One Tasman Development Limited Partnership

WIND TUNNEL STUDY:

ONE PUKEAHU PARK DEVELOPMENT, WELLINGTON

REPORT NO 21-529P79.00

17 SEPTEMBER 2021

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One Tasman Development Limited Partnership

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EXECUTIVE SUMMARY

This report presents the results of a wind tunnel study of pedestrian wind conditions around the One Pukeahu Park development, which is proposed for a site on the corner of Tasman Street and Old Buckle Street in central Wellington.

Three design options were tested for the proposed development, these being the original design and two modified designs. Testing showed that, taken overall, the original development design causes an identifiable deterioration in wind conditions in the pedestrian areas surrounding the site. Accordingly, additional testing of modified designs was undertaken. These modified designs were guided by a combination of heritage, urban design and wind advice, and influenced by the acquisition of the site to the south.

The testing of design changes showed that the negative effects of the original design of the development, as first tested, could be partially mitigated. An aggregation of different design changes (Option 1), produced some significant improvements over the original design. The further inclusion of a large canopy (Option 2) offered additional mitigation of some of the effects identified in Tasman Street.

It is understood that the design changes that were tested as Option 1 and Option 2 have been included in the development design that is being submitted for resource consent.

1 PROJECT BACKGROUND

1.1 INTRODUCTION

This report presents the results of a wind tunnel study of pedestrian wind conditions around the One Pukeahu Park development, which is proposed for a site on the corner of Tasman Street and Old Buckle Street in central Wellington. The proposal for this relatively large site involves the development of two taller and larger multi-storey buildings, together with four smaller and lower rise buildings and landscaped external space.

The objective of the wind tunnel study is to quantify the extent and magnitude of any significant effects of the proposed development on pedestrian level wind conditions in the surrounding public areas. This investigation is required (1) to meet the reporting requirements of the Wellington City District Plan relating to the wind effects of new buildings and (2) as part of the resource consent process.

1.2 WELLINGTON DISTRICT PLAN – WIND EFFECTS

The Wellington City District Plan contains objectives, policies and standards relating to the potential effects of new buildings on pedestrian wind conditions in various parts of the city, particularly in the Central Area. The intent is to ensure that buildings are designed to avoid, remedy or mitigate potential adverse effects and to improve the wind environment where reasonably practical. Performance criteria have been set in the District Plan with three main goals in mind. The first of these is a Safety Criteria, which is specified in terms of a maximum gust speed of 20m/s. The second criteria uses a “frequency of occurrence” approach to define an acceptable level of comfort and the third criteria uses the change in “frequency of occurrence” to limit the overall deterioration in wind conditions that can occur with a proposed development. Sections of the District Plan specifically relating to wind effects are reproduced in Appendix B.

2 SITE, AREA AND PROPOSED DEVELOPMENT

2.1 DEVELOPMENT SITE

The development site at 1 Tasman Street is a large irregularly shaped area located on the southeast corner of the intersection of Tasman and Old Buckle Streets in Mount Cook in central Wellington. Pukeahu National War Memorial Park is located to the northwest of the site. State Highway 1, which winds around the Basin Reserve to the east of the site, then sweeps around to the north of the site, where it goes underground through the Arras Tunnel. The development site is currently occupied by several different building elements, some of which are interconnected, and some freestanding. These range from low-rise one or two-storey blocks through to a six-storey block that sits roughly at the centre of the site.

2.2 SURROUNDING AREA

Buildings in this part of central Wellington vary widely in terms of their size, height, design, age and use. There are significant numbers of older mostly low-rise buildings ranging from residential houses through to larger footprint blocks, such as the largest building on the development site and the old Dominion Museum building, now part of Massey University, on top of the hill to the west. There are significant open spaces in the area around the site, including Pukeahu National War Memorial Park, The Basin Reserve and the adjacent streets and footpaths. Substantial areas around the old Dominion Museum building are covered with large mature trees.

Much of the change that has occurred in the surrounding area in recent years has been through demolition of buildings, the most significant of which occurred during the relatively recent development of Pukeahu National War Memorial Park. Other demolition has also occurred south of Rugby Street further south from the site.

2.3 PROPOSED DEVELOPMENT

The 1 Tasman Street development proposal involves the construction of two taller and larger multi-storey buildings, together with four smaller and lower rise buildings and landscaped external space. These residential buildings are all aligned approximately normal to Old Buckle Street. The tallest of the new buildings, which also has the largest footprint, is around 34m high, with a small rooftop service element adding slightly under 2m more in height. The next tallest building is around 26m high and includes another small 2-3m high element on the roof. All four of the remaining buildings are much shorter, being around 10-12m in height. Separation between the buildings allows for landscaped outdoor open space, including common areas and private areas associated with individual units. Figure 1 shows views of the wind tunnel model of the development and the immediate surroundings. These show the articulation of the different buildings in the development, both horizontally and vertically. Figure 2 shows an aerial photo of the area around the development site. Superimposed on this is a plan of the development site that shows the relative sizes and locations of the buildings. Also included on this figure are the site boundary, the direction sectors for the prevailing winds over Wellington City and the locations of the wind speed measurements.

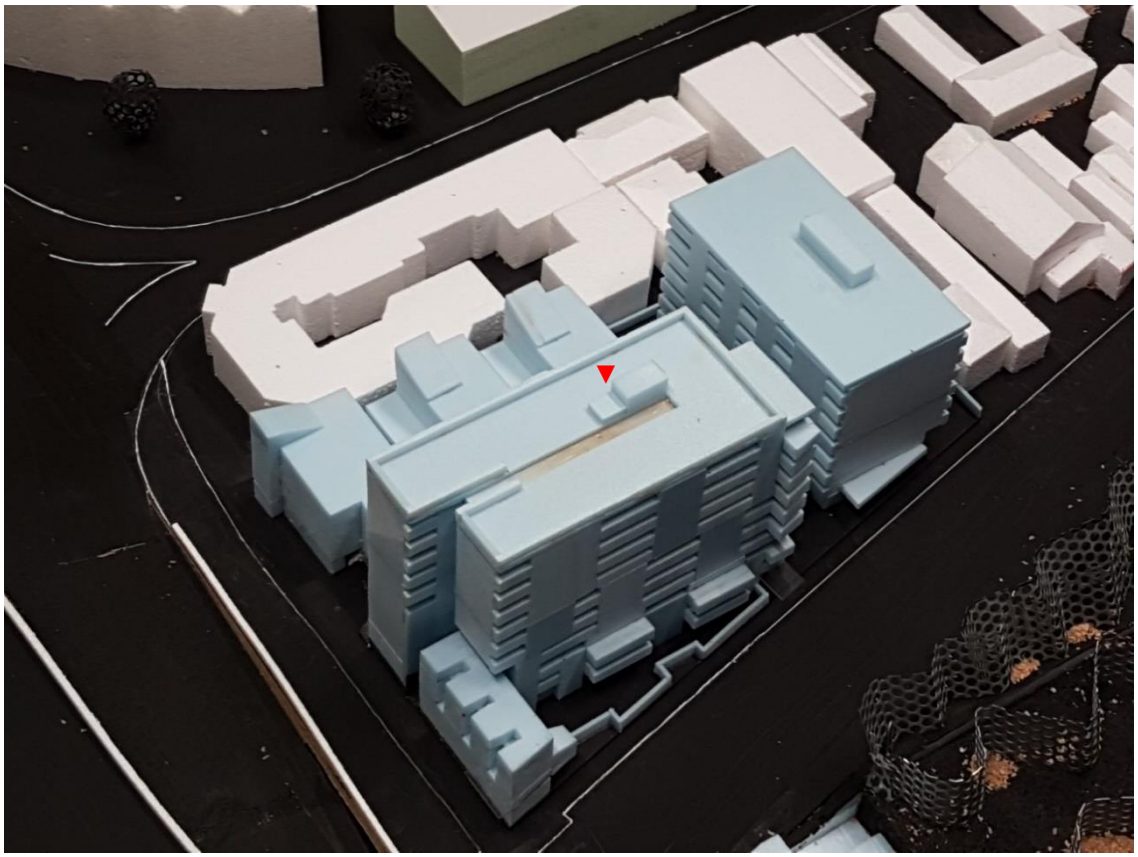

Figure 1 (a): View of the proposed development (blue coloured buildings▼) *from the Northwest.*

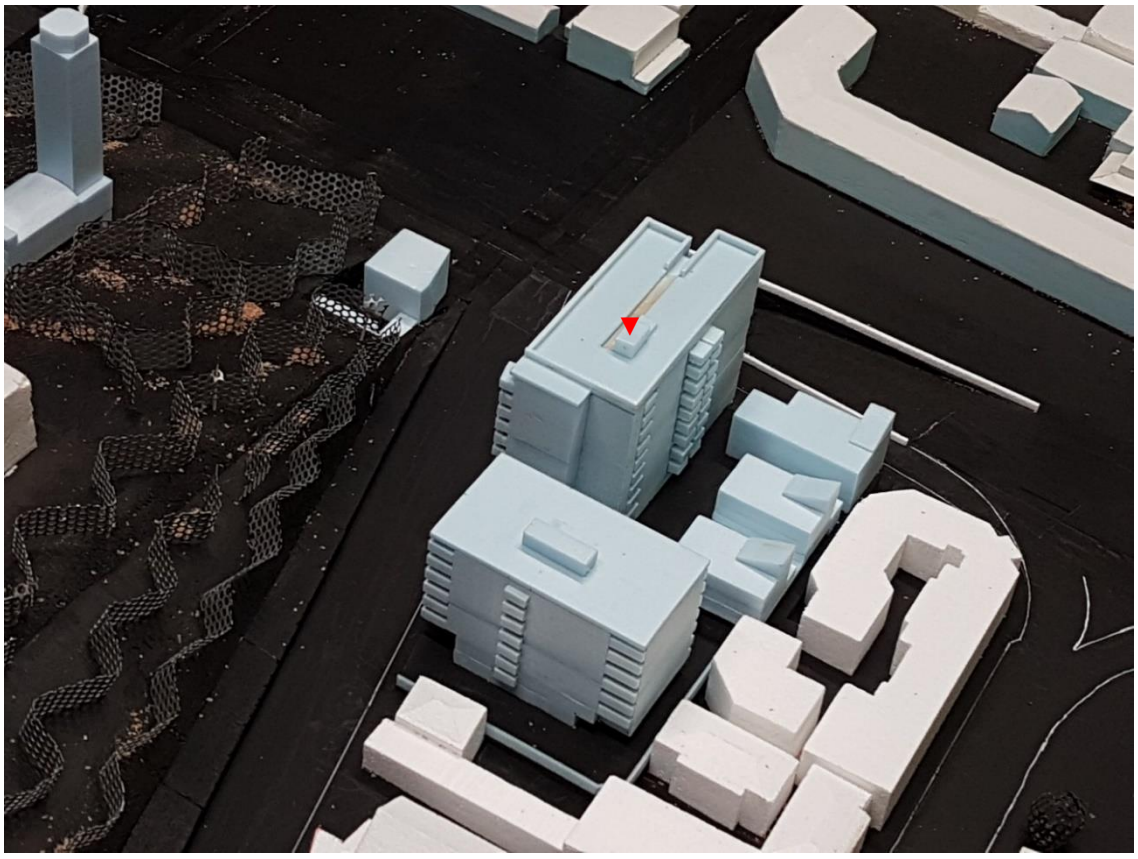

Figure 1 (b): View of the proposed development (blue coloured buildings▼) *from the South.*

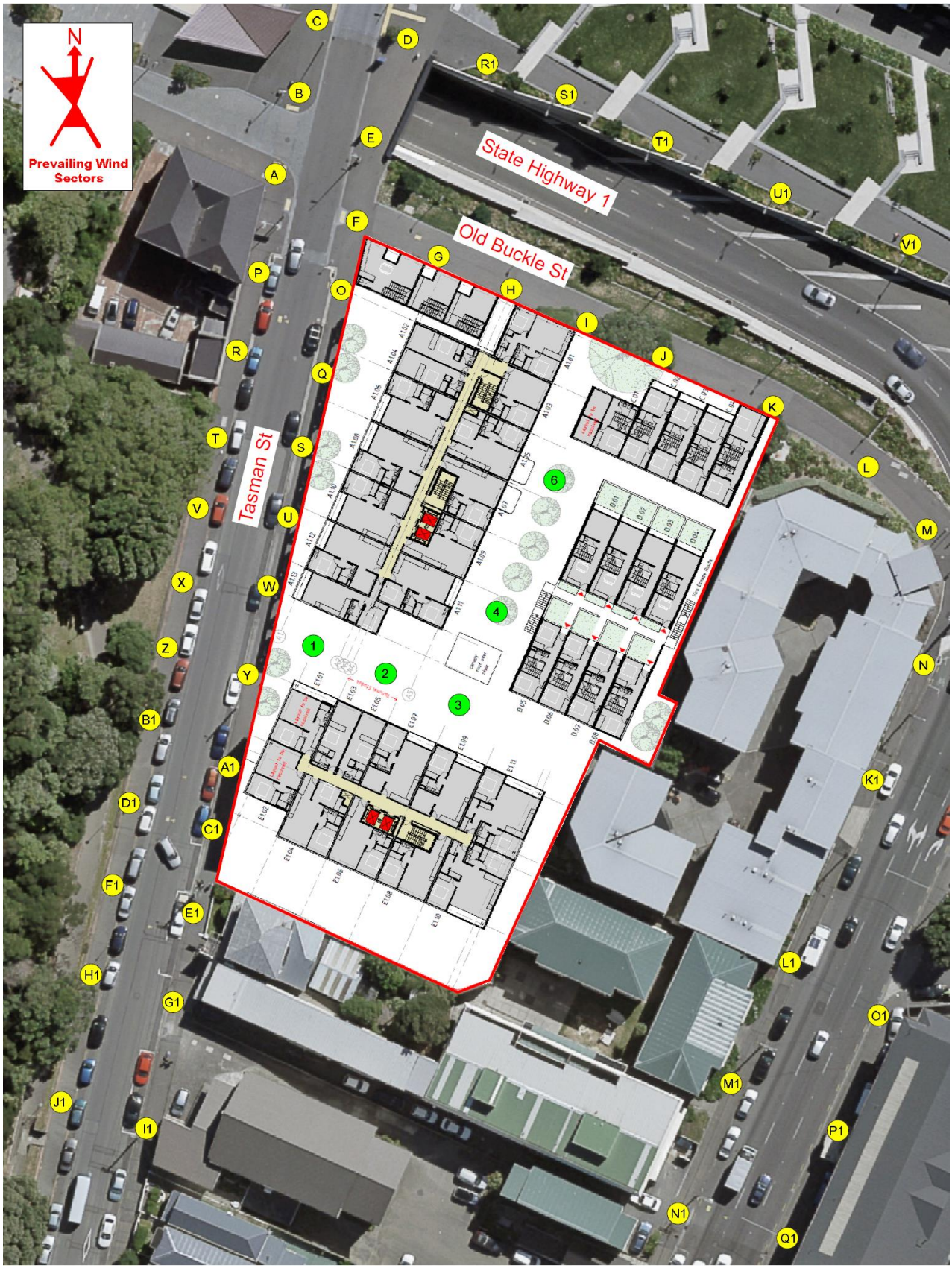

Figure 2: Site and surrounding area (aerial image – LINZ, 2021)

Notes:
Red = site outline.
Yellow = measurement locations (public space)
Green = measurement locations (on site)
Also shown are the prevailing directions for strong winds.

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.

The following two methods of testing were employed.

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 were carried out for the existing situation and 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 conditions 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 situation and the proposed development.

The measured wind speed data is processed in two different ways:

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

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

  where V_{mean} is the maximum annual hourly mean wind speed, and V_{rms} is the standard deviation corresponding to this mean speed. The calculated gust speeds are compatible with the Safety Criteria for wind speeds specified in the Wellington City District Plan (refer Appendix B).

2 The mean wind speeds for each location for each wind direction are divided by the directional mean reference wind speed to provide a mean velocity ratio. These are then combined with the

Wellington City wind climate data listed in Appendix C to calculate the number of days for which mean wind speeds of 2.5m/s and 3.5m/s are equalled or exceeded in a year.

4 FLOW VISUALISATION TESTS

4.1 BACKGROUND

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 mounted 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.

4.2 NORTHERLY WINDS

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

(a) The area of Wellington around the development site south of Old Buckle Street is currently well sheltered from northwesterly winds by the hill to the west on which the old Dominion Museum sits. Old Buckle Street itself and the open area in and around Pukeahu Park are much more exposed, with the Park being aligned approximately parallel to this wind direction. As the wind direction shifts to the north, the whole area around the site becomes more exposed to strong horizontal wind flows, as it loses much of the shelter afforded by the upstream topography.

(b) For both wind directions of 320˚ and 360˚ the erosion images show that the proposed development deflects additional wind flows down and along its windward faces into the adjacent areas of both Tasman Street and Old Buckle Street. Some of these wind flows are also channelled into the interior of the site between the two tallest new buildings. However, the erosion images for both wind directions also suggest that the proposed development affords areas downwind, including around the Basin Reserve, with increased shelter.

4.3 SOUTHERLY WINDS

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

(a) As for northerly winds, the upstream topography significantly affects the degree of shelter afforded the site. For a wind direction of 170˚ both Tasman Street and the area around the Basin Reserve are currently exposed to strong horizontal wind flows. As the wind direction shifts to the southwest (210˚), the site and surrounding areas generally become more sheltered by the topography.

(b) The contour images show that both of the taller buildings of the proposed development defect wind flow down and along their windward faces into the adjacent pedestrian areas in Tasman Street. These effects also impact on the interior spaces between the development buildings. As for the existing situation areas around the site are generally more exposed for a wind direction of 170˚than 210˚ because of the difference in the shelter afforded by the upstream topography. However, the development does also appear to provide some shelter for areas directly downstream, most noticeably in Pukeahu Park for wind from 170˚.

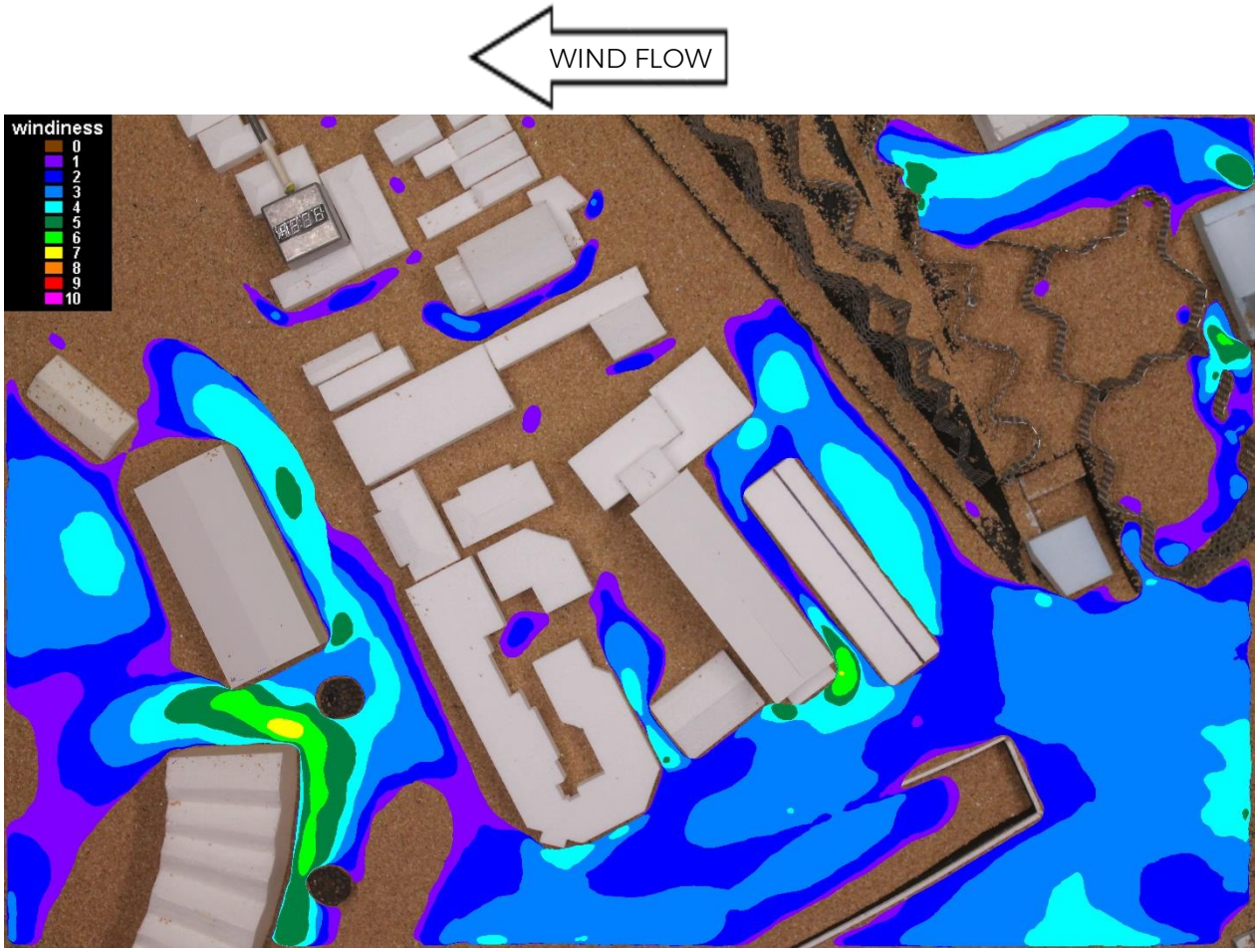

Figure 3 (a): Relative Windiness – Existing Situation – Wind from 320˚

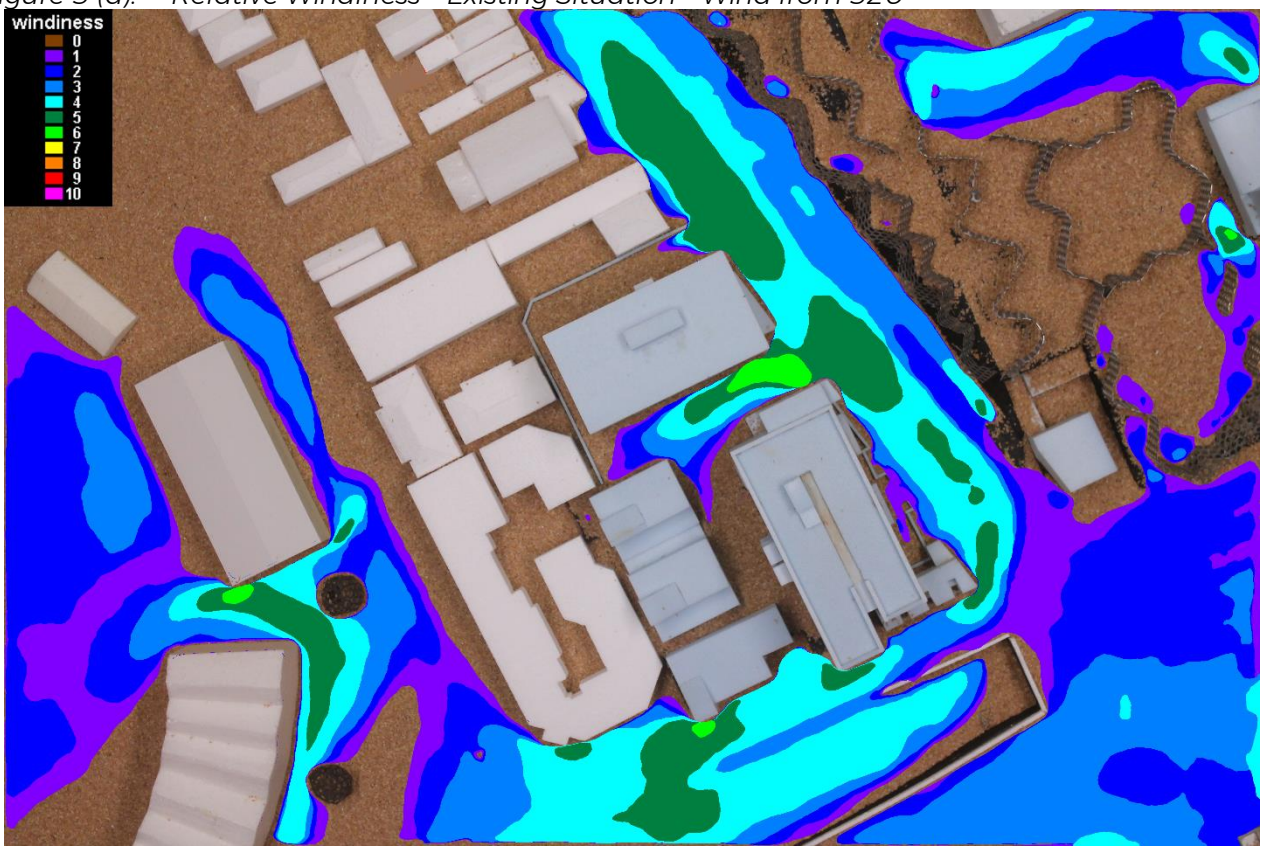

Figure 3 (b): Relative Windiness – Proposed Development – Wind from 320˚

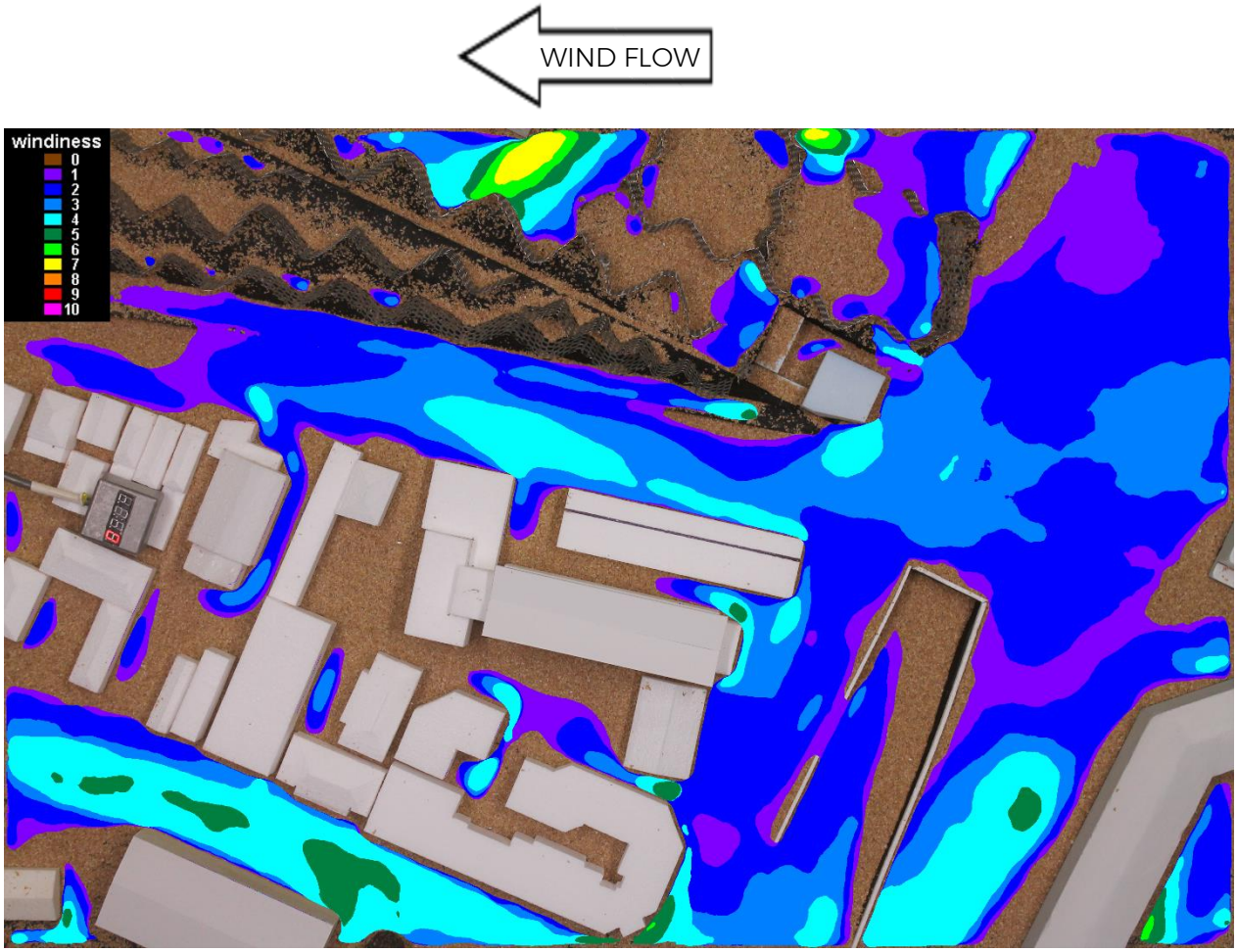

Figure 4 (a): Relative Windiness – Existing Situation – Wind from 360˚

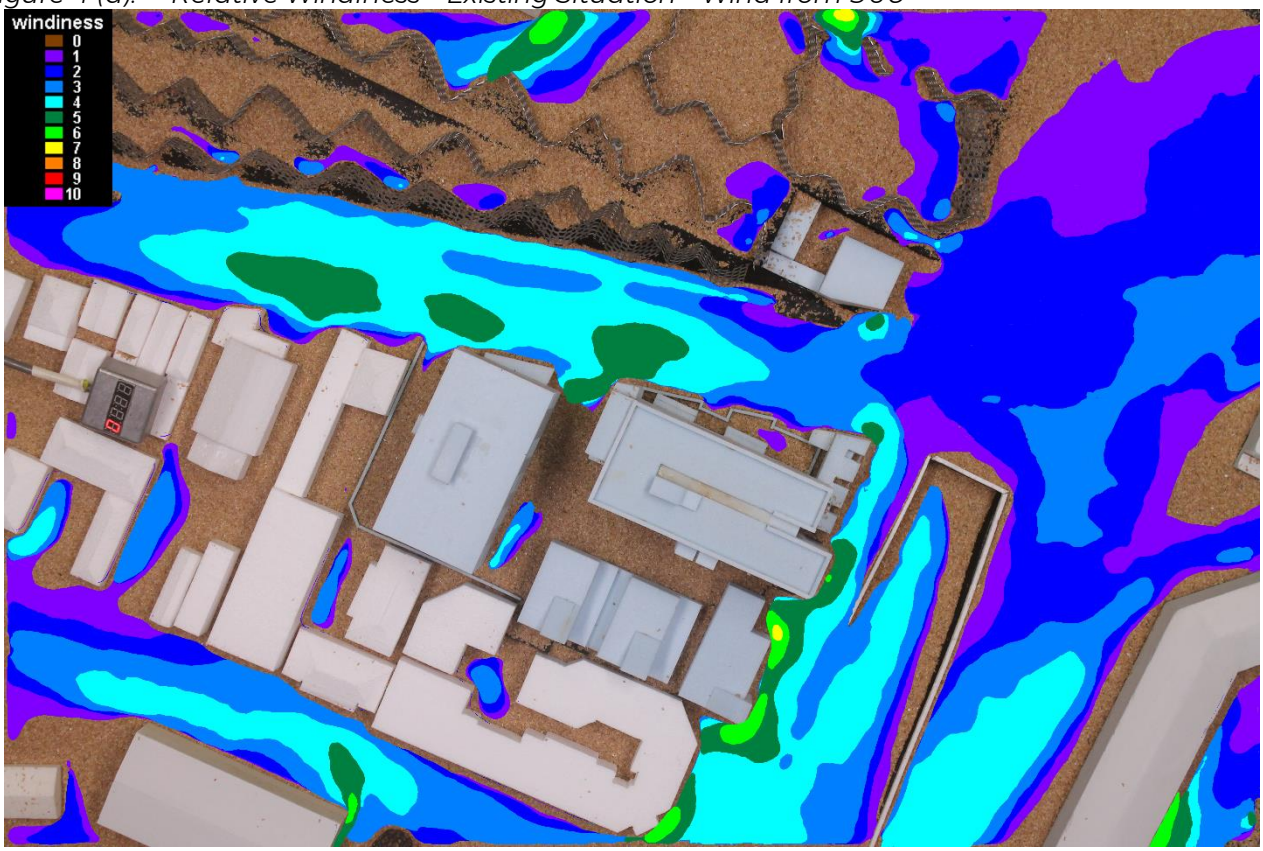

Figure 4 (b): Relative Windiness – Proposed Development – Wind from 360˚

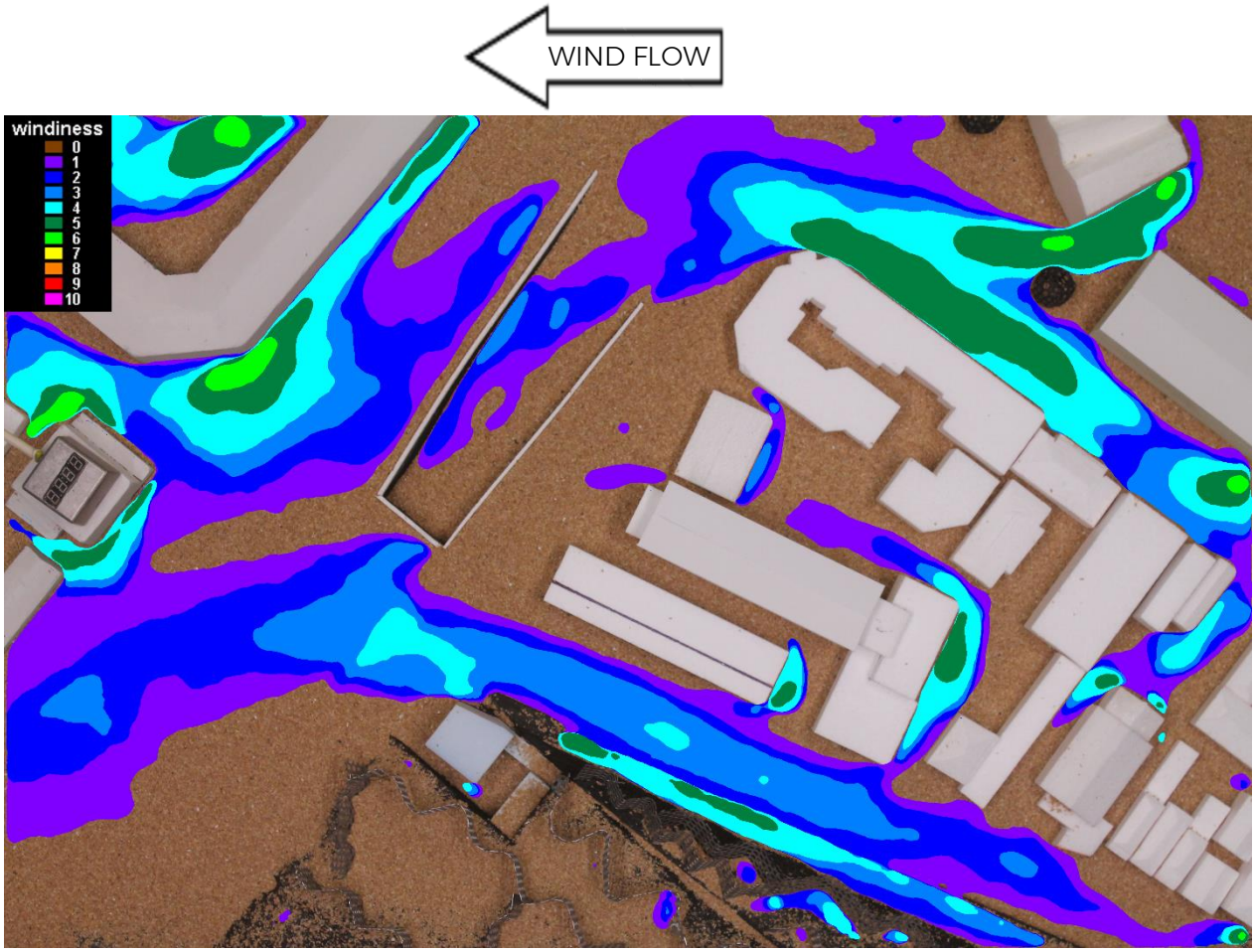

Figure 5 (a): Relative Windiness – Existing Situation – Wind from 170˚

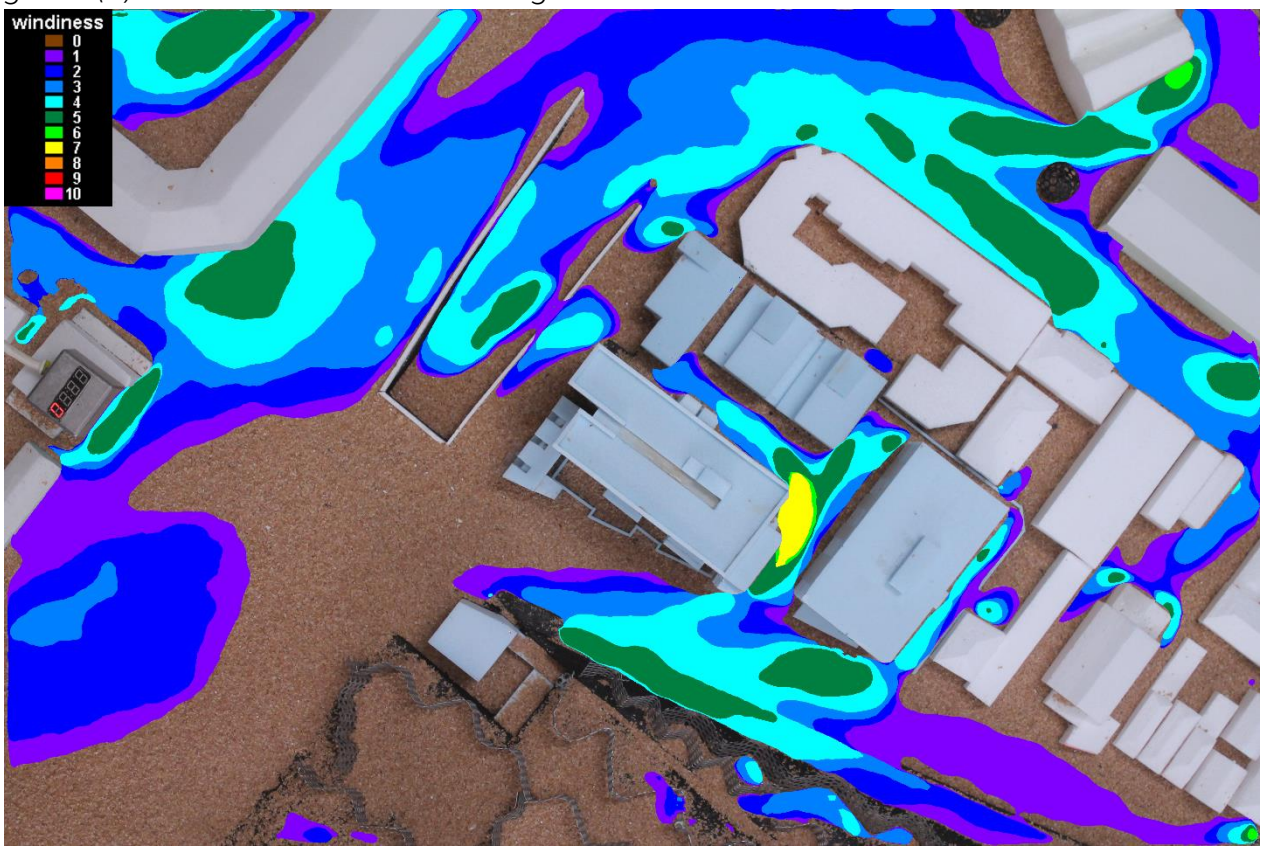

Figure 5 (b): Relative Windiness – Proposed Development – Wind from 170˚

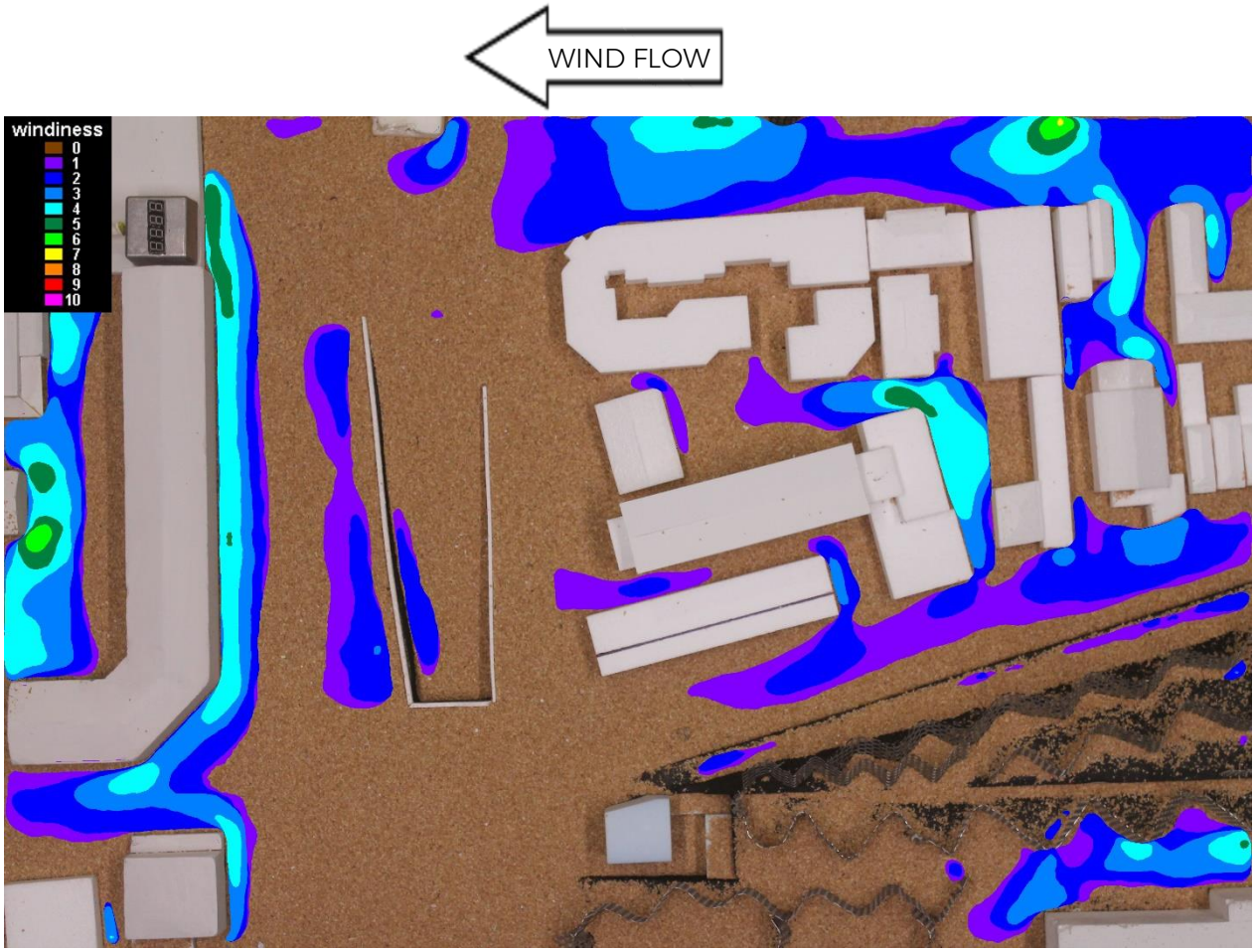

Figure 6 (a): Relative Windiness – Existing Situation – Wind from 210°

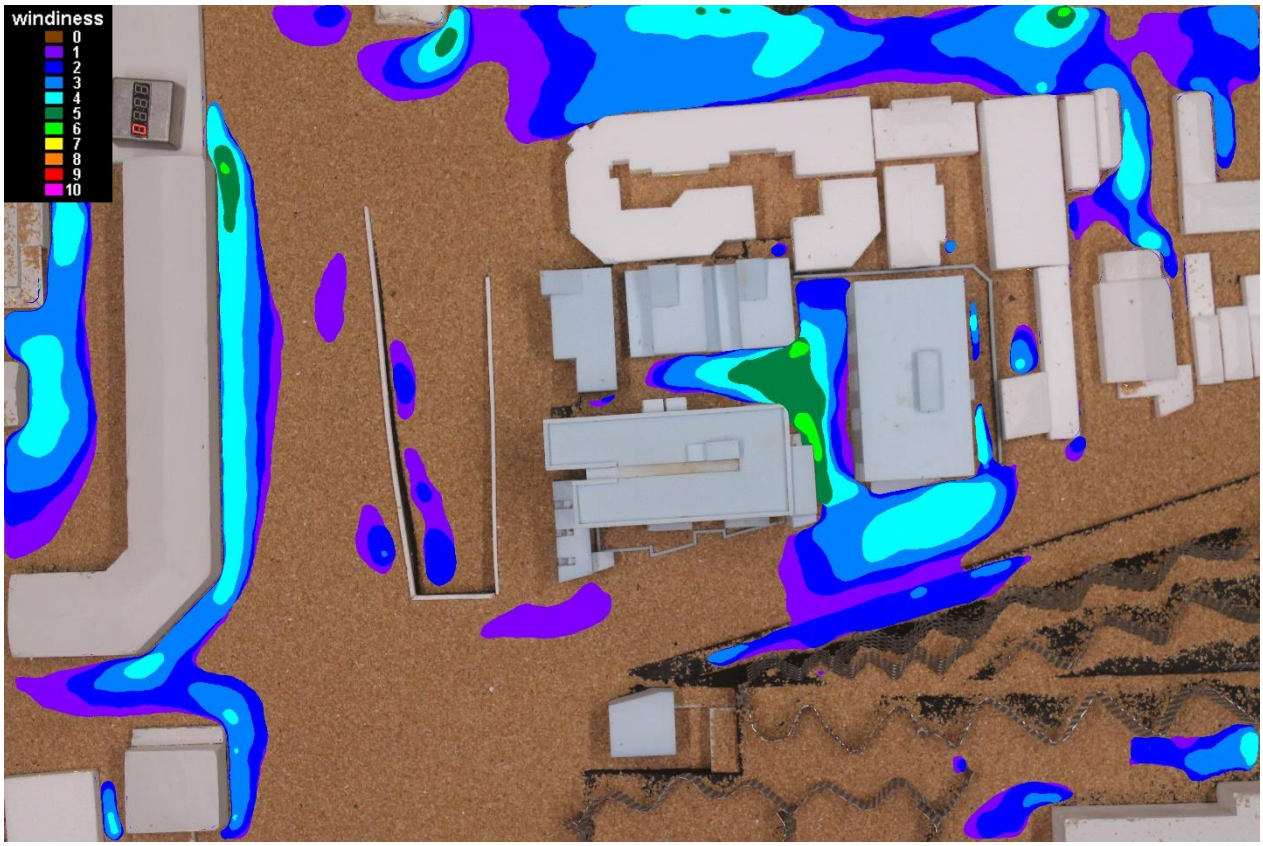

Figure 6 (b): Relative Windiness – Proposed Development – Wind from 210°

5 WIND SPEED MEASUREMENTS

5.1 RESULTS

Wind speeds were measured for the existing situation and the proposed development for the eight wind directions described in Section 3. The maximum calculated gust wind speeds at each location out of the eight wind directions are listed in Table 1. These speeds can be compared with the District Plan Safety Criteria wind speed of 20m/s. A change of 1 m/s in the wind 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 2m/s or more, or (2) increased the gust speed above the 20m/s Safety Criteria. The calculated gust speed for individual directions are listed in Appendix F.

Table 1: *Calculated Gust Speeds, V_C (m/s).*

Notes: Exg = with existing situation, New = with proposed development

= calculated gust speed > 20m/s Safety Criteria, - = not measured

▲ = increase of 2m/s or more over existing maximum gust speed,

▽ = decrease of 2m/s or more over existing maximum gust speed

Location	Exg		New	Location	Exg		New
A	21		20	A1	21	▲	27
B	20		21	B1	16	▲	19
C	20		21	C1	19	▲	25
D	21		22	D1	16	▲	20
E	21		21	E1	19	▲	25
F	20	▽	17	F1	17	▲	21
G	17		17	G1	17	▲	25
H	18		19	H1	16	▲	21
I	20	▲	22	I1	16	▲	26
J	19		18	J1	16	▲	21
K	20	▲	25	K1	21	▽	18
L	19	▲	23	L1	19		18
M	21	▲	25	M1	18		19
N	21		21	N1	18		18
O	20	▽	18	O1	20		19
P	19		20	P1	21	▽	18
Q	20	▽	17	Q1	22		23
R	17	▲	19	R1	20		19
S	21	▽	18	S1	20	▽	18
T	17	▲	20	T1	19		19
U	21		21	U1	19		19
V	18	▲	21	V1	20		20
W	20	▲	24	1	-		28
X	16	▲	20	2	-		21
Y	20		20	3	-		20
Z	16	▲	21	4	-		14
				6	-		13

	Decrease of 2m/s or more		Increase of 2m/s or more		Increased over 20m/s Safety Threshold		No Change		Change Not Measured

Figure 7: Significant Gust Speed Changes. (aerial image – LINZ, 2021)

6 FREQUENCY OF OCCURRENCE

6.1 RESULTS

The wind speeds listed in Section 5, and in Appendix F, can also be described in terms of the number of days per year the District Plan Cumulative Effect mean wind speeds of 2.5m/s) and 3.5m/s will be equalled or exceeded. This does not change the underlying data, but simply changes the variable from wind speed to days per year. Tables 2 and 3 list the total days per year that 2.5m/s and 3.5m/s are equalled or exceeded respectively, for the existing situation and the proposed development. An increase of 20 days/year is the maximum change that is acceptable according to the Wind Standard. Note that, in this context, a day is defined as a cumulative duration of 24 hours, which may be spread over several calendar days and different wind directions.

Table 2: Days per year Cumulative Effect Criteria (2.5m/s) Are Equalled or Exceeded.

Notes: Exg = existing situation, New = proposed development, - = not measured.

Δ = change between existing situation and proposed development.

= increase in time of occurrence > 20days.

= decrease in time of occurrence > 20days

Location	Exg	New	Δ	Location	Exg	New	Δ
A	220	171	-49	A1	28	242	214
B	207	142	-65	B1	197	235	38
C	202	134	-68	C1	84	233	149
D	144	120	-24	D1	206	213	7
E	184	109	-75	E1	61	149	88
F	172	85	-87	F1	192	205	13
G	103	40	-63	G1	74	169	95
H	128	106	-22	H1	155	192	37
I	140	184	44	I1	53	156	103
J	128	72	-56	J1	146	179	33
K	119	215	96	K1	158	103	-55
L	135	196	61	L1	190	194	4
M	150	169	19	M1	198	185	-13
N	80	84	4	N1	176	139	-37
O	166	78	-88	O1	216	206	-10
P	75	153	78	P1	117	61	-56
Q	183	89	-94	Q1	129	105	-24
R	78	165	87	R1	155	140	-15
S	188	124	-62	S1	143	139	-4
T	118	200	82	T1	137	138	1
U	200	128	-72	U1	139	156	17
V	166	224	58	V1	124	144	20
W	183	188	5	1	-	149	-
X	161	227	66	2	-	163	-
Y	153	181	28	3	-	118	-
Z	167	238	71	4	-	37	-
				6	-	0	-

Table 3: *Days per year Cumulative Effect Criteria (3.5m/s) Are Equalled or Exceeded.*

Notes: *Exg = existing situation, New = proposed development, - = not measured.*

Δ = change between existing situation and proposed development.

= increase in time of occurrence > 20days.

= decrease in time of occurrence > 20days

Location	Exg	New	Δ	Location	Exg	New	Δ
A	158	95	-63	A1	14	207	193
B	143	84	-59	B1	111	165	54
C	137	83	-54	C1	40	193	153
D	83	74	-9	D1	119	147	28
E	120	63	-57	E1	22	120	98
F	106	26	-80	F1	103	142	39
G	49	10	-39	G1	28	124	96
H	65	61	-4	H1	68	128	60
I	78	107	29	I1	28	98	70
J	70	30	-40	J1	59	118	59
K	58	151	93	K1	84	52	-32
L	65	125	60	L1	103	111	8
M	104	126	22	M1	117	109	-8
N	57	62	5	N1	96	63	-33
O	85	28	-57	O1	135	122	-13
P	42	73	31	P1	49	14	-35
Q	119	32	-87	Q1	82	54	-28
R	41	86	45	R1	84	74	-10
S	124	74	-50	S1	75	72	-3
T	50	121	71	T1	68	70	2
U	131	88	-43	U1	67	81	14
V	78	157	79	V1	63	81	18
W	111	138	27	1	-	83	-
X	72	160	88	2	-	87	-
Y	78	113	35	3	-	56	-
Z	75	170	95	4	-	11	-
				6	-	1	-

Figure 8 shows the differences in the time for which the Cumulative Effect Criteria threshold of 2.5m/s is exceeded between the existing situation and the proposed development. The diagram for the Cumulative Effect Criteria Threshold of 3.5m/s has not been reproduced as the locations of the changes and the general trends in the data are similar.

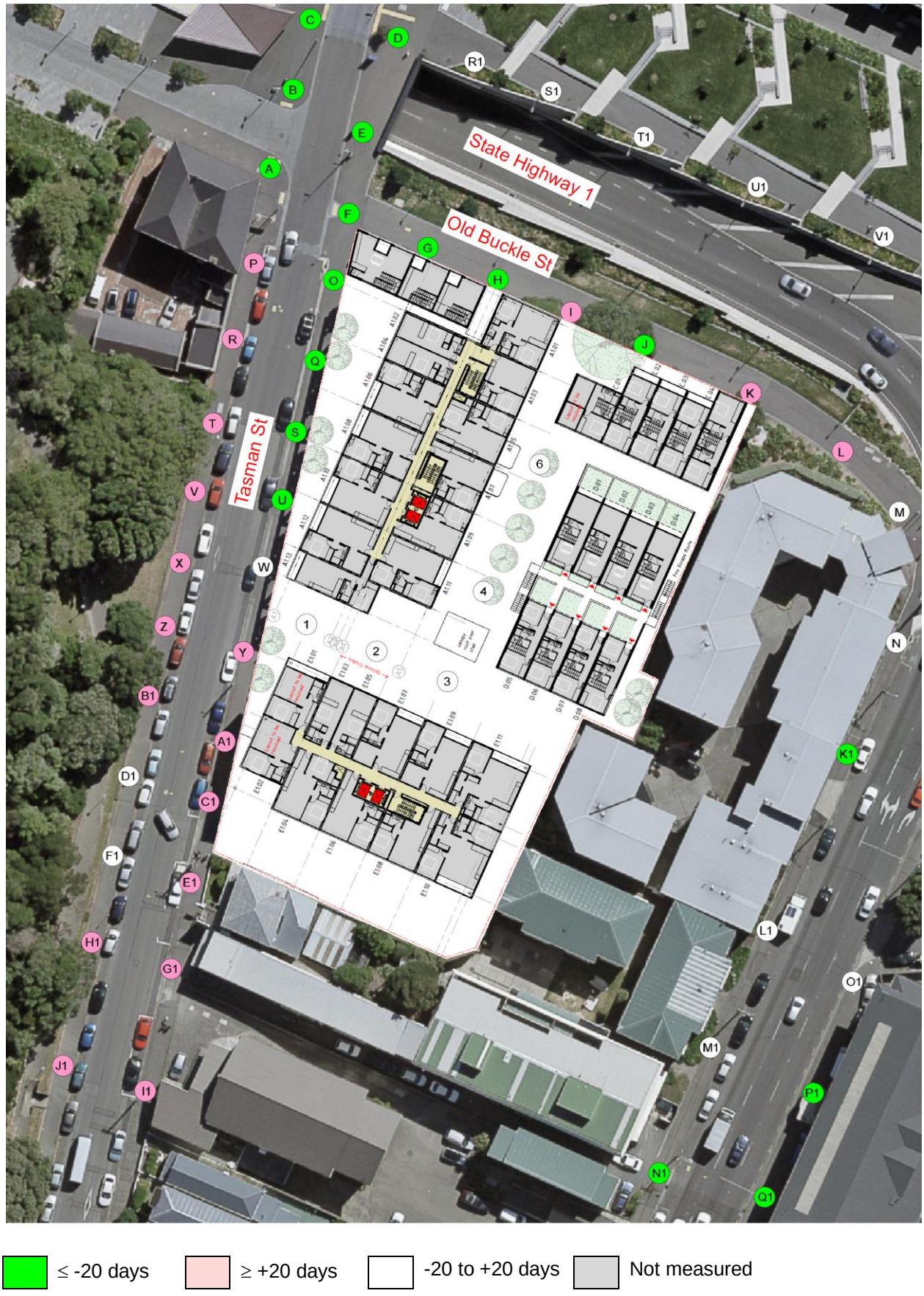

Figure 8: Changes in Number of Days Exceeding 2.5m/s Cumulative Effect Criteria.

7 DISCUSSION OF RESULTS

7.1 EXISTING LOCAL WIND ENVIRONMENT

The wind environment in the area around the development site is largely determined by a combination of (1) the orientation of the streets to the prevailing wind directions, (2) the width of the streets, (3) the topography and (4) the exposure to direct wind flows that different buildings have because of their height or because of open ground upwind of them.

Existing wind conditions around the site range from moderate to high, with localised areas of higher wind speeds. Overall, maximum gust speeds at around a quarter of locations exceed the 20m/s District Plan Safety Criteria.

7.2 HOT-FILM WIND SPEED MEASUREMENTS

Table 4 below summarises the calculated gust speed data from Table 1 and Appendix F. Included in this table are the numbers of locations where the 20m/s Safety Criteria gust speed threshold is exceeded.

Table 4: Summary of Calculated Gust Speed Results.
Exg = existing situation, New = proposed development, - = Not Measured

Parameter			Configuration	
			Exg	New
Maximum Gust Speed (m/s)[1]	-	Streets and open areas (offsite)	22	27
	-	Open areas (onsite)	-	28
Minimum Gust Speed (m/s)[1]			16	17
Number of locations where calculated gust speed V_c > 20m/s			11	22
Number of increases in gust speeds Vc of 2m/s or more (Exg – New)			20	
Number of locations where gust speeds Vc are increased over 20m/s			15	
Number of reductions in gust speeds Vc of 2m/s or more (Exg – New)			7	
Number of locations where gust speeds Vc over 20m/s are reduced			3	

1 – maximum or minimum from the eight wind directions measured

Tables 1 and 4, and Figures 7 show the following:

- The lowest gust speeds are about the same for the existing situation and the proposed development.
- The highest gust speeds are higher for the proposed development, both in the streets and surrounding open areas, and within the site itself.
- There are around three times the number of increases of 2m/s or more than there are reductions of 2m/s or more, and there are significant numbers of locations where the maximum gust speed is increased over the 20m/s District Plan Safety Threshold. Of

these latter locations, most occur in Tasman Street, although several also occur in Old Buckle Street east of the development midline.

- Overall, the proposed development causes a deterioration in the local gust wind speed environment.

7.3 FREQUENCY OF OCCURRENCE DATA

7.3.1 CUMULATIVE EFFECT CRITERIA

Table 5 summarises the frequency of occurrence data for both the 2.5m/s and 3.5m/s Cumulative Effect Criteria. Included in this table are the numbers of locations where changes in the frequency of occurrence are greater than ±20days/year. An increase of 20 days/year is the maximum acceptable change allowed for by the Wind Standard at a specific location. The parameters described are intended to provide an overview of how the development is performing.

Table 5: Summary of Frequency of Occurrence Data.
Exg = existing situation, New = proposed development, - = Not Measured

Parameter	speed = 2.5 m/s		speed = 3.5 m/s	
	Exg	New	Exg	New
Maximum Days Exceeding the speed (at any location)	220	242	158	207
Minimum Days Exceeding the speed (at any location)	28	40	14	10
No of locations where speed **increases** (Exg to New) > 20 days	18		22	
No of locations where speed **decreases** (Exg to New) > 20 days	17		15	
Largest **increase** in days exceeding speed (Exg to New)	214		193	
Largest **decrease** in days exceeding speed (Exg to New)	-95		-87	

Tables 2, 3 and 5 and Figure 8 show the following:

- The maximum number of days the speed is exceeded is higher for the proposed development than the existing situation, for the 2.5m/s threshold and for the 3.5m/s threshold.
- The minimum number of days the speed is exceeded is about the same for the existing situation and the proposed development.
- The number of locations where the proposed development increases the time that the mean speed equals or exceeds the Cumulative Effect thresholds of 2.5m/s and 3.5m/s is comparable to the number of locations where it reduces the time. However, in general the increases are larger than the reductions.
- Overall, the proposed development represents a deterioration in the amenity of the pedestrian wind speed environment in the surrounding area.

7.4 OVERALL ASSESSMENT OF BUILDING DESIGN

The wind tunnel data shows that the proposed development causes a net deterioration in the local pedestrian wind environment, with the increases in wind speeds, mostly in Tasman Street, outweighing the reductions that occur around the northern end of the development, including in Pukeahu Park. The increases in wind conditions identified are primarily due to a combination of vertical wind flows being deflected down the windward faces of the two taller buildings in the development proposal and horizontal wind flows at ground level being channelled and deflected around these two buildings.

7.5 INVESTIGATION OF DESIGN CHANGES

Having identified locations where either (1) the maximum gust speeds were increased above the 20m/s Safety Criteria, (2) changes in the frequency of occurrence data were greater than 20 days/year, or (3) both gust speeds and changes in frequency of occurrence were increased, it was considered appropriate to investigate the effect of design configuration changes and potential wind mitigation options. In addition, the acquisition of the neighbouring site to the south created scope for design changes. Accordingly, additional wind speed measurements were carried out for a selected locations and wind directions for two options.

Option 1 comprises an aggregation of the following design changes, which were guided by a combination of heritage, urban design and wind advice, and influenced by the acquisition of the site to the south:

- North tower block shifted 2m South and 0.4m east.
- North tower block level 9 setback back west façade (i.e. one floor reduction in height)
- North West Corner townhouses extended further south along Tasman St
- Large trees included along Tasman St in front of Northern Apartments.
- South tower block shifted south approx. 7m (site to south has also been acquired)
- South tower block increased by 1 level
- South tower block footprint adjusted – steps on the south corners
- Proposed planting in the gap between North and South tower blocks
- Proposed planting in the space between the southern boundary and South tower block.

Option 2 comprises the design changes listed in Option 1, with the inclusion of a large canopy. This canopy extends from the northwest corner of the South tower block to the southern site boundary, 0.3m from the Tasman Street kerb and also extends along part of the southern façade of the South tower block.

Wind speed measurements were carried out at locations and for wind directions where changes in the gust speed and frequency of occurrence data were identified between the existing situation and the proposed development. Table 6 summarises the gust speed data in terms of the maximum calculated gust speed at each location for any wind direction.

Table 6: Effects of Design Changes – Maximum Calculated Gust Speeds, V_C (m/s).

Notes: E = with existing situation, N = with original design, 1 = Option 1, 2 = Option 2
= calculated gust speed > 20m/s Safety Criteria, - = not measured

Location	340°				360°				170°				190°			
	E	N	1	2	E	N	1	2	E	N	1	2	E	N	1	2
I	20	22	18	-	18	20	17		15	19	-	-	10	16	-	-
K	20	25	22	22	16	24	24	22	15	20	-	-	13	19	-	-
L	19	23	22	22	16	20	20	20	17	19	-	-	13	17	-	-
M	21	25	24	23	21	24	23	24	12	16	-	-	17	14	-	-
P	13	20	17	-	14	18	17	-	16	16	-	-	19	16	-	-
R	11	15	15	-	11	14	15	-	16	18	-	-	17	19	-	-
T	13	16	16	-	13	15	16	-	16	20	-	-	17	20	-	-
V	14	19	18	-	14	16	17	-	17	20	20	21	18	21	20	20
W	20	24	20	-	18	23	21	-	14	16	-	-	18	15	-	-
X	13	19	18	-	13	16	17	-	16	20	21	20	16	20	21	21
Z	14	19	18	18	13	17	17	15	16	19	21	21	16	21	20	21
A1	10	24	19	18	12	23	18	16	15	23	13	10	21	27	14	10
B1	15	19	18	18	14	17	17	15	16	17	19	18	16	19	20	19
C1	12	25	21	20	13	22	23	18	17	21	26	19	19	24	26	20
D1	16	20	18	18	15	18	18	15	16	15	-	-	16	17	-	-
E1	13	25	22	19	13	23	21	16	16	11	19	18	19	15	22	20
F1	17	21	18	17	15	19	18	15	16	14	-	-	16	16	-	-
G1	13	25	22	19	14	23	22	18	15	13	-	-	17	16	-	-
H1	14	21	18	18	16	19	17	19	14	14	-	-	15	15	-	-
I1	7	26	23	22	11	22	22	22	14	11	-	-	16	16	-	-
J1	15	21	18	18	15	19	18	19	15	13	-	-	16	15	-	-
1	-	28	16	-	-	21	-	-	-	16	-	-		16	10	-
2	-	21	11	-	-	17	-	-	-	20	-	-		20	13	-
3	-	16	14	-	-	11	-	-	-	19	-	-		20	17	-

Table 7 summarises the frequency of occurrence data in terms of the number of days per year that the 2.5m/s mean speed is exceeded.

Table 7: Effects of Design Changes – Frequency of Occurrence (days/year > 2.5m/s).

Notes: E = with existing situation, N = with original design, 1 = Option 1, 2 = Option 2
- = not measured

Location	340°				360°				170°				190°			
	E	N	1	2	E	N	1	2	E	N	1	2	E	N	1	2
I	52	51	47	-	48	52	34	-	19	33	-	-	0	12	-	-
K	50	56	55	-	39	69	66	-	12	30	-	-	3	21	-	-
L	48	54	54	-	42	57	60	-	24	33	-	-	7	21	-	-
M	53	56	55	-	68	71	71	-	0	9	-	-	10	1	-	-
P	0	46	39	-	2	21	18	-	28	28	-	-	28	19	-	-
R	2	41	43	-	1	24	32	-	29	34	-	-	26	26	-	-
T	17	48	49	-	17	45	54	-	29	36	-	-	28	29	-	-
V	34	53	52	-	43	59	63	-	31	37	36	35	29	31	30	28
W	51	57	54	-	65	71	66	-	14	24	-	-	18	9	-	-
X	35	54	52	-	43	62	65	-	29	37	36	34	26	31	31	29
Z	35	53	52	52	47	66	66	60	27	36	36	36	25	33	31	31
A1	0	56	52	52	1	73	63	56	1	39	3	0	19	36	3	0
B1	45	54	52	51	56	66	64	61	31	32	36	34	27	30	31	31
C1	3	57	55	55	12	72	71	66	27	37	39	30	25	32	36	27
D1	46	54	52	52	59	69	66	63	31	19	-	-	27	25	-	-
E1	4	56	55	53	13	71	71	62	13	0	29	30	21	7	28	26
F1	43	55	52	52	57	71	67	62	27	16	-	-	26	22	-	-
G1	7	55	55	54	15	69	71	66	17	9	-	-	24	17	-	-
H1	28	54	52	52	52	68	65	69	22	16	-	-	24	20	-	-
I1	0	53	51	51	0	55	59	64	20	7	-	-	23	21	-	-
J1	26	54	51	51	48	65	65	65	23	11	-	-	23	20	-	-
1	-	54	22	-	-	23	-	-	-	20	-	-	-	17	0	-
2	-	50	1	-	-	24	-	-	-	30	-	-	-	21	3	-
3	-	32	6	-	-	1	-	-	-	29	-	-	-	24	18	-

Table 8 shows the differences between (a) the existing situation and the original design, (b) the original design and Option 1, and (c) Option 1 and Option 2. To illustrate trends the differences of 2 days/year or more have been highlighted. For example, at Location K for a wind direction of 340° the original design increases the time by 6days/yr compared to the existing situation.

Table 8: *Effects of Design Changes – Frequency of Occurrence (days/year > 2.5m/s). Differences* (= increase = decrease)

Notes: E = with existing situation, N = with original design, 1 = Option 1, 2 = Option 2
- = not measured,

Location	340°			360°			170°			190°		
	Δ N-E	Δ 1-N	Δ 2-1	Δ N-E	Δ 1-N	Δ 2-1	Δ N-E	Δ 1-N	Δ 2-1	Δ N-E	Δ 1-N	Δ 2-1
I	-1	-4	-	3	-17	-	14	-	-	12	-	-
K	6	-1	-	30	-3	-	18	-	-	18	-	-
L	6	0	-	14	3	-	9	-	-	14	-	-
M	3	0	-	3	0	-	9	-	-	-9	-	-
P	46	-7	-	19	-3	-	-1	-	-	-9	-	-
R	39	2	-	23	8	-	6	-	-	0	-	-
T	31	1	-	28	9	-	7	-	-	1	-	-
V	19	-1	-	16	4	-	6	-1	0	2	-1	-2
W	5	-2	-	6	-5	-	10	-	-	-9	-	-
X	19	-1	-	19	3	-	8	-1	-2	5	0	-2
Z	18	-1	0	20	-1	-5	8	1	0	8	-1	0
A1	56	-4	0	71	-10	-7	38	-36	-3	17	-33	-3
B1	8	-2	0	10	-2	-3	1	4	-1	3	1	1
C1	54	-1	-1	61	-2	-5	9	3	-10	8	3	-9
D1	8	-2	0	10	-3	-3	-12	-	-	-2	-	-
E1	52	-1	-2	58	0	-9	-13	29	0	-14	21	-2
F1	11	-3	0	13	-4	-4	-11	-	-	-5	-	-
G1	49	0	-1	55	1	-5	-8	-	-	-7	-	-
H1	27	-2	1	15	-3	4	-5	-	-	-4	-	-
I1	53	-2	0	55	5	4	-13	-	-	-2	-	-
J1	28	-3	0	17	0	0	-11	-	-	-3	-	-
1	-	-32	-	-	-	-	-	-	-	-	-17	-
2	-	-50	-	-	-	-	-	-	-	-	-18	-
3	-	-27	-	-	-	-	-	-	-	-	-7	-

Tables 6, 7 and 8 show that Option 1 performed better than the original design, both in terms of the gust speeds and the frequency of occurrence data. Adding a substantial canopy in Option 2 resulted in further mitigation of wind conditions in Tasman Street, with these changes eliminating some of the increases over the 20m/s Safety Criteria identified with the original design.

8 CONCLUSIONS

The following conclusions have been drawn from a wind tunnel study of pedestrian wind conditions around a proposed development for a large site at One Tasman Street in southern central Wellington. Three design options were tested for the proposed development, these being the original design and two modified designs – Option 1 and Option 2.

Existing Wind Conditions

1 Existing wind conditions in the area around the site mostly range from moderate to high, with localised areas of higher wind speed, where gust speeds exceed the safety threshold of 20m/s specified in the District Plan.

Gust Speeds – Safety Criteria

2 The gust speed data shows that the original development design causes a net deterioration in the local pedestrian wind environment, with the increases in wind speeds, mostly in Tasman Street, outweighing the reductions, mostly around the northwest corner of the development. Most of the larger increases identified occurred in northerly winds, with vertical wind flows being deflected down the windward faces of the two taller buildings and being channelled south along Tasman Street.

3 There are seven locations where the gust speeds are reduced with the original development design, compared to twenty-two locations where the gust speed is increased. At fifteen of these locations the gust speeds are increased over the 20m/s District Plan Safety Criteria.

Frequency of Occurrence – Cumulative Effect Criteria

4 There are more locations where the original development design increases the time that the mean speed equals or exceeds the District Plan Cumulative Effect mean speed thresholds of 2.5m/s and 3.5m/ by more than 20 days/year than where it reduces the time by more than 20days/year. Overall, this represents a deterioration in the amenity of the wind environment in the surrounding area.

5 The original development design does produce an improvement in the amenity around the northwest corner of the development, including over a sizeable area of Pukeahu Park.

Overall Assessment of Design

6 Taken overall, the original development design causes an identifiable deterioration in wind conditions in the pedestrian areas surrounding the site. This includes a substantial part of Tasman Street adjacent to the site.

Effects of Design Changes

7 Additional testing of design changes showed that the negative effects of the original design of the development, as first tested, could be partially mitigated. An aggregation of different design changes (Option 1), including those informed by heritage, urban design and wind inputs, and influenced by the acquisition of the site to the south, produced some significant improvements over the original design. The further inclusion of a large canopy (Option 2) offered additional mitigation of some of the effects identified in Tasman Street.

8 It is understood that the design changes that were tested as Option 1 and Option 2 have been included in the development design that is being submitted for resource consent.

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9 LIMITATIONS

This report ('Report') has been prepared by WSP exclusively for One Tasman Development Limited Partnership ('Client') in relation to the pedestrian level wind study of the proposed One Pukeahu Park development in Wellington ('Purpose') and in accordance with our offer of service dated 15th April 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.

APPENDIX A WIND EFFECTS ON PEOPLE

GENERAL

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 below gives a summary of the typical effects of 3-second gust speeds on people in an urban situation (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 most widely accepted is in terms of the “annual maximum 3 second gust”. The criteria used (after Melbourne) 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

For Wellington wind tunnel studies, we calculate a gust speed, which is based on the annual maximum hourly mean speed for a particular wind direction. It describes 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 a factor, as defined in the Wellington City District Plan.

The Wellington City District Plan specifies a gust speed of 20m/s as a maximum 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 City. It may be seen that the gust speed of 20m/s, which is the maximum allowable by the Wellington City Council, 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 within Wellington, whereas Table A1 describes the effects of these wind speeds on people.

Note the differences between the three tables listed here, as they use similar wind speed measurements, but describe different issues:

Table A1: Describes the effects on people when they experience a gust of wind.
Table A2: Internationally recognised criteria for determining the acceptability of wind conditions at a certain location throughout the year.
Table A3: Relative descriptions of the variation of wind conditions that occur at different locations in Wellington.

Table A3: Suggested descriptive terms for the range of gust wind speeds which typically occur at different locations within Wellington City.

Annual maximum gust speed (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 Wellington City District Plan, including the Objectives, Policies and Standards relating to wind 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.

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 Figure C2.

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.

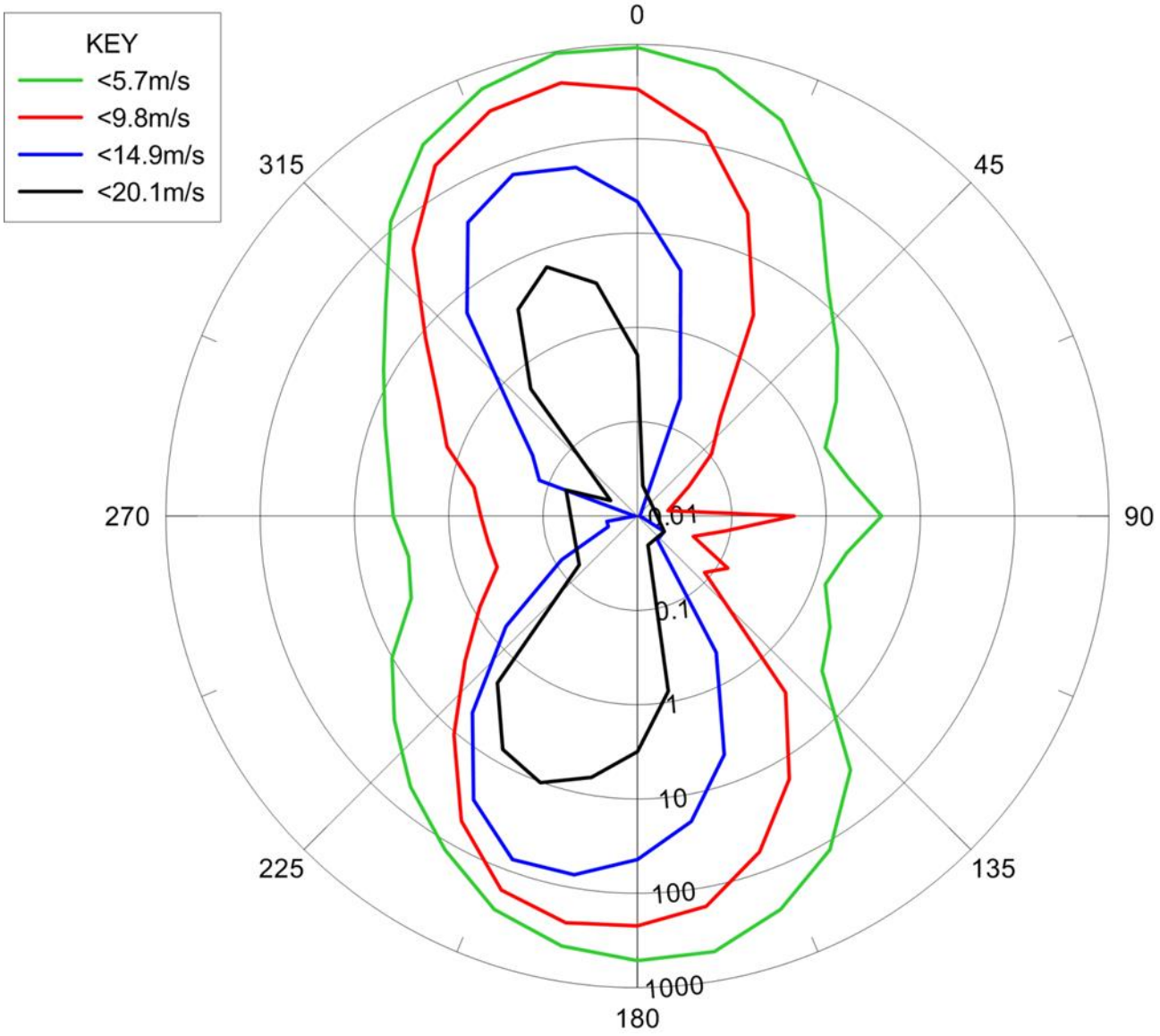

Figure C1: Wind Rose for Wellington City – 150m above ground level. (number of hours/year wind speeds are equalled or exceeded)

Figure C2: Wellington City Wind Data.

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

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

Figure C2: Wellington City Wind Data (continued).

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 7 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 City. The building was tested in the standard terrain category 3 atmospheric boundary layer simulation, which is used for environmental building studies in Wellington City. 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.

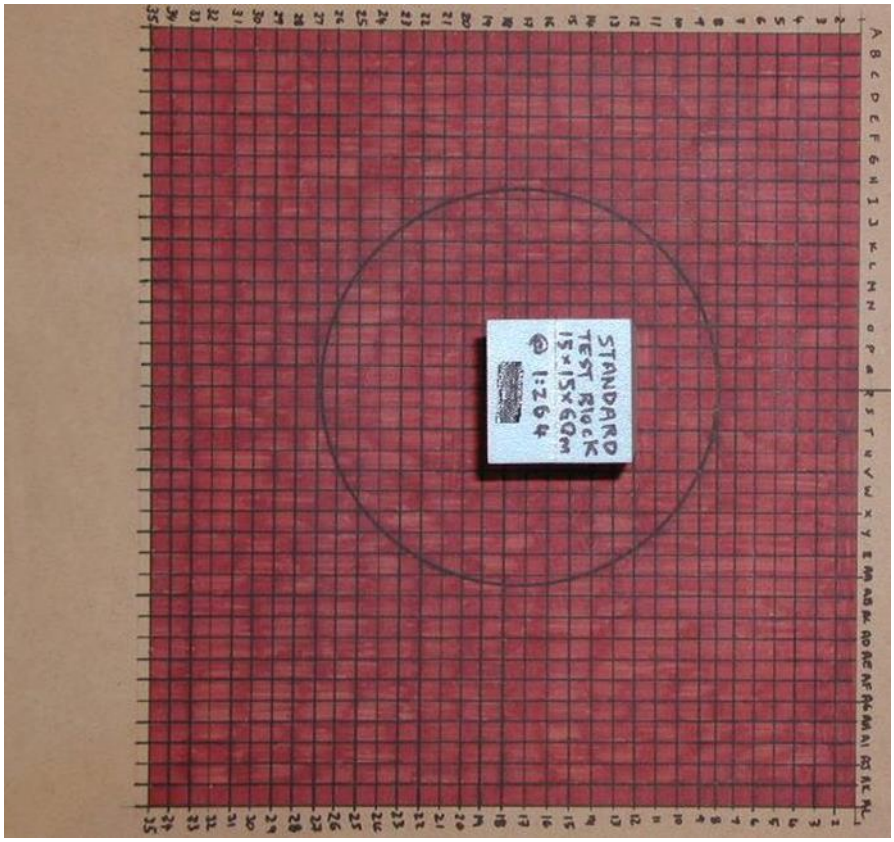

Figure E1: Aerial view of the calibration model building and measurement grid.

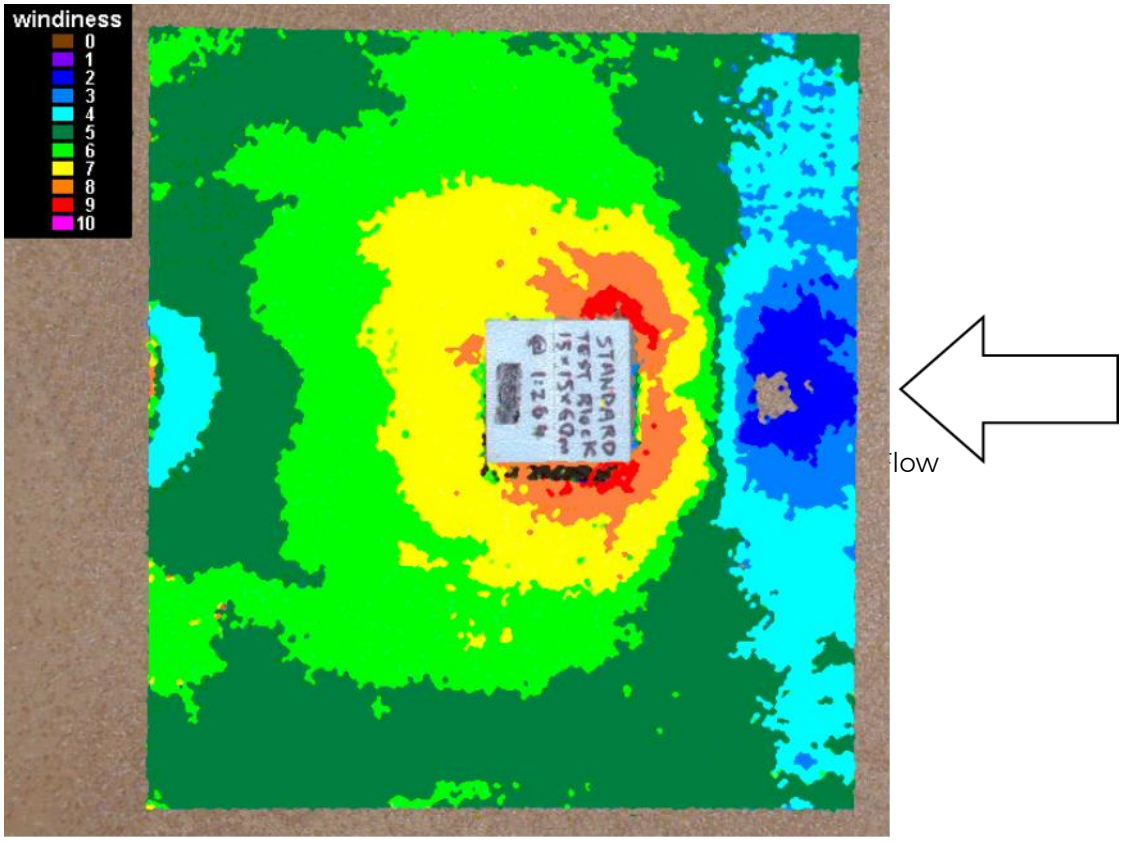

Figure E2: Erosion contours for calibration building (60m x 15m x 15m).

APPENDIX F GUST WIND SPEEDS

A change of 1 m/s in the wind speeds 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: Calculated Maximum Annual Gust Wind Speeds, V_c (m/s)

Notes: Exg = existing situation, New = proposed development, - = not measured

	320 Deg		340 Deg		360 Deg		20 Deg		150 Deg		170 Deg		190 Deg		210 Deg	
Location	Exg	New	Exg	New	Exg	New	Exg	New	Exg	New	Exg	New	Exg	New	Exg	New
A	20	16	20	20	21	20	14	12	16	14	18	17	19	16	14	15
B	19	18	20	21	19	19	12	12	16	12	19	14	19	15	15	14
C	20	17	19	21	19	19	11	11	15	11	19	14	20	13	16	14
D	19	18	21	22	19	19	12	11	13	9	14	14	16	11	16	17
E	19	16	21	21	20	19	13	11	11	8	15	10	18	12	17	18
F	18	13	19	16	18	16	12	15	12	10	18	13	20	12	17	17
G	15	15	17	17	17	15	11	9	10	9	9	10	8	6	8	4
H	15	14	18	19	18	18	11	10	12	9	14	8	10	8	17	8
I	17	20	20	22	18	20	12	14	11	16	15	19	10	16	8	9
J	16	18	19	18	17	16	12	12	10	9	14	8	12	7	10	5
K	16	21	20	25	16	24	11	17	11	13	15	20	13	19	13	12
L	16	21	19	23	16	20	12	14	10	12	17	19	13	17	9	14
M	18	20	21	25	21	24	14	18	10	12	12	16	17	14	8	12
N	10	9	9	7	10	9	10	8	14	15	21	21	21	21	18	19
O	14	14	19	18	16	15	14	8	11	8	15	9	20	8	16	13
P	7	16	13	20	14	18	13	13	13	13	16	16	19	16	15	16
Q	17	14	20	17	18	16	12	11	11	10	14	10	17	9	16	13
R	9	13	11	15	11	14	12	12	13	15	16	18	17	19	15	18
S	18	15	21	18	19	16	12	11	11	10	13	12	17	9	16	13
T	11	14	13	16	13	15	11	12	14	16	16	20	17	20	15	18
U	18	17	21	21	19	16	12	11	11	8	14	10	19	9	15	13
V	12	16	14	19	14	16	11	11	12	16	17	20	18	21	15	20
W	17	22	20	24	18	23	12	10	10	14	14	16	18	15	16	15
X	12	16	13	19	13	16	10	11	13	15	16	20	16	20	15	20
Y	15	17	20	20	18	18	12	11	10	13	12	17	18	18	16	18
Z	12	17	14	19	13	17	11	12	13	15	16	19	16	21	14	18
A1	6	22	10	24	12	23	11	10	11	17	15	23	21	27	18	25
B1	13	17	15	19	14	17	11	13	14	14	16	17	16	19	15	17
C1	8	22	12	25	13	22	12	11	13	16	17	21	19	24	18	23
D1	15	18	16	20	15	18	12	13	14	12	16	15	16	17	14	14
E1	6	22	13	25	13	23	11	10	13	10	16	11	19	15	18	12
F1	13	17	17	21	15	19	12	13	14	13	16	14	16	16	15	13
G1	8	22	13	25	14	23	10	10	11	10	15	13	17	16	16	13
H1	9	19	14	21	16	19	12	12	14	13	14	14	15	15	14	13
I1	4	23	7	26	11	22	10	9	10	10	14	11	16	16	16	16
J1	7	19	15	21	15	19	12	11	13	13	15	13	16	15	14	14
K1	11	7	18	11	15	14	11	9	15	15	21	18	18	18	16	17
L1	13	14	16	16	17	18	13	12	15	14	19	17	17	17	16	15
M1	13	13	18	19	18	19	13	11	12	12	16	15	17	18	16	17
N1	12	12	16	17	18	16	12	10	12	12	17	15	18	18	16	17
O1	14	18	19	19	20	19	16	13	14	14	20	18	17	19	17	17
P1	14	10	20	17	21	18	9	10	12	11	14	13	13	14	17	17
Q1	16	12	20	21	20	18	10	10	7	6	11	11	17	18	22	23
R1	17	17	20	19	17	17	12	10	14	15	17	18	15	17	15	14
S1	17	17	20	18	16	16	13	10	13	14	17	16	16	17	14	12
T1	17	17	19	19	16	16	12	11	14	13	16	16	16	17	13	11
U1	17	17	19	19	17	17	13	12	13	13	17	18	16	18	15	12
V1	17	18	20	20	18	19	12	12	13	12	14	15	15	17	15	12
1	-	25	-	28	-	21	-	13	-	12	-	16	-	16	-	16
2	-	20	-	21	-	17	-	13	-	14	-	20	-	20	-	16
3	-	14	-	16	-	11	-	11	-	14	-	19	-	20	-	17
4	-	8	-	9	-	13	-	10	-	13	-	14	-	12	-	13
6	-	9	-	10	-	13	-	11	-	10	-	13	-	9	-	13

APPENDIX G FREQUENCY OF OCCURRENCE DATA

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 exceeds 2.5m/s.

Notes: Exg = existing situation, New = proposed development, - = not measured

	320 Deg		340 Deg		360 Deg		20 Deg		150 Deg		170 Deg		190 Deg		210 Deg	
Location	Exg	New	Exg	New	Exg	New	Exg	New	Exg	New	Exg	New	Exg	New	Exg	New
A	13	10	53	52	67	58	8	8	12	5	35	19	28	14	4	4
B	13	13	53	54	59	53	4	5	11	1	35	8	27	5	4	3
C	13	13	52	53	60	54	1	2	10	1	32	6	28	1	5	4
D	13	13	53	53	49	43	3	2	2	0	6	3	12	0	6	6
E	13	11	54	51	62	39	7	2	4	0	18	0	20	0	7	6
F	12	6	51	33	54	23	0	15	2	0	21	1	24	0	7	6
G	11	8	42	26	48	4	1	0	0	0	0	1	0	0	0	0
H	12	11	48	51	49	44	2	1	4	0	10	0	0	0	3	0
I	12	12	52	51	48	52	4	13	5	11	19	33	0	12	0	0
J	12	11	52	41	47	16	4	4	1	0	11	0	1	0	0	0
K	12	13	50	56	39	69	1	19	1	7	12	30	3	21	1	0
L	11	13	48	54	42	57	1	12	2	3	24	33	7	21	0	3
M	12	13	53	56	68	71	6	18	1	2	0	8	10	1	0	0
N	2	0	0	0	0	0	0	0	2	5	36	37	32	32	9	10
O	8	7	46	41	52	28	10	0	3	0	15	0	25	0	7	2
P	0	10	0	46	2	21	4	14	8	10	28	28	28	19	6	6
Q	11	9	52	40	65	34	5	5	4	0	16	0	23	0	6	1
R	1	9	2	41	1	24	5	12	8	12	29	34	26	26	6	7
S	12	11	53	50	69	56	8	5	6	1	14	1	21	0	6	2
T	5	11	17	48	17	45	6	12	9	12	29	36	28	29	6	7
U	12	12	53	54	67	57	14	4	5	0	19	0	25	0	5	1
V	7	12	34	53	43	59	9	12	7	12	31	37	29	31	7	8
W	11	13	51	57	65	71	15	1	3	9	14	24	18	9	5	4
X	7	12	35	54	43	62	9	13	7	11	29	37	26	31	6	8
Y	9	12	46	53	56	64	13	12	1	3	5	15	18	16	6	5
Z	7	12	35	53	47	66	12	18	8	11	27	36	25	33	6	8
A1	0	13	0	56	1	73	0	0	0	12	1	39	19	36	7	12
B1	9	12	45	54	56	66	14	22	9	11	31	32	27	30	6	8
C1	0	13	3	57	12	72	2	2	8	11	27	37	25	32	7	9
D1	10	13	46	54	59	69	18	21	9	6	31	19	27	25	6	6
E1	0	13	4	56	13	71	1	0	3	0	13	0	21	7	7	1
F1	6	12	43	55	57	71	17	18	9	7	27	16	26	22	6	5
G1	0	13	7	55	15	69	1	0	4	1	17	9	24	17	6	4
H1	0	13	28	54	52	68	13	10	9	6	22	16	24	20	6	5
I1	0	12	0	53	0	55	0	0	3	2	20	7	23	21	7	6
J1	0	13	26	54	48	65	14	6	7	5	23	11	23	20	6	5
K1	2	0	43	3	36	22	2	2	6	6	35	32	27	29	8	9
L1	9	9	47	46	59	64	18	17	7	6	22	21	21	23	6	7
M1	9	5	50	47	61	66	19	14	3	3	26	19	23	24	6	6
N1	7	3	47	41	52	34	7	2	3	4	29	24	26	26	6	6
O1	9	11	50	45	61	59	20	15	9	9	36	33	24	25	7	7
P1	6	0	44	26	45	16	0	0	3	1	10	8	3	2	6	7
Q1	10	1	51	47	58	46	0	0	0	0	0	0	3	2	7	8
R1	12	12	52	50	39	24	2	1	9	11	28	30	9	10	4	2
S1	12	12	52	48	30	21	3	1	8	10	26	28	11	17	1	1
T1	12	12	51	50	26	23	3	3	9	9	22	24	13	15	0	1
U1	12	12	50	51	34	35	4	6	6	6	22	27	9	17	2	1
V1	12	13	51	52	38	51	0	3	5	2	6	10	7	11	3	1
1	-	13	-	54	-	23	-	11	-	5	-	20	-	17	-	6
2	-	13	-	50	-	24	-	13	-	7	-	30	-	21	-	6
3	-	8	-	32	-	1	-	9	-	9	-	29	-	24	-	6
4	-	0	-	0	-	0	-	0	-	7	-	20	-	5	-	4
5	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0
6	-	0	-	0	-	0	-	2	-	0	-	7	-	0	-	0

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

Notes: Exg = existing situation, New = proposed development, - = not measured

	320 Deg		340 Deg		360 Deg		20 Deg		150 Deg		170 Deg		190 Deg		210 Deg	
Location	Exg	New	Exg	New	Exg	New	Exg	New	Exg	New	Exg	New	Exg	New	Exg	New
A	11	6	44	41	48	33	1	1	8	1	24	7	20	4	1	1
B	11	10	44	45	34	26	0	0	8	0	25	1	20	0	1	0
C	11	10	42	44	36	27	0	0	5	0	20	1	20	0	3	1
D	11	11	43	45	21	15	0	0	0	0	1	0	3	0	4	3
E	11	8	46	39	38	12	1	0	1	0	6	0	11	0	5	5
F	10	2	39	12	27	3	1	5	0	0	8	0	15	0	5	4
G	7	3	22	6	20	0	0	0	0	0	0	0	0	0	0	0
H	8	7	32	38	21	16	0	0	1	0	2	0	0	0	1	0
I	9	10	41	39	20	24	0	4	1	7	7	22	0	2	0	0
J	9	8	40	20	18	2	0	0	0	0	2	0	0	0	0	0
K	8	12	36	51	12	50	0	7	0	2	3	17	0	13	0	0
L	7	11	32	45	15	31	0	3	0	1	11	21	1	13	0	1
M	9	11	43	51	50	56	1	6	0	0	0	2	1	0	0	0
N	0	0	0	0	0	0	0	0	0	1	26	29	24	25	6	7
O	4	2	29	21	24	6	2	0	1	0	4	0	17	0	5	0
P	0	5	0	29	0	2	0	4	3	5	15	14	20	10	4	4
Q	8	4	42	19	44	9	1	0	1	0	5	0	14	0	4	0
R	0	4	0	20	0	3	1	3	3	9	15	23	18	18	4	5
S	8	7	43	37	51	30	1	0	1	0	4	0	12	0	4	0
T	1	6	2	32	2	17	1	3	4	9	16	27	20	21	4	6
U	9	10	43	47	48	31	4	0	1	0	7	0	17	0	3	0
V	3	9	13	44	16	34	2	3	2	9	18	28	21	23	5	6
W	8	13	40	54	45	57	5	0	1	4	4	11	8	1	2	1
X	2	9	14	45	15	39	2	3	2	8	15	28	18	23	4	6
Y	4	9	28	44	30	43	4	3	0	0	0	5	8	6	4	3
Z	2	10	14	43	18	46	3	7	3	8	14	25	17	26	4	6
A1	0	12	0	53	0	60	0	0	0	10	0	33	9	30	5	9
B1	5	9	27	45	30	46	4	10	4	6	18	19	19	22	4	6
C1	0	12	0	53	1	60	0	0	3	8	14	28	16	25	5	7
D1	5	11	29	47	34	51	7	9	4	2	18	7	19	16	4	4
E1	0	12	0	52	1	56	0	0	0	0	4	0	12	1	5	0
F1	1	10	24	48	32	55	6	7	4	2	13	5	18	13	5	3
G1	0	12	0	50	1	52	0	0	1	0	6	2	15	7	5	1
H1	0	11	7	46	25	48	4	2	4	2	9	6	15	10	5	3
I1	0	10	0	43	0	28	0	0	1	0	8	1	15	12	5	4
J1	0	11	6	46	19	44	4	1	2	1	9	2	14	11	4	3
K1	0	0	22	0	10	3	0	0	2	2	25	19	19	22	6	6
L1	5	4	31	28	33	43	7	6	2	2	9	8	12	15	4	5
M1	5	1	37	31	37	45	7	4	1	1	12	7	15	16	4	4
N1	2	0	30	20	24	9	1	0	1	1	16	11	18	18	4	4
O1	4	8	35	28	37	34	9	5	4	4	25	21	16	17	5	6
P1	2	0	25	6	16	2	0	0	1	0	2	1	0	0	4	5
Q1	6	0	39	31	33	17	0	0	0	0	0	0	0	0	5	6
R1	9	9	42	36	12	3	0	0	4	7	15	17	1	1	1	0
S1	9	9	42	33	6	3	0	0	3	6	12	15	2	7	0	0
T1	9	10	39	37	5	3	0	0	4	4	9	11	3	5	0	0
U1	9	10	37	38	8	9	0	1	2	2	9	14	1	7	0	0
V1	9	10	39	42	11	24	0	0	1	0	1	2	1	2	1	0
1	-	12	-	47	-	3	-	3	-	1	-	8	-	6	-	3
2	-	10	-	36	-	4	-	4	-	2	-	16	-	12	-	3
3	-	4	-	11	-	0	-	2	-	3	-	15	-	16	-	5
4	-	0	-	0	-	0	-	0	-	2	-	8	-	0	-	1
6	-	0	-	0	-	0	-	0	-	0	-	1	-	0	-	0

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