ENVIRONMENTAL WIND SPEED MEASUREMENTS ON A WIND TUNNEL MODEL OF THE 102-108 HUMFFRAY ST DEVELOPMENT, BALLARAT EAST

by

[redacted]

SUMMARY

Wind tunnel tests have been conducted on a 1/400 scale model of the Proposed 102-108 Humffray Street Development, Ballarat East. The model of the Development within surrounding buildings and with no existing or future street trees, was tested in a simulated upstream boundary layer of the natural wind to determine likely environmental wind conditions. These wind conditions have been related to the freestream mean wind speed at a reference height of 300m and compared with criteria developed for the Ballarat region as a function of wind direction.

For the Proposed Configuration, wind conditions in and around the development site were shown to achieve the walking comfort criterion or better with the exception at the north-east corner of the commercial building, which was shown to be above the walking comfort criterion. The introduction of a 3m wide canopy along the east side of the Commercial Building was shown to improve the wind conditions to achieve the walking comfort criterion at this location.

In areas where outdoor dining has been proposed, additional screening (1.5m in height) was required at the location north of the Residential Building, so that the sitting criterion was achieved.

Within the Plaza and with the inclusion of the proposed landscaping plan, the wind conditions within this area were shown to achieve the sitting criterion for designated outdoor dining areas and a mix of standing and sitting criteria for all other areas.

The wind conditions on the balconies and rooftop terraces were shown to achieve a minimum of the walking comfort criterion with the exception of the large Level 7 terrace at

the northern end of the Residential Building, which required a 1.8m high balustrade around its perimeter to achieve conditions within the walking comfort criterion.

Wind conditions associated with Test Locations at the main and secondary entrances of the development were shown to pass the standing comfort criterion as a minimum, satisfying the suggested criterion for building entrances.

The wind conditions for the Existing Configuration for ground level Test Locations have been included for comparison.

The wind conditions in the streetscapes that surround the Proposed 102-108 Humffray Street Development have been shown to pass the safety criterion for the Proposed Configuration.

MEL CONSULTANTS

Report 106-22-WT-ENV-00

ENVIRONMENTAL WIND SPEED MEASUREMENTS
102-108 HUMFFRAY ST, BALLARAT EAST

MEL CONSULTANTS REPORT NO: **106-22-WT-ENV-00**

PREPARED FOR:
Hygge Property
Suite 8, 11 Davey St
Ballarat VIC 3350

Contact:
[redacted]
Ph: [redacted]

PREPARED BY:
MEL Consultants Pty Ltd
22 Cleeland Road
South Oakleigh VIC 3167

Contact:
[redacted]
Ph: +61 3 8516 9680

PREPARED BY:

[redacted]

Director Date: 5 Oct 2022

REVIEWED BY:

[redacted]

Managing Director Date: 11 Oct 2022

RELEASED BY:

[redacted]

Managing Director Date: 11 Oct 2022

REVISION HISTORY

Revision No:	Date Issued	Reason/Comment
0	11 October 2022	Initial Issue

DISTRIBUTION

Copy No: 1

Copy	Location	Type
1	Hygge Property	Electronic PDF
2	MEL Consultants – Report Library	Hardcopy
3	MEL Consultants – Report Library	Hardcopy
4	MEL Consultants – Project File	Hardcopy

NOTE: This is a controlled document within the document control system. If revised, it must be marked SUPERSEDED and returned to the MEL Consultants Pty Ltd contact.

CONTENTS

1. INTRODUCTION

The proposed development at 102-108 Humffray Street, Ballarat East, will comprise a 6 level commercial and 7 level residential building located on a site bounded by Porter Street to the north, Humffray Street to the east and Bradbys Lane to the west as highlighted in Figure 1.

Figure 1: Location of the proposed development at the 102-108 Humffray Street, Ballarat East site.

A wind tunnel model study was commissioned by Hygge Property to investigate the environmental wind effects of the proposed development and, if necessary, to develop wind amelioration features to achieve conditions satisfying the recommended environmental wind criteria. This study was undertaken in the MEL Consultants' 400kW Boundary Layer Wind Tunnel during September 2022.

2. ENVIRONMENTAL WIND CRITERIA

The advancement of wind tunnel testing techniques, using large boundary layer flows to simulate the natural wind, has facilitated the prediction of wind speeds likely to be induced around a development. To assess whether the predicted wind conditions are likely to be acceptable or not, some forms of criteria are required. The Department of Environment, Land, Water and Planning (DELWP) has developed wind comfort criteria for the assessment of the wind conditions for apartment developments in Victoria. These are known as the Better Apartment Design (BAD) Guidelines. The definition of the criteria is as follows:

Unsafe wind conditions means the hourly maximum 3 second gust which exceeds 20 metres/second from any wind direction considering at least 16 wind directions with the corresponding probability of exceedance percentage.

Comfortable wind conditions means a mean wind speed from all wind directions combined with probability of exceedance less than 20% of the time, equal to or less than:

- 3 metres/second for **sitting areas**
    - Sitting criterion: generally acceptable for stationary, long exposure activities such as dining at outdoor restaurants or theatres.
- 4 metres/second for **standing areas**
    - Standing criterion: generally acceptable for stationary short exposure activities such as window shopping, standing or sitting in plazas.
- 5 metres/second for **walking areas**
    - Walking criterion: generally acceptable for walking in urban and suburban areas.

Mean wind speed means the maximum of:

- Hourly mean wind speed, or
- Gust equivalent mean wind speed (3 second gust wind speed divided by 1.85)

The above comfort criteria are pass/fail criteria which assess the integrated probability of all wind directions to determine whether a location passes or fails the threshold criterion.

The safety criterion is a pass/fail criterion based upon exceedance of the wind speed for any one wind direction. For completeness, this report will provide data for each Test Location as a function of wind direction in Appendix A.

The BAD Guidelines do not provide any methodology or worked example as how to obtain the 'from all wind directions combined'. Therefore, to obtain the probability for all wind directions combined we will apply the methodology described in Melbourne (1978) to determine the probability for all wind directions. The Guidelines use the definition of mean wind speed as based on the hourly wind speed so the probabilities will be determined from the hourly wind data for an applicable automatic weather station for the Melbourne City. The probability data used have been corrected for the approach terrain at the location of the automatic weather station and referenced to 10m in Terrain Category 2. This is the standard reference height of AS/NZS1170.2:2011.

2.1 Suggested Pedestrian Comfort Criteria.

The Proposed 102-108 Humffray Street Development will have the residential building on the west side of the site and the commercial building on the east side. A central plaza area occupies the space between the two buildings. There will be terraces/balconies on various levels of both buildings.

The following wind criteria are suggested for the surrounding streetscapes:

- Pedestrian transit areas — Walking Criterion
- Building/Tenancy entrances — Standing Criterion
- Outdoor plaza — Sitting/Standing (dependent on activation)
- Terraces/Balconies — Walking Criterion

The activation of the public realm external to the site would depend on the existing wind conditions in the streetscapes that are often beyond the control of the proposed development. For cases where the existing wind conditions in the public realm external to the site are on or above the walking criterion, then the proposed development should not have any adverse wind effects in these areas.

The wind conditions on private outdoor areas have been recommended to satisfy the walking criterion as these spaces could be considered elective when external conditions would be perceived as acceptable for the desired activity. Users of these terraces will need to be educated on the wind effects and loose objects should not be left unattended in outdoor areas. However, if outdoor terraces are intended to be used as breakout spaces for commercial offices, then standing and sitting criteria may be appropriate due to an expectation of higher utilisation.

3. MODEL AND EXPERIMENTAL TECHNIQUES

A 1/400 scale model of the Proposed 102-108 Humffray Street Development was constructed from architectural drawings and digital information provided by Six Degrees and dated 2nd September 2022.

The scale model of the Development was inserted into a proximity model with significant surrounding buildings, including any under construction out to a minimum radius of 300m. The building model was tested in a model of the natural wind generated by flow over roughness elements augmented by vorticity generators at the beginning of the wind tunnel working section. The basic natural wind model was for flow over suburban terrain roughness, terrain category 3, as shown in Figure 2. The surrounding wind tunnel model modified the approach wind model for the presence of the surrounding buildings.

The techniques used to investigate the environmental wind conditions and the method of determining the local criteria are given in detail in Reference 2. In these tests measurements in the Development areas are inside separated regions and peak velocity squared ratios were required to make conclusions about likely wind conditions. In summary, measurements were made of the peak gust wind velocity with a hot wire anemometer at various stations and expressed as a squared ratio with the mean wind velocity at a scaled reference height of 300m. This gives the peak velocity squared ratio

$$\left|\frac{\hat{V}_{local}}{\bar{V}_{300m}}\right|^2$$

Wind tunnel velocity measurements were made for an equivalent 1 hour period in full scale and filtered to provide an equivalent full scale 3 second gust wind speed. Photographs of the model as tested in the wind tunnel are shown in Figures 3 and 4.

4. DISCUSSION OF RESULTS

Velocity measurements were made at various locations around the Proposed 102-108 Humffray Street Development for different wind directions at 22.5° intervals. As discussed in Section 2, the BAD Guidelines wind comfort criteria are pass/fail criteria based on an assessment of the probability for all wind directions combined. The wind comfort criteria for sitting, standing and walking are given in percentage for which a given mean wind speed is exceeded. A test location will pass the sitting, standing and walking criteria if the percentage for which a given mean wind speed is exceeded is below 20%. Therefore, to assess the wind conditions the exceedances will be presented in tabular form in Tables 1 – 7 and colour coded; green for below 20% exceedance, orange for above 20% exceedance and green or red for passing/failing the safety criterion respectively. For completeness these data are also provided in Appendix A as a function of wind direction and compared with the pedestrian criteria for gust wind speeds.

The Proposed Configuration, is as outlined in the architectural drawings and digital information provided by Six Degrees dated 2nd September 2022. The Existing Configuration is defined as the present single storey factory building on the site. The Proposed configuration used the landscaping scheme for the plaza area as defined in the landscape drawings provided by Acre Architecture for Landscapes dated 1st September 2022. These landscape areas lie within the site boundary and any reliance upon landscaping outside the site boundary has not been used. The Test Locations for the Proposed 102-108 Humffray Street Development are shown in Figures 5a – 5d. The following Sections detail the results for the various areas tested.

4.1 Summary of Discussion

To assist with the assessment of the wind conditions, summaries of the highest wind criteria achieved based on the BAD Guidelines at the Test Locations have been presented using a colour code system in the following figures:

- Figures 6a to 6c Existing, Proposed and Proposed with mitigation Configurations

- Figures 7a to 7c Terraces and Balconies for Proposed and Proposed with mitigation Configurations

Different colours have been used to represent the wind criteria achieved at the respective Test Locations.

4.2. Porter Street

The wind conditions for the Proposed Configuration along Centre Road (Test Locations 1-10 and 46) have been shown to pass the walking comfort criterion as a minimum, with conditions at many locations also passing the standing comfort criterion. The wind criteria satisfied at most Test Locations along Porter Street were similar to those of the Existing Configuration, with a noticeable increase in the wind criterion achieved at Test Locations close to the development site. Wind conditions at Test Locations 5, 8 and 10 were influenced by wind flow deflecting off the building edges and increasing the local wind conditions in these areas, but achieve the walking comfort criterion.

The area where local outdoor dining has been proposed, Test Location 3A, was shown to only achieve the standing comfort criterion. With the addition of a solid 1.5m screen surrounding the area (see Figure 6c) the wind conditions were shown to improve to achieve the sitting criterion.

Outdoor retail has also been proposed at Test Location 7A and this area benefitted from the shielding provided by both the Residential and Commercial Buildings, achieving the sitting comfort criterion.

The criteria achieved at these Test Locations have been presented in Table 1 as well as the data for the Existing Configuration.

The wind conditions as a function of wind direction based on the gust criteria developed for Melbourne are presented in Appendix A (Figures A2 to A4 and A21). It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for certain incident wind directions.

COLOUR DESIGNATION	Test Location	Configuration	Wind Comfort Criteria			
			Sitting	Standing	Walking	Safety
E	1	Existing	2.7%	0.2%	0.0%	PASS
P		Proposed	8.8%	1.2%	0.1%	PASS
E	2	Existing	6.4%	0.5%	0.0%	PASS
P		Proposed	16.1%	4.0%	1.0%	PASS
E	3	Existing	35.5%	14.9%	4.8%	PASS
P		Proposed	32.7%	17.8%	8.6%	PASS
E	3A	Existing	38.6%	17.9%	6.3%	PASS
P		Proposed	25.8%	11.8%	5.4%	PASS
P		P + 1.5m Screen	18.8%	6.3%	2.0%	PASS
E	4	Existing	31.6%	15.7%	6.7%	PASS
P		Proposed	31.9%	19.0%	10.0%	PASS
E	5	Existing	38.9%	16.8%	5.3%	PASS
P		Proposed	41.8%	25.7%	13.9%	PASS
E	6	Existing	31.3%	13.3%	5.0%	PASS
P		Proposed	39.9%	19.2%	7.9%	PASS
E	7	Existing	37.3%	15.3%	4.7%	PASS
P		Proposed	29.2%	13.8%	4.7%	PASS
E	7A	Existing	24.1%	9.4%	2.9%	PASS
P		Proposed	17.7%	5.0%	1.0%	PASS
E	8	Existing	38.6%	17.9%	6.4%	PASS
P		Proposed	45.7%	31.4%	19.1%	PASS
E	9	Existing	24.1%	11.3%	4.6%	PASS
P		Proposed	30.4%	17.2%	8.8%	PASS
N/A	9A	Existing	N/A	N/A	N/A	N/A
P		Proposed	27.2%	17.0%	9.3%	PASS
E	10	Existing	27.1%	8.0%	1.7%	PASS
P		Proposed	48.3%	26.8%	11.7%	PASS
E	46	Existing	23.1%	6.0%	1.1%	PASS
P		Proposed	26.1%	10.4%	3.9%	PASS

Table 1: Pedestrian Wind Comfort and Safety – Porter Street

4.3. Humffray Street

The wind conditions for the Proposed Configuration along Humffray Street (Test Locations 11 - 18) have been shown to all pass the walking comfort criterion except Test Location 11. High wind conditions at this location arose due to the local acceleration of wind flow around the north-east corner which was induced to ground level by the north and east face of the building, for north sector and south-east sector wind directions, respectively. As a result, wind conditions began to approach the safety comfort criterion for the northern wind directions. A 3m wide canopy along the east face of the building was shown to be effective at mitigating the downwash induced by this face for the south and east sector wind directions. A canopy on the north face was shown to be ineffective and, in fact, further accelerated the wind flow underneath it, and so was not included. With the east side canopy the wind conditions improved to achieve the walking comfort criterion.

Wind conditions along Humffray Street were also affected by wind flow deflecting off the southern Commercial Building corner, which affected Test Locations 15, 17 and 18 and off the north-east Commercial Building corner, which affected Test Location 14.

The criteria achieved at these Test Locations have been presented in Table 2 as well as the data for the Existing Configuration.

The wind conditions as a function of wind direction based on the gust criteria developed for Melbourne are presented in Appendix A (Figures A4 – A6). It is noted that at the Test Location the directional specific wind conditions may be higher than those of the tabulated results for certain incident wind directions.

COLOUR DESIGNATION	Test Location	Configuration	Wind Comfort Criteria			
			Sitting	Standing	Walking	Safety
E	11	Existing	34.71%	14.37%	4.16%	PASS
P		Proposed	60.00%	43.90%	29.60%	PASS
P		P + 3m east canopy	52.20%	33.70%	19.50%	PASS
N/A	11A	Existing	N/A	N/A	N/A	N/A
P		Proposed	32.56%	14.30%	4.81%	PASS
N/A	11B	Existing	N/A	N/A	N/A	N/A
P		Proposed	32.15%	11.40%	2.72%	PASS
E	12	Existing	26.10%	6.61%	0.95%	PASS
P		Proposed	37.80%	16.40%	5.63%	PASS
E	13	Existing	15.66%	3.54%	0.59%	PASS
P		Proposed	20.13%	5.65%	1.28%	PASS
E	14	Existing	32.12%	13.92%	5.26%	PASS
P		Proposed	53.83%	33.13%	18.31%	PASS
E	15	Existing	13.07%	2.61%	0.31%	PASS
P		Proposed	43.17%	21.18%	7.76%	PASS
E	16	Existing	17.44%	3.35%	0.46%	PASS
P		Proposed	20.16%	4.62%	0.59%	PASS
E	17	Existing	17.67%	3.62%	0.47%	PASS
P		Proposed	44.91%	25.33%	12.73%	PASS
E	18	Existing	29.53%	12.97%	4.83%	PASS
P		Proposed	42.28%	21.50%	9.04%	PASS

Table 2: Pedestrian Wind Comfort and Safety – Humffray Street

4.4. Eastwood Street

The wind conditions for the Proposed Configuration along Eastwood Street (Test Locations 19-24) have all been shown to pass the standing comfort criterion. The wind conditions have been shown to be similar to those of the Existing Configuration indicating little adverse effect from the proposed development.

The criteria achieved at these Test Locations have been presented in Table 3 as well as the data for the Existing Configuration.

The wind conditions as a function of wind direction based on the gust criteria developed for Melbourne are presented in Appendix A (Figures A6 and A7). It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for certain incident wind directions.

COLOUR DESIGNATION	Test Location	Configuration	Wind Comfort Criteria			
			Sitting	Standing	Walking	Safety
E	19	Existing	32.9%	10.8%	2.4%	PASS
P		Proposed	34.5%	15.1%	5.4%	PASS
E	20	Existing	36.0%	17.9%	8.9%	PASS
P		Proposed	22.8%	5.9%	1.3%	PASS
E	21	Existing	29.5%	13.6%	5.3%	PASS
P		Proposed	33.9%	17.0%	7.5%	PASS
E	22	Existing	42.0%	18.5%	6.2%	PASS
P		Proposed	41.5%	18.7%	6.9%	PASS
E	23	Existing	21.4%	5.6%	1.1%	PASS
P		Proposed	22.8%	7.5%	2.0%	PASS
E	24	Existing	29.2%	8.3%	1.4%	PASS
P		Proposed	21.5%	5.7%	0.9%	PASS

Table 3: Pedestrian Wind Comfort and Safety – Eastwood Street

4.5. Retail Car Park and Bradbys Lane

The wind conditions for the Proposed Configuration in the Retail Car Park (Test Location 25) and along Bradbys Lane (Test Locations 26 – 33) have been shown to pass the standing comfort criterion, with the exception of Test Location 27 which achieved the walking comfort criterion. In all cases the criterion achieved was equivalent to or better than that of the Existing Configuration, with only conditions at Test Location 27 increasing noticeably above the existing conditions.

The criteria achieved at these Test Locations have been presented in Table 4 as well as the data for the Existing Configuration.

The wind conditions as a function of wind direction based on the gust criteria developed for Ballarat are presented in Appendix A (Figures A8 - A10). It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for certain incident wind directions.

COLOUR DESIGNATION	Test Location	Configuration	Wind Comfort Criteria			
			Sitting	Standing	Walking	Safety
E	25	Existing	21.4%	6.5%	1.5%	PASS
P		Proposed	25.2%	8.5%	2.2%	PASS
E	26	Existing	33.0%	12.7%	4.0%	PASS
P		Proposed	35.9%	14.9%	5.3%	PASS
E	27	Existing	24.8%	8.1%	2.2%	PASS
P		Proposed	52.1%	30.1%	14.9%	PASS
E	28	Existing	24.4%	9.0%	2.8%	PASS
P		Proposed	35.0%	14.9%	5.3%	PASS
E	29	Existing	14.8%	4.5%	1.0%	PASS
P		Proposed	25.7%	13.7%	6.7%	PASS
E	30	Existing	27.7%	12.3%	4.3%	PASS
P		Proposed	34.6%	17.2%	7.7%	PASS
E	31	Existing	30.8%	16.5%	8.2%	PASS
P		Proposed	26.8%	14.0%	6.2%	PASS
E	32	Existing	18.4%	4.5%	0.8%	PASS
P		Proposed	30.6%	15.2%	6.3%	PASS
E	33	Existing	46.1%	25.6%	11.4%	PASS
P		Proposed	34.9%	12.9%	3.6%	PASS

Table 4: Pedestrian Wind Comfort and Safety – Retail Car Park & Bradbys Lane

4.6. Plaza

The wind conditions for the Proposed Configuration in the Plaza area, between the Residential and Commercial Buildings were measured for a configuration with and without the proposed landscaping (where the landscape plan has been provided by Acre, dated 1st September 2022).

Without any proposed landscaping the wind conditions in the Plaza area where all shown to achieve the walking comfort criterion, with conditions in some areas also achieving the standing and sitting comfort criteria. The introduction of the landscaping (fully mature) was shown to significantly improve the wind conditions in the Plaza, particularly at the southern end (Test Locations 38, 40, 41 and 42A), where wind conditions were now shown to achieve the sitting criteria. The wind conditions at the tenancy entries were shown to achieve the standing comfort criterion.

The area to the south of the Plaza (Test Location 42) was also shown to benefit from the landscaping, improving from the walking to the standing comfort criterion.

The criteria achieved at these Test Locations have been presented in Table 5 as well as the data for the Existing Configuration.

The wind conditions as a function of wind direction based on the gust criteria developed for Melbourne are presented in Appendix A (Figures A10 to A12). It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for certain incident wind directions.

COLOUR DESIGNATION	Test Location	Configuration	Wind Comfort Criteria			
			Sitting	Standing	Walking	Safety
E	34	Existing	24.5%	7.2%	1.6%	PASS
P		Proposed	41.5%	22.0%	9.5%	PASS
P + L		P + Landscaping	25.8%	10.7%	3.5%	PASS
E	35	Existing	31.4%	12.5%	4.0%	PASS
P		Proposed	44.9%	21.2%	8.0%	PASS
P + L		P + Landscaping	20.1%	7.1%	1.9%	PASS
E	36	Existing	21.5%	10.7%	4.1%	PASS
P		Proposed	29.9%	13.1%	4.9%	PASS
N/A	37	Existing	N/A	N/A	N/A	N/A
P		Proposed	1.5%	0.1%	0.0%	PASS
E	38	Existing	49.1%	29.2%	14.2%	PASS
P		Proposed	33.1%	12.4%	4.0%	PASS
P + L		P + Landscaping	5.5%	0.7%	0.1%	PASS
E	39	Existing	31.7%	13.1%	4.8%	PASS
P		Proposed	37.8%	16.1%	5.1%	PASS
P + L		P + Landscaping	3.8%	0.6%	0.1%	PASS
E	40	Existing	17.8%	7.4%	2.2%	PASS
P		Proposed	55.7%	30.7%	12.8%	PASS
P + L		P + Landscaping	19.3%	5.2%	1.0%	PASS
E	41	Existing	22.0%	7.4%	2.0%	PASS
P		Proposed	13.9%	5.7%	2.7%	PASS
E	42	Existing	0.9%	0.0%	0.0%	PASS
P		Proposed	54.6%	31.4%	14.1%	PASS
P + L		P + Landscaping	40.9%	17.7%	5.8%	PASS
E	42A	Existing	27.5%	14.7%	7.4%	PASS
P		Proposed	54.2%	30.5%	13.9%	PASS
P + L		P + Landscaping	15.1%	3.6%	0.7%	PASS

Table 5: Pedestrian Wind Comfort and Safety – Plaza

4.7. Peel Street and Main Road Car Parks

The wind conditions for the Proposed Configuration in the Peel Street and Main Road carparks (Test Locations 43 and 44) have been shown to pass the standing comfort criterion, with little adverse impact from the Proposed development, as shown in comparison to the criteria achieved for the Existing Configuration.

The criteria achieved at these Test Locations have been presented in Table 6.

The wind conditions as a function of wind direction based on the gust criteria developed for Ballarat are presented in Appendix A (Figures A12 and A13). It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for certain incident wind directions.

COLOUR DESIGNATION	Test Location	Configuration	Wind Comfort Criteria			
			Sitting	Standing	Walking	Safety
E	43	Existing	32.5%	13.9%	4.3%	PASS
P		Proposed	26.8%	10.2%	2.9%	PASS
E	44	Existing	36.3%	14.5%	4.2%	PASS
P		Proposed	33.3%	12.8%	3.8%	PASS
E	45	Existing	22.3%	5.9%	1.2%	PASS
P		Proposed	29.6%	10.5%	2.5%	PASS

Table 6: Pedestrian Wind Comfort and Safety – Peel Street Car Park

4.8. Residential Terraces

The wind conditions for the Proposed Configuration on the Residential Building Terraces (Test Locations B1-B18) have been shown to pass the walking comfort criterion, with the exception of Test Location B18 (large Level 7 terrace) which was shown to exceed the walking comfort criterion. This terrace was shown to be particularly exposed to north and west sector wind directions which resulted in wind conditions approaching the safety criterion. It was shown that the use of a minimum 1.8m high solid balustrade around the perimeter was effective at improving the wind conditions to achieve the walking and standing comfort criteria, whilst mitigating the directionally specific wind levels away from the safety threshold.

The criteria achieved at these Test Locations have been presented in Table 8.

The wind conditions as a function of wind direction based on the gust criteria developed for Melbourne are presented in Appendix A (Figure A17). It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for certain incident wind directions.

COLOUR DESIGNATION	Test Location	Configuration	Wind Comfort Criteria			
			Sitting	Standing	Walking	Safety
P	B1	Proposed	16.6%	5.4%	1.1%	PASS
P	B2	Proposed	35.7%	17.8%	7.4%	PASS
P	B3	Proposed	28.9%	12.3%	4.0%	PASS
P	B4	Proposed	23.7%	10.5%	3.1%	PASS
P	B5	Proposed	44.9%	24.9%	11.4%	PASS
P	B6	Proposed	21.8%	8.7%	2.8%	PASS
P	B7	Proposed	39.3%	21.8%	10.2%	PASS
P	B8	Proposed	32.4%	17.7%	8.6%	PASS
P	B9	Proposed	31.9%	16.3%	6.8%	PASS
P	B10	Proposed	21.8%	9.3%	2.6%	PASS
P	B11	Proposed	25.0%	11.9%	4.0%	PASS
P	B12	Proposed	45.4%	29.0%	16.0%	PASS
P	B13	Proposed	43.3%	26.7%	14.6%	PASS
P	B14	Proposed	47.9%	31.4%	18.5%	PASS
P	B15	Proposed	18.6%	6.0%	1.6%	PASS
P	B16	Proposed	29.7%	17.7%	8.3%	PASS
P	B17	Proposed	18.0%	6.0%	1.3%	PASS
P	B18	Proposed	53.7%	39.0%	26.5%	PASS
P		P + 1.8m Balustrade	30.3%	19.4%	11.4%	PASS

Table 8: Pedestrian Wind Comfort and Safety – Residential Terraces

4.9. Commercial Terraces

The wind conditions for the Proposed Configuration on the Commercial building Terraces (Test Locations B19-B25) have been shown to pass the standing comfort criterion or better.

The criteria achieved at these Test Locations have been presented in Table 9.

The wind conditions as a function of wind direction based on the gust criteria developed for Melbourne are presented in Appendix A (Figure A19 and A20). It is noted that at each Test Location the directional specific wind conditions may be higher than those of the tabulated results for certain incident wind directions.

COLOUR DESIGNATION	Test Location	Configuration	Wind Comfort Criteria			
			Sitting	Standing	Walking	Safety
P	B19	Proposed	31.2%	16.0%	6.2%	PASS
P	B20	Proposed	24.8%	9.5%	2.4%	PASS
P	B21	Proposed	14.0%	3.6%	0.6%	PASS
P	B22	Proposed	26.6%	13.1%	5.8%	PASS
P	B23	Proposed	9.4%	1.7%	0.2%	PASS
P	B24	Proposed	21.6%	10.1%	3.7%	PASS
P	B25	Proposed	28.0%	16.2%	8.5%	PASS

Table 9: Pedestrian Wind Comfort and Safety – Commercial Terraces

5. CONCLUSIONS

Wind tunnel tests have been conducted on a 1/400 scale model of the Proposed 102-108 Humffray Street Development, Ballarat East to determine likely environmental wind conditions and compared with criteria developed for the Ballarat region as a function of wind direction.

For the Proposed Configuration, wind conditions in and around the development site were shown to achieve the walking comfort criterion or better with the exception of a number of locations which exceeded the recommended comfort criterion associated with their intended activation. In these cases, wind mitigation strategies have been recommended so that the target comfort criteria are achieved.

Within the Plaza and with the inclusion of the proposed landscaping plan, the wind conditions within this area were shown to achieve the sitting criterion for designated outdoor dining areas and a mix of standing and sitting criteria for all other areas.

The wind conditions on the balconies and rooftop terraces were shown to achieve a minimum of the walking comfort criterion with the exception of the large Level 7 terrace at the northern end of the Residential Building, which required mitigation to achieve the target comfort criterion.

The wind conditions in the streetscapes that surround the Proposed 102-108 Humffray Street Development have been shown to pass the safety criterion for the Proposed Configuration.

Prepared by
J.Kostas (RPEV)
MEL Consultants Pty Ltd

6. REFERENCES

1. W. H. Melbourne, Criteria for environmental wind conditions, Journal of Industrial Aerodynamics, Volume 3, 1978, pp. 241-249
2. W. H. Melbourne, Wind environment studies in Australia, Journal of Industrial Aerodynamics, Volume 3, 1978, pp. 201-214

FIGURES

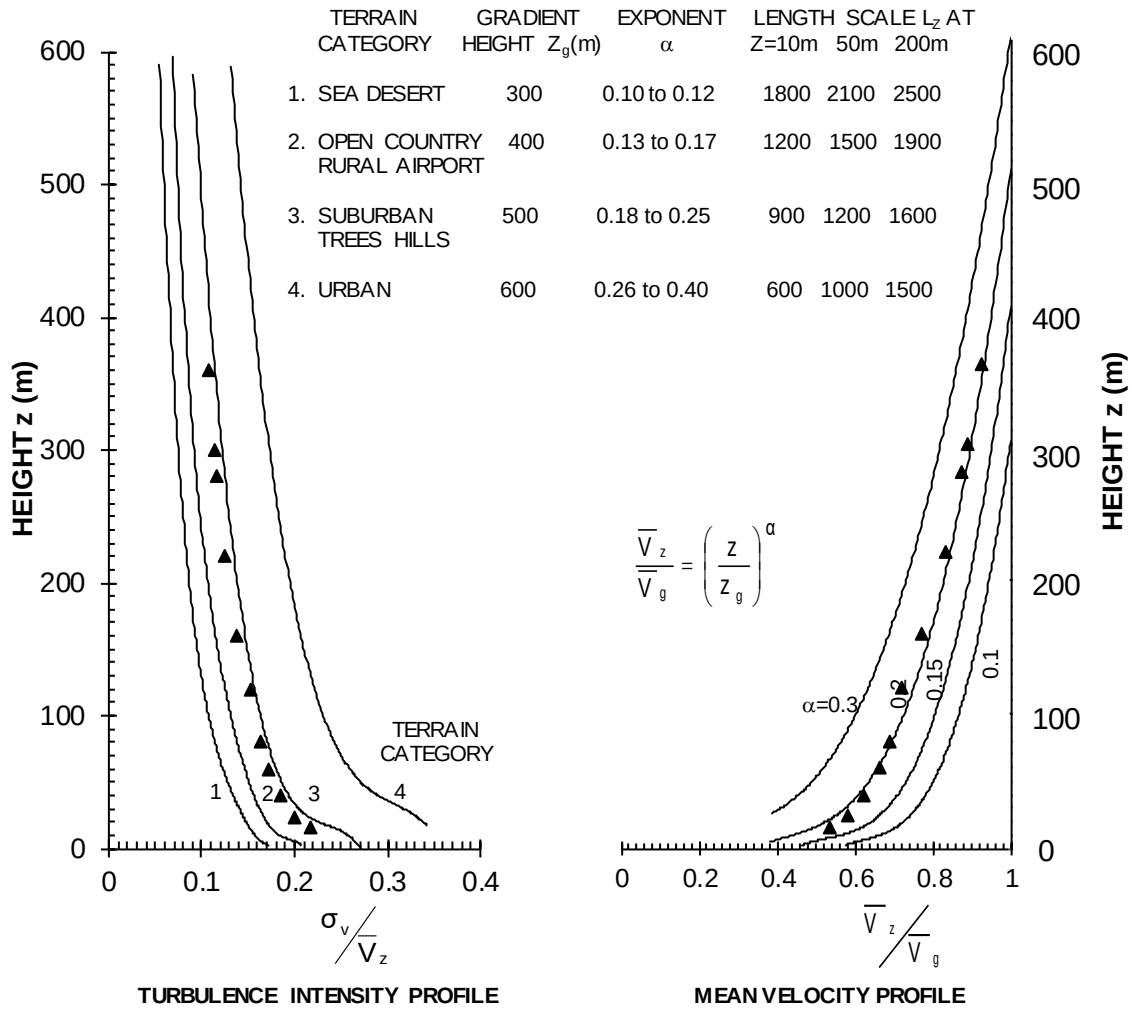


Figure 2 - 1/400 scale TC3 boundary layer turbulence intensity and mean velocity profiles and spectra in the MEL Consultants Boundary Layer Wind Tunnel 5m x 2.4m working section, scaled to full scale dimensions

Figure 3 – Close-up view from the north-northeast of the 1/400 scale Proposed 102-108 Humffray Street Development in the wind tunnel

Figure 4 – View from the south-southwest of the 1/400 scale Proposed 102-108 Humffray Street Development in the wind tunnel.

Figure 5a – Ground Level Test Locations in the surrounding streetscapes for the Proposed 102-108 Humffray Street Development

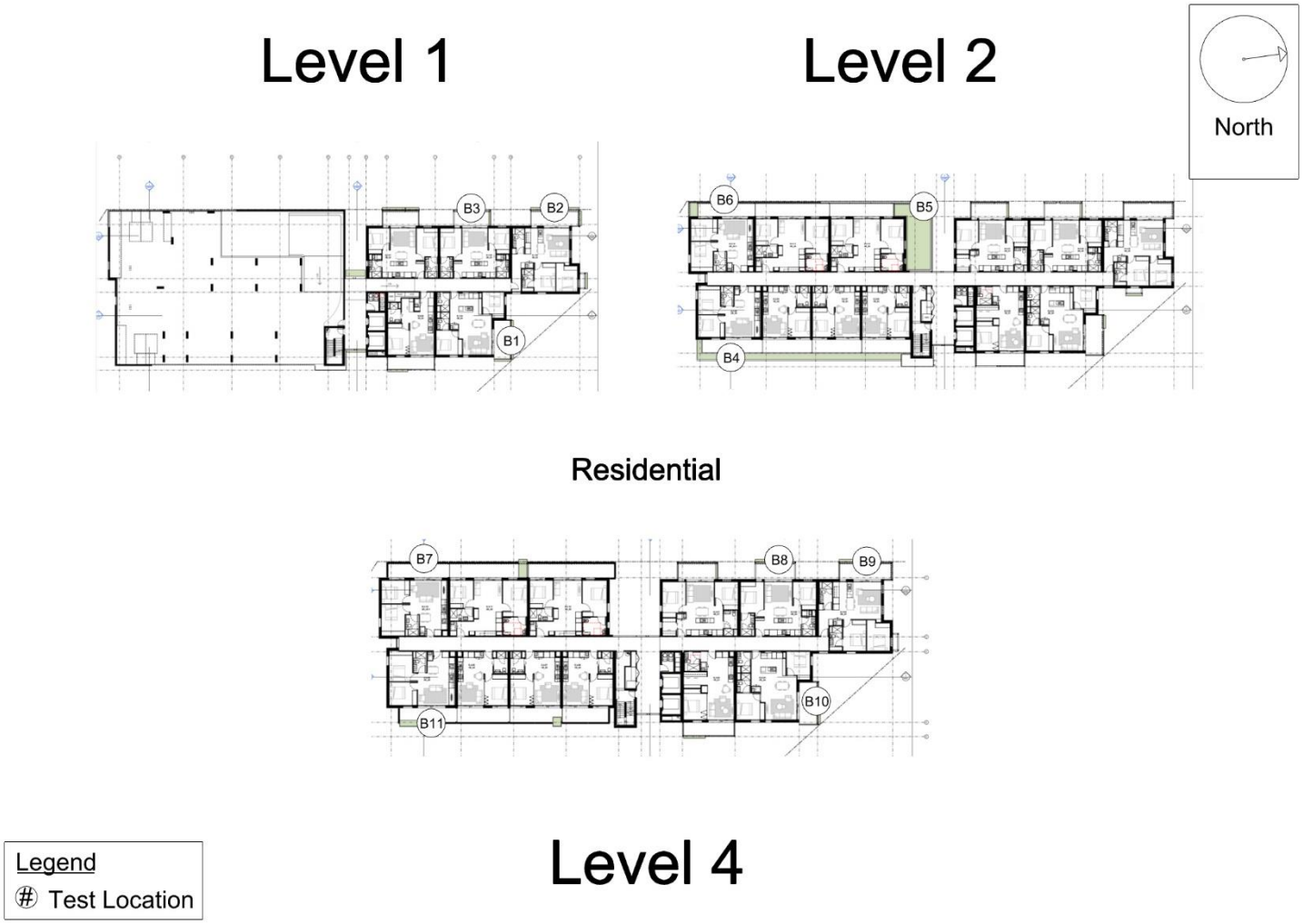


Figure 5b - Terrace and Balcony Test Locations on the Residential building

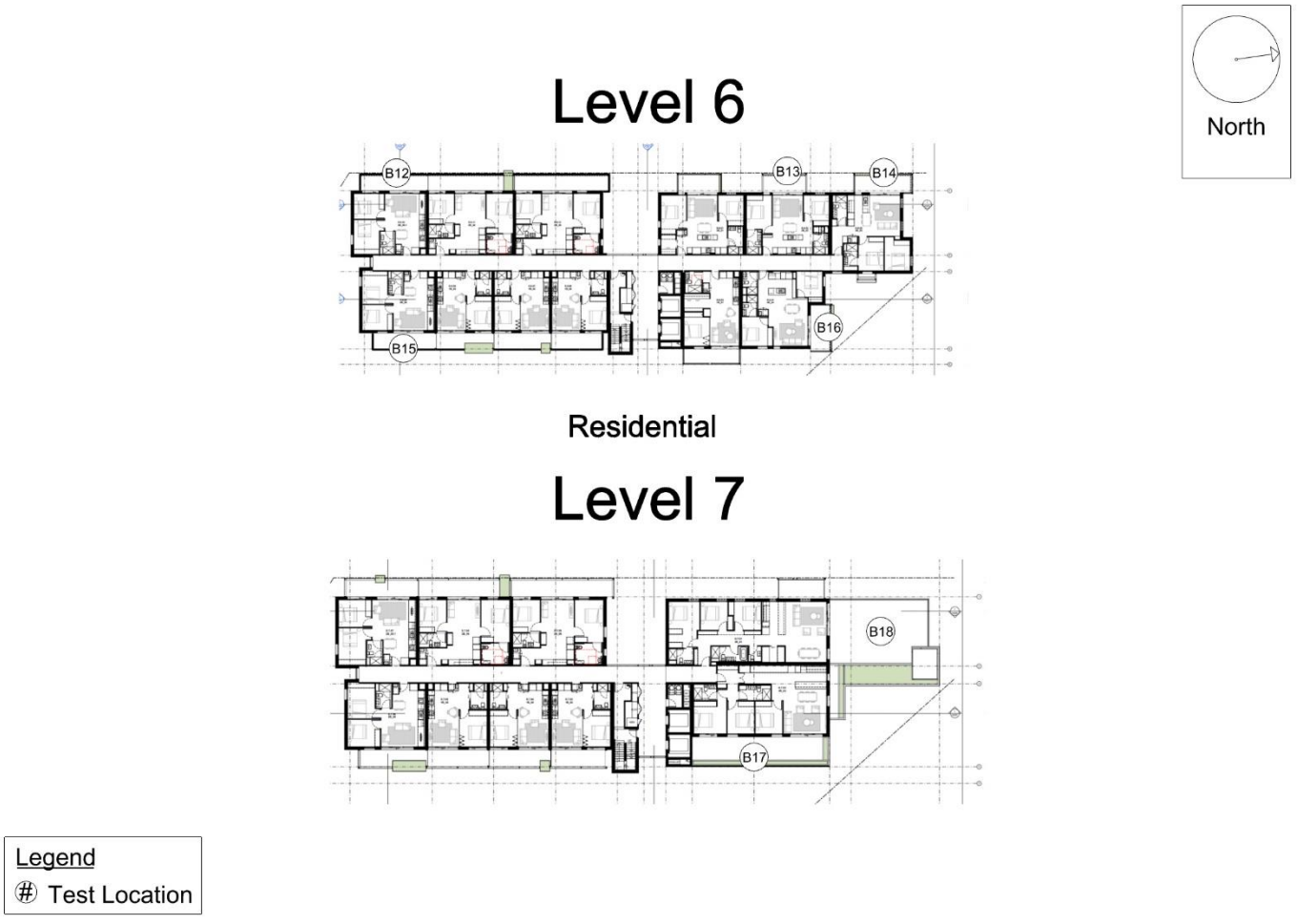


Figure 5c - Terrace and Balcony Test Locations on the Residential building

Figure 5d - Terrace and Balcony Test Locations on the Commercial building

Figure 6a - Summary of wind conditions at Ground Level Test Locations around the 102-108 Humffray Street Development for the Existing Configuration for 360º of wind direction

Figure 6b - Summary of wind conditions at Ground Level Test Locations around the 102-108 Humffray Street Development for the Proposed Configuration (no landscaping) for 360º of wind direction

Figure 6c - Summary of wind conditions at selected Ground Level Test Locations around the 102-108 Humffray Street Development for the Proposed Configuration with Plaza landscaping and mitigation strategies.

Figure 7a - Summary of wind conditions on the Residential Building Balconies of the 102-108 Humffray Street Development for the Proposed Configuration for 360º of wind direction

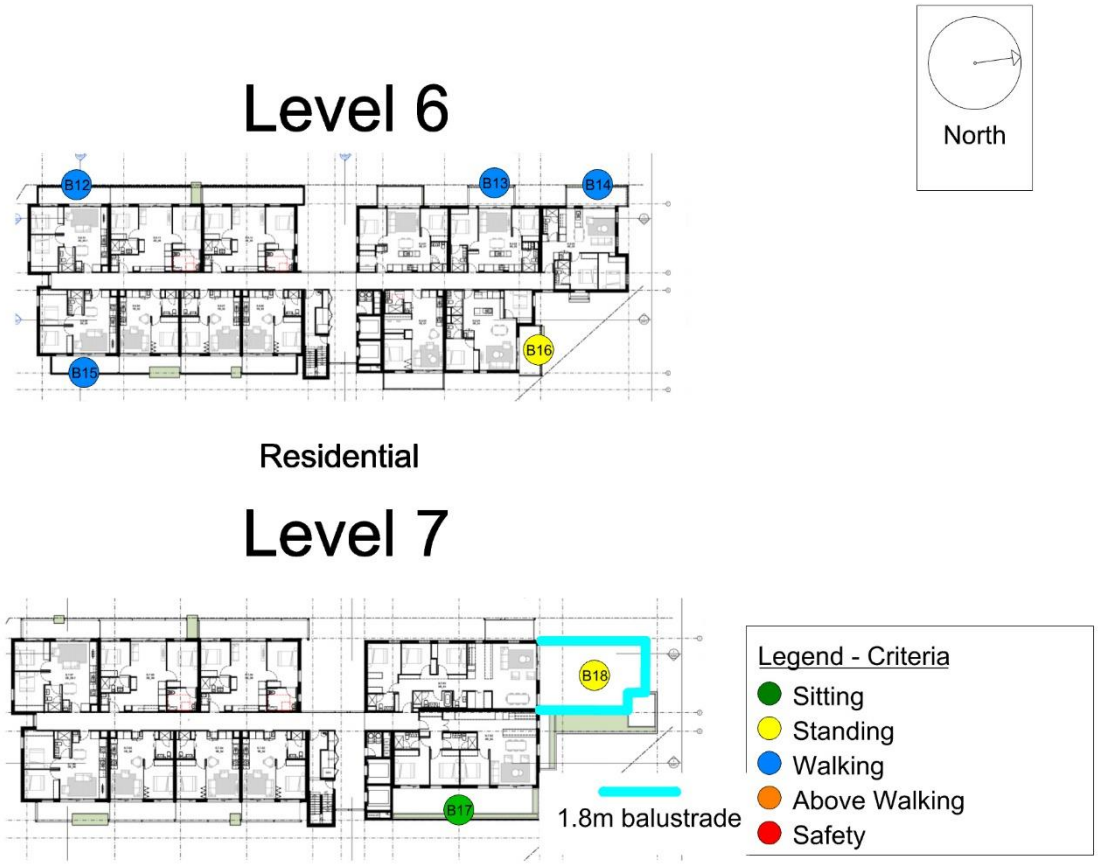


Figure 7b - Summary of wind conditions on the Residential Building Balconies of the 102-108 Humffray Street Development for the Proposed Configuration with mitigation for 360º of wind direction

Figure 7c - Summary of wind conditions on the Commercial Building Terraces of the 102-108 Humffray Street Development for the Proposed Configuration for 360º of wind direction.

APPENDIX A – TEST LOCATION 3 SECOND GUST WIND CRITERIA PLOTS AS A FUNCTION OF WIND DIRECTION

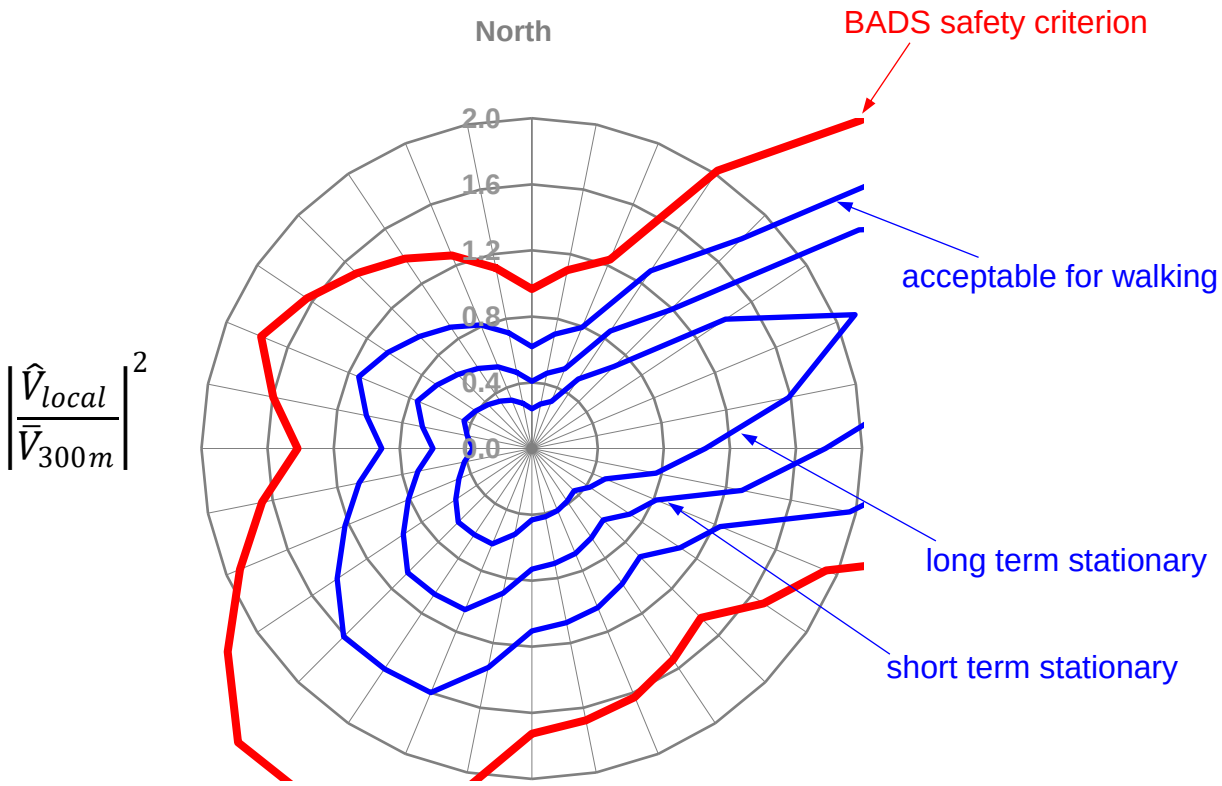
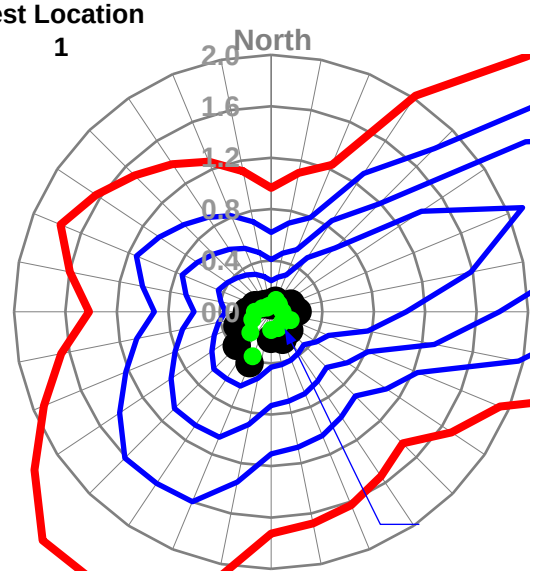


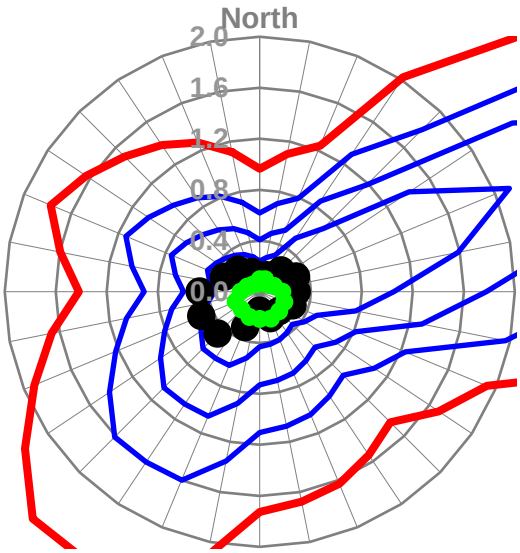
Figure A1 - Environmental wind criteria for Ballarat as a function of wind direction based on a 3 second gust

Test Location

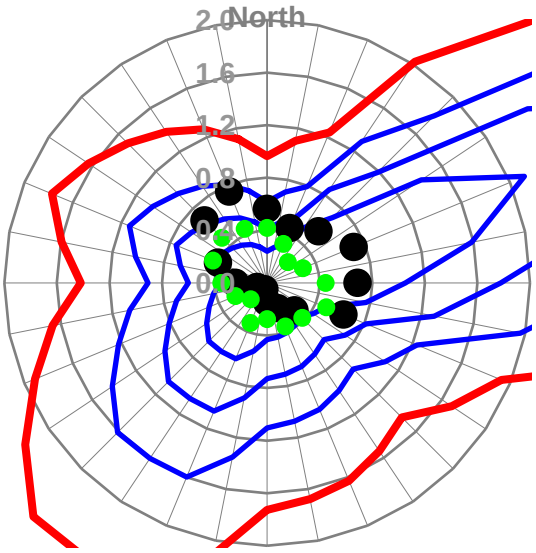
1



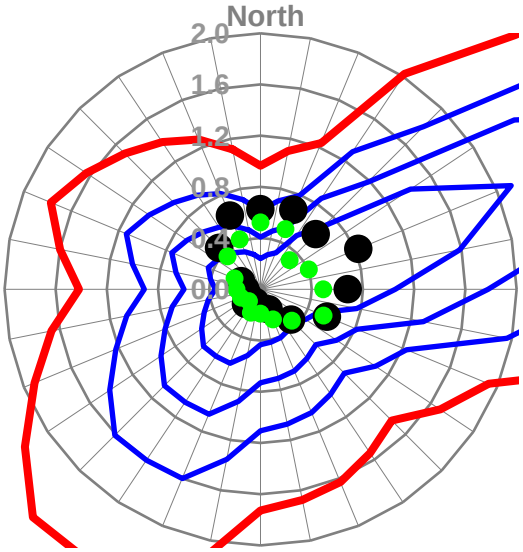
2



3



4



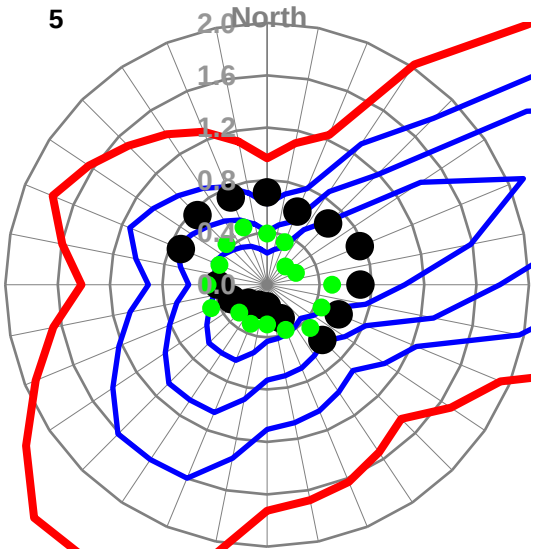
Peak velocity squared ratio $\left|\frac{\widehat{V}_{local}}{\overline{V}_{300m}}\right|^2$ as a function of wind direction

Proposed Configuration
Existing Configuration

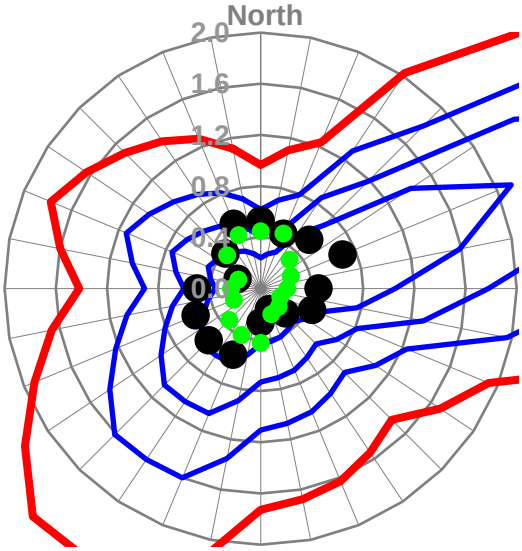
Figure A2 - Porter Street

Test Location

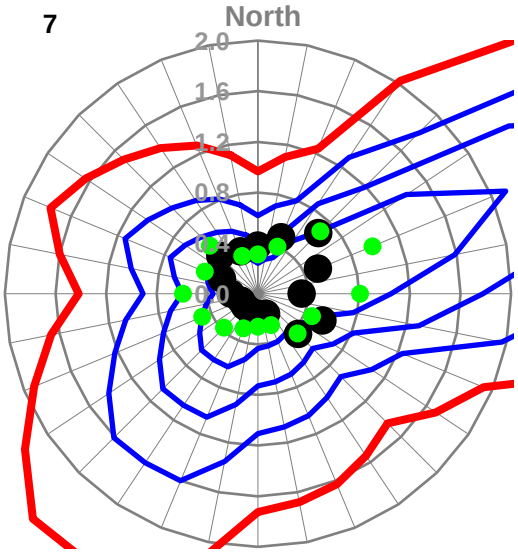
5



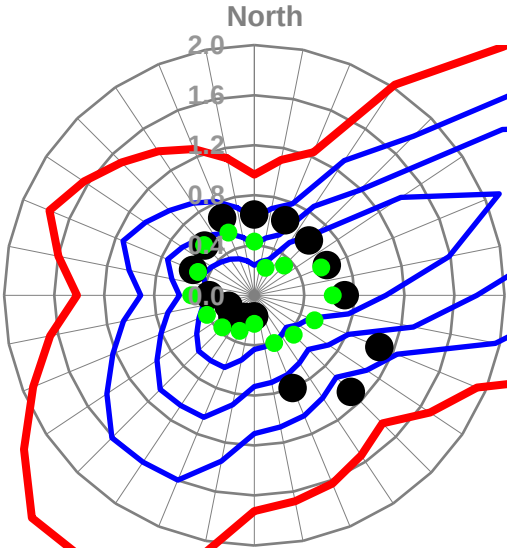
6



7



8



Peak velocity squared ratio $\left|\frac{\widehat{V}_{local}}{\overline{V}_{300m}}\right|^2$ as a function of wind direction

Proposed Configuration
Existing Configuration

Figure A3 - Porter Street [CONTINUED]

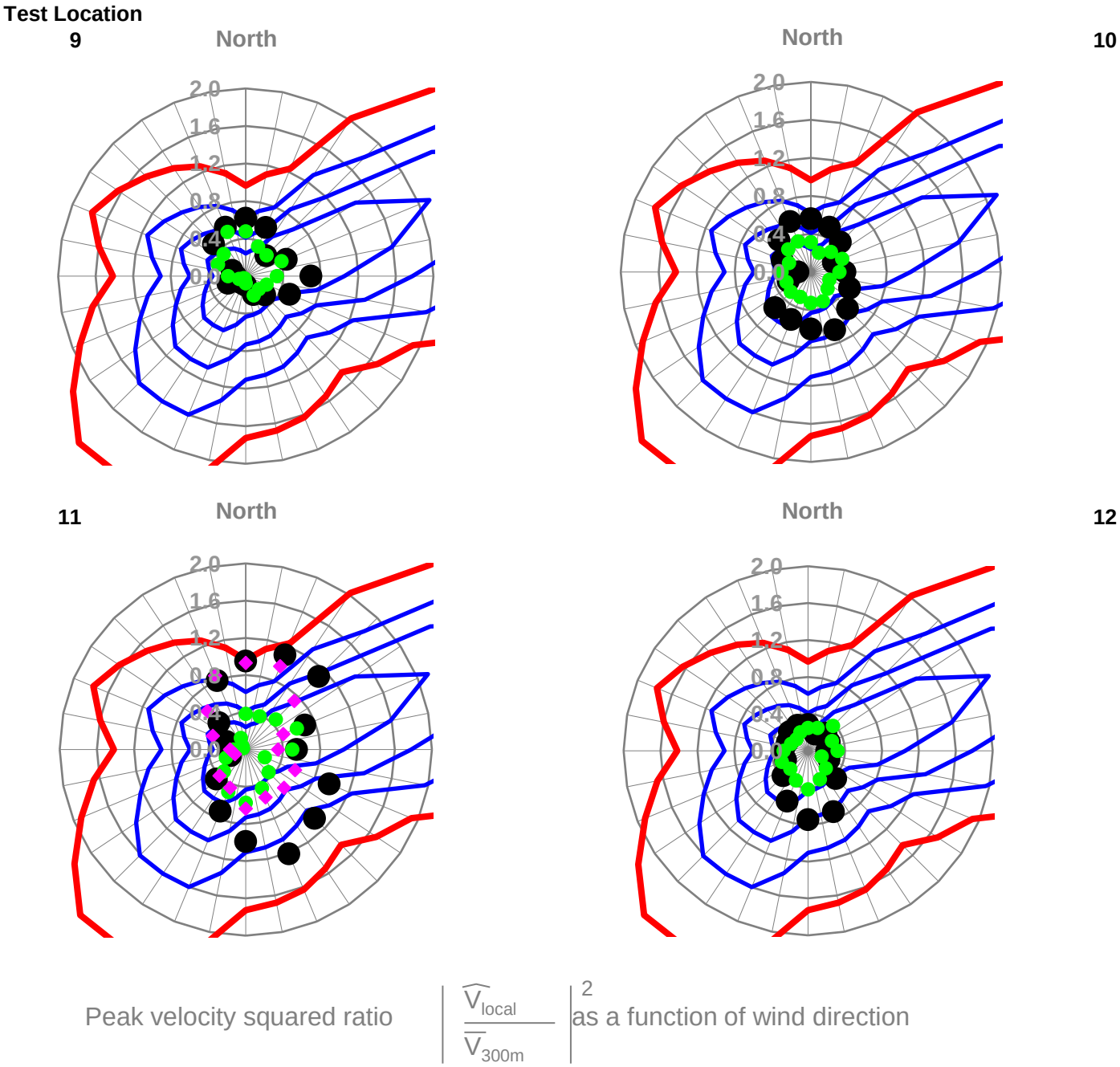
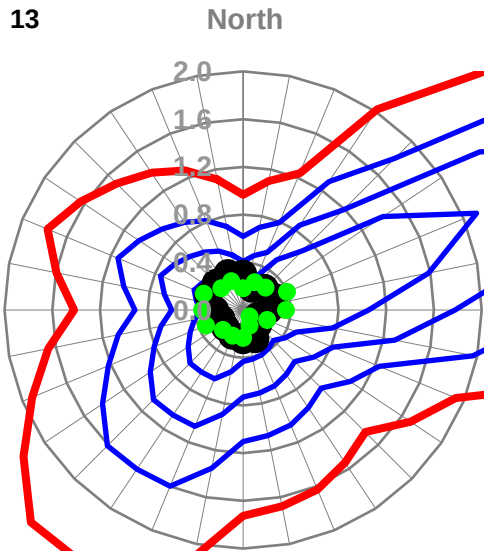


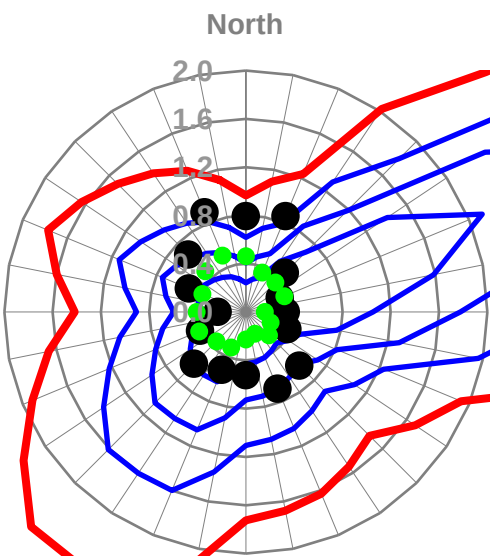
Figure A4 - Porter Street [CONTINUED] & Humffray Street

Test Location

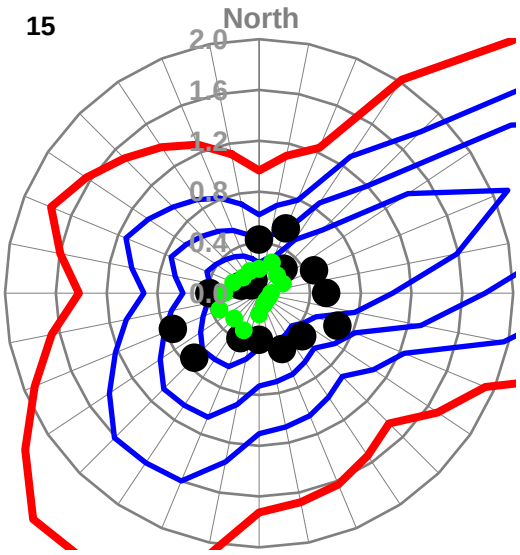
13



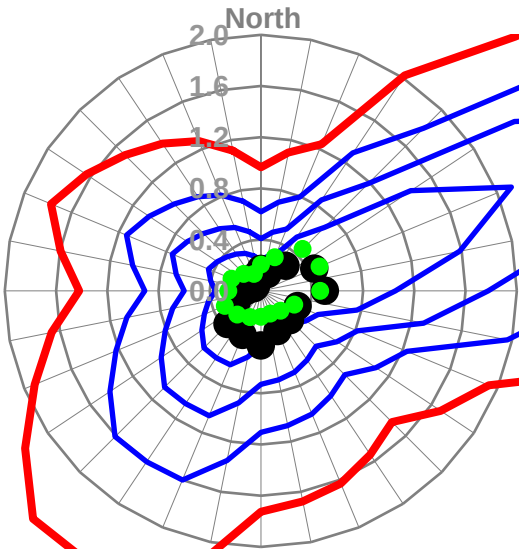
14



15



16



Peak velocity squared ratio $\left|\frac{\widehat{V}_{local}}{\overline{V}_{300m}}\right|^2$ as a function of wind direction

Proposed Configuration
Existing Configuration

Figure A5 - Humffray Street [CONTINUED]

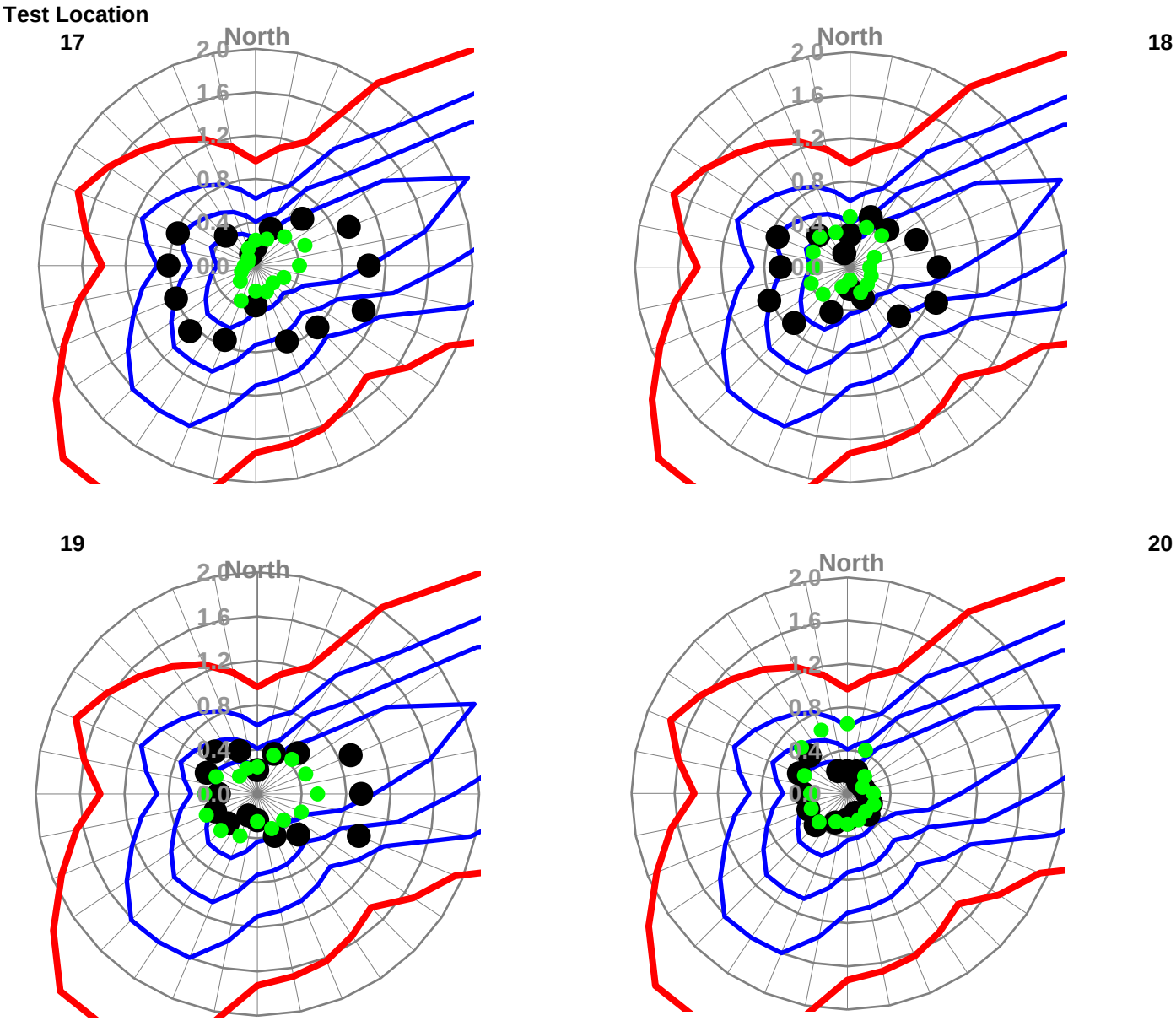


Figure A6 - Humffray Street [CONTINUED] & Eastwood Street

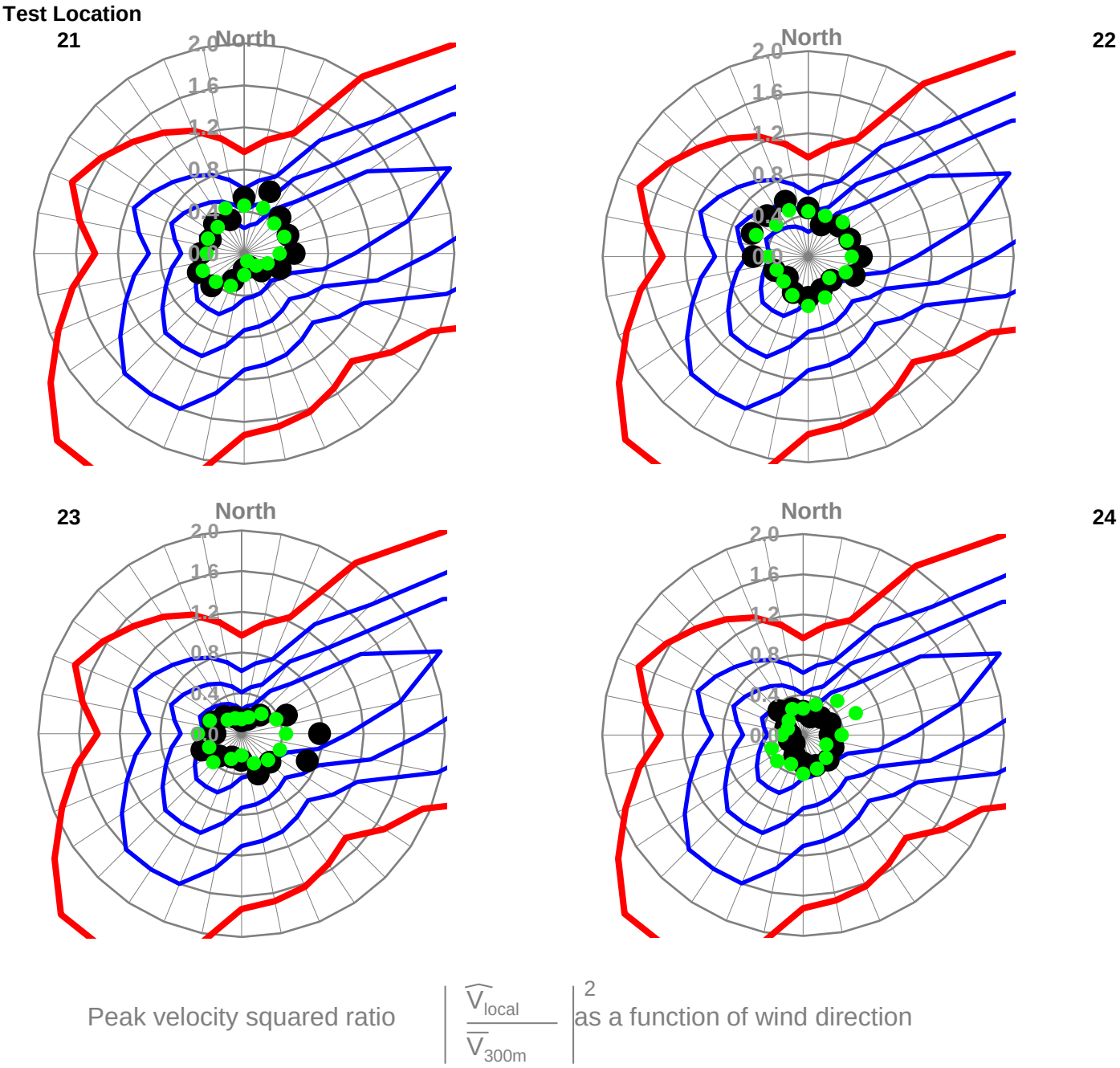
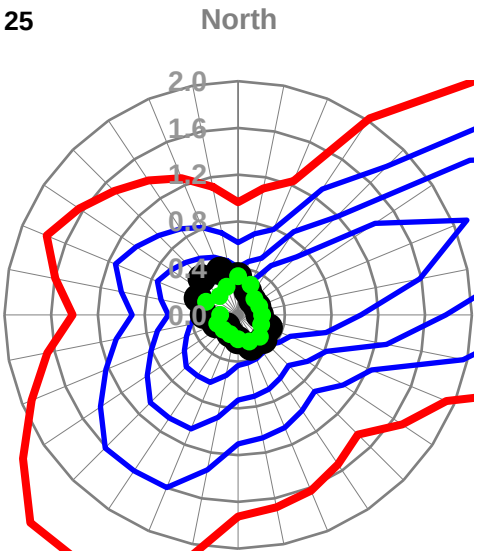


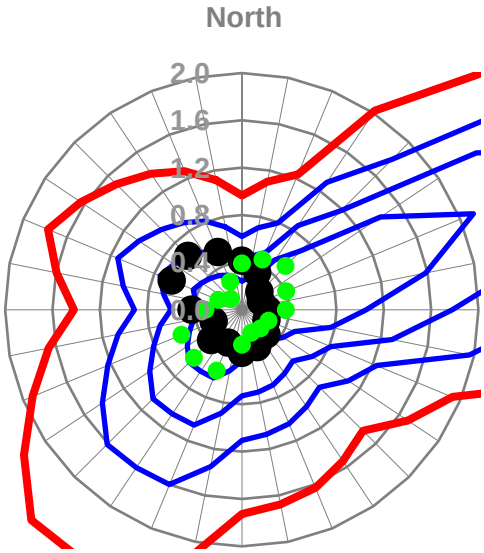
Figure A7 - Eastwood Street [CONTINUED]

Test Location

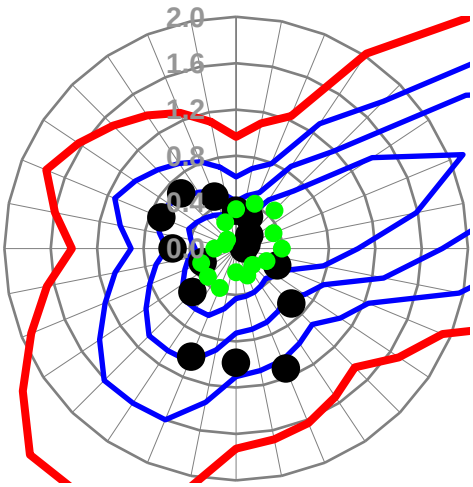
25



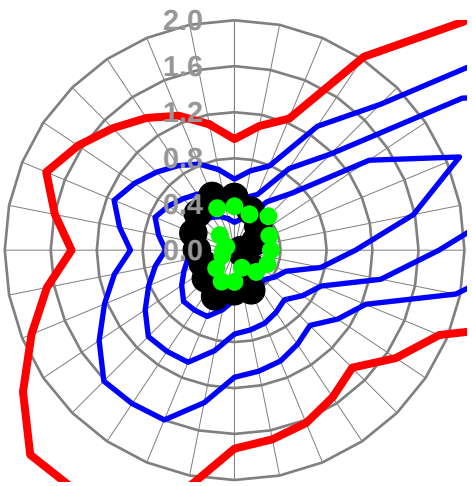
26



27



28



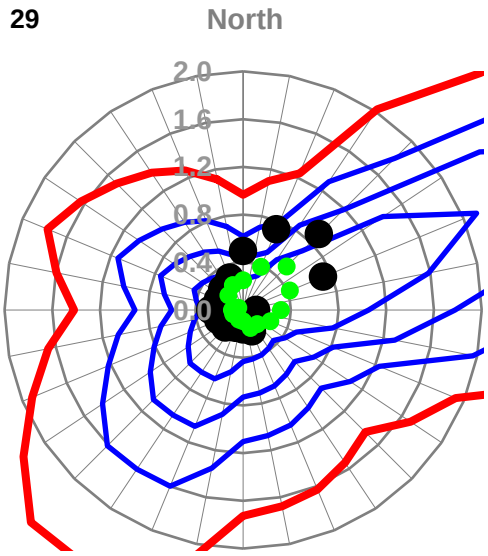
Peak velocity squared ratio $\left|\frac{\widehat{V}_{local}}{\overline{V}_{300m}}\right|^2$ as a function of wind direction

Proposed Configuration
Existing Configuration

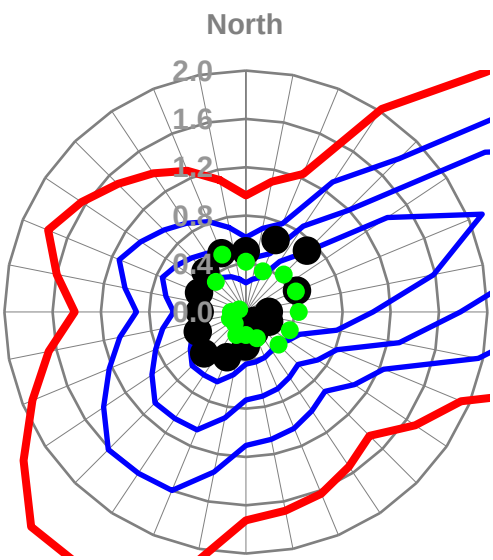
Figure A8 - Retail Car Park & Bradbys Lane

Test Location

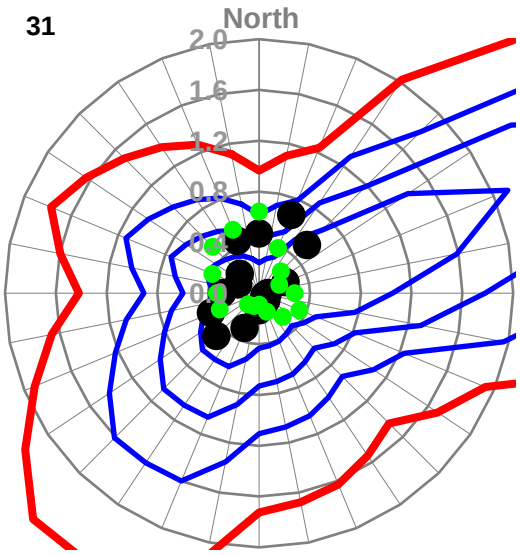
29



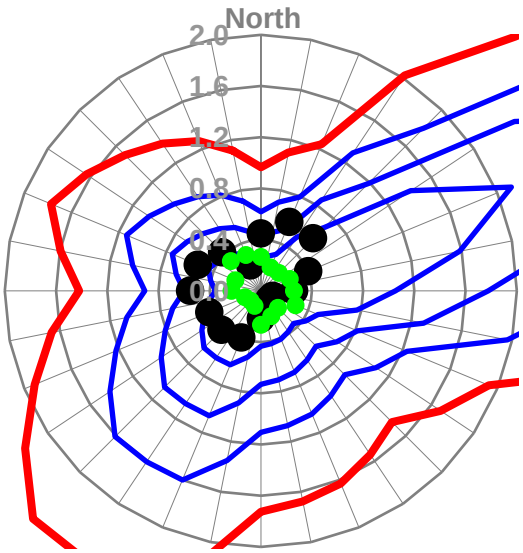
30



31



32



Peak velocity squared ratio $\left|\frac{\widehat{V}_{local}}{\overline{V}_{300m}}\right|^2$ as a function of wind direction

Proposed Configuration
Existing Configuration

Figure A9 - Bradbys Lane [CONTINUED]

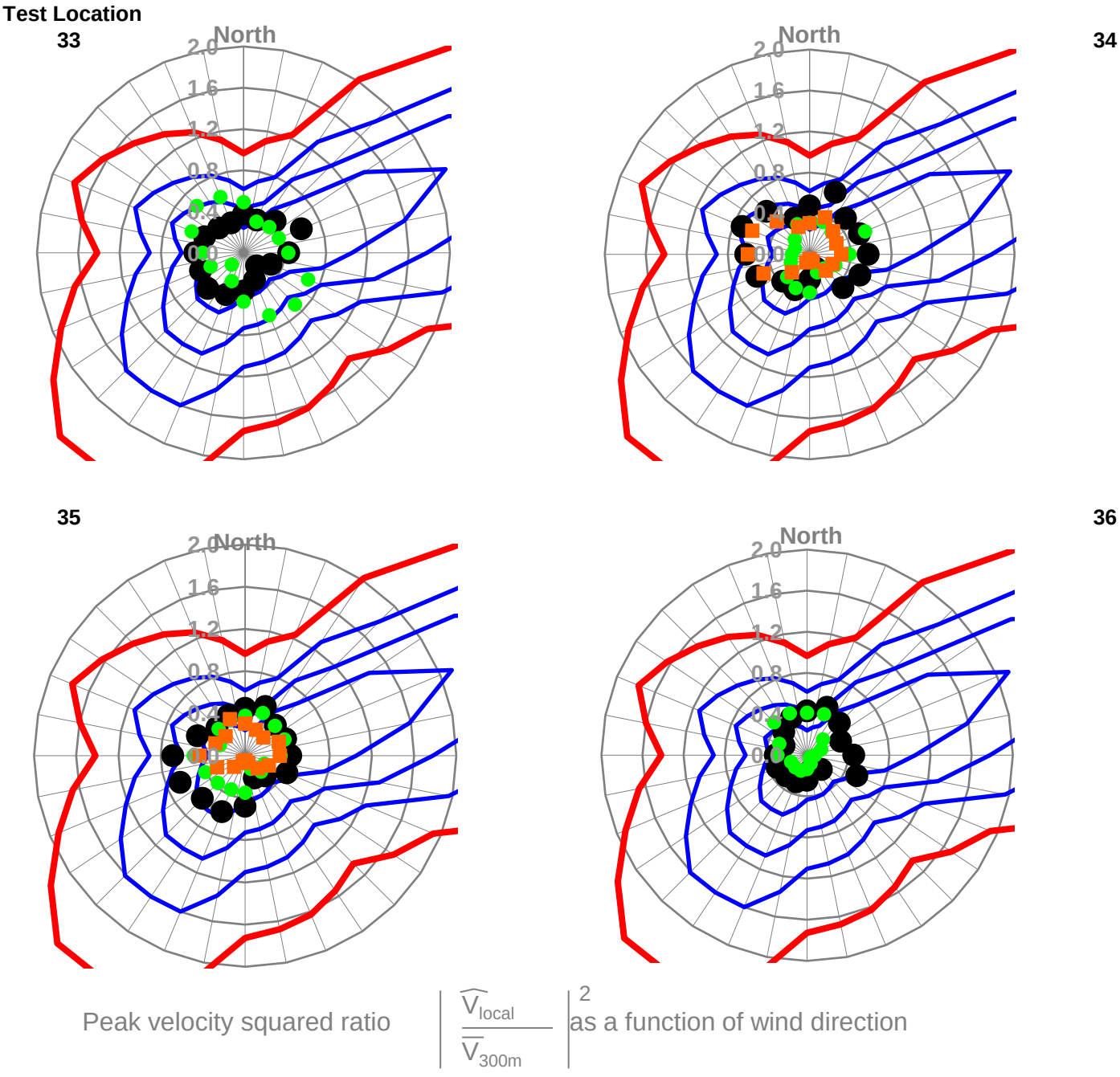


Figure A10 - Bradbys Lane [CONTINUED] & Development Plaza

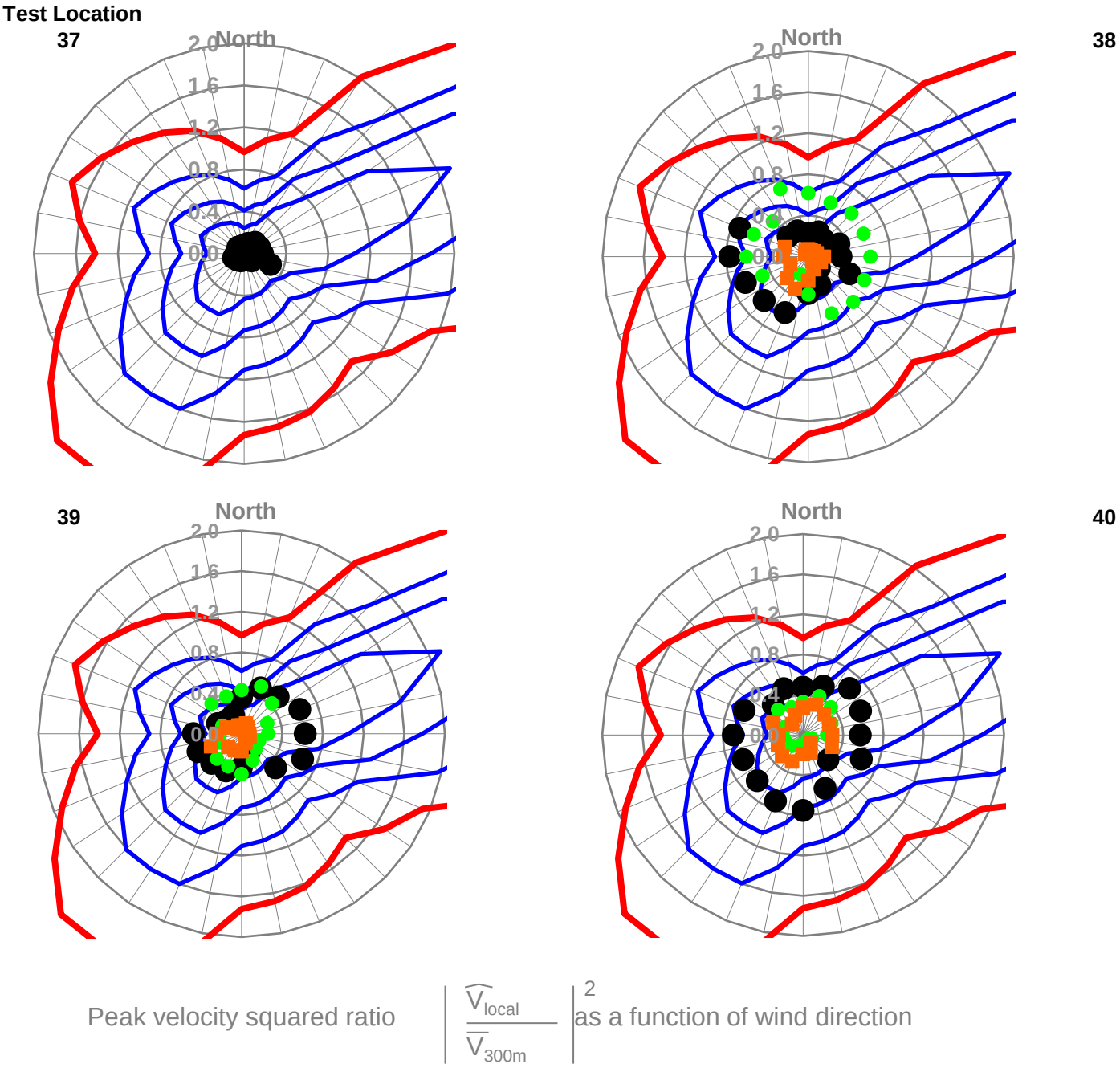


Figure A11 - Development Plaza [CONTINUED]

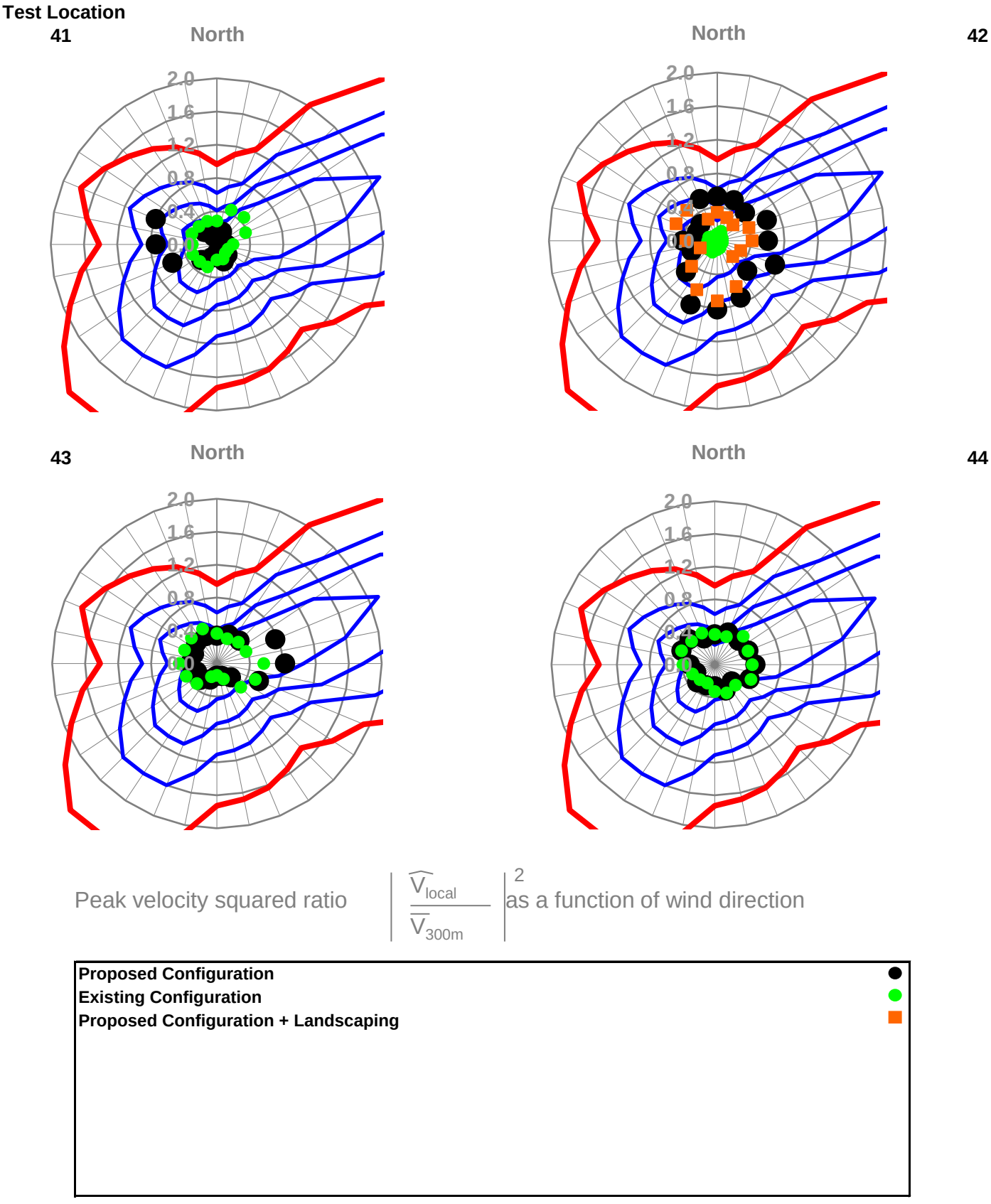


Figure A12 - Development Plaza [CONTINUED] & Peel Street Car Park

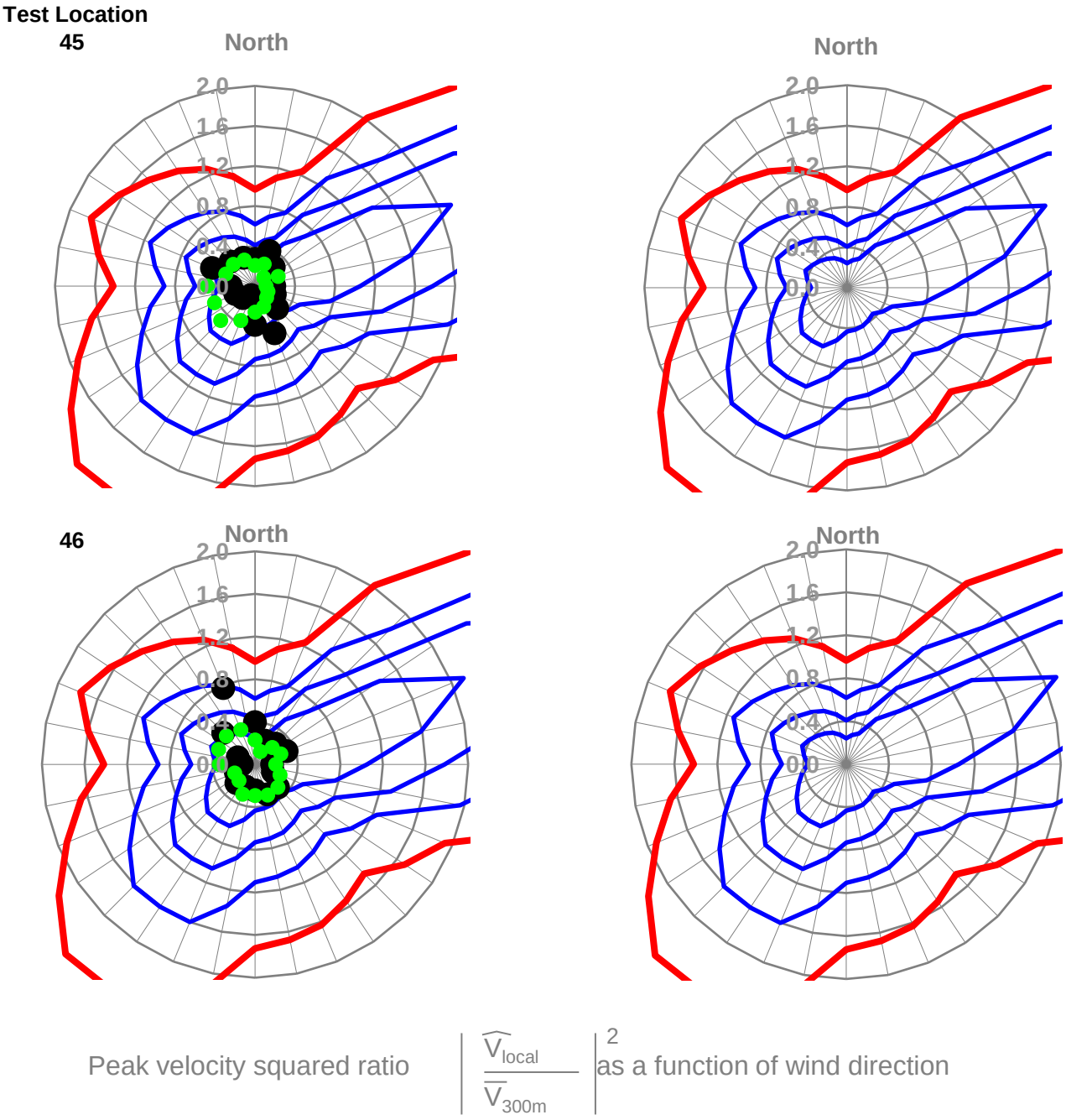


Figure A13 - Main Road Car Park & Porter Street

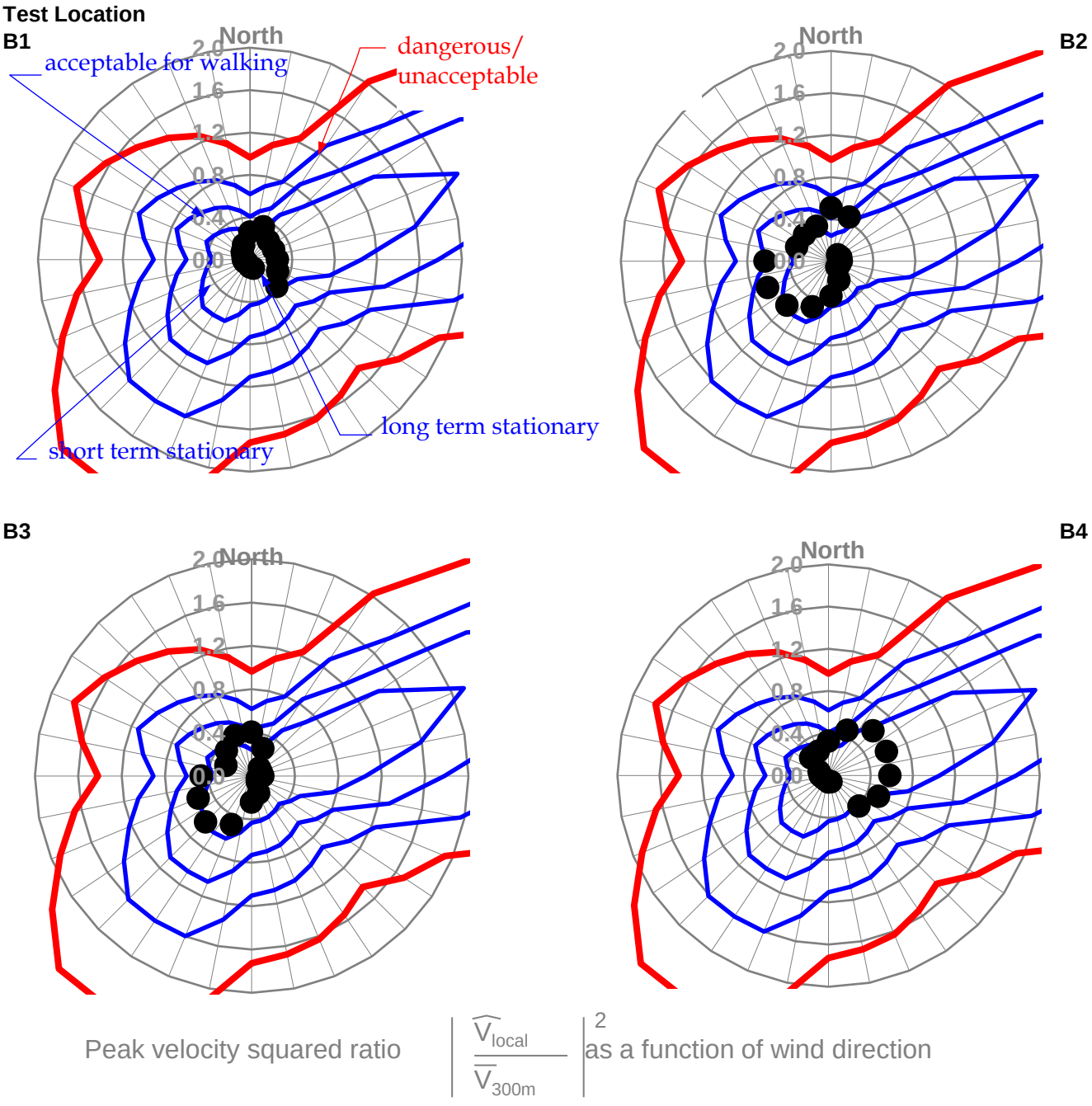


Figure A14 - Residential Terraces

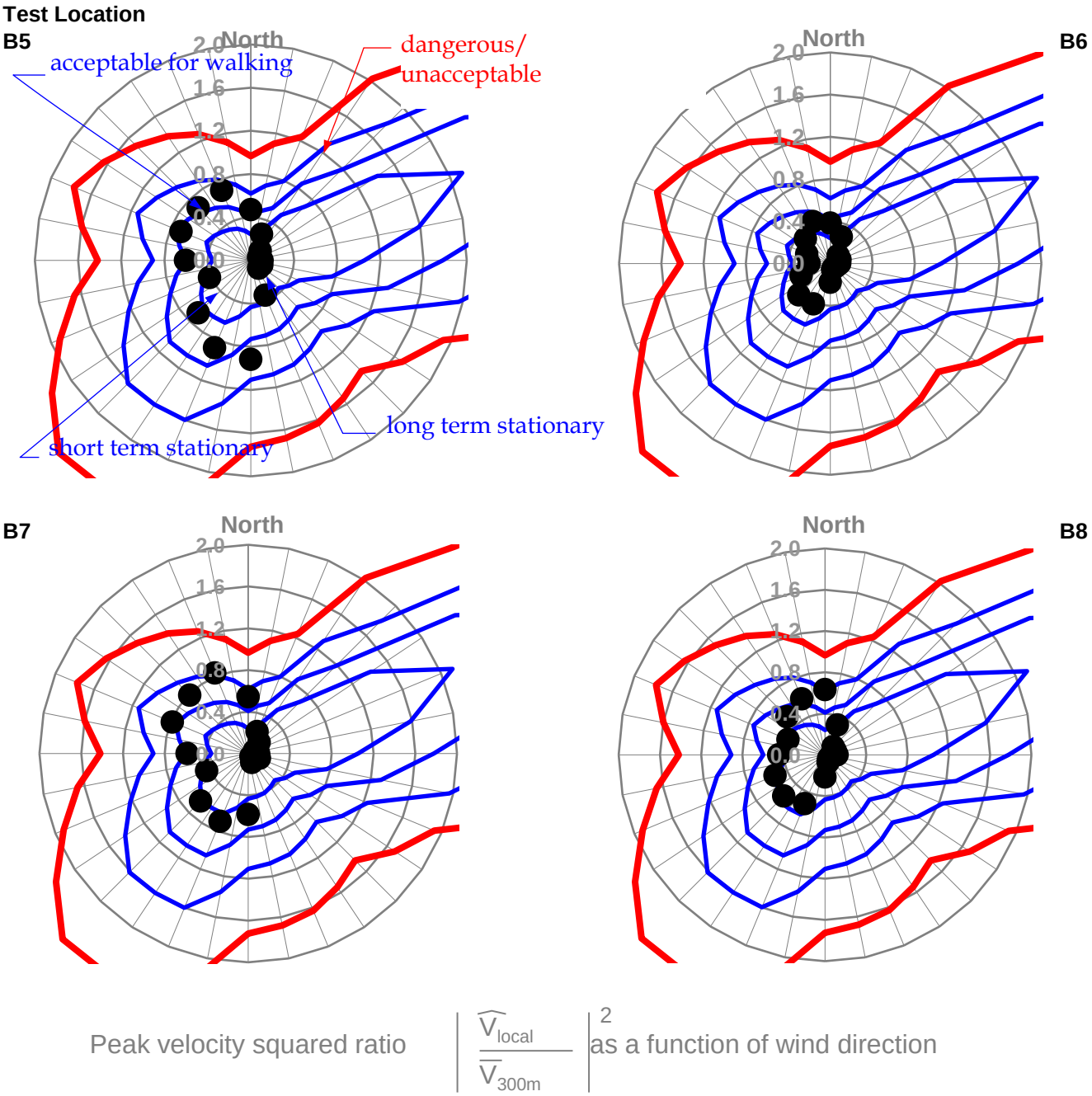


Figure A15 - Residential Terraces [CONTINUED]

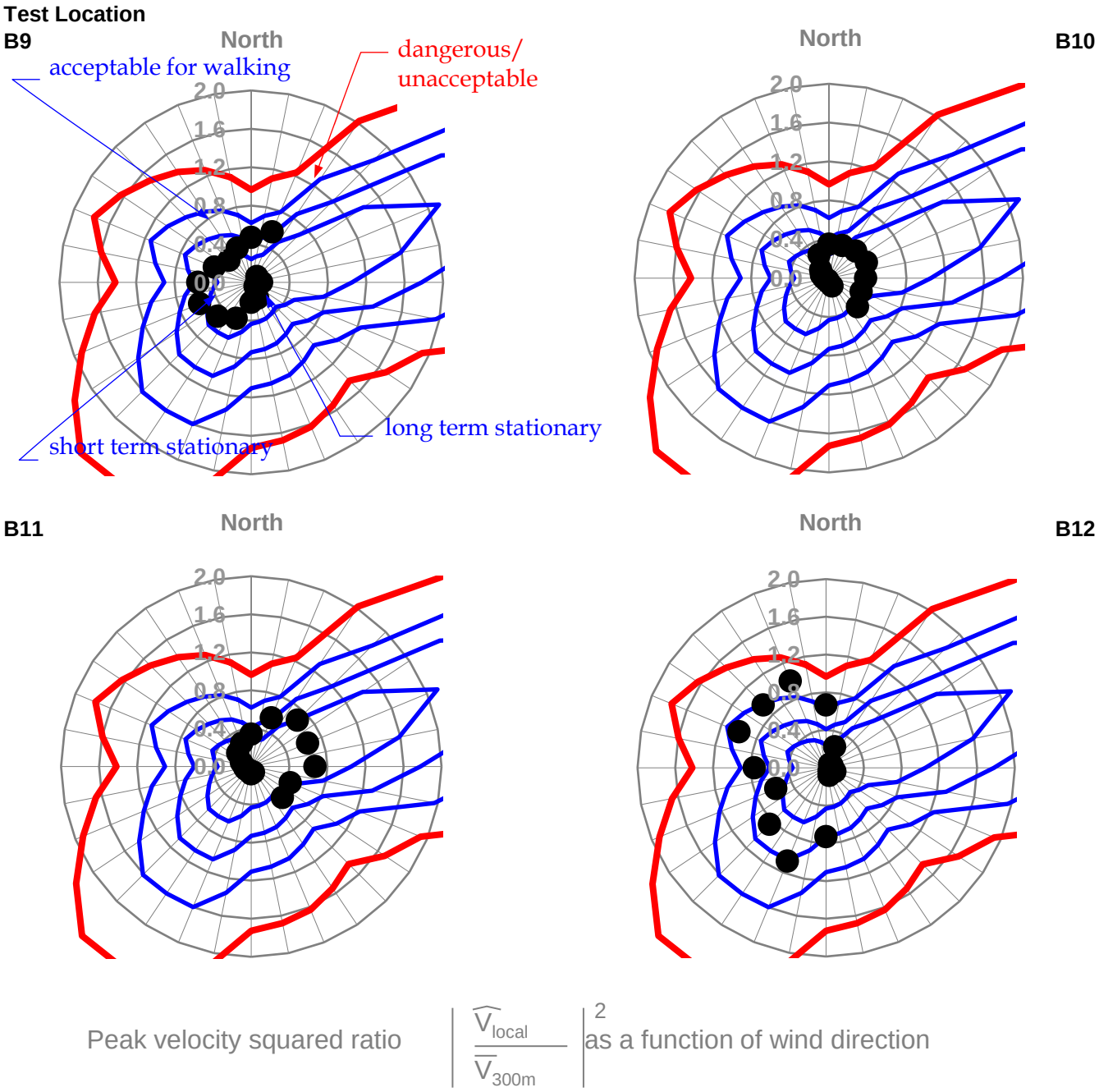


Figure A16 - Residential Terraces [CONTINUED]

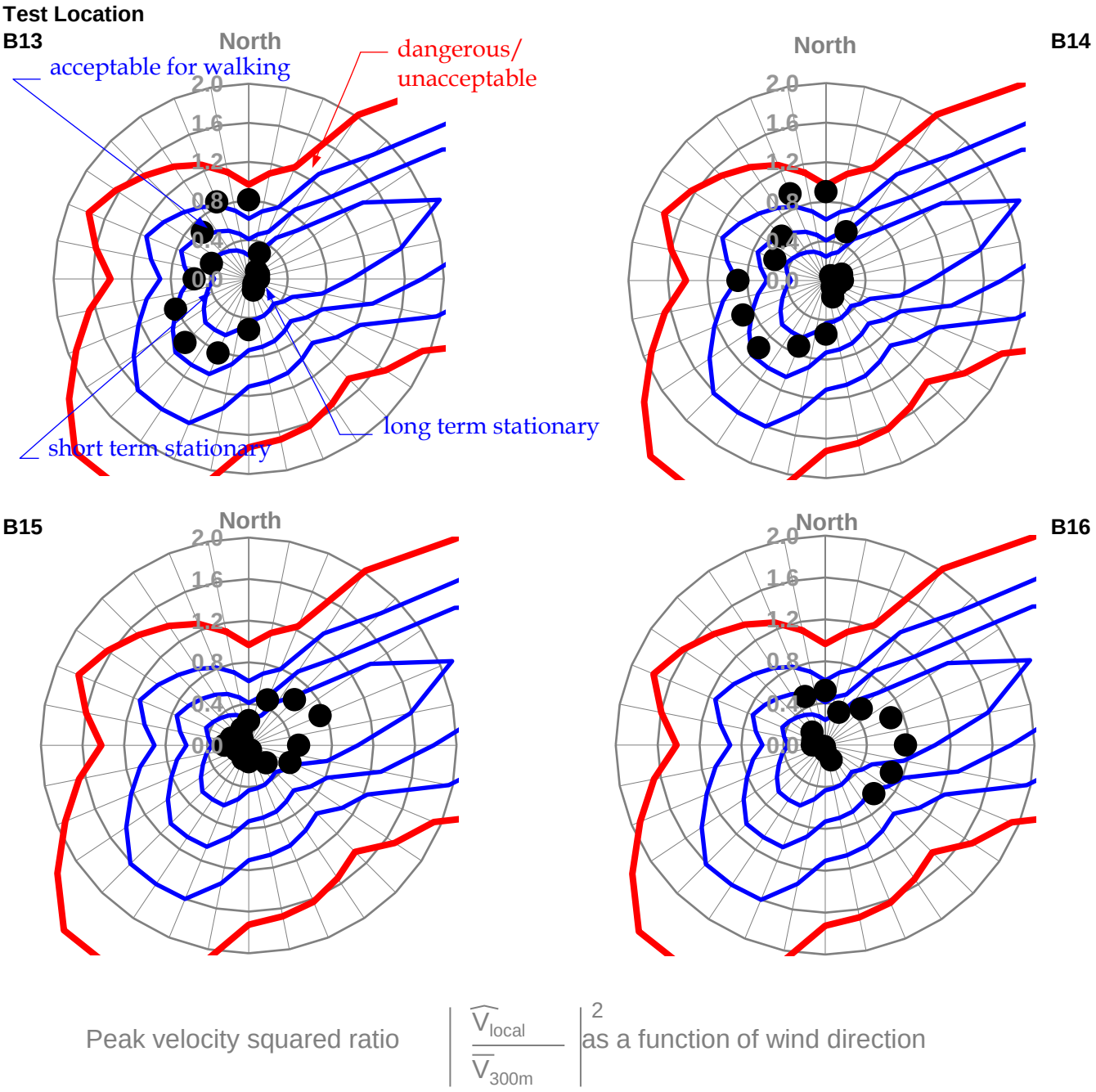
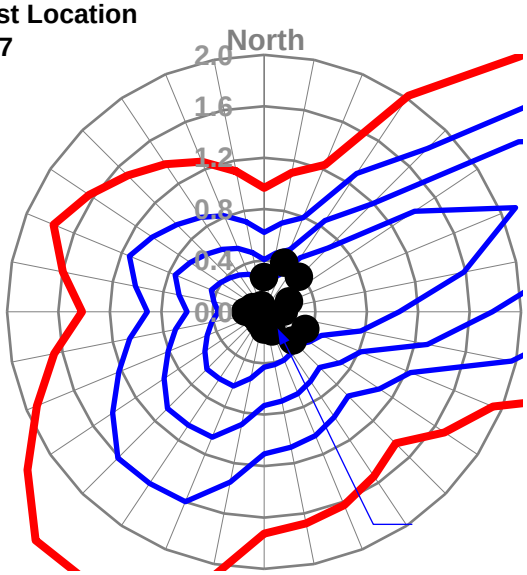
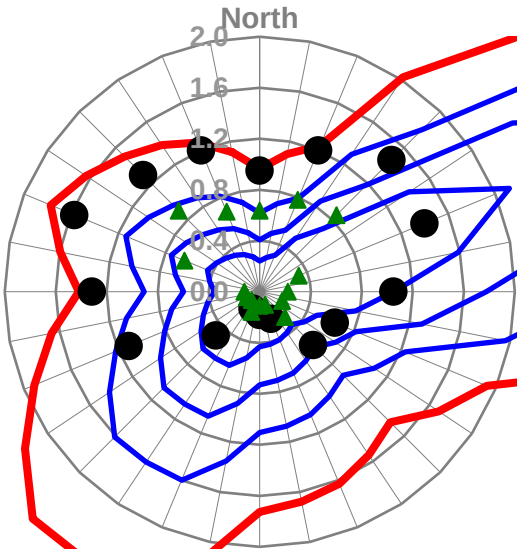


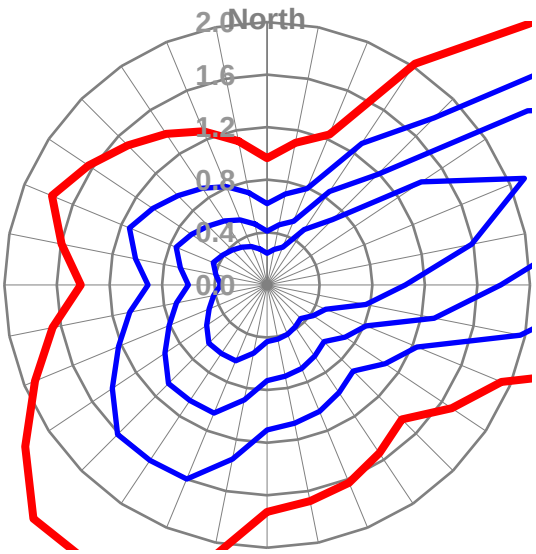
Figure A17 - Residential Terraces [CONTINUED]

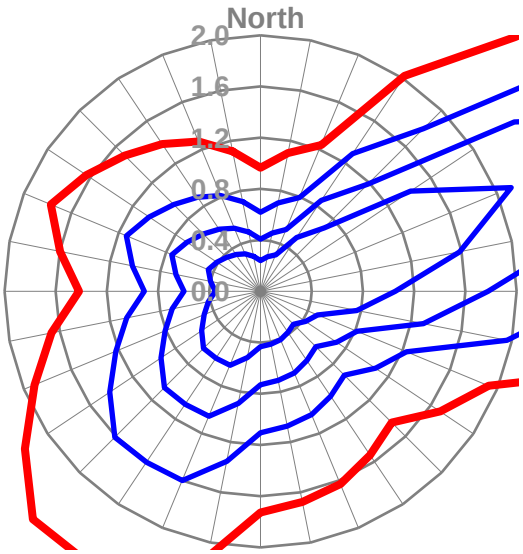
Test Location
B17





B18





Peak velocity squared ratio $\left|\frac{\widehat{V}_{local}}{\overline{V}_{300m}}\right|^2$ as a function of wind direction

Proposed Configuration ●

Proposed Configuration + 1.8m Balustrade ▲

Figure A18 - Residential Terraces [CONTINUED]

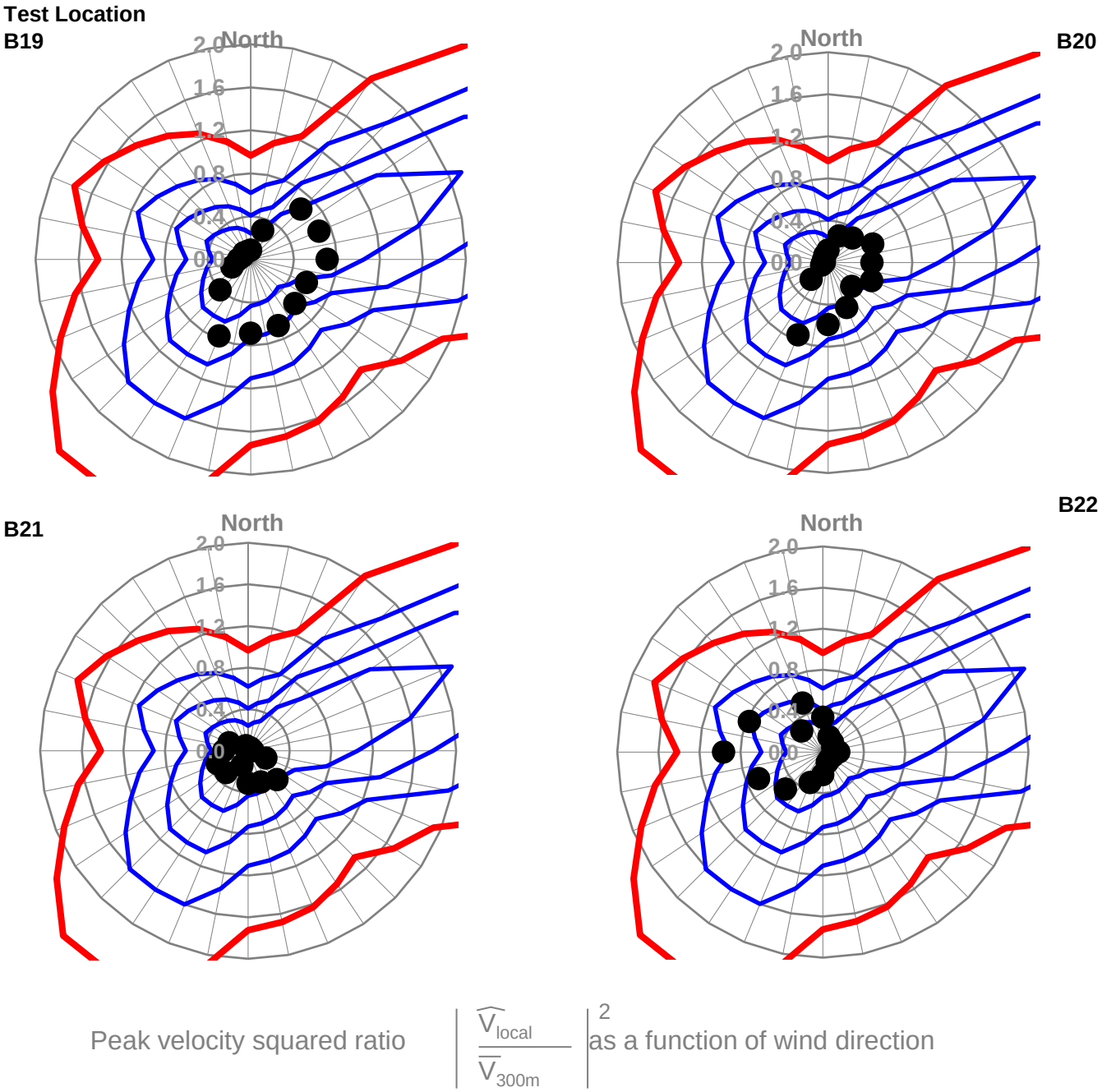
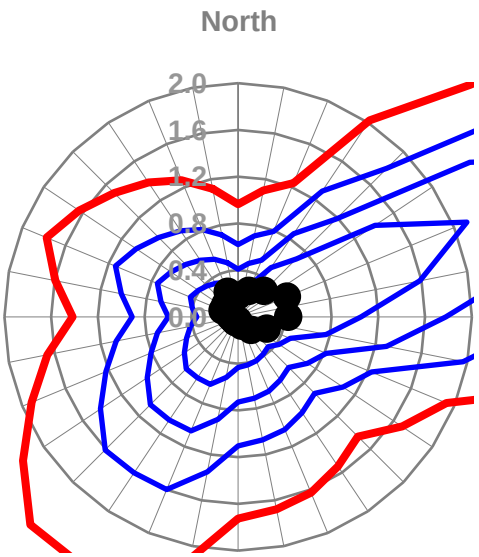


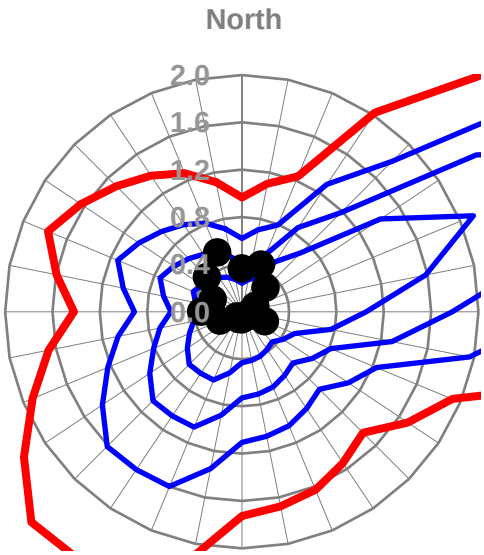
Figure A19 - Commercial Terraces

Test Location

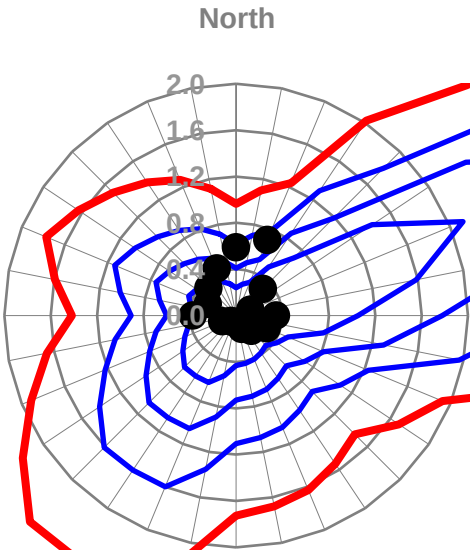
B23

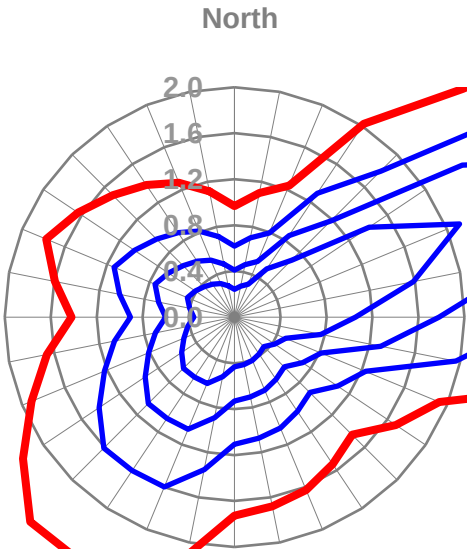


B24



B25





Peak velocity squared ratio $\left|\frac{\widehat{V}_{local}}{\overline{V}_{300m}}\right|^2$ as a function of wind direction

Proposed Configuration

Figure A20 - Commercial Terraces [CONTINUED]

Test Location

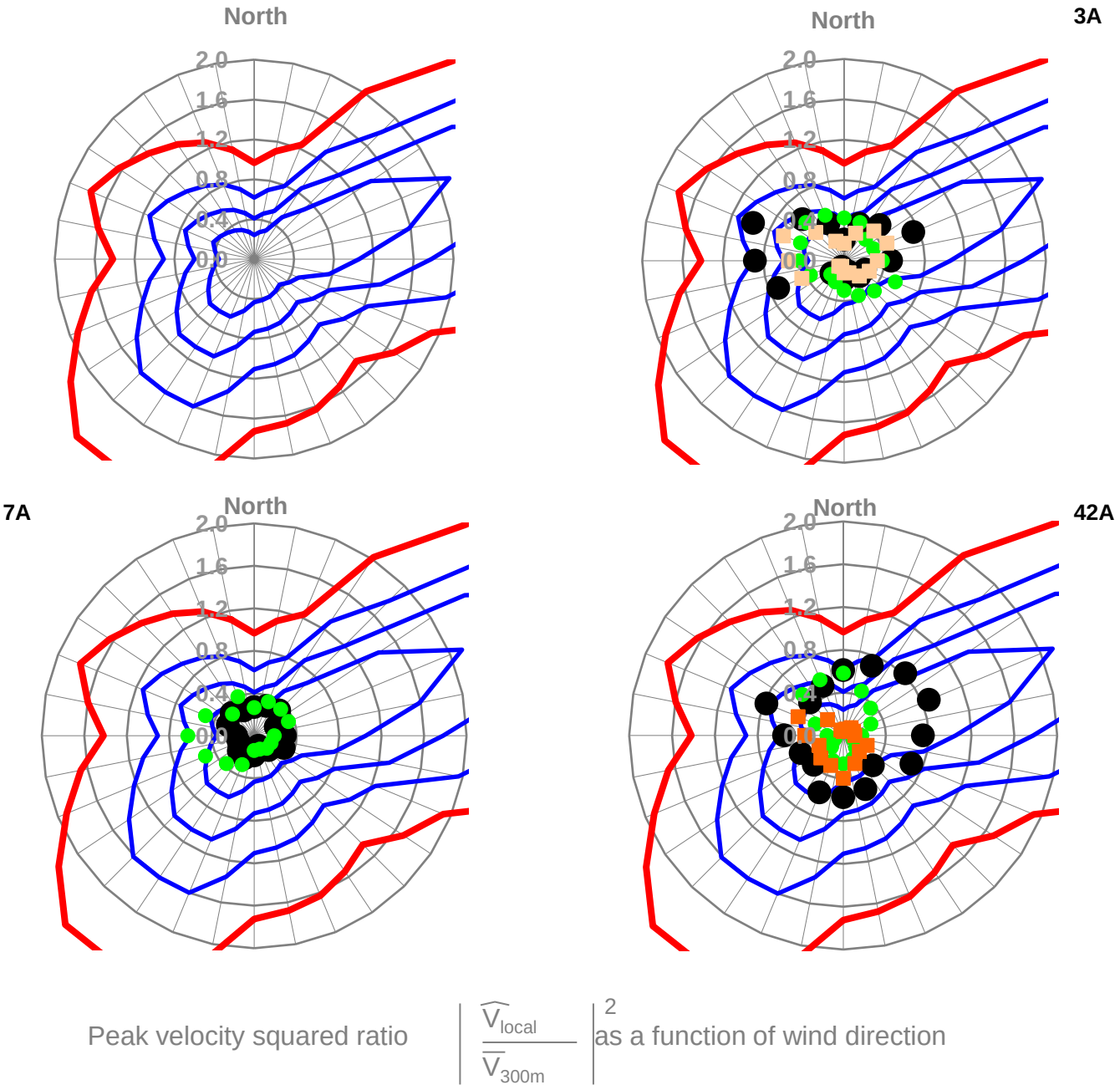


Figure A21 - misc