gust speed of 20m/s as a safety limit. However, existing wind conditions exceed this limit in many parts of the city. The criteria therefore describes a desired wind environment, which may not always be achievable in practice.

We suggest the use of the descriptive terms in Table A3 as a means of interpretation of how the wind speeds measured in a wind tunnel study compare with the speeds which typically occur at other locations in Wellington. It may be seen that the gust speed of 20m/s, is only in the moderately high category using these descriptions. Note that this table simply compares the level of wind speeds that occur from place to place, whereas Table A1 describes the effects of these wind speeds on people.

The information in Tables A1 – A3 are described below, as they use similar wind speed measures but describe different effects:

Table A1: Describes the effects on people when they experience a gust of wind.

Table A2: Lists internationally recognised criteria for the acceptability of wind conditions at a certain location throughout the year.

Table A3: Describes the variation of wind conditions that occur at different locations in Wellington.

Table A3: Descriptive terms for the range of gust wind speeds which typically occur within Wellington City.

Annual Maximum 3 Second Gust (m/s)	
11 and below	very low
12 – 14	low
15 – 17	moderate
18 – 20	moderately high
21 – 23	high
24 – 26	very high
27 and above	extremely high

Appendix B
District plan wind rules

Relevant sections of the Operative District Plan, including the Objectives, Policies and Standards relating to the wind effects of buildings are reproduced below. These can be found on the Wellington City Council website (http://wellington.govt.nz/your-council/plans-policies-and-bylaws/district-plan/eplan).

Objectives

OBJECTIVE – EFFECTS OF NEW BUILDING WORKS

12.2.5 **Encourage the development of new buildings within the Central Area provided that any potential adverse effects can be avoided, remedied or mitigated.**

POLICIES

To achieve this objective, Council will:

12.2.5.6 **Ensure that buildings are designed to avoid, remedy or mitigate the wind problems that they create and where existing wind conditions are dangerous, ensure new development improves the wind environment as far as reasonably practical.**

12.2.5.7 **Ensure that the cumulative effect of new buildings or building alterations does not progressively degrade the pedestrian wind environment.**

12.2.5.8 **Ensure that the wind comfort levels of important public spaces are maintained.**

12.2.5.9 **Encourage consideration of wind mitigation measures during the early stages of building design and ensure that such measures are contained within the development site.**

Standards

13.6 Central Area Standards

13.6.3.5 Wind

13.6.3.5.1 The following wind standards apply to the Central Area, excluding buildings and structures for Operational Port Activities in the Operational Port Area.

13.6.3.5.2 New buildings, structures, or additions above 18.6 metres in height will be designed to comply with the following standards:

(a) SAFETY: The safety criteria shall apply to all public space.
The maximum gust speed shall not exceed 20 m/s. If the speed exceeds 20 m/s with the proposed development, it must be reduced to 20 m/s or below.

(b) CUMULATIVE EFFECT: The cumulative criteria shall apply to all public space. Any proposed development must meet the requirements for both of the following wind strengths, at each measurement location.

Wind strength	Change in annual days of occurrence with the development at all measurement points	Requirements on developer
Strong (mean hourly wind speed = 3.5 m/s)	If days that 3.5 m/s is equalled or exceeded increase by more than 20 days/year (i.e. 5.5% of the year)	Reduce change in days to a maximum of 20 days.
Moderate (mean hourly wind speed = 2.5 m/s)	If days that 2.5m/s is equalled or exceeded increase by more than 20 days/year (i.e. 5.5% of the year)	Reduce change in days to a maximum of 20 days.

(c) Under the Cumulative Effect Criterion, the overall impact of a building on the wind conditions must be neutral or beneficial.

(d) COMFORT: The comfort criteria only applies to the public spaces listed in standard 13.6.3.4

Comfort wind strength	Annual days of occurrence with the development	Requirements on developer
Mean hourly wind speed = 2.5 m/s	If days that 2.5 m/s is equalled or exceeded increase above 73 days/year (i.e. 20% of the year).	If existing building exceeds 73 days, then reduce number of days for proposed building to existing levels. If existing building is below 73 days then reduce number of days for proposed building to below 73 days.

13.6.3.5.3 To show that a development complies with these standards a wind report must be supplied that meet the requirements outlined in Appendix 8 (see also section 3.2.2.15 of the Information Requirements).

For information purposes, the effects of wind speeds, which correspond to those used in, the safety criteria, are

20 metres/second gust - Completely unacceptable for walking.

the comfort or cumulative criteria, are

3.5 metres/second mean - Corresponds to threshold of danger level.
2.5 metres/second mean - Generally the limit for comfort when sitting for lengthy periods in an open space.

Appendix C
Wellington wind climate

The wind over Wellington City is predominantly either northerly or southerly. This is demonstrated by a sample wind rose, plotted in Figure C1, for the wind at a height of 150 m. The rose is obtained from the wind data listed in Table C1.

The wind data is derived from that recorded over a 47-year period at Wellington Airport. The mean wind speed at 150 m over the city is calculated to be the same as that at the airport reference anemometer at a height of 10 m, but with the northerly winds rotated 10 degrees to the west. This relationship is based on work carried out by Jackson (1976). It is also consistent with the Deaves and Harris (1978) wind model.

From this data, the following values have been estimated for the mean hourly wind speeds that occur during 6 hours per year for a 20° sector, centred on the listed wind direction.

Reference Wind Speeds for Wellington City

Direction (degrees)	150	170	190	210	320	340	360	020
Speed (m/s)	15	20	22	22	19	22	20	15

The measured wind speeds around a building, as quoted in this report, are calculated gust speeds based on the mean wind speed that is exceeded for only 6 hours per year and the corresponding standard deviation in the wind speed.

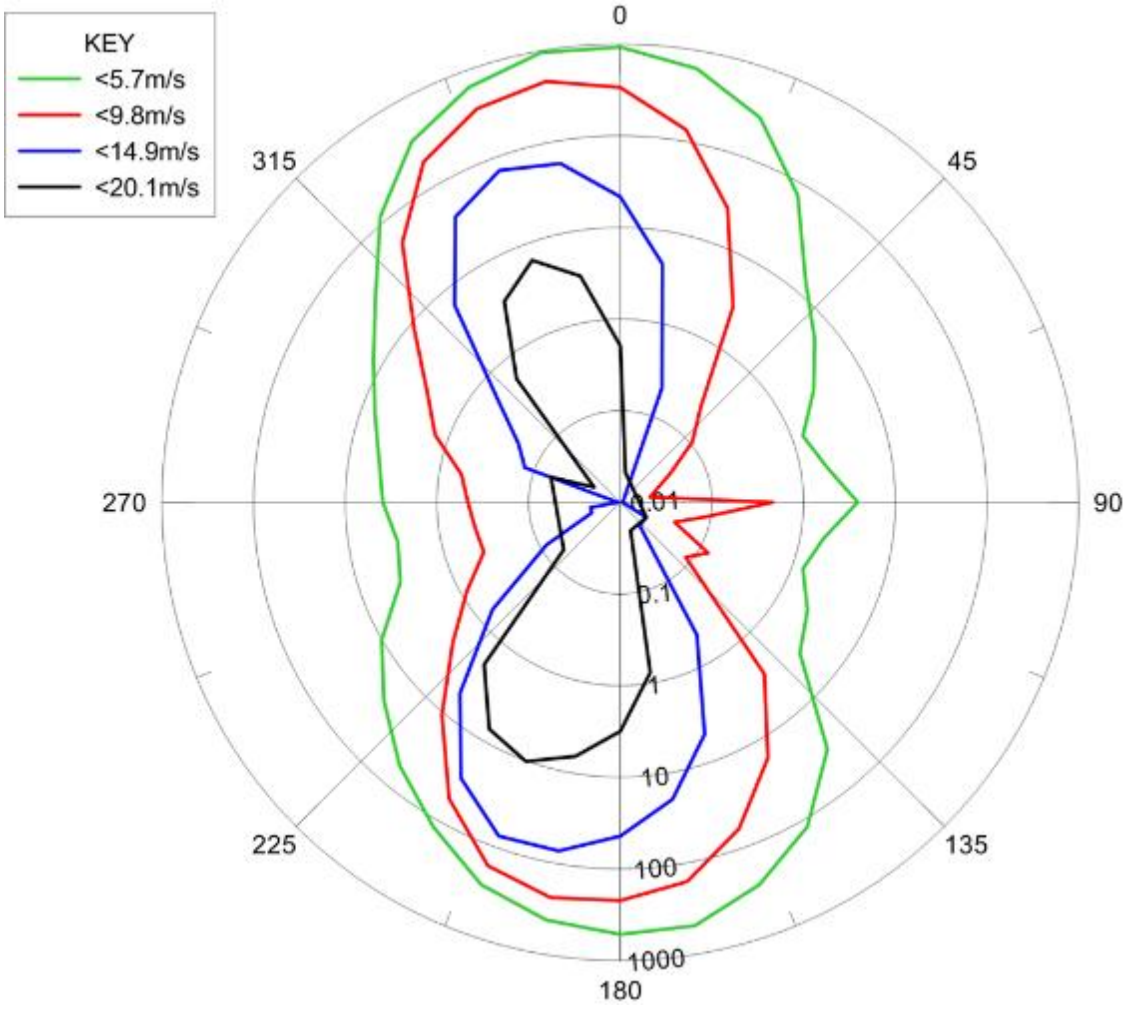


Figure C1: Wind Rose for Wellington City – 150m above ground level.
(number of hours/year wind speeds are equalled or exceeded)

Wellington City mean wind speed data at 150m. Jan 1960 - Oct 2007. Based on 8760 hours per year.
This table gives the hours per year that the wind is likely to equal or exceed a given wind speed for a given direction.

Direction	kts	1.0	3.0	5.0	7.0	9.0	11.0	13.0	15.0	17.0	19.0	21.0	23.0	25.0	27.0	29.0	31.0
	m/s	0.5	1.5	2.6	3.6	4.6	5.7	6.7	7.7	8.7	9.8	10.8	11.8	12.9	13.9	14.9	15.9
10		868.6	846.6	807.7	731.4	638.3	541.0	419.3	309.8	211.9	134.3	76.2	44.5	24.1	10.0	4.4	1.7
20		494.5	468.9	425.3	357.6	290.5	218.3	140.2	84.6	47.1	26.2	11.2	6.3	2.7	0.7	0.2	0.1
30		190.0	168.9	134.9	99.3	74.2	51.3	28.2	14.4	6.4	2.9	0.9	0.3	0.2	0.0	0.0	0.0
40		70.8	55.5	37.1	21.9	14.0	8.7	4.1	1.8	0.7	0.2	0.1	0.0	0.0	0.0	0.0	0.0
50		44.0	31.8	20.8	10.4	5.9	3.3	1.5	0.7	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
60		22.5	15.1	9.5	5.3	2.7	1.4	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70		13.8	9.1	5.8	3.1	1.3	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80		15.3	10.9	7.8	3.9	1.9	0.8	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90		9.1	7.6	6.4	4.9	3.9	3.0	2.3	1.5	1.0	0.5	0.3	0.1	0.1	0.0	0.0	0.0
100		13.2	9.9	7.1	4.0	1.8	0.7	0.3	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
110		13.1	10.6	6.9	3.4	1.3	0.4	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
120		20.2	16.7	11.4	5.2	2.3	1.1	0.5	0.3	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0
130		24.2	21.0	15.3	7.4	3.6	2.0	1.1	0.6	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0
140		68.7	65.2	57.4	43.6	32.8	23.8	15.8	10.1	5.8	2.8	1.2	0.6	0.3	0.0	0.0	0.0
150		174.0	168.6	159.2	141.6	121.0	99.7	73.7	49.9	29.4	16.6	8.7	5.0	2.9	1.4	0.5	0.1
160		335.6	331.2	322.3	301.6	274.1	239.9	189.2	140.5	94.3	61.3	38.6	25.8	16.4	8.6	4.9	2.1
170		561.9	557.4	547.3	523.9	489.1	438.7	367.2	292.0	219.2	159.1	109.7	78.6	53.3	31.2	19.4	10.9
180		603.1	596.4	583.7	555.0	516.6	467.5	401.7	335.8	274.2	221.0	169.5	133.5	100.3	65.8	43.9	26.5
190		527.6	521.5	508.2	470.9	425.6	384.2	341.5	306.6	273.0	239.1	203.6	173.7	140.8	102.1	72.7	47.2
200		374.4	368.1	353.9	315.7	274.6	241.4	214.1	196.0	180.8	166.1	150.5	135.1	117.0	95.6	75.1	53.9
210		190.1	184.4	173.5	148.5	121.2	95.6	77.0	66.8	59.9	54.2	48.5	45.0	41.2	35.2	29.8	24.0
220		99.0	95.6	88.2	73.4	55.6	39.2	26.1	18.1	13.3	10.7	9.2	8.2	7.2	6.1	5.3	4.3
230		47.5	45.0	40.1	31.6	23.2	15.1	8.6	5.4	3.3	2.4	1.7	1.4	1.1	0.8	0.7	0.3
240		25.6	23.0	19.6	14.6	10.1	6.6	3.7	2.3	1.4	0.9	0.5	0.4	0.3	0.2	0.1	0.1
250		11.2	9.7	7.4	5.3	3.6	2.7	1.5	1.0	0.6	0.4	0.2	0.1	0.1	0.0	0.0	0.0
260		8.2	6.7	5.6	4.0	2.9	2.1	1.5	1.1	0.7	0.4	0.3	0.1	0.1	0.0	0.0	0.0
270		9.1	7.6	6.4	4.9	3.9	3.0	2.3	1.5	1.0	0.5	0.3	0.1	0.1	0.0	0.0	0.0
280		9.7	8.4	7.3	5.8	4.7	3.6	2.6	1.7	1.0	0.6	0.4	0.2	0.1	0.1	0.0	0.0
290		13.2	11.7	10.5	8.7	7.1	5.8	4.5	3.3	2.2	1.4	0.7	0.4	0.3	0.1	0.1	0.1
300		18.9	17.5	16.7	15.0	12.8	11.2	8.9	6.6	4.4	2.7	1.8	1.1	0.6	0.2	0.2	0.1
310		40.0	38.3	36.3	33.8	30.5	27.1	22.5	18.0	12.8	8.6	5.1	3.4	1.9	1.1	0.6	0.2
320		137.2	134.1	130.4	124.8	118.1	109.0	95.9	81.4	65.2	49.9	35.5	26.4	18.9	10.7	6.5	3.6
330		383.4	379.1	372.7	362.9	351.5	334.7	308.4	277.1	238.0	195.2	152.6	120.5	90.2	59.1	39.3	23.6
340		722.5	715.8	705.5	683.6	660.4	630.1	584.0	523.6	450.0	371.3	288.4	222.6	165.0	106.3	71.3	41.6
350		1074.1	1062.4	1044.2	1003.7	957.7	900.6	818.5	716.1	591.2	461.4	334.1	243.1	163.5	94.1	56.7	29.4
360		1099.4	1083.4	1058.0	997.5	926.5	845.9	733.2	604.5	468.2	336.0	219.7	144.1	87.2	41.3	21.6	8.8
Totals :		8333.7	8103.5	7750.6	7128.2	6465.2	5760.2	4900.8	4073.8	3258.2	2527.0	1869.3	1420.9	1036.1	670.7	453.3	278.8

Hours of calm : 426.3
Total hours : 8760.0

Table C1: Wellington City wind data

Table C1: Wellington City wind data (continued)

Wellington City mean wind speed data at 150m. Jan 1960 - Oct 2007. Based on 8760 hours per year.
This table gives the hours per year that the wind is likely to equal or exceed a given wind speed for a given direction.

Direction	kts	33.0	35.0	37.0	39.0	41.0	43.0	45.0	47.0	49.0	51.0	53.0	55.0	57.0	59.0	61.0	63.0
	m/s	17.0	18.0	19.0	20.1	21.1	22.1	23.2	24.2	25.2	26.2	27.3	28.3	29.3	30.4	31.4	32.4
10		0.7	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
120		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
130		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
140		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
160		1.2	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170		7.1	4.3	2.2	0.8	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
180		17.7	10.9	5.8	3.2	1.1	0.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
190		32.3	21.2	11.4	6.5	3.3	1.8	1.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200		38.5	25.4	15.6	10.2	6.3	4.0	2.8	1.8	1.0	0.6	0.4	0.3	0.1	0.1	0.1	0.0
210		19.4	15.0	10.1	7.2	5.1	3.9	3.0	2.0	1.3	0.7	0.5	0.3	0.2	0.0	0.0	0.0
220		3.7	3.2	2.5	2.0	1.6	1.2	0.9	0.6	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0
230		0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
240		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
250		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
260		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
270		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
280		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
290		0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300		0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310		0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
320		2.4	1.7	0.9	0.6	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
330		15.5	9.7	5.8	3.4	2.0	1.4	0.9	0.5	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
340		28.4	18.3	11.1	6.5	3.4	2.0	1.1	0.7	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0
350		18.6	10.7	5.6	3.2	1.6	1.0	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
360		4.8	2.5	1.1	0.5	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals :		**190.9**	**124.3**	**72.4**	**44.2**	**25.0**	**16.1**	**10.8**	**6.3**	**3.5**	**1.7**	**1.1**	**0.7**	**0.4**	**0.2**	**0.2**	**0.1**

Hours of calm : 426.3
Total hours : 8760.0

Appendix D
Wind tunnel boundary layer

The WSP Research and Innovation Centre wind tunnel is a recirculating type, with an overall length of approximately 30 m. The working section measures 3.0 m wide x 1.5 m high. The airflow is generated by a six blade, 2.0 m diameter, 45 kW axial flow fan in the upper circular section of the wind tunnel. The maximum air speed in the working section is around 15m/s. A variable speed drive controls the air speed. Figure D1 shows a view of the wind tunnel.

The section of the wind tunnel upwind of the turntable allows the development of a deep turbulent boundary layer to simulate the natural atmospheric boundary layer at an appropriate scale. The correct velocity and turbulence profiles are generated by vertical spires, horizontal fence elements and an array of wooden blocks on the floor of the tunnel.

The Deaves and Harris (1978) mathematical model of the structure of strong winds is recognised as the recommended model for engineering design purposes. It is used in the wind loading design Standard, AS/NZS 1170.2. The four main terrain categories defined in AS/NZS 1170.2 are:

Terrain Categories

1 Flat, treeless plains, sea coasts

2 Open terrain, well scattered obstructions (air fields)

3 Suburban, industrial and well wooded areas

4 City centre condition

Figure D1: WSP Research and Innovation Centre wind tunnel.

Appendix E
Flow visualisation

Methodology

Flow visualisation using bran flakes provides a means of quickly identifying the relative wind speeds over the surface of a model.

The bran flakes are sieved to provide flakes between 1.0 mm and 1.4 mm in size. With the wind tunnel switched off, the model is sprinkled with a thin uniform layer of the bran. The layer is approximately two bran flakes deep, but it completely obscures the surface of the model. The wind tunnel speed is then steadily increased over a period of 20 minutes and the bran is progressively blown away. The areas where the bran first blows away indicate where the highest gust speeds are likely to occur. In other areas the bran accumulates slowly and these are generally where the lowest gust speeds occur. The changing patterns in the bran are photographed as the test proceeds.

The photographs from each test are processed to give the contour images shown in the wind report. Areas of the photographs that change from one photograph to the next in the test sequence are coloured, to give contours of increasing erosion. These contours correspond loosely to gust wind speeds on the surface of the model, although no accurate gust speed can be determined for a particular location from the contours. It is possible to compare the results from two separate tests, but the comparison must be made with caution because each test is inevitably slightly different. Ideally, the bran tests should only be used as a rough visual indication of where the highest wind speeds occur and as a guide to where hot wire speed measurements should be concentrated.

While the test is in progress, the movement of the bran is also useful for visualisation of the flow around the model. Usually this only indicates the direction of the flow at ground level, but in certain flow conditions (e.g. in vortices or in high turbulence) the bran flakes also become airborne and the three-dimensional flow is then apparent. Unfortunately, this movement is not detectable in the still photographs.

The details of the test procedure are as follows:

Windiness	Elapsed Time (minutes)	Fan Control Frequency (Hz)	Photograph	Reference Tunnel Speed (m/s)
	0	0	0	0.0
10	2	7	1	2.2
9	4	10	2	3.1
8	6	13	3	4.0
7	8	16	4	4.9
6	10	18	5	5.8
5	12	21	6	6.7
4	14	25	7	7.8
3	16	28	8	9.0
2	18	32	9	10.1
1	20	35	10	11.2

The tunnel speed is held constant at each control setting for two minutes before taking each photograph. This provides a reasonable time for the bran erosion to stabilise after each speed increase.

Although the local gust speed is the greatest single factor in producing movement of the bran flakes, there are numerous other factors that make it difficult to produce an accurate correlation with the measured wind speeds. These include:

The model surface:	The bran can accumulate on rough or sticky surfaces and in cracks and hollows.
Loose bran flakes:	The bran moves more easily when it is loose, e.g. at the edge of a cleared area, than when it is closely packed. Therefore, a clearing may expand rapidly once it has been initiated.
Discontinuities:	The bran tends to be disturbed around corners and small obstructions in the airflow. It is not easily disturbed in regions of flat, uniform flow.
Vertical wind flow:	The bran is more easily disturbed where there is a downward component in the air velocity than where the flow is horizontal.
Turbulence:	The bran tends to be disturbed by turbulence and fluctuating flow direction.
Tunnel gusts:	Occasional random low frequency fluctuations in the tunnel speed produce rapid changes in the bran erosion patterns. These tunnel gusts occur about once or twice per minute.
Vortices:	Bran flakes can accumulate in the core of a steady local vortex. This then appears to be a comparatively calm area in the photographs because the vortex is not visible.
Bran mounds:	The bran can accumulate in mounds as each test proceeds, and the mounds subsequently modify the flow conditions in their vicinity.

Calibration

Figure E2 shows a bran erosion contour image for the calibration building specified in Appendix 8 of the Wellington City District Plan. The calibration building is an isolated rectangular block, measuring 60m high, and 15m square in plan, at full-scale. This building was built at a scale of 1:264, which is the scale of the WSP Research and Innovation Centre wind tunnel model of Wellington. The building was tested in the standard terrain category 3 atmospheric boundary layer simulation, which is used for environmental building studies in Wellington. Figure E1 shows the grid on the wind tunnel floor that was used to determine the extent of the erosion. The circle marked in Figure E1 indicates an area 50m in diameter (at full-scale) which is centred on the back face of the model, as specified in the Wellington City District Plan. Contour number 7 (i.e. windiness="7") corresponds to approximately 80% of this circle being cleared of bran.

Figure E1: Aerial view of the calibration model building and measurement grid.

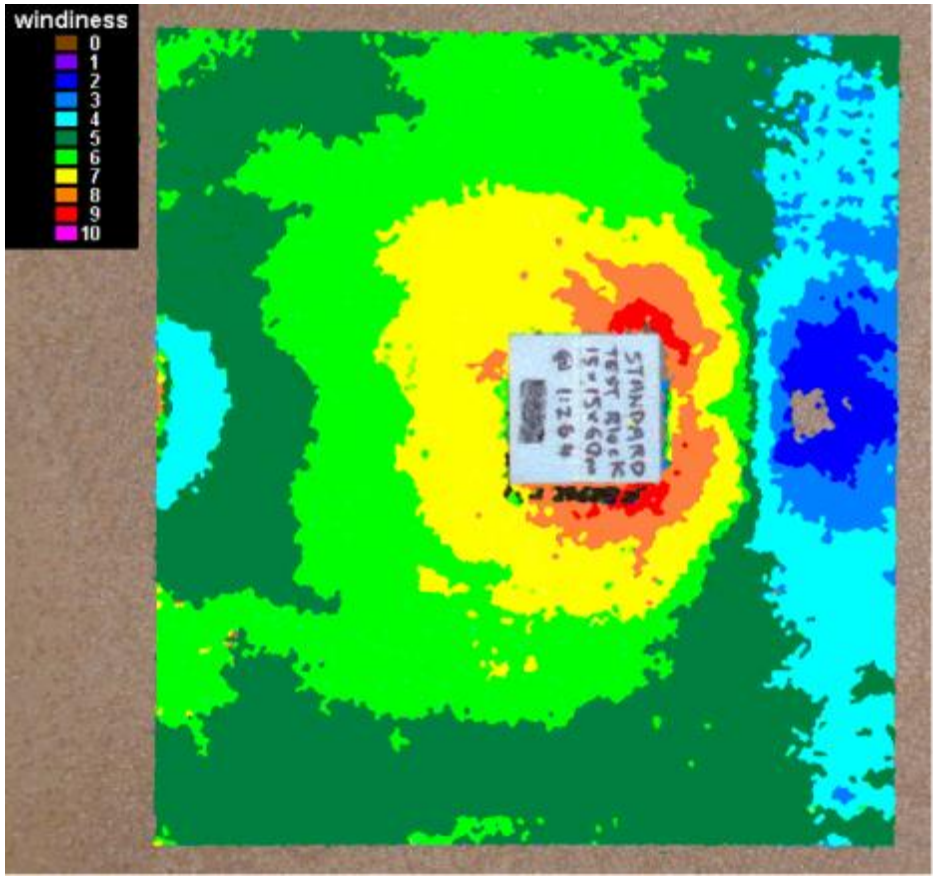


Figure E2: Erosion contours for calibration building (60m x 15m x 15m).

Appendix F
Gust wind speeds

Maximum gust speed by wind direction

A change of 1 m/s in the wind speed is not considered significant within the limitations of the test method, whereas a change of 2 m/s generally indicates a reproducible wind effect.

Table F1: Maximum gust wind speeds, Vc (m/s)

Notes: exg = existing situation, new = proposed development, - = not measured

The shading applied to the table corresponds to the description of wind conditions given in Appendix A and in the Key below.

gust speed	150		170		190		210		320		340		360		20	
	exg	new	exg	new	exg	new	exg	new	exg	new	exg	new	exg	new	exg	new
A	18	19	22	19	14	12	21	23	16	13	16	15	12	15	10	10
B	19	19	20	16	12	10	21	21	16	15	16	15	16	18	12	13
C	21	19	17	16	12	9	24	22	19	16	16	14	16	15	12	11
D	16	18	12	12	12	10	21	21	19	17	17	15	15	16	13	11
E	10	11	12	11	20	20	25	25	16	14	19	17	21	21	13	12
F	11	9	10	10	19	17	22	22	14	21	17	18	13	13	13	10
G	8	8	8	6	13	10	25	25	15	10	17	13	12	8	9	9
H	12	13	11	9	10	10	20	22	14	23	15	27	13	15	13	11
I	12	11	12	11	11	9	24	21	19	11	22	12	15	10	13	9
J	14	11	15	11	9	7	21	20	21	13	24	12	13	12	10	8
K	12	14	12	8	9	6	23	18	18	10	24	12	15	8	12	7
L	11	5	9	4	9	4	21	15	13	15	22	18	12	11	10	8
M	12	6	11	5	12	6	19	18	17	11	21	13	14	11	10	11
N	9	8	10	9	12	8	19	10	21	12	18	15	12	11	10	8
O	11	11	10	10	13	8	19	11	21	18	22	17	11	15	8	10
P	13	11	11	10	15	14	19	18	24	17	24	15	17	12	10	12
Q	8	12	8	8	13	11	12	11	15	15	13	14	8	9	7	8
R	14	10	13	9	14	9	20	13	22	12	24	19	19	13	12	11
S	12	11	12	8	11	8	17	12	21	21	28	23	20	16	14	12
T	14	13	12	10	12	10	14	14	21	21	27	30	21	20	16	13
U	13	12	13	9	14	12	15	15	22	15	24	25	20	17	16	13
V	12	11	12	13	15	14	17	16	23	10	22	27	19	21	14	13
W	11	13	15	12	17	14	24	20	23	23	24	26	18	21	13	12
X	11	9	11	12	14	12	14	15	21	19	24	24	22	19	13	12
Y	9	8	11	14	15	15	21	21	17	21	17	16	13	12	10	9
Z	9	8	17	17	20	19	22	23	16	17	24	27	19	18	15	15
A1	9	9	9	8	11	9	15	14	21	22	25	26	23	23	14	13
B1	5	10	6	7	7	8	8	9	9	14	17	12	15	13	12	8
C1	13	-	18	-	16	-	13	-	15	-	15	-	11	-	8	-
D1	9	-	13	-	12	-	12	-	16	-	16	-	13	-	9	-
E1	12	-	14	-	17	-	12	-	19	-	18	-	14	-	10	-

Key: Colour coding to wind conditions	
<= 11	very low
12-14	low
15 - 17	moderate
18 - 20	moderately high
21 - 23	high
24 - 26	very high
>= 27	extremely high

Appendix G
Frequency of occurrence

Days per year by wind direction

A change of 20 days/year is the minimum level considered to be significant within the limitations of the test method, i.e. a physical change, e.g. a new building.

Table G1: Days per year that the hourly mean wind speed equals or exceeds 2.5m/s.

Notes: exg = existing situation, new = proposed development, - = not measured

The depth of shading applied to the table highlights to the relative magnitude of the number of days 2.5 m/s is equalled or exceeded.

	150		170		190		210		320		340		360		20	
	exg	new	exg	new	exg	new	exg	new	exg	new	exg	new	exg	new	exg	new
A	10	10	19	11	9	0	6	7	10	5	29	14	0	9	1	1
B	11	11	13	6	4	0	7	8	10	8	22	18	13	36	2	5
C	11	11	1	1	7	0	8	8	9	7	20	5	8	4	2	2
D	4	9	0	0	6	0	7	7	9	9	17	13	6	13	4	1
E	0	1	0	0	27	23	10	10	7	3	37	29	50	52	8	5
F	0	0	0	0	21	7	8	7	3	12	15	28	1	0	6	1
G	0	0	0	0	8	0	10	10	6	0	22	2	0	0	0	0
H	0	4	0	0	0	0	6	8	4	13	14	54	0	8	6	5
I	1	1	0	0	1	0	9	8	12	2	45	3	8	1	6	1
J	1	1	0	0	0	0	7	8	13	5	51	9	3	3	1	0
K	1	4	0	0	0	0	8	6	12	0	54	0	21	0	4	0
L	1	0	0	0	0	0	7	3	5	5	49	11	1	0	1	0
M	1	0	0	0	2	0	7	7	9	3	47	2	4	0	1	2
N	0	0	0	0	2	0	6	0	10	2	24	8	0	0	0	0
O	0	5	0	0	6	0	6	1	10	12	45	11	0	3	0	1
P	3	1	0	0	12	1	7	5	13	7	53	21	14	0	0	3
Q	0	2	0	0	5	0	1	0	8	8	3	11	0	0	0	0
R	5	1	0	0	11	0	7	1	13	2	54	35	31	1	2	2
S	1	0	0	0	2	0	6	0	13	13	56	54	45	29	9	10
T	6	4	0	0	10	0	3	4	13	12	56	57	54	48	11	12
U	5	2	0	0	13	0	4	4	13	5	54	54	50	32	12	10
V	1	0	0	0	13	1	4	4	13	0	51	54	44	51	8	9
W	0	1	2	0	19	3	8	6	13	13	53	56	39	50	7	4
X	0	0	0	0	12	1	1	3	13	12	54	53	57	43	10	5
Y	0	0	0	1	10	3	6	6	10	12	26	16	1	0	0	0
Z	0	0	20	17	32	28	11	11	10	10	54	54	54	53	24	23
A1	0	0	0	0	2	0	3	2	13	13	55	56	64	60	9	8
B1	0	0	0	0	0	0	0	0	0	2	26	0	0	0	4	0
C1	2	-	25	-	18	-	1	-	10	-	24	-	1	-	0	-
D1	0	-	0	-	2	-	0	-	12	-	35	-	15	-	0	-
E1	1	-	2	-	20	-	0	-	10	-	36	-	13	-	0	-

Table G2: Days per year that the hourly mean wind speed equals or exceeds 3.5m/s.

Notes: exg = existing situation, new = proposed development, - = not measured

The depth of shading applied to the table highlights to the relative magnitude of the number of days 3.5 m/s is equalled or exceeded.

	150		170		190		210		320		340		360		20	
	exg	new	exg	new	exg	new	exg	new	exg	new	exg	new	exg	new	exg	new
A	5	5	7	2	1	0	3	5	5	1	8	2	0	0	0	0
B	7	8	4	1	0	0	5	6	5	3	5	3	1	10	0	1
C	7	6	0	0	1	0	6	6	5	3	4	0	0	0	0	0
D	1	5	0	0	0	0	5	5	5	4	2	1	0	1	0	0
E	0	0	0	0	19	15	7	7	2	0	16	9	22	25	1	1
F	0	0	0	0	12	1	6	6	0	8	2	8	0	0	1	0
G	0	0	0	0	1	0	7	7	1	0	5	0	0	0	0	0
H	0	1	0	0	0	0	3	6	1	12	2	47	0	0	1	1
I	0	0	0	0	0	0	7	6	8	0	26	0	0	0	1	0
J	0	0	0	0	0	0	5	6	10	1	40	1	0	0	0	0
K	0	1	0	0	0	0	6	5	9	0	45	0	3	0	0	0
L	0	0	0	0	0	0	5	0	1	1	35	1	0	0	0	0
M	0	0	0	0	0	0	5	5	5	0	30	0	0	0	0	0
N	0	0	0	0	0	0	4	0	6	0	5	1	0	0	0	0
O	0	1	0	0	0	0	5	0	6	8	27	1	0	0	0	0
P	1	0	0	0	2	0	5	2	11	2	44	4	1	0	0	0
Q	0	0	0	0	0	0	0	0	4	4	0	1	0	0	0	0
R	1	0	0	0	2	0	5	0	11	0	46	14	7	0	0	0
S	0	0	0	0	0	0	3	0	10	11	51	47	17	6	2	2
T	2	1	0	0	1	0	0	1	10	9	52	53	26	20	2	3
U	1	0	0	0	3	0	1	1	11	1	46	45	22	7	3	2
V	0	0	0	0	3	0	1	1	11	0	39	46	16	24	1	2
W	0	0	0	0	10	0	6	4	12	12	45	51	12	23	1	0
X	0	0	0	0	2	0	0	1	11	10	47	43	32	15	2	1
Y	0	0	0	0	2	0	3	4	5	8	6	2	0	0	0	0
Z	0	0	8	6	25	20	7	8	6	6	45	47	27	26	12	11
A1	0	0	0	0	0	0	0	0	11	12	50	52	42	36	2	1
B1	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0
C1	0	-	12	-	7	-	0	-	5	-	5	-	0	-	0	-
D1	0	-	0	-	0	-	0	-	8	-	14	-	1	-	0	-
E1	0	-	0	-	11	-	0	-	5	-	15	-	1	-	0	-

Appendix H
Response to section 92 request

Memorandum

To	Peter Coop
Copy	Michael Davis, Julie Stewart
From	Nick Locke
Office	WSP Petone
Date	19 July 2022
File/Ref	5-29P84.00 task 3
Subject	Parliamentary FAS: Section 92 RFI – Wind (Service Request 514663)

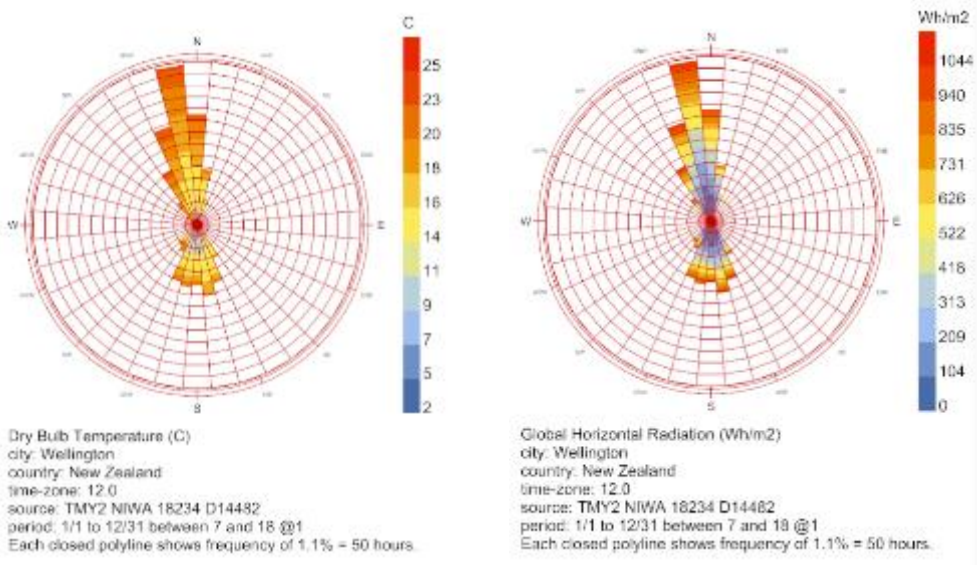
This memo contains responses to paragraphs 19 to 22 (i.e wind effects) of the Request for Further Information under Section 92 of the Resource Management Act 1991 from Wellington City Council, dated 4 July 2022 (Service Request No: 514663, File Reference: 1199795).

References to wind speeds and locations in this memo correspond to those in the WSP report, Wind tunnel study of Parliamentary precinct development, Wellington, 6 October 2021.

Paragraph 19 – Wind conditions in the western plaza

Please provide further discussion of the performance of the adjacent park area in regard to the City's performance requirements for parks. Such a discussion might/should address the following data:

When considering wind in Wellington in relation to when it is warm, the strong Northerly winds are closely associated with the warmest temperatures (during the day from 7am to 6pm) (left image below), which is also true of the sunny periods of the year (right image below):



The wind standards in the District Plan for the Central Area have comfort criteria that limit the number of days that the mean wind speed at a location can equal or exceed 2.5 m/s, in a typical year. The comfort criteria in the wind standards only apply to specific public spaces that are listed in clause 13.6.3.4, and shown in Appendix 7, of the Central Area rules.

Assuming the "adjacent park area" refers to the west courtyard (ie the area between the Bowen State Building and the proposed Museum Street Building ("MUS")) and the sculpture park (i.e the grassed area adjacent to Bowen Street and the Bowen State Building), then the adjacent park area

is not one of the designated public spaces in clause 13.6.3.4 that the comfort criteria apply to, and no assessment has therefore been made of its compliance with the comfort criteria.

In general, the adjacent park area is expected to have relatively windy conditions, mainly as a consequence of downwash wind flows off the Bowen State Building during northwest and southwest winds. Northwest winds currently flow across the northern end of the site and impact Parliament House but will be redirected through the west courtyard by the MUS building. This directional wind effect is most prominent in the predicted gust speeds.

Gust wind speeds, which correspond to the very windiest times of the year, will exceed the safety threshold of 20 m/s in the wind standards, for some wind directions. The maximum gust speeds increase at some locations and decrease at other locations. Within the adjacent park area, the net effect of the proposed development on the gust speeds is neutral. The maximum gust speed in the adjacent park area is 28 m/s, which occurs at location S with existing conditions (ie without the proposed development) and shifts to location H where the gust speed of 27 m/s occurs with the proposed development. This shift in location, and the neutral effect over the adjacent park area, reflects the channelling effect of the MUS building, which simply shifts existing strong wind flows within the site.

The net effect of the development on moderate wind speeds (measured by the number of days that the mean hourly wind speed equals or exceeds 2.5 m/s) in the adjacent park area is neutral or a slight reduction in the number of days (ie improvement in wind conditions). In most locations within the adjacent park area, the number of days where the mean wind speed equals or exceeds 2.5 m/s is reduced by the development, except at location H where the number of days increase (refer Table 2 in the WSP report, Wind tunnel study of Parliamentary precinct development, Wellington, 6 October 2021). Therefore, the adjacent park area is generally expected to comply with the comfort criteria, except near the southwest corner of the MUS building, where the building concentrates existing strong wind flows during northwest and southwest winds.

Air temperature is generally recognised to influence people's comfort in outdoor spaces but is not recognised as affecting people's safety from high winds. In Wellington, warmer air temperatures are more likely to increase people's comfort (by reducing heat loss) compared to colder winds (ie "wind chill" effect), although the thermal balance of individual pedestrians will vary widely (for example, clothing and activity level have a large influence on comfort). Temperature is not included or assessed for compliance with the wind standards in the Wellington District Plan, and no analysis has been done to determine the relative frequency of temperatures within the adjacent park area.

Lastly, and as advised by the Applicant, while the Sculpture Park is referred to as a park, this is not its status under the District Plan. It's status under the District Plan is a "Central Area" zoned building development site with a building height standard of 27m. It is therefore an area within the Parliamentary Precinct that is available for building development should further floorspace (over and above what is proposed in the application for resource consent) be required in the long-term future to meet Parliament's needs.

Paragraph 20 – Safe passage through the site during periods of high winds

> *The building design assessment requirement in the wind rules asks for an indication of how the building design in its placement and design has ensured that people post-construction have a means of walking through the site in relative security avoiding the worst wind conditions. Please provide more information of the pedestrian access past the building avoiding areas identified as unsafe by the wind analysis.*

Pedestrians currently navigate, or avoid, areas within the existing site that are assessed to have unsafe wind conditions. Because the development simply shifts the high gust speeds from one location to another, rather than create additional wind flows, it does not increase the gust speeds overall. Therefore, the development is not expected to degrade the safety of pedestrians using the area, although some adaptation to find a new optimum route is expected.

The wind standard for safety requires a new building to improve existing unsafe wind speeds where possible, and the proposed MUS building does this along the eastern side of the site (between the MUS building and Parliament House and the location where the Ministerial Building would have been) where existing unsafe gust speeds are reduced. The northern and eastern sides of the site are therefore the most likely areas that pedestrians would use as a new preferred route when high gust speeds occur in the adjacent park area. Pedestrians may also transit through the existing Bowen State Building colonnade, along the western edge of the adjacent park area. This route is shown on SPA 2650 FAS LAN A2 SK-002, Proposed alternative pedestrian route.

Paragraph 21 – Integration of wind into the design of the Museum Street Building entrances

> *There is no acknowledgement in the design of the building of the spectacularly high predicted wind speeds. Placement of pedestrian access, size of wind lobbies, and effect of the overpass on wind acceleration come to mind as building design features about which there is no integration of the wind information with the building design documentation. Further assessment and consideration in this regard is requested.*

The Museum Street entrance to the MUS building is located approximately halfway along the eastern face of the building, under the link bridge that connects the MUS building to Parliament House. This area is predicted to have very low to moderate wind speeds and has wind conditions which meet the comfort criteria in the wind standards. On this basis, the entrance is in an ideal location relative to the rest of the site. The Museum Street entrance also features a wind lobby, comprising two sets of sliding doors, separated by 2 metres, which should lessen the impact of external wind flows penetrating into the interior of the building.

The link bridge is not expected to have a noticeable effect on pedestrian wind speeds beneath it, including at the Museum Street entrance. Cladding pressures (measured in a wind tunnel study) on the upper and lower surfaces of the link bridge show no significant differences, indicating there is no localised acceleration of wind flowing between the ground and the link bridge, compared to wind flowing above the link bridge.

The west entrance to the MUS building is located almost directly opposite the Museum Street entrance on the western side of the building, noting that there is an offset of approximately 3.6 metres. This entrance has a wind lobby with 2 sets of sliding doors spaced 3 metres apart. A horizontal canopy and small vertical screens project out approximately 1 metre above and either side of the exterior doors. This is shown on SPA 2650 FAS MUS A4 SK-001. This entrance is expected to be most uncomfortable during northwest winds, although its placement avoids the strongest winds, which occur near the southwest corner of the building.

During strong northwest winds, it is likely people will use the Museum Street entrance in preference to the west entrance. Anyone using the west entrance will be exposed to windy conditions, but wind gusts are not expected to exceed the safety threshold at the entrance. The greatest wind effect from the west entrance is likely to be inside the MUS building, where strong winds will penetrate into the interior as people enter or exit through the west entrance. The wind

lobby will ameliorate this inflow. Wind speeds at the entrance could be further reduced by vertical screening and/or offsetting the sliding doors to help avoid a direct line of wind flow into the interior of the building.

Paragraph 22 – Integration of wind into the design of the Museum Street Building entrances

> *The wind tunnel test only examines screens around the buildings as potential solutions to the identified existing and new safety issues. This then makes it possible in the design statements and drawings to reduce these to a problem to be avoided due to potential conflict with Crime Prevention through Environmental Design restrictions, and provide no information on wind mitigation measures. No cross-analysis appears to have been performed integrating the wind information with the CPTED analysis or the architectural design. Can this please be assessed in terms of solutions that are likely to work from all points of view, rather than merely testing screens and then suggesting they are unlikely to pass the CPTED test.*

Wind mitigation was tested with the aim of ameliorating the very high gust speeds that occur in west courtyard. Testing showed that the mitigation options (ie a range of vertical screens) had a localised effect that did not extend far enough to enable the gust speeds to be controlled without essentially creating a maze of screening within the courtyard. A number of factors are typically considered when assessing the suitability of wind mitigation, including CPTED. In this situation, the amount and height of screening that would be needed for wind mitigation would turn the courtyard into a maze for pedestrians and visually close in the space. The benefits of lower gust speeds are therefore not believed to outweigh the loss in amenity of a more open courtyard.

A secondary consideration for wind mitigation is the surrounding wind environment. If pedestrians experience similar wind speeds accessing or exiting a particular space, then wind conditions within that space are less problematic than circumstances where wind speeds increase within the space relative to its surroundings. In this instance, high wind speeds occur in areas to the northwest and to the south of the courtyard. The gust speeds in the general area will be no different to the gust speeds that pedestrians currently face.

Some additional screens are now proposed at or near the bench seats in the west courtyard (refer 2650 FAS LAN A2 SK-001 Proposed West Courtyard – Wind Shelter). The screens will likely be timber or planted screens and will be 1.0 to 1.5 m in height. These screens will improve the amenity for people sitting on the benches during both northerly and southerly winds and could conceivably provide a sheltered stopping point for people walking through the courtyard on very windy days.

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