Attachment A11

Environmental Wind Tunnel Study

118-130 EPSOM ROAD AND 905 SOUTH DOWLING STREET, ZETLAND

Environmental Wind Tunnel Study

Prepared for:

Karimbla Constructions Services (NSW) Pty Ltd
Level 11, 528 Kent Street
SYDNEY NSW 2000

SLR Ref: 610.30825-R01
Version No: -v1.1
November 2020

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Karimbla Constructions Services (NSW) Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.30825-R01-v1.1	15 August 2022	Nikhil Pardeshi	Dr Peter Georgiou	Dr Neihad Al-Khalidy
610.30825-R01-v1.0	4 July 2022	Nikhil Pardeshi	Dr Peter Georgiou	Dr Neihad Al-Khalidy

EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Karimbla Constructions Services Pty Ltd, to undertake a quantitative wind assessment of the envelopes of the proposed developments located at 118-130 Epsom Road & 905 South Dowling Street, Zetland.

An initial assessment of the proposed envelops was performed in July 2022, via a Discrete Sensor Environmental Wind Tunnel Study whereby wind tunnel measurements were made to investigate wind conditions around the envelopes of the proposed development (simulated via a 1:400 scale model) at areas to be used by visitors and occupants of the development itself.

Feedback on this initial study led to further wind tunnel testing (August 2022), involving additional measurement sensor locations on the opposite sides of existing and proposed streets around the site, along all site frontages with a higher density of testing locations and greater testing extent around the taller proposed buildings.

The site is located at 118-130 Epsom Road & 905 South Dowling Street, Zetland, with Link Road to the east, Zetland Avenue to the north, Epsom Road to the south, and proposed George Julius Avenue to the west. Proposed developments comprise multiple envelopes ranging in heights from 3 to 23 storeys.

In terms of the surrounding buildings, the surrounding built environment comprises a mix of medium to high-rise buildings to the south clockwise around to the north-northeast, low-rise residential dwellings to the northeast and east, and Australian Golf Club to the southeast. Green Square station is located to the northwest. Immediately to the north and north-northeast across Zetland Avenue are a series of tall buildings. The terrain is gently undulating in the surrounding built environment, with no particularly significant topographical variations (ie hills, escarpments, etc) influencing local wind speeds.

Built Environment Scenarios Assessed

The study has involved the testing of two built environment "scenarios":

- Scenario 1 – "Baseline" The existing built environment (as of June 2022),
- Scenario 2 – "Proposed" "Baseline" + Proposed Development with Planned Wind Mitigation

Zetland Wind Climate

The study has developed a site-specific statistical wind climate model based on long-term wind records obtained from nearby Bureau of Meteorology stations at Sydney Kingsford Smith Airport and Bankstown Airport. For Zetland, SLR has determined that local winds have characteristics very close to Sydney (KS) Airport compared to Bankstown Airport, given Zetland's proximity to Sydney (KS) Airport and similar distance inland from the coastline. Key prevailing wind directions of interest are the northeast, southeast and south for summer and mainly west quadrant winds for winter.

"Baseline" (Existing) Wind Environment

Close to the ground, the "regional" wind patterns described above are affected by the local terrain, topography and built environment, all of which influence the "local" wind environment.

- As noted in **Section 1.3**, the site is currently surrounded by a mixture of medium to high-rise commercial and residential buildings, vegetation and trees, with modest change in topography. Immediately to the north and north-northeast, across Zetland Avenue are a series of tall buildings

- The site will therefore receive reasonable wind shielding depending upon oncoming wind direction at lower levels with upper levels exposed to higher winds from most wind directions.

"Proposed" Wind Environment

- In general, the site is expected to receive reasonable shielding especially at ground level from majority of the wind directions provided by the proposed envelops themselves as well as by the neighbouring existing buildings.

Already Planned Wind Amelioration Treatments

The following treatments relevant to wind mitigation have already been proposed:

- Existing and significant trees located along Zetland Avenue, Link Road, and Epsom Road – refer **Figure 12A**;
- Already proposed and significant tree planting along the new proposed roads located within the site, and around the new proposed Mulgu Park – refer **Figure 12B**.

It is recommended that all of the above planned features are retained and that new landscaping treatments (trees, hedges, etc) are evergreens (providing year-round protection) and of mature foliage when installed.

All proposed landscaping should be densely foliated and evergreen, given the occurrence of adverse winter wind conditions.

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DOCUMENT REFERENCES

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by Karimbla Constructions Services Pty Ltd, to undertake a quantitative wind assessment of the envelopes of the proposed developments located at 118-130 Epsom Road & 905 South Dowling Street, Zetland.

The assessment has been performed using a Discrete Sensor Environmental Wind Tunnel Study whereby wind tunnel measurements were made to investigate wind conditions throughout and around the proposed development (simulated via a 1:400 scale model) at areas to be used by visitors and occupants of the development itself.

1.1 Location of the Development Site

The site is located at 118-130 Epsom Road & 905 South Dowling Street, Zetland, with Link Road to the east, Zetland Avenue to the north, Epsom Road to the south, and proposed George Julius Avenue to the west. Proposed developments comprise multiple envelopes ranging in heights from 3 to 23 storeys – refer **Figure 1.**

Figure 1 Development Site Location

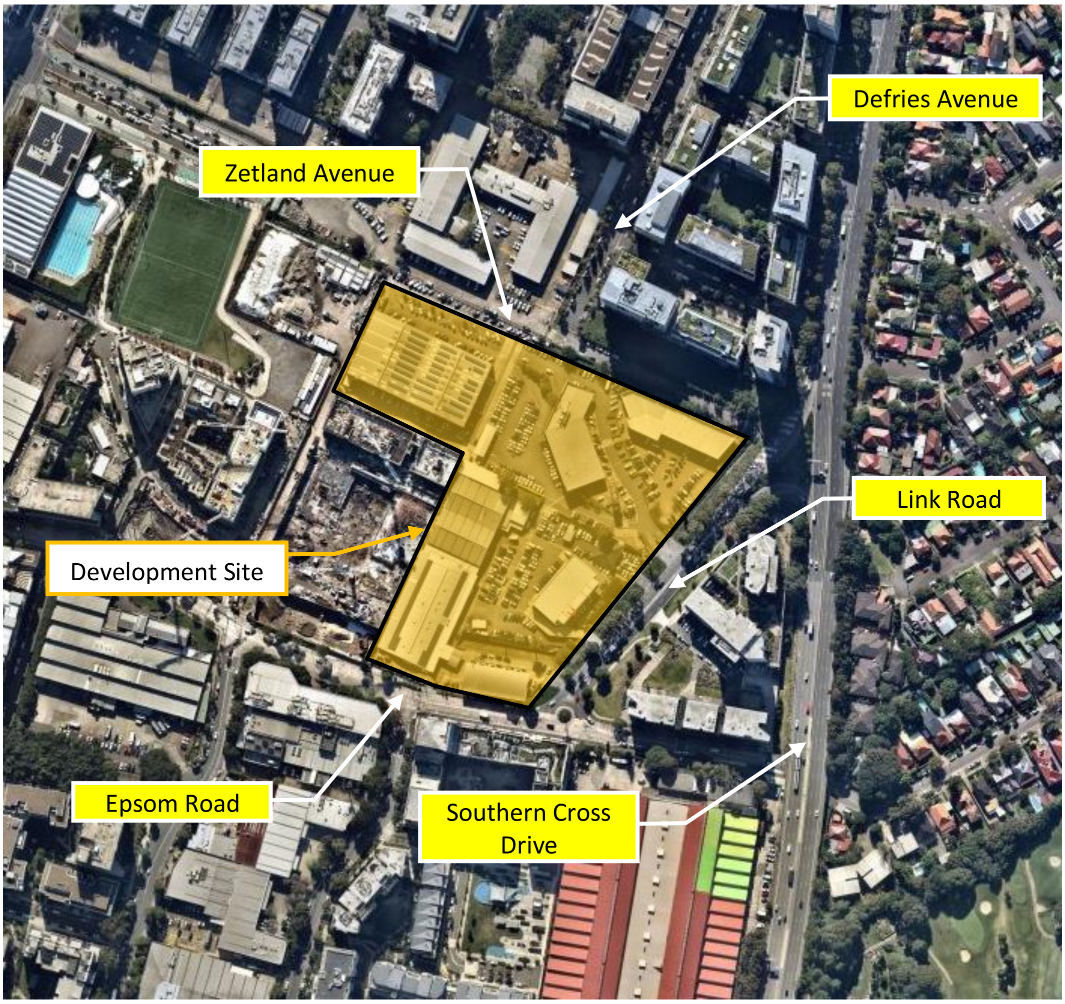


Image: Nearmap June 2022

1.2 Description of the Proposed Envelopes

The Proposed developments comprise multiple envelopes ranging in heights from 3 to 23 storeys. There are several new proposed roads cutting through the site in between the proposed envelop blocks. Proposed Mulgu Park is located within the site towards the southern end of site, surrounded by proposed roads. The proposed envelopes plan along with a perspective view of the site is shown in **Figure 2.**

Figure 2 Architectural Views of the Proposed Envelopes

Ground Floor

Perspective View from South

1.3 Surrounds

In terms of the surrounding built and natural environment (refer **Figure 3**):

- The surrounding built environment comprises a mix of medium to high-rise buildings to the south clockwise around to the north-northeast, low-rise residential dwellings to the northeast and east, and Australian Golf Club to the southeast;
- Green Square station is located to the northwest;
- Immediately to the north and north-northeast across Zetland Avenue are a series of tall buildings.
- The terrain is gently undulating in the surrounding built environment, with no particularly significant topographical variations (ie hills, escarpments, etc) influencing local wind speeds.

Figure 3 Surrounding Built Environment

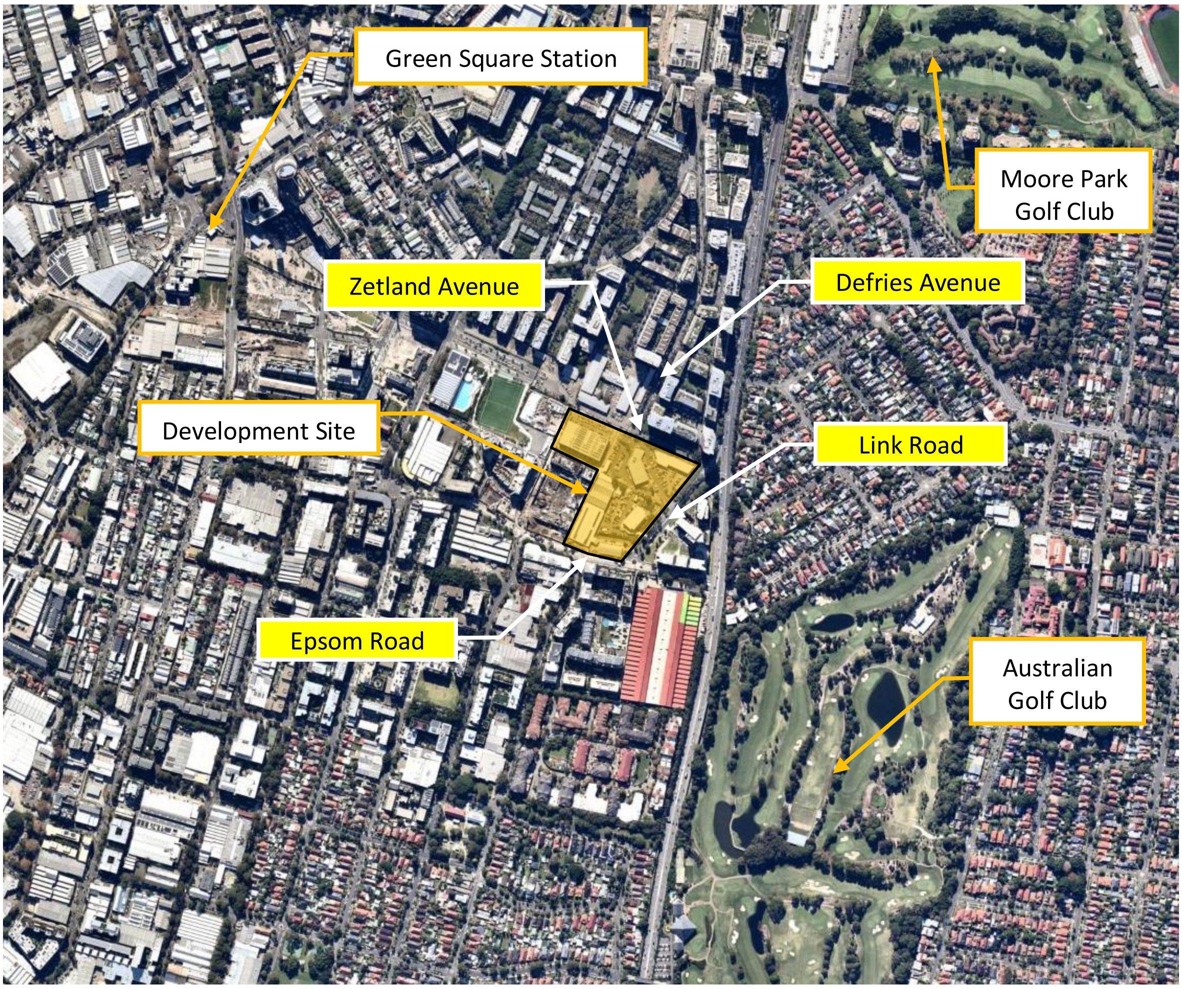


Image: Nearmap June 2022

2 SYDNEY'S WIND CLIMATE

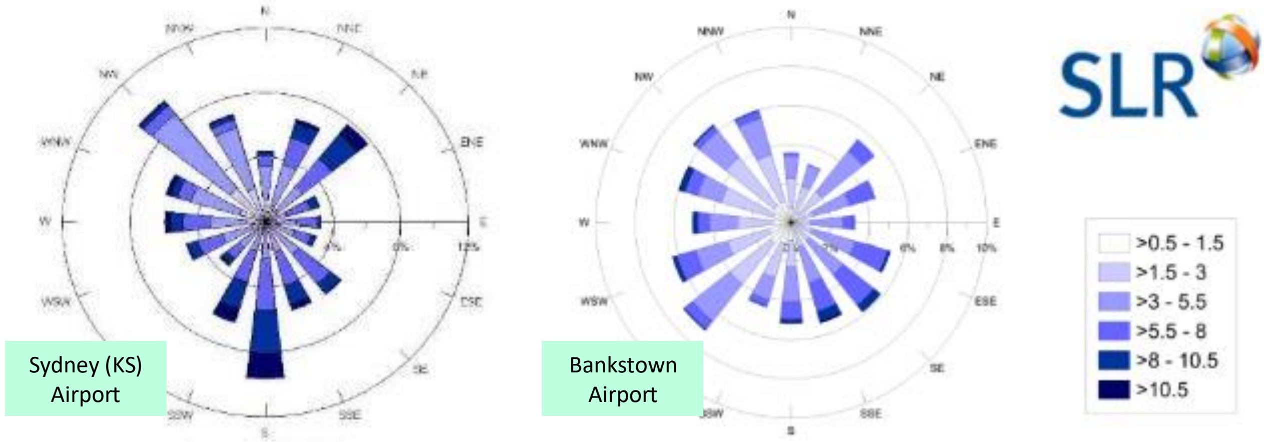
The data of interest in this study are the mean hourly wind speeds and largest gusts experienced throughout the year (especially higher, less frequent winds), how these winds vary with azimuth, and the seasonal break-up of winds into the primary Sydney Region wind seasons.

2.1 Annual and Seasonal Variations

Key characteristics of Sydney's Regional Wind Climate are illustrated in two representative wind roses shown in **Figure 4**, taken from Bureau of Meteorology (BoM) data recorded during the period 1999-2017 at Sydney (Kingsford Smith) Airport and Bankstown Airport. A review of the associated seasonal wind roses (refer **Appendix A**) shows that Sydney is affected by two primary wind seasons with relatively short (1-2 month) transition periods in between:

- Summer winds occur mainly from the northeast, southeast and south. While northeast winds are the more common prevailing wind direction (occurring typically as offshore land-sea breezes), southeast and southerly winds generally provide the strongest gusts during summer. Both northeast winds (as sea breezes) and stronger southerly winds associated with "Southerly Busters" and "East Coast Lows" typically have a significantly greater impact along the coastline. Inland, these systems lose strength and have altered wind direction characteristics.
- Winter/Early Spring winds occur mainly from west quadrants and to a lesser extent from the south. West quadrant winds provide the strongest winds during winter and in fact for the whole year, particularly at locations away from the coast.

Figure 4 Annual Wind Roses for Sydney (KS) Airport and Bankstown Airport (BoM Data)



2.2 Wind Exposure at the Site – the "Local"' Wind Environment

Close to the ground, the "regional" wind patterns described above are affected by the local terrain, topography and built environment, all of which influence the "local" wind environment.

- As noted in **Section 1.3**, the site is currently surrounded by a mixture of medium to high-rise commercial and residential buildings, vegetation and trees, with modest change in topography. Immediately to the north and north-northeast, across Zetland Avenue are a series of tall buildings
- The site will therefore receive reasonable wind shielding depending upon oncoming wind direction at lower levels with upper levels exposed to higher winds from most wind directions.

2.3 Design Wind Speeds

SLR has carried out a detailed study of Sydney Basin wind speeds using continuous records of wind speed and direction measured at the Bureau of Meteorology's (BoM) Sydney weather stations.

In particular, SLR has determined statistical wind information for locations not situated in close proximity (ie within say approximately a kilometre) of BoM weather stations. Particular emphasis was given to weather stations with a "clean" surrounding exposure, ie stations such as Sydney (Kingsford Smith) Airport and Bankstown Airport, which are relatively free of immediately surrounding obstacles such as buildings, vegetation, trees, etc, which would otherwise distort the winds seen by the weather station anemometer.

For Zetland, SLR has determined that local upper level winds reflective of the weather systems experienced at the site have characteristics in between Bankstown Airport than Sydney (KS) Airport, given the site's distance (30 km) inland from the coast compared to Bankstown Airport (25 km) and Sydney (KS) Airport (5 km).

Accordingly, the adopted Zetland wind model has slightly lower strength characteristics from the northeast and south compared to Sydney (Kingsford Smith) Airport and correspondingly higher strengths from the southeast and southwest/northwest compared to Sydney (KS) Airport.

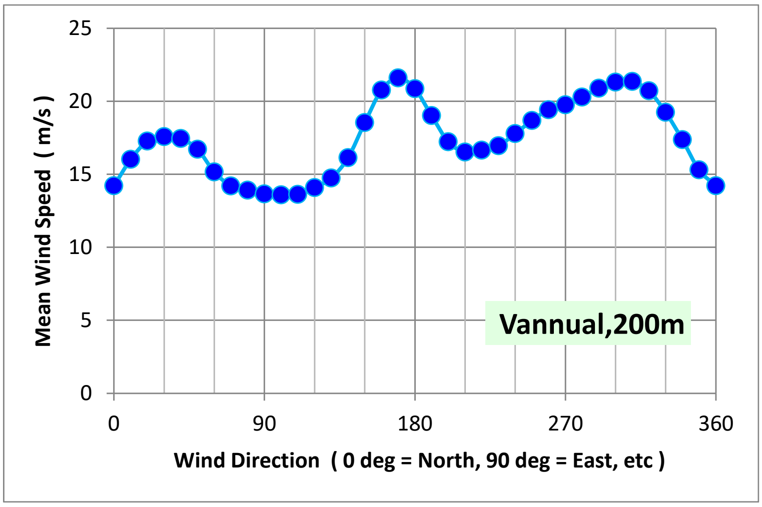
The above analysis is described in detail in:

- SLR Technical Note: *"9300-TN-CW&E-v2.0 Sydney Region Design Winds"*, March 2018.

2.4 Reference Height Annual Mean Wind Speeds

In the wind tunnel testing, the reference dynamic pressure used to record all wind speed data was measured at an equivalent (full-scale) height of 200 m above ground level (500 mm in the wind tunnel). Accordingly, conversion from wind tunnel speeds to full-scale speeds requires the determination of reference height design mean wind speeds for the site. These are shown in **Figure 5** and have been based on the adopted Zetland wind model as described above. The winds shown have a once-per-year exceedance probability.

Figure 5 Reference Height (200 m) Annual Recurrence Mean Wind Speed at Project Site



3 WIND ACCEPTABILITY CRITERIA

The choice of suitable criteria for evaluating the acceptability of particular ground level conditions has been the subject of international research over several decades.

3.1 Comfort and Safety Criteria

The criteria used in the evaluation of pedestrian level winds surrounding the proposed development are:

- **COMFORT:** the "Lawson (2001)" criteria which couple the probability of exceeding winds at given statistical levels with wind speed magnitudes and associated impacts originally related to the Beaufort Wind Speed Land Scale – refer **Table 1**.; and
- **SAFETY:** the Melbourne (1978) criteria, based on the exceedance of annual peak gust wind speeds.

Table 1 Beaufort Wind Speed – LAND Scale

Beaufort Force	Hourly Average Wind Speed (m/s)	Description of Wind	Noticeable Wind Effect
0	< 0.45	Calm	Smoke rises vertically
1	0.45 to 1.55	Light air	Direction shown by smoke drift but not by wind vanes
2	1.55 to 3.35	Light breeze	Wind felt on face; leaves rustle; wind vanes begin to move
3	3.35 to 5.0	Gentle breeze	Leaves, small twigs in constant motion; Light flags extended
4	5.6 to 8.25	Moderate breeze	Raises dust and loose paper; small branches move
5	8.25 to 10.95	Fresh breeze	Small trees, in leaf, sway
6	10.95 to 14.10	Strong breeze	Large branches begin to move; telephone wires whistle Umbrellas used with difficulty
7	14.1 to 17.2	Moderate Gale	Whole trees in motion Inconvenience felt when walking against the wind.
8	17.2 to 20.8	Gale	Twigs break off trees; personal progress impeded
9	20.8 to 24.35	Strong/Severe Gale	Slight structural damage (chimney pots, slates removed)
10	24.35 to 28.4	Storm	Trees uprooted; considerable structural damage
11	28.4 to 32.4	Violent Storm	Widespread damage – unusual event
12	> 32.4	Hurricane	Devastation – only occurs in the tropics

Comfort Criteria

As noted above, in relation to comfort, the Lawson (2001) criteria used in this report make use of the same Beaufort wind speed ranges to characterise issues of interest in terms of both pedestrian comfort and safety.

- The **Lawson (2001) Comfort** criteria relate a range of typical pedestrian activities such as purpose-walking, strolling, sitting, etc, to the local "GEM" wind speed which is exceeded 5% of the time, on an annual return period basis – refer **Table 2**.

The "GEM" (Gust Equivalent Mean) wind speed used in the criteria is the maximum of the local mean wind speed or the local gust speed divided by 1.85.

Table 2 Lawson Wind Acceptability Criteria – COMFORT Guidelines

Comfort Level	Beaufort Equivalent	"GEM" Wind Speed 5% Annual Exceedance	Description (see also Notes)
C5	1	2.5 m/sec	Dining
C4	2	4 m/sec	Sitting
C3	3	6 m/sec	Standing
C2	4	8 m/sec	Leisure Walking (Strolling)
C1	5	10 m/sec	Business (Purpose) Walking
CX	> 5	> 10 m/sec	Exceeds Comfort Criteria

Notes: C4 is suitable for promenades, popular recreation areas with seating, reading newspapers, etc

C3 is suitable for locations where pedestrians will likely be waiting for relatively short periods, eg at building entrances, at pedestrian crossings, bus stops, etc

C2 is suitable for activities such as window-shopping

C1 is suitable for footpaths used for purposeful pedestrian traffic only (eg not where shops might induce slower activities like window-shopping)

CX suggest winds whose force can be felt by the body (branches on trees would be visibly swaying) and where walking will start to become inconvenient or challenging for certain classes of pedestrians, eg the frail, pedestrians holding parcels, parents holding children, etc.

Safety Criterion

The safety acceptability criteria used in this report, currently referenced by many Australian Local Government Development Control Plans, are the so-called "Melbourne" criteria, summarised in **Table 3.**

Table 3 Melbourne (1978) Wind Acceptability Criteria - SAFETY

Type of Criteria	Gust Wind Speed Occurring Once Per Year	Activity Concerned
Safety	24 m/s	Knockdown in Isolated Areas
	23 m/s	Knockdown in Public Access Areas

3.2 Significance Criteria - Comfort

The significance criteria used by SLR in the assessment of "Comfort-related" wind effects at measurement locations surrounding the site are based on comparing the wind-tunnel predicted conditions at any particular location with the target usage at the same location (eg sitting, strolling, leisure walking, etc) as defined by the Lawson (2001) Comfort Criteria.

- The proposed development is deemed to have a **"Beneficial"** impact at any particular location if wind conditions are calmer than the levels associated with the target usage at that location.
- When wind conditions at any particular location, with the addition of the proposed development, are close to the levels associated with the target usage at that location, the impact is termed **"Negligible"**.
- The proposed development is deemed to have an **"Unfavourable"** impact at any particular location if wind conditions are higher (windier) than the levels associated with the target usage at that location.

The chosen significance criteria are shown **Table 4**.

- All "Unfavourable" impacts (whether minor, moderate or major) are considered to be "significant", requiring consideration of mitigation for local conditions to become suitable for the intended use of the area.
- In considering mitigation under these such circumstances, "Baseline" wind conditions should also be considered if pre-existing conditions are already exceeding the target wind levels at the project site.

Table 4 Significance Criteria Related to Lawson Acceptability Criteria

Impact	Predicted Wind Microclimate
Beneficial – Major	Wind Conditions are 3-levels **calmer** than desired
Beneficial – Moderate	Wind Conditions are 2-levels **calmer** than desired
Beneficial – Minor	Wind Conditions are 1-level **calmer** than desired
Negligible	Wind Conditions are at the **same** level as desired
Unfavourable – Minor	Wind Conditions are 1-level **windier** than desired
Unfavourable – Moderate	Wind Conditions are 2-levels **windier** than desired
Unfavourable – Major	Wind Conditions are 3-levels **windier** than desired **OR** Wind Conditions are in the Lawson "CX" or "SX" category

Comments on the Application of the Acceptability Criteria

In many urban locations, either because of exposure to open upstream conditions or because of street "canyon" effects, etc, the relevant Comfort and Safety criteria may already be currently exceeded. In such instances:

- a new development should ideally not exacerbate existing adverse wind conditions; and
- wherever feasible and reasonable, ameliorate such conditions.

For this reason, in the assessment of wind tunnel predictions of wind conditions associated with a newly proposed development, it can be useful to compare the wind microclimate in the "Proposed" condition (ie with the proposed development) with the wind microclimate of the pre-existing "Baseline" condition – as has been done in the present study.

The probabilistic way in which the Comfort Criteria are defined indicates that the relevant activity may be unsuitable at a particular location for about 5% of the time (say around 18 days per year). For the rest of the time, the relevant activity may be suitable (given that winds will be lower than the prescribed acceptability level). Moreover, it is noted that the recommended limiting values for comfort-related wind conditions were generally derived from subjective assessments of wind acceptability. These have been found to vary considerably with the height, strength, age, etc, of the pedestrian concerned. Accordingly, some latitude can be applied to the Comfort Criteria in particular taking into account the extent of windy conditions, eg some relaxation of the criteria may be acceptable for small areas under investigation which are used infrequently.

The safety criteria shown in **Table 3** reflect the potential for stronger winds to cause a loss of balance and even possible wind knock-down, especially for frail pedestrians. The criteria are accordingly significantly more stringent.

Mitigation Using Landscaping

The Australasian Wind Engineering Society (AWES) *Guidelines for Pedestrian Wind Effects Criteria* provides advice related to the use of landscaping (trees, shrubs, etc) for mitigation of adverse wind conditions. In particular, the AWES Guideline notes the following:

- Trees planted in locations where the 23 m/s safety criterion is exceeded are likely to experience wind speeds every 5 years or so which will be sufficient to destroy or severely damage many trees.
- Moreover, landscaping planted in high wind locations rarely matures to its normal full height assumed for wind mitigation and trees placed in high wind areas have the potential to shed limbs during windstorms, thereby causing a public danger and a public nuisance.
- Finally, trees located on public footpaths become the responsibility of the local municipality. Their maintenance, replacement following damage, loss of limbs, etc, can become burdensome financially (assuming the Municipality is even aware of such damage) and cannot be guaranteed.

Accordingly, the AWES Guideline does not recommend the use of landscaping when seeking to mitigate wind conditions that equal or exceed the public safety 23 m/s criterion.

4 WIND TUNNEL TEST METHODOLOGY

4.1 Simulation of Natural Wind

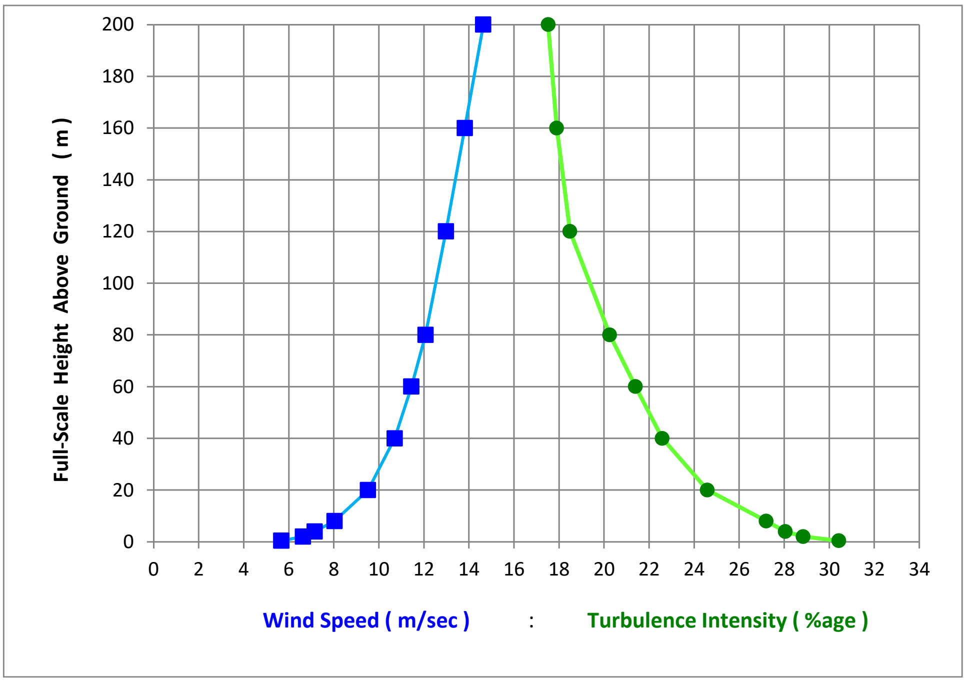
Similarity requirements between the wind tunnel model and prototype (ie full-scale) need to be fulfilled so that similitude in the flow conditions is satisfied. Usually all requirements cannot be satisfied, and compromises need to be made. In this type of wind tunnel test, it is possible to waive strict adherence to the full range of similarity parameters, eg the need to take into account buoyancy effects which are not relevant under strong wind conditions.

The wind tunnel test has been carried out using a geometric length scale of 1:400 for all dimensions (standard wind tunnel test scaling) and by scaling the boundary layer approach wind in the wind tunnel to the same scale as in the atmosphere.

The approach wind was modelled by matching terrain category conditions for all wind directions. In the wind tunnel, this is achieved by an almost 20-metre fetch of appropriate roughness elements.

The upstream profile conditions simulated in the present study is Terrain Category 3 associated with medium density suburban surroundings. The variation of mean wind speed (blue curve) and turbulence intensity (green curve) is shown in **Figure 6**.

Figure 6 Wind Tunnel Test Profiles for Mean Wind and Turbulence Intensity



4.2 Proposed Development Model and Proximity Model

Development Model

A 1:400 scale models of the proposed envelopes were built for the testing – refer **Figure 7**.

Figure 7 1:400 Scale Model of the Proposed Envelopes

Proximity Model

To take into account the influence of the immediate surrounding physical environment, all neighbouring buildings and local topography within a diameter of almost 900 m around the site were included in the purpose-built 1:400 scale "proximity model" used for the test as shown in **Figure 9**.

The study has involved the testing of two built environment "scenarios":

- Scenario 1 – "Baseline" The existing built environment (as of June 2022),
- Scenario 2 – "Proposed" "Baseline" + Proposed Development with Planned Wind Mitigation

Figure 8 Proximity Model in Wind Tunnel

Scenario 1-

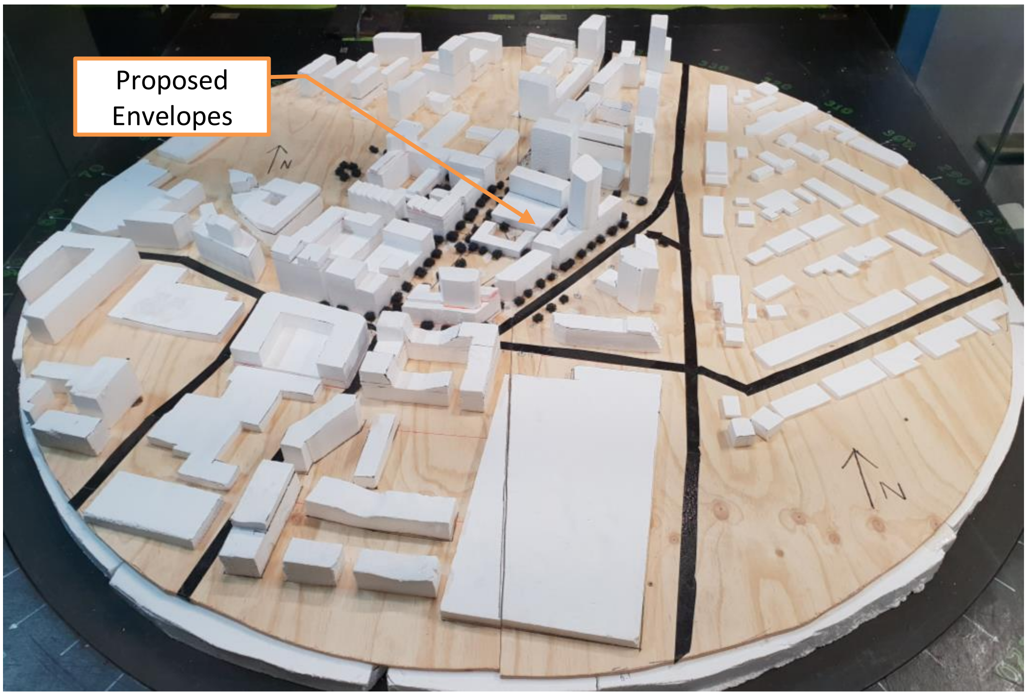
"Baseline" Scenario (Existing)

View from south

Scenario 2-

"Proposed" Scenario (Existing + Proposed Development)

View from south



4.3 Data Processing

Wind speed measurements were taken at 10° intervals:
the 0° wind direction is from the north, with east at 90°, south at 180°, etc.

Wind speeds in the wind tunnel were measured at a height
corresponding to approximately chest height (1.5 m) in full scale.

Wind speed measurements are recorded as dimensionless ratios
of the mean and gust ground level velocity to a mean reference wind speed
at a (full-scale) height of 200 m above ground level.

The wind speeds at the locations of interest are measured
in the wind tunnel using Irwin sensors.

The reader is referred to the publication referenced below for a full description of this technique and validation of Irwin sensor data using hot-wire anemometry.

- LTR-LA-242 *"A Simple Omni-Directional Sensor for Wind Tunnel Studies of Pedestrian Level Winds"* (Irwin, National Aeronautical Establishment, Ottawa, Canada, May 1980)

The measured wind speeds are transformed using the directional wind speed information derived from the local wind climate to yield ground level wind speeds as a function of annual return period and directional mean reference wind speed - refer **Figure 6**. The measured ground level wind speeds thus incorporate both the building and terrain/topographical aspects of the location as well as the directional probability of wind speed for the Project Site. The results are computed on a probabilistic basis, enabling calculation of wind events which will occur at the probability levels relevant to the Lawson Criteria, ie 5% and 0.02% exceedance levels on an annual basis, using the local Project Site statistical wind distribution.

4.4 Test Method – Sensor Locations

In the wind tunnel testing, Irwin wind sensors were positioned at the locations shown in **Figure 9.** These locations were chosen as potentially susceptible to adverse wind conditions, eg near building corners, or represent locations of interest throughout the site, eg along footpaths.

- Total of 97 sensors were used throughout the site. All sensors were positioned at ground level within and around the proposed site;
- Locations 22,23,29,32,33,38,40,41,42, and 47 were measured for only "Proposed" scenario as these sensors are located within the existing buildings footprint on site and therefore were covered by the existing buildings; and
- All other sensors were measured for the "Baseline" and "Proposed" scenarios.

Figure 9 Sensor Locations

4.5 Sample Test Result

An example of the test results and interpretation of these results is shown in **Figure 10**, illustrating the peak annual mean and representative gust wind speeds at:

Sensor: Location 50
Location: Rose Valley Way, towards the southern end of the site

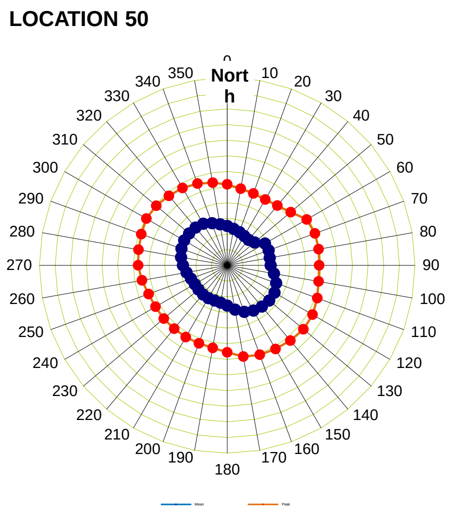
The polar diagram shows the output of the wind tunnel test results in terms of the ratio of local ground level wind speeds to the 200 m height reference mean wind speed:

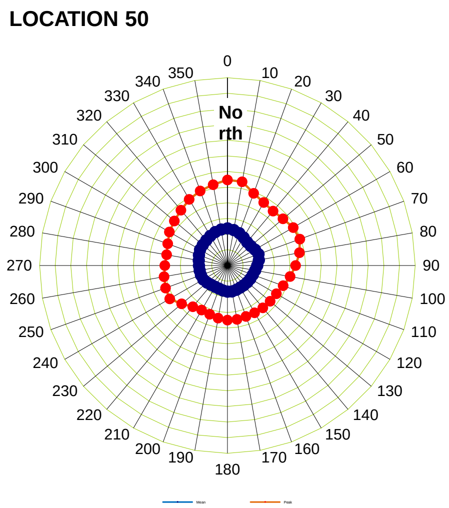
Mean wind speed ratio: "navy blue" data points
Gust wind speed ratio: "red" data points.

The polar diagram circumferential markings show ratios in "0.1" intervals.

Figure 10 Sample Polar Plot Test Result – Location 50 – Scenarios 1 and 2

Scenario 1 – "Baseline" (Existing Built Environment)	Scenario 2 – "Proposed" ("Baseline" + Proposed Development)





Scenario 1 - "Baseline" …

- Existing winds at Location 50 are moderate. Winds are expected to be stronger from the southeast and northwest.

Scenario 2 - "Proposed" (with the proposed development) …

- With the addition of the proposed development, wind speeds at Location 50 are slightly increased from the north, this is due to the northerly winds downwashing off the northern façade of the proposed envelop tower.
- Similarly, winds at location 50 see a noticeable decrease in wind from the south quadrant, this is due to the shielding provided by the proposed envelop itself.

5 TEST RESULTS

5.1 Lawson (2001) and Melbourne (1978) Calculation Methodology

As described in previous sections, the wind tunnel results are processed as follows:

- The wind tunnel test data yield ratios of the local ground level wind speed (mean and peak gust) to the reference height (200 m full-scale) mean wind speed (refer **Figure 5**) in the wind tunnel.
- The local Project wind speed and wind direction probability distribution is then used to calculate the probability of occurrence of the "GEM" wind speeds at annual exceedance levels of 5% to compare to the Lawson (2001) Comfort Criteria and the peak annual gust to compare to the Melbourne (1978) 23 m/sec Safety Criterion.

5.2 Wind Tunnel Test Data - "Baseline" and "Proposed" Scenarios

Appendices B & C shows the relevant wind tunnel test result polar plots respectively for all locations for the Scenario 1 and 2 test runs.

5.3 Wind Tunnel Test Results - Lawson Comfort Levels: "Baseline" & "Proposed"

The results of the combination of wind tunnel test results (local ground level wind speed ratios) with the wind speed and wind direction probability distribution (5% annual exceedance level) derived for the site compared to the Lawson Comfort criteria are shown in **Figure 11**.

Figure 11 Predicted Lawson Comfort Levels – "Baseline" and "Proposed" Scenarios

N

Baseline

Proposed


N
Comfort Level
CX
C1
C2
C3
C4
C5
BLOCK NW-1
BLOCK NW-2
BLOCK NE-2
BLOCK NE-1
BLOCK NE-3
BLOCK S-4
BLOCK S-1
BLOCK S-3
BLOCK S-2
ZETLAND AVENUE
ZETLAND AVENUE OPEN SPACE
DEFRIES AVENUE
BINDON PLACE
GUNYAMA PARK
GEORGE JULIUS AVENUE
NEW PARK
PETERS STREET
NEW STREET
CHIMES STREET
MULGU PARK
ROSE VALLEY WAY
EPSOM ROAD
LINK ROAD
SOUTH DOWLING STREET
ROSEBERY AVE

5.4 Wind Tunnel Test Results – Melbourne Safety Level: "Baseline" and "Proposed"

The results of the combination of wind tunnel test results (local ground level wind speed ratios) with the wind speed and wind direction probability distribution annual exceedance level relevant to safety yielded the following results:

- In the "Baseline" scenario, all ground level locations around the site are below the Melbourne (1978) 23 m/s Safety Criterion.
- In the "Proposed" scenario, annual peak gusts all remain below the 23 m/s criterion for all ground level locations.

5.5 Relative Impact of the Proposed Development on Existing Wind Conditions

Figure 11 shows that:

- In the "Baseline" scenario, majority of the locations surrounding the site fall into the Lawson "C3" and Lawson "C2", with several within the Lawson "C4" category. The Lawson "C2" category are typically locations with open exposure to winds from majority of the wind directions.
- In the "Proposed" scenario, 47 locations surrounding the site will experience minimal to no change in local wind speed with the addition of the proposed development.
- 38 locations decrease in wind speed resulting in a beneficial change in the Lawson Comfort Criteria level, either from a C3 to C4 (19 locations), from C2 to C3 (16 locations) or from C1 to C2 (2 locations) which is an improvement on the Lawson target level. One location (location 81) decreases wind speed by 2 Lawson Levels going from C2 to C4 Lawson target level.
- No Locations increase in their local wind speed with the addition of the proposed development.

5.6 Impact of the Proposed Development Relative to Target Comfort Wind Criteria

The wind-tunnel predicted "Proposed" Lawson (2001) Comfort levels are compared to the Target Comfort levels for areas surrounding and within the proposed development in **Table 5.**

Table 5 Assessment of Impacts of the Proposed Development – Proposed Scenario

Location	Target Comfort Level	Wind Tunnel Predicted Comfort Level – "Proposed"	"Proposed" Impact (refer Table 4) Relative to Target Comfort Level
1	C2	C3	Favourable Minor
2	C2	C3	Favourable Minor
3	C2	C3	Favourable Minor
4	C2	C3	Favourable Minor
5	C2	C3	Favourable Minor
6	C2	C3	Favourable Minor
7	C2	C3	Favourable Minor
8	C2	C3	Favourable Minor
9	C2	C3	Favourable Minor
10	C2	C4	Favourable moderate
11	C2	C3	Favourable Minor
12	C2	C3	Favourable Minor
13	C2	C4	Favourable moderate
14	C2	C3	Favourable Minor

Location	Target Comfort Level	Wind Tunnel Predicted Comfort Level – "Proposed"	"Proposed" Impact (refer Table 4) Relative to Target Comfort Level
15	C2	C3	Favourable Minor
16	C2	C4	Favourable moderate
17	C2	C3	Favourable Minor
18	C2	C3	Favourable Minor
19	C2	C3	Favourable Minor
20	C2	C3	Favourable Minor
21	C2	C4	Favourable moderate
22	C2	C4	Favourable moderate
23	C2	C3	Favourable Minor
24	C2	C4	Favourable moderate
25	C2	C4	Favourable moderate
26	C2	C4	Favourable moderate
27	C2	C4	Favourable moderate
28	C2	C4	Favourable moderate
29	C2	C3	Favourable Minor
30	C2	C4	Favourable moderate
31	C2	C3	Favourable Minor
32	C2	C4	Favourable moderate
33	C2	C4	Favourable moderate
34	C2	C4	Favourable moderate
35	C2	C4	Favourable moderate
36	C2	C3	Favourable Minor
37	C2	C4	Favourable moderate
38	C2	C4	Favourable moderate
39	C2	C4	Favourable moderate
40	C2	C4	Favourable moderate
41	C2	C4	Favourable moderate
42	C2	C4	Favourable moderate
43	C2	C3	Favourable Minor
44	C2	C3	Favourable Minor
45	C2	C3	Favourable Minor
46	C2	C4	Favourable moderate
47	C2	C3	Favourable Minor
48	C2	C4	Favourable moderate
49	C2	C4	Favourable moderate
50	C2	C3	Favourable Minor
51	C2	C3	Favourable Minor
52	C2	C3	Favourable Minor
53	C2	C3	Favourable Minor
54	C2	C4	Favourable moderate
55	C2	C3	Favourable Minor
56	C2	C4	Favourable moderate
57	C2	C3	Favourable Minor

Location	Target Comfort Level	Wind Tunnel Predicted Comfort Level – "Proposed"	"Proposed" Impact (refer Table 4) Relative to Target Comfort Level
58	C2	C3	Favourable Minor
59	C2	C3	Favourable Minor
60	C2	C2	Negligible
61	C2	C3	Favourable Minor
62	C2	C4	Favourable Moderate
63	C2	C2	Negligible
64	C2	C3	Favourable Minor
65	C2	C2	Negligible
66	C2	C3	Favourable Minor
67	C2	C3	Favourable Minor
68	C2	C4	Favourable Moderate
69	C2	C2	Negligible
70	C2	C3	Favourable Minor
71	C2	C3	Favourable Minor
72	C2	C3	Favourable Minor
73	C2	C2	Negligible
74	C2	C2	Negligible
75	C2	C3	Favourable Minor
76	C2	C2	Negligible
77	C2	C2	Negligible
78	C2	C3	Favourable Minor
79	C2	C3	Favourable Minor
80	C2	C2	Negligible
81	C2	C4	Favourable Moderate
82	C2	C3	Favourable Minor
83	C2	C4	Favourable Moderate
84	C2	C2	Negligible
85	C2	C3	Favourable Minor
86	C2	C2	Negligible
87	C2	C2	Negligible
88	C2	C3	Favourable Minor
89	C2	C3	Favourable Minor
90	C2	C2	Negligible
91	C2	C3	Favourable Minor
92	C2	C3	Favourable Minor
93	C2	C3	Favourable Minor
94	C2	C3	Favourable Minor
95	C2	C3	Favourable Minor
96	C2	C3	Favourable Minor
97	C2	C3	Favourable Minor

Note 1 All Unfavourable impacts are deemed "significant" and require consideration of wind mitigation

Note 2 Locations 22,23,29,32,33,38,40,41,42, and 47 were present in only the "Proposed" scenario.

Note 3 All the rest of the sensors were present in both "Baseline" and "Proposed" scenarios.

“Proposed” Built Environment Scenario

- There are NO areas with the potential to experience winds which exceed the “CX” Comfort Criterion.
- Lawson Comfort Levels range from “C2” (suitable for Leisure walking) to “C4” (suitable for sitting).

As noted in Section 5.4:

- In the “Proposed” scenario, annual peak gusts all remain below the 23 m/s criterion for all ground level locations.

6 MITIGATION AND TREATMENT RECOMMENDATIONS

6.1 Currently Planned Landscaping and Other Wind Mitigation Features

The following features, all of which would have a significant ameliorating impact on local wind conditions, were incorporated in the testing of the proposed development for the “Proposed” scenario:

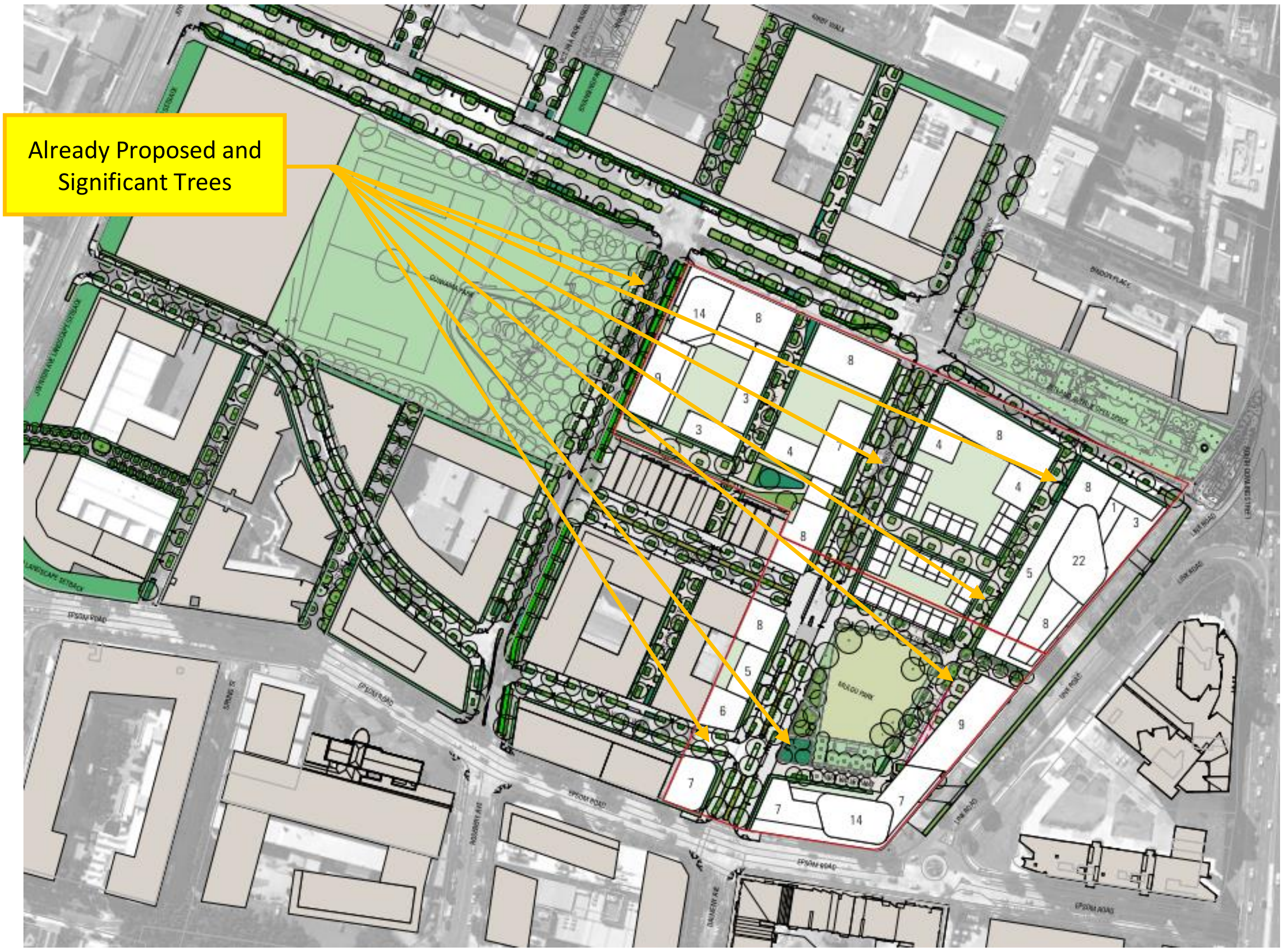
- Existing and significant trees located along Zetland Avenue, Link Road, and Epsom Road – refer **Figure 12A**;
- Already proposed and significant tree planting along the new proposed roads located within the site, and around the new proposed Mulgu Park – refer **Figure 12B**.

SLR recommends retention of all of the above landscaping. Further, any proposed landscaping should be densely foliated and evergreen, given the occurrence of adverse winter wind conditions.

Figure 12 Existing Landscaping and Already Planned Treatments Relevant to Wind Mitigation

A - Existing and Significant Trees along Zetland Avenue, Link Road, and Epsom Road

B - Already proposed and significant Tree planting within and around the site



6.2 Discussion of Results – Overall

A comparison of the wind tunnel test results for the "Baseline" and "Proposed" scenarios showed that locations either experience minimal change or an improvement with the inclusion of the proposed development and already proposed mitigations.

- Majority of the locations within and around the site are the "C3" (suitable for Standing) to "C4" (suitable for sitting) Lawson Criteria.
- In general, the site receives reasonable shielding especially at ground level from majority of the wind directions provided by the proposed envelops themselves as well as by the neighbouring existing buildings.
- In addition, a substantial number of trees are already proposed within and around the site, especially along the new proposed roads. These already proposed significant trees are expected to reduce winds funnelling along the new proposed roads, in between the proposed envelopes.

6.3 Residual Effects

The following summarises the results of the wind tunnel testing for the proposed development:

- With the incorporation of all the already proposed wind mitigation treatments, all the locations within and surrounding the site are expected to achieve the target Lawson Comfort Criteria and Melbourne Safety Criterion established for the project.

On the basis of all of the above, the overall effect of the proposed development on the local wind microclimate, with the wind mitigation treatments recommended, is predicted to be “not significant”.

7 Conclusion

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Karimbla Constructions Services Pty Ltd, to undertake a quantitative wind assessment of the envelopes of the proposed developments located at 118-130 Epsom Road & 905 South Dowling Street, Zetland.

An initial assessment of the proposed envelops was performed in July 2022, via a Discrete Sensor Environmental Wind Tunnel Study whereby wind tunnel measurements were made to investigate wind conditions around the envelopes of the proposed development (simulated via a 1:400 scale model) at areas to be used by visitors and occupants of the development itself.

Feedback on this initial study led to further wind tunnel testing (August 2022), involving additional measurement sensor locations on the opposite sides of existing and proposed streets around the site, along all site frontages with a higher density of testing locations and greater testing extent around the taller proposed buildings.

The site is located at 118-130 Epsom Road & 905 South Dowling Street, Zetland, with Link Road to the east, Zetland Avenue to the north, Epsom Road to the south, and proposed George Julius Avenue to the west. Proposed developments comprise multiple envelopes ranging in heights from 3 to 23 storeys.

In terms of the surrounding buildings, the surrounding built environment comprises a mix of medium to high-rise buildings to the south clockwise around to the north-northeast, low-rise residential dwellings to the northeast and east, and Australian Golf Club to the southeast. Green Square station is located to the northwest. Immediately to the north and north-northeast across Zetland Avenue are a series of tall buildings. The terrain is gently undulating in the surrounding built environment, with no particularly significant topographical variations (ie hills, escarpments, etc) influencing local wind speeds.

Built Environment Scenarios Assessed

The study has involved the testing of two built environment “scenarios”:

- Scenario 1 – “Baseline” The existing built environment (as of June 2022),
- Scenario 2 – “Proposed” “Baseline” + Proposed Development with Planned Wind Mitigation

Zetland Wind Climate

The study has developed a site-specific statistical wind climate model based on long-term wind records obtained from nearby Bureau of Meteorology stations at Sydney Kingsford Smith Airport and Bankstown Airport. For Zetland, SLR has determined that local winds have characteristics very close to Sydney (KS) Airport compared to Bankstown Airport, given Zetland’s proximity to Sydney (KS) Airport and similar distance inland from the coastline. Key prevailing wind directions of interest are the northeast, southeast and south for summer and mainly west quadrant winds for winter.

“Baseline” (Existing) Wind Environment

Close to the ground, the “regional” wind patterns described above are affected by the local terrain, topography and built environment, all of which influence the “local” wind environment.

- As noted in **Section 1.3**, the site is currently surrounded by a mixture of medium to high-rise commercial and residential buildings, vegetation and trees, with modest change in topography. Immediately to the north and north-northeast, across Zetland Avenue are a series of tall buildings

- The site will therefore receive reasonable wind shielding depending upon oncoming wind direction at lower levels with upper levels exposed to higher winds from most wind directions.

"Proposed" Wind Environment

- In general, the site is expected to receive reasonable shielding especially at ground level from majority of the wind directions provided by the proposed envelops themselves as well as by the neighbouring existing buildings.

Already Planned Wind Amelioration Treatments

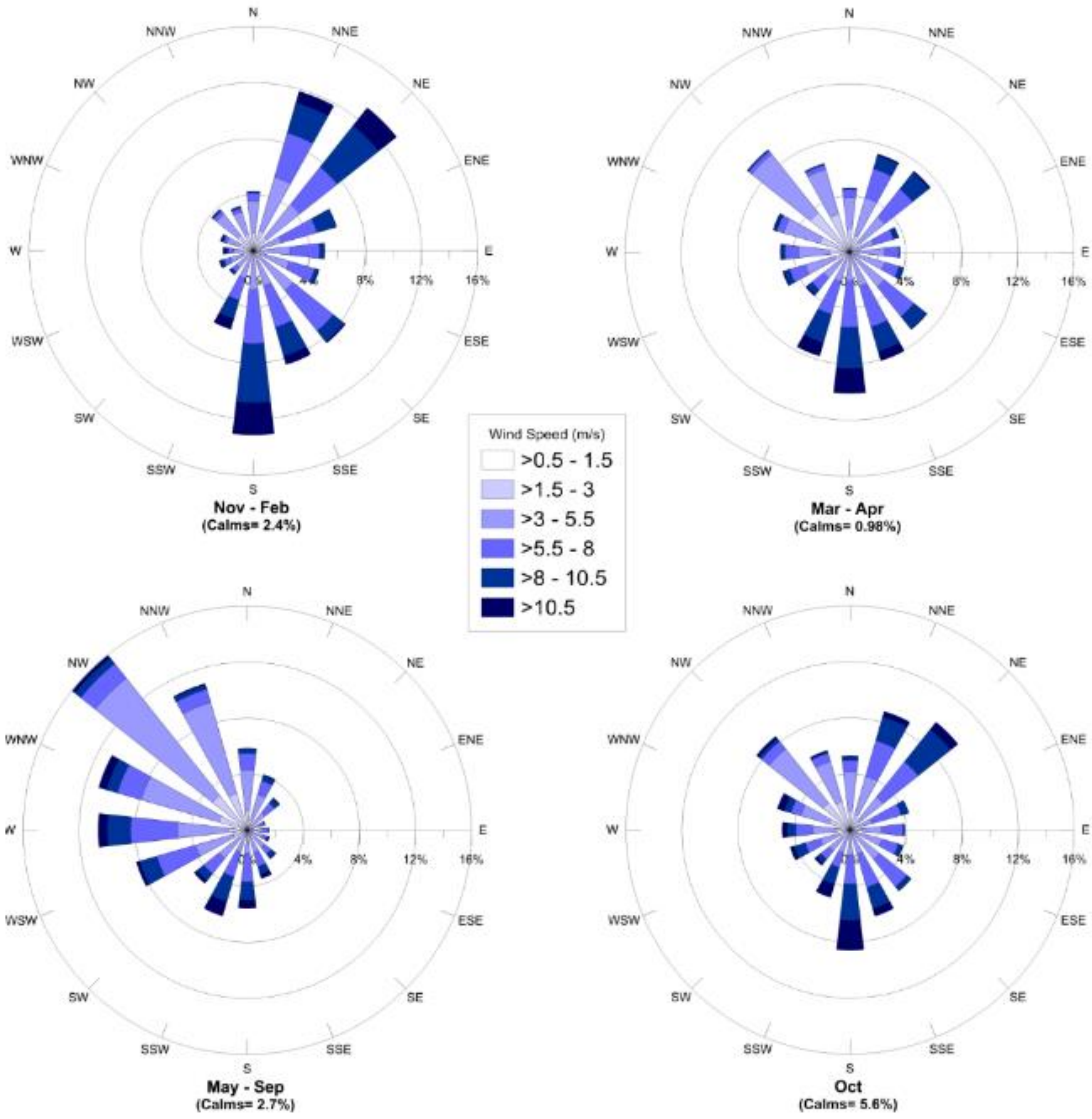
The following treatments relevant to wind mitigation have already been proposed:

- Existing and significant trees located along Zetland Avenue, Link Road, and Epsom Road – refer **Figure 12A**;
- Already proposed and significant tree planting along the new proposed roads located within the site, and around the new proposed Mulgu Park – refer **Figure 12B**.

It is recommended that all of the above planned features are retained and that new landscaping treatments (trees, hedges, etc) are evergreens (providing year-round protection) and of mature foliage when installed.

All proposed landscaping should be densely foliated and evergreen, given the occurrence of adverse winter wind conditions.

Sydney Airport AWS
(Observations)
1999-2017
600.09300



Bankstown Airport AWS
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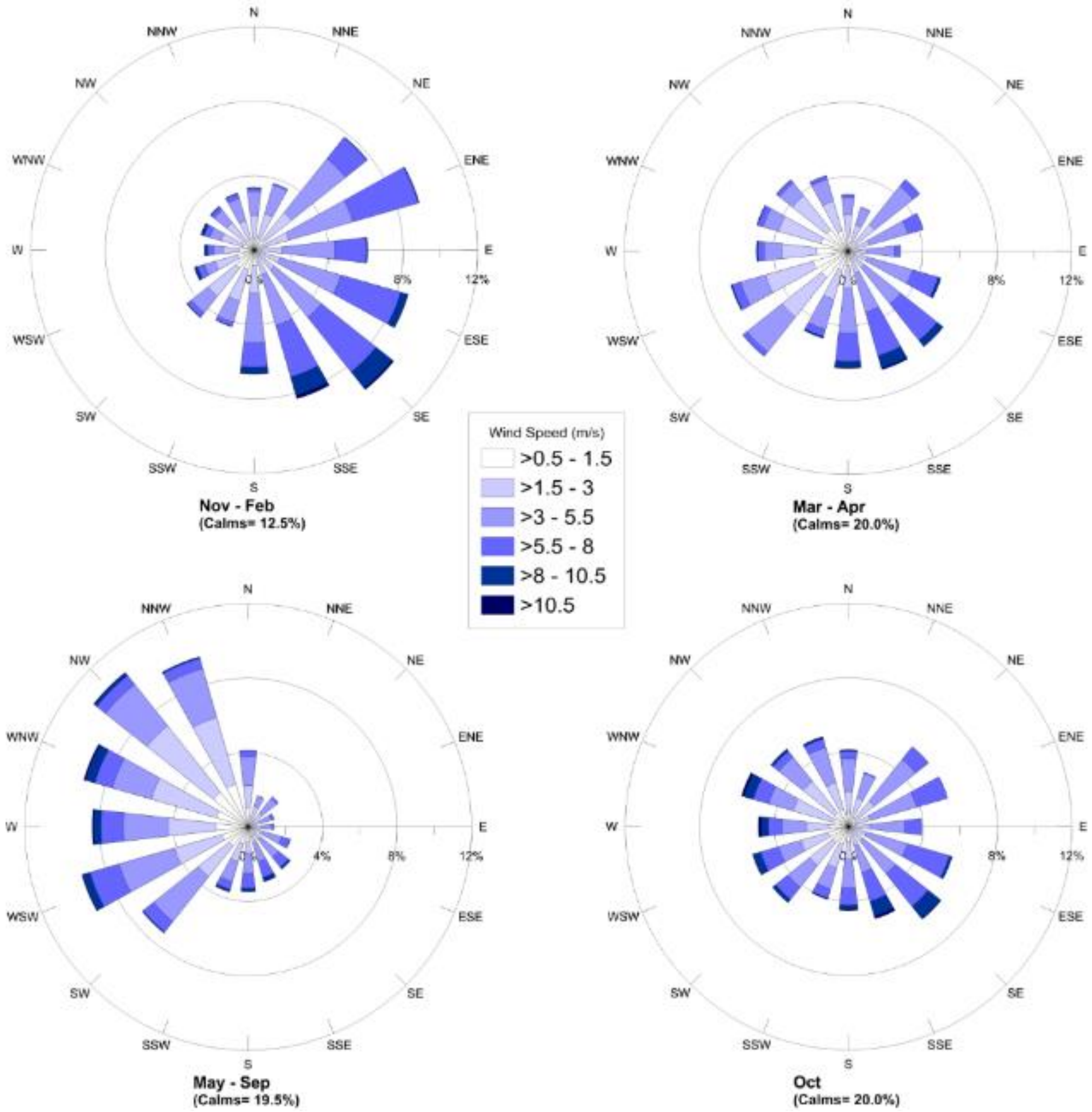

APPENDIX B

Wind Tunnel Test Data (Polar Plots) – **BASELINE** Scenario 1

The polar diagram plots show the local (ground level) mean and peak gust wind speed as a ratio of the mean reference wind speed (at a full-scale height of 200 m).

The polar diagram circumferential lines representing gradations in 0.1 intervals, ie 10% ratios.

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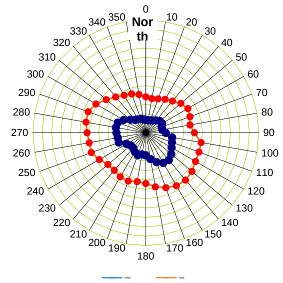

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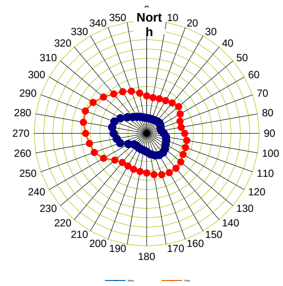

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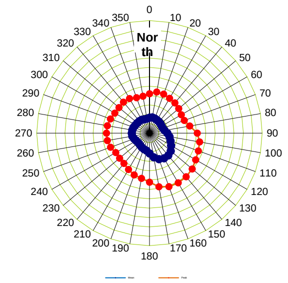

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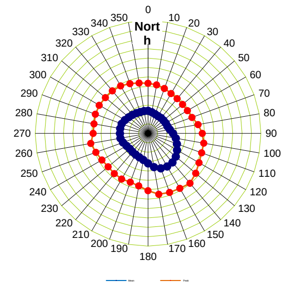

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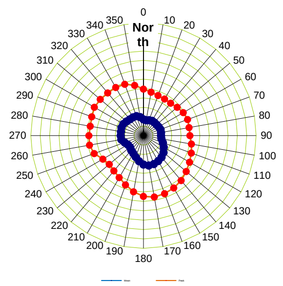

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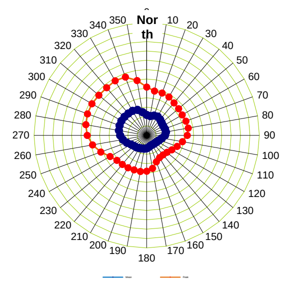

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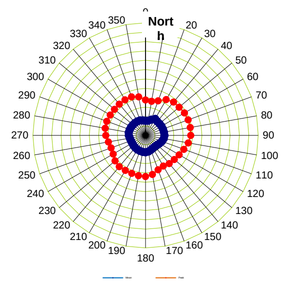

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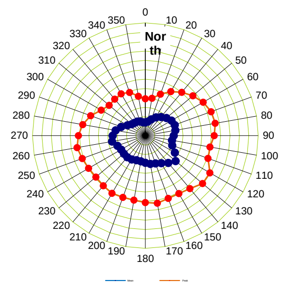

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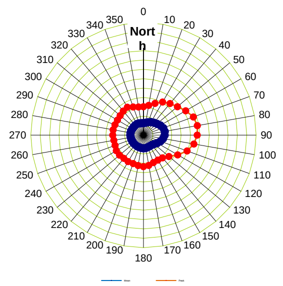

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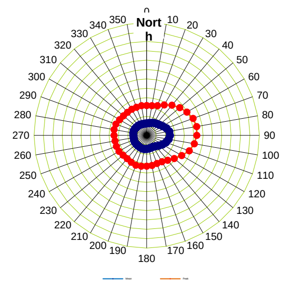

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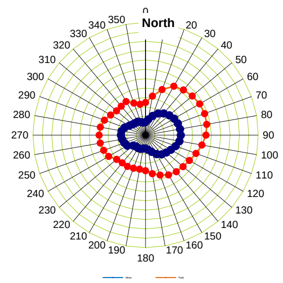

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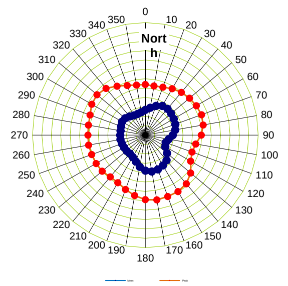

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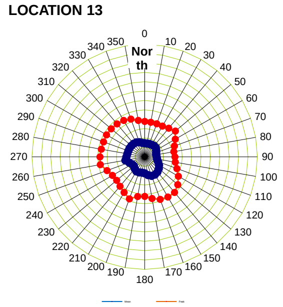

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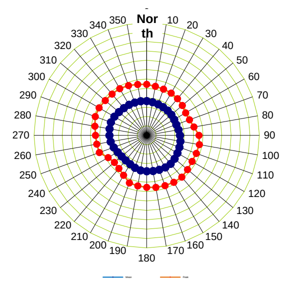

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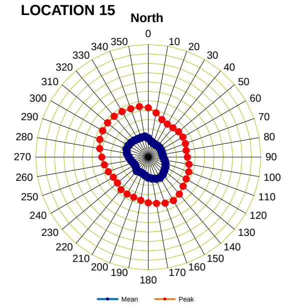

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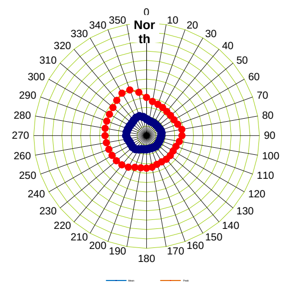

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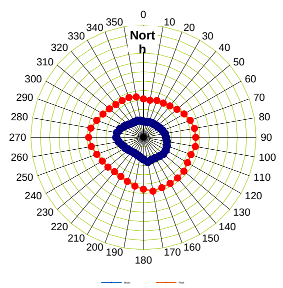

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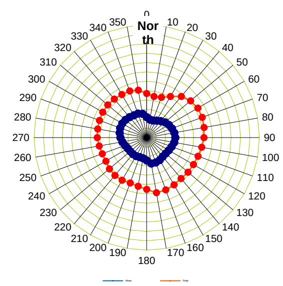

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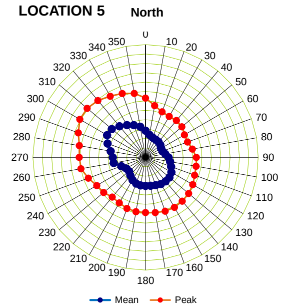

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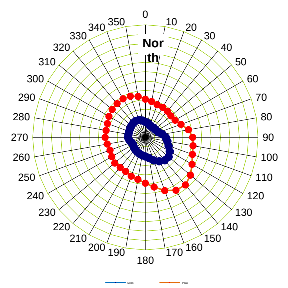

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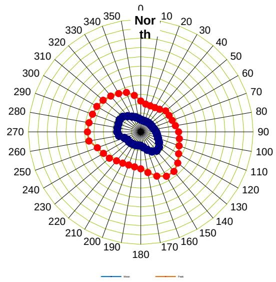

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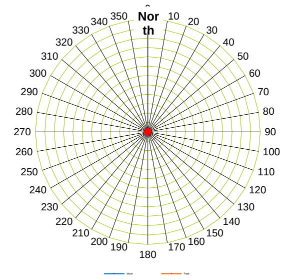

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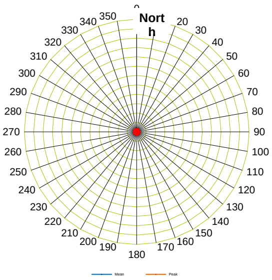

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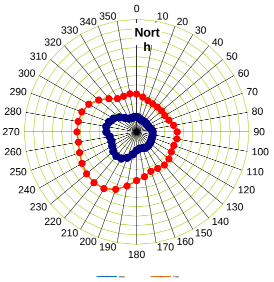

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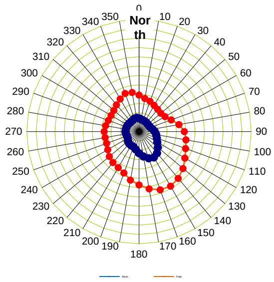

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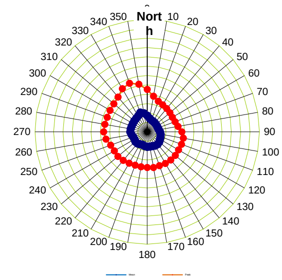

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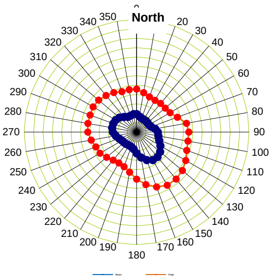

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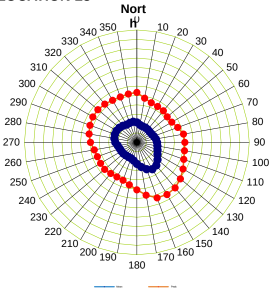

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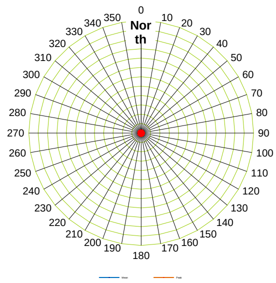

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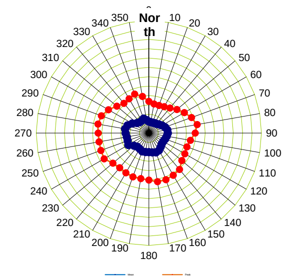

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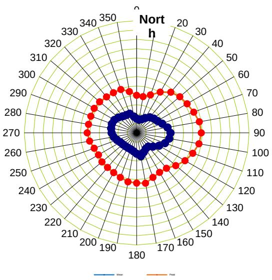

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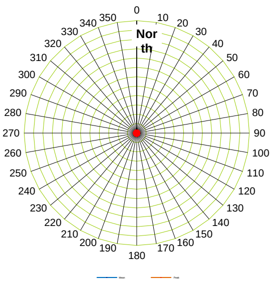

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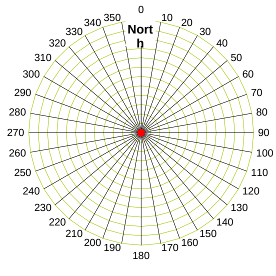

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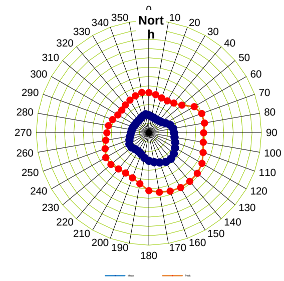

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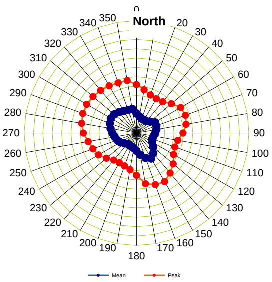

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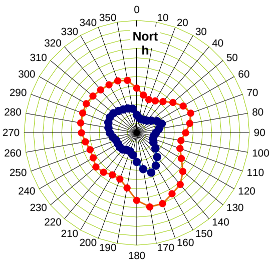

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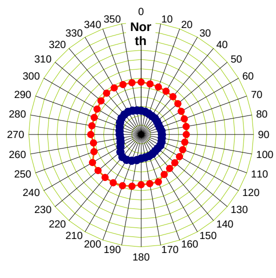

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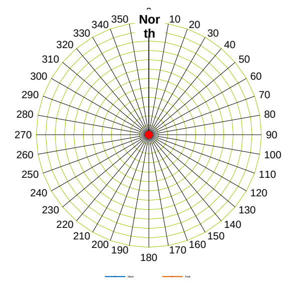

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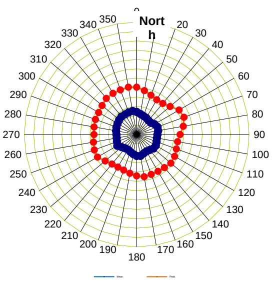

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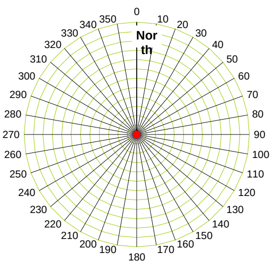

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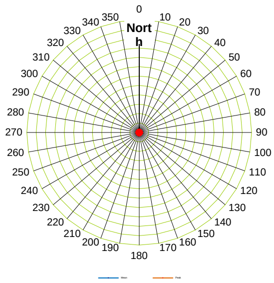

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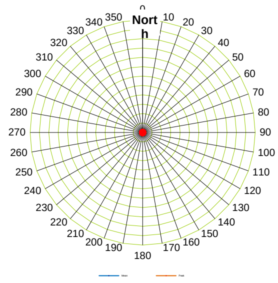

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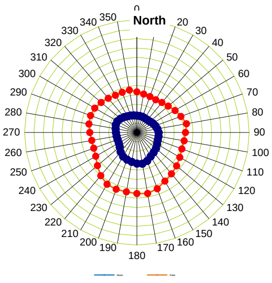

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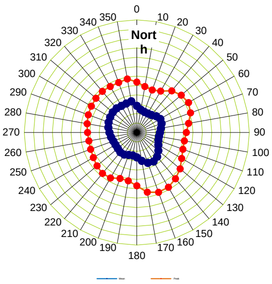

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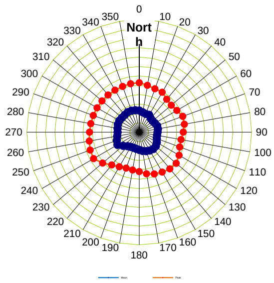

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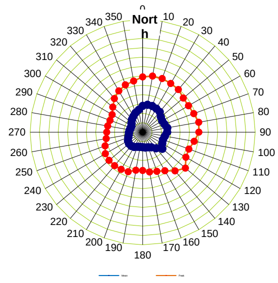

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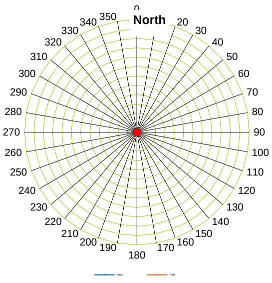

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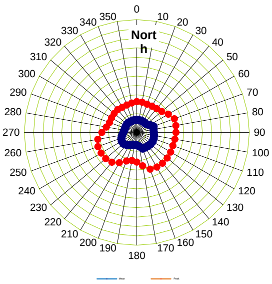

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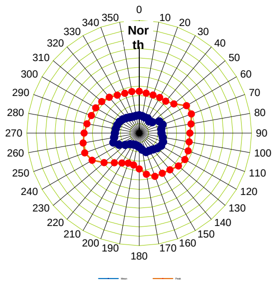

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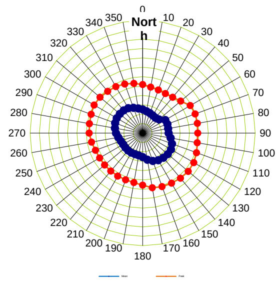

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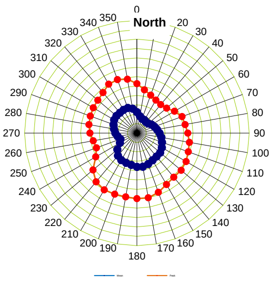

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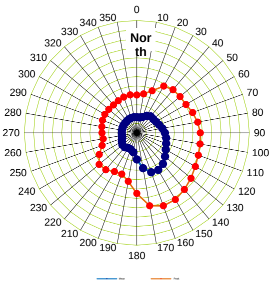

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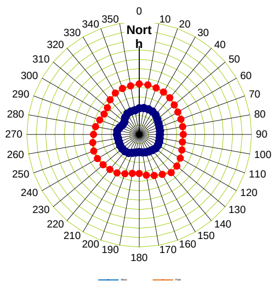

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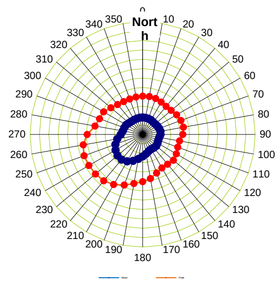

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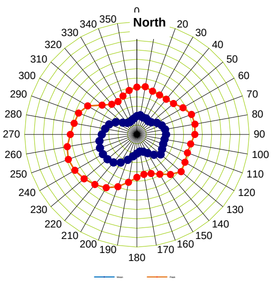

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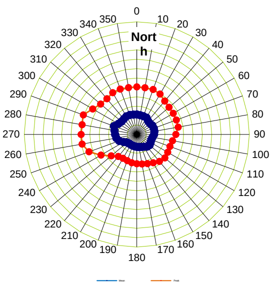

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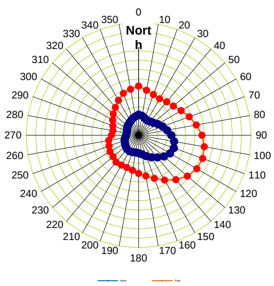

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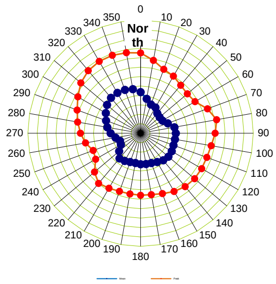

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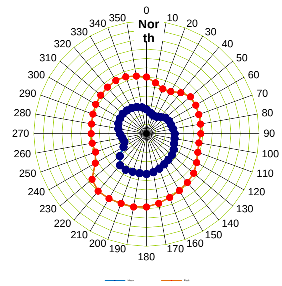

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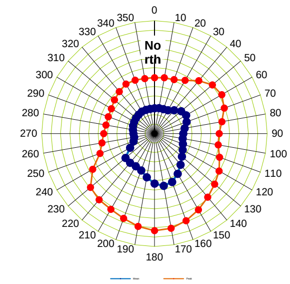

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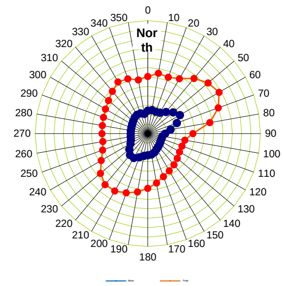

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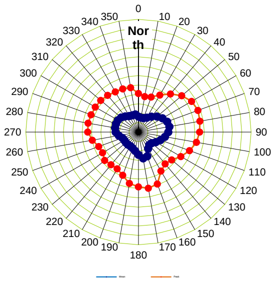

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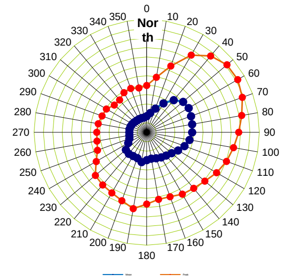

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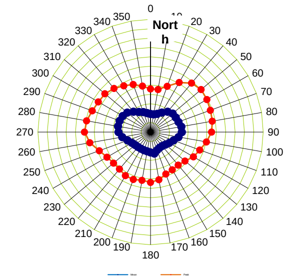

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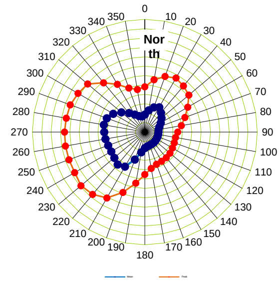

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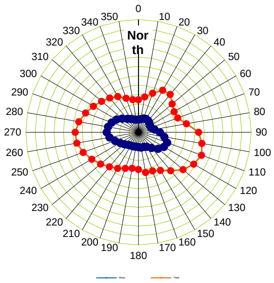

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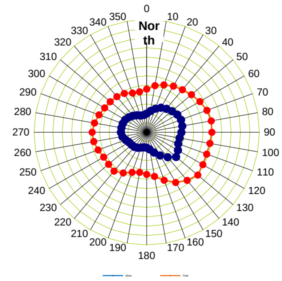

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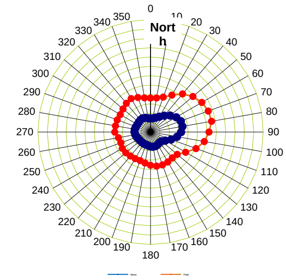

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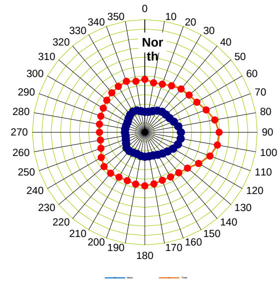

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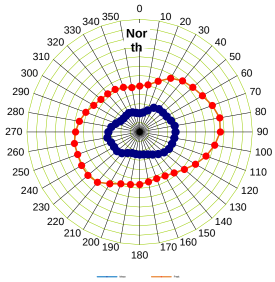

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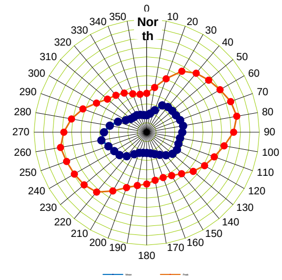

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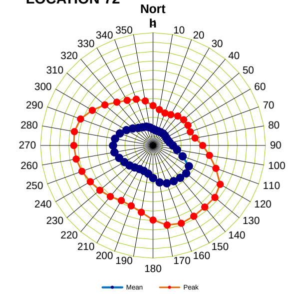

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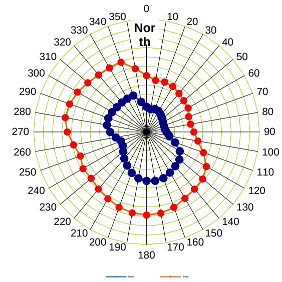

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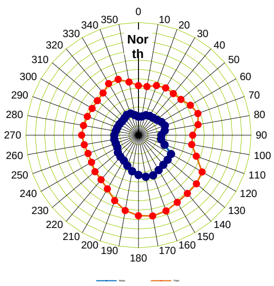

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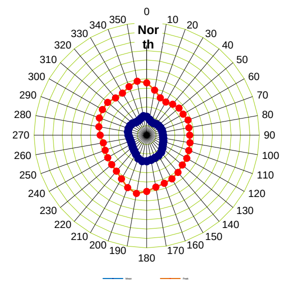

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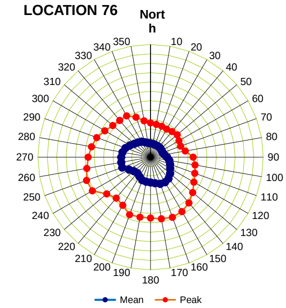

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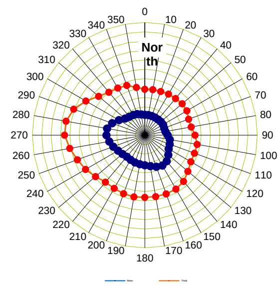

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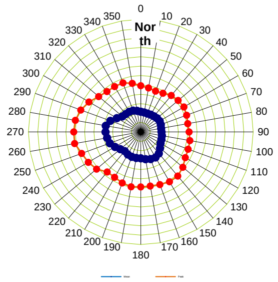

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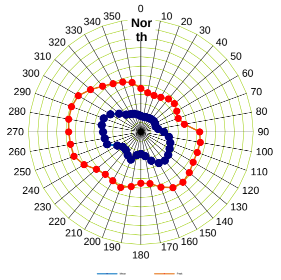

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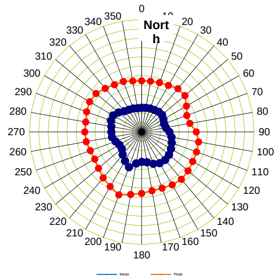

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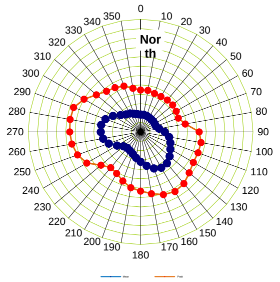

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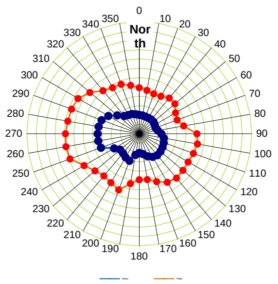

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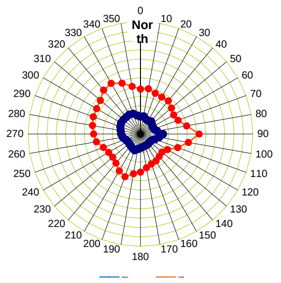

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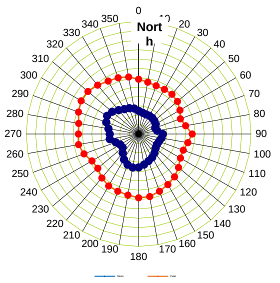

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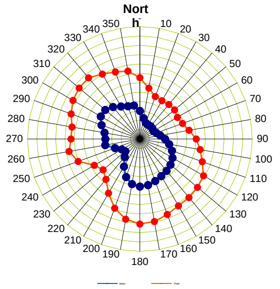

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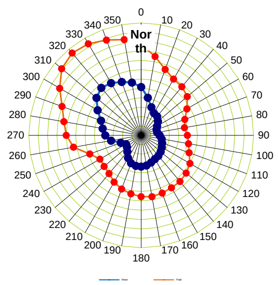

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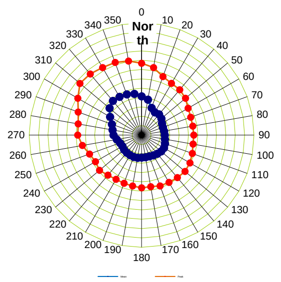

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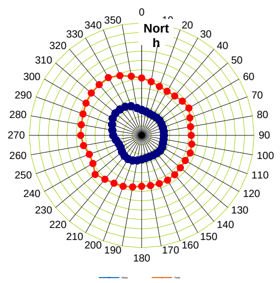

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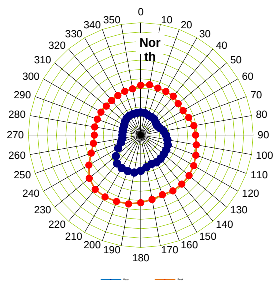

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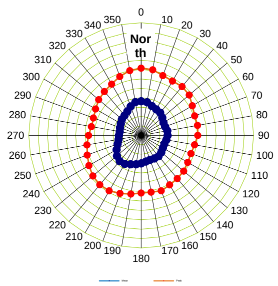

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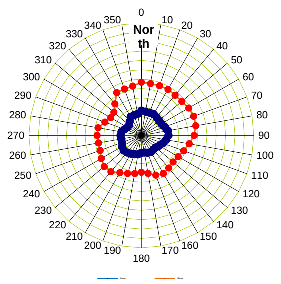

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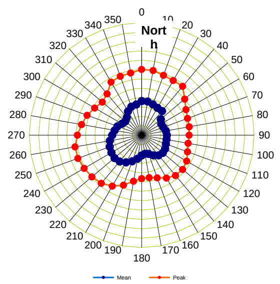

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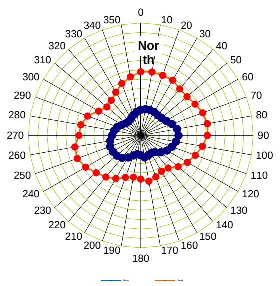

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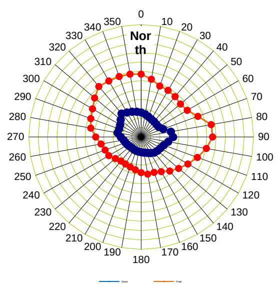

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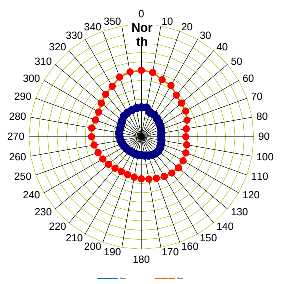

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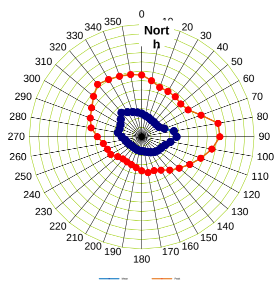

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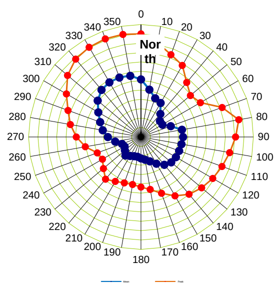


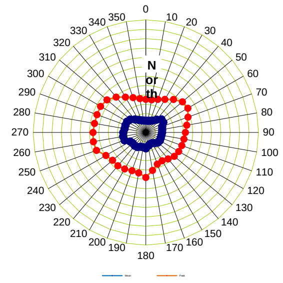
APPENDIX C

Wind Tunnel Test Data (Polar Plots) – **Proposed** Scenario 2

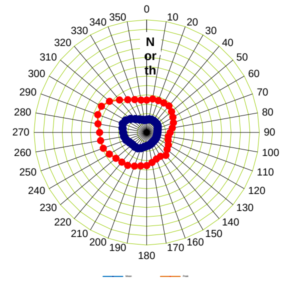
The polar diagram plots show the local (ground level) mean and peak gust wind speed as a ratio of the mean reference wind speed (at a full-scale height of 200 m).

The polar diagram circumferential lines representing gradations in 0.1 intervals, ie 10% ratios.

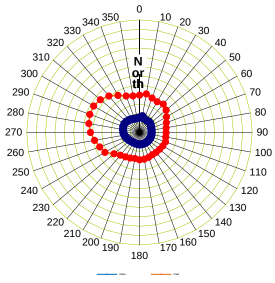
LOCATION 1



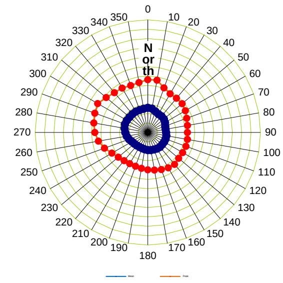
LOCATION 2



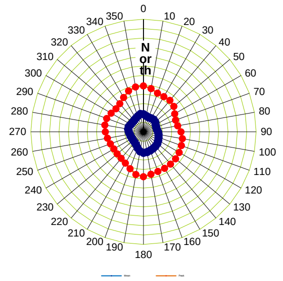
LOCATION 3



LOCATION 4



LOCATION 5



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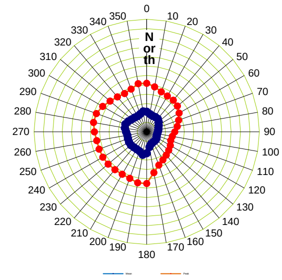

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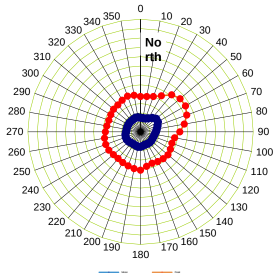

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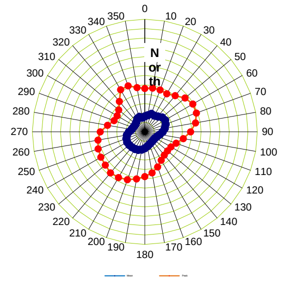
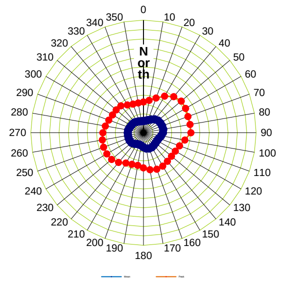
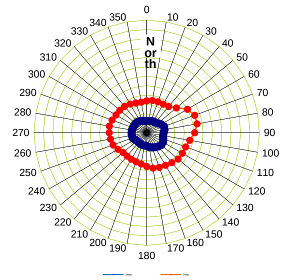


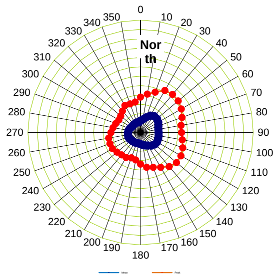
LOCATION 9



LOCATION 10



LOCATION 11



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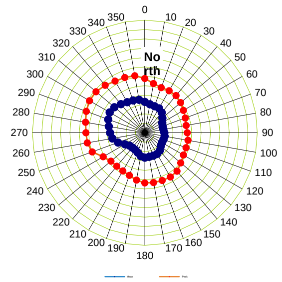

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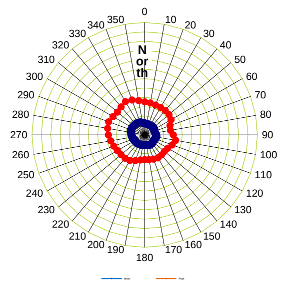

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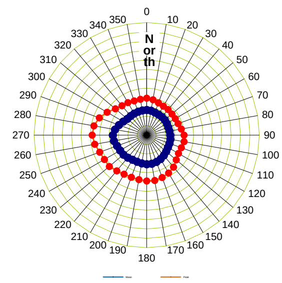
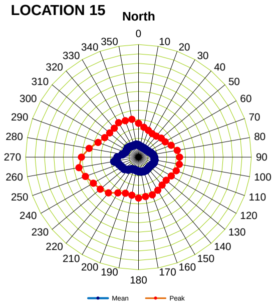
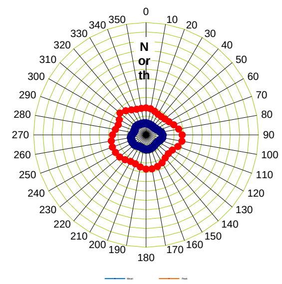


LOCATION 15



LOCATION 16



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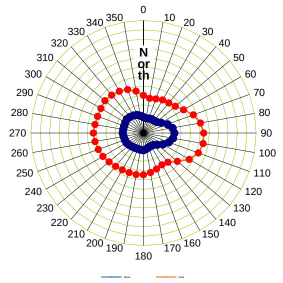

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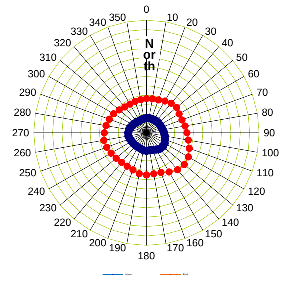

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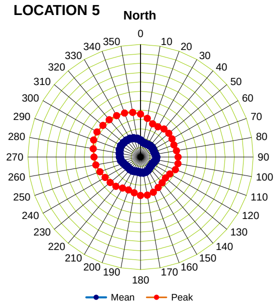

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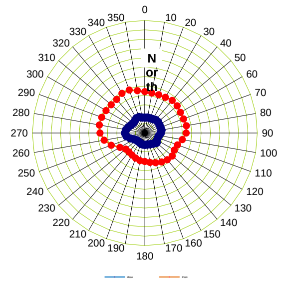

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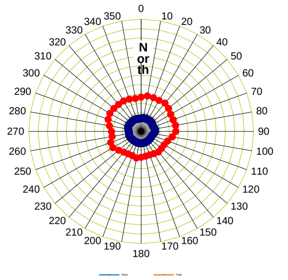

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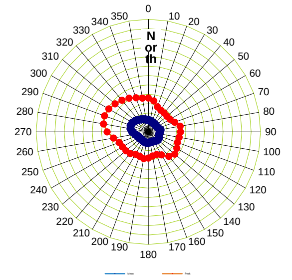

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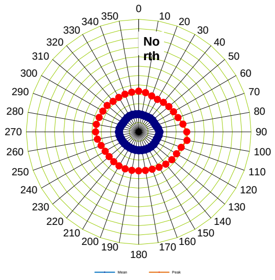

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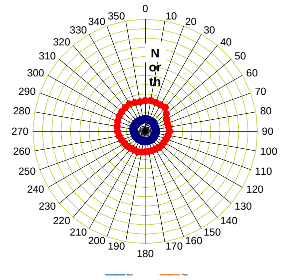

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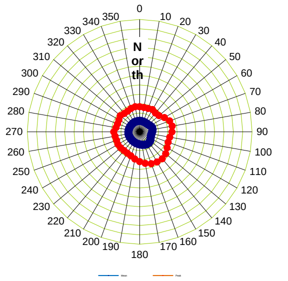

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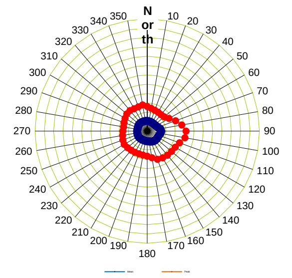

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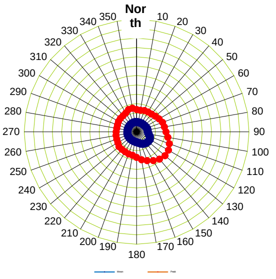

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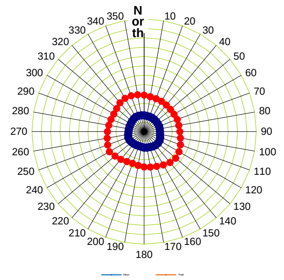

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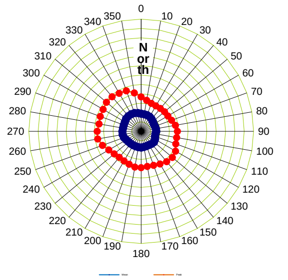

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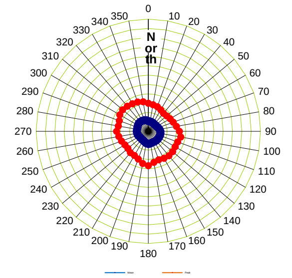

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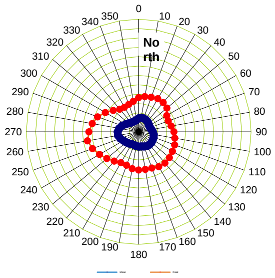

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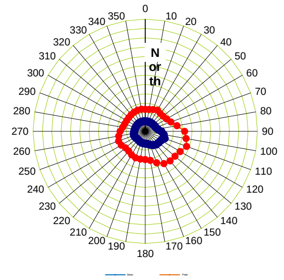

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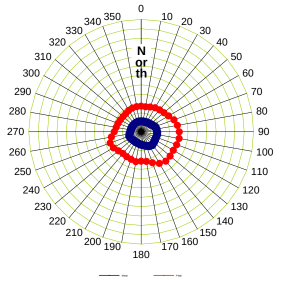

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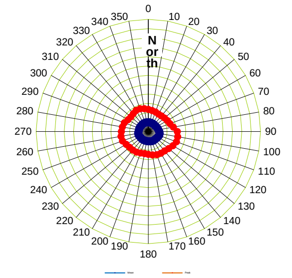

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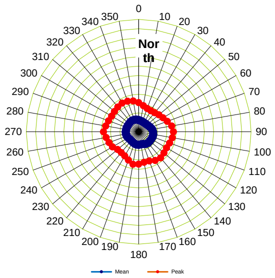

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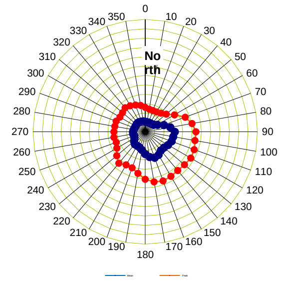

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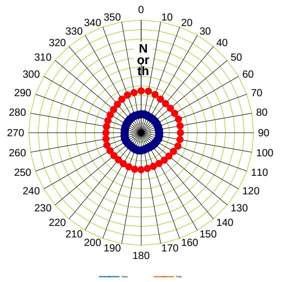

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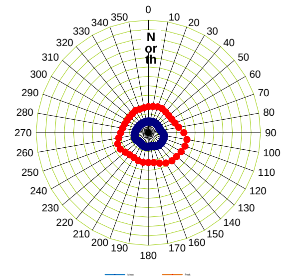

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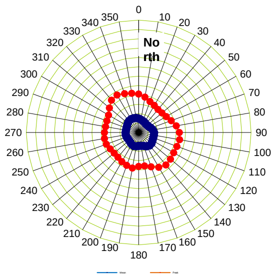

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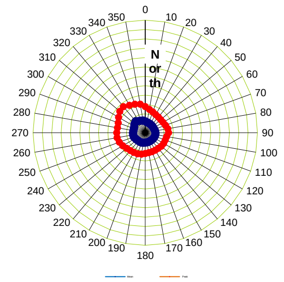

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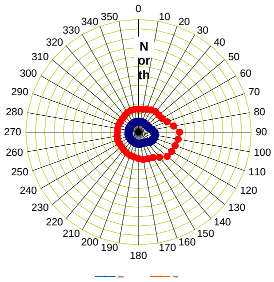

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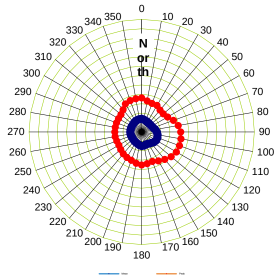

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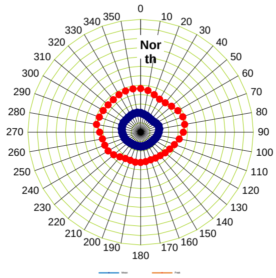

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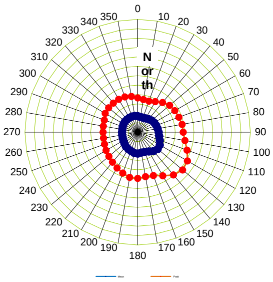

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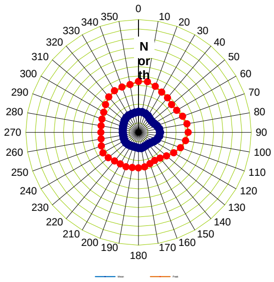

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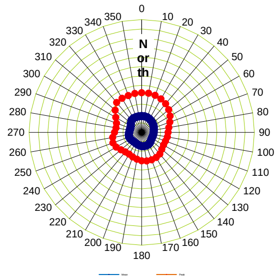

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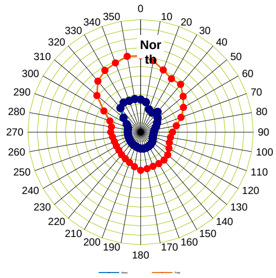

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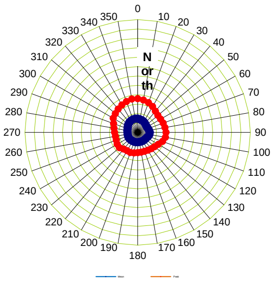

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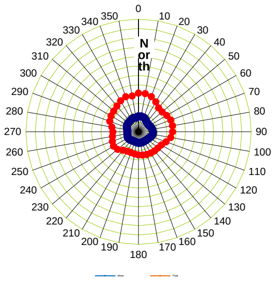

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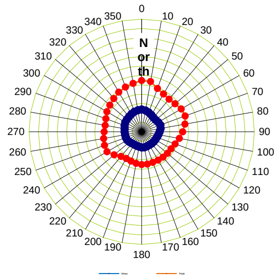

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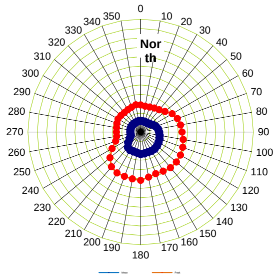

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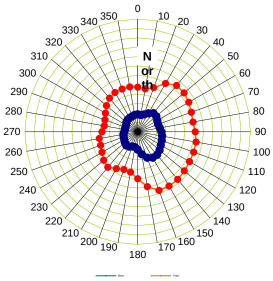

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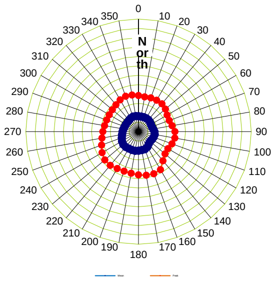

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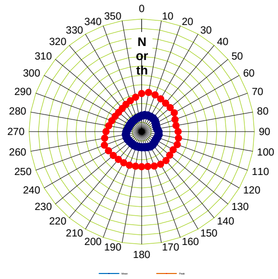

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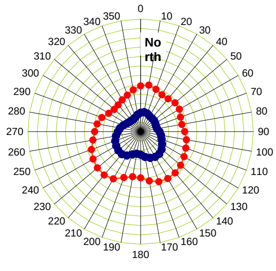

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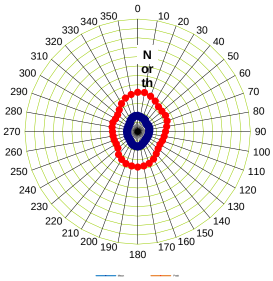

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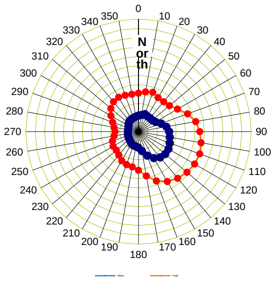

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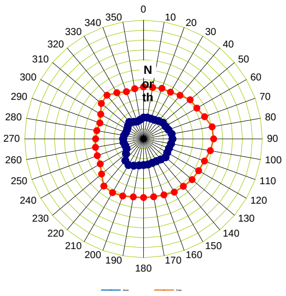

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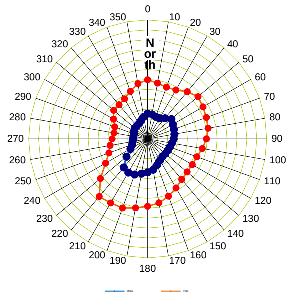

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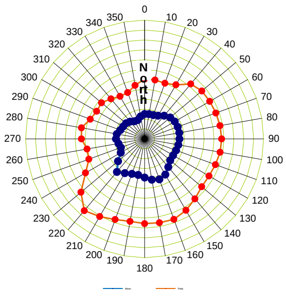

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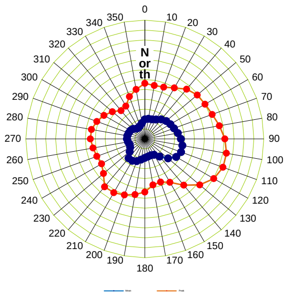

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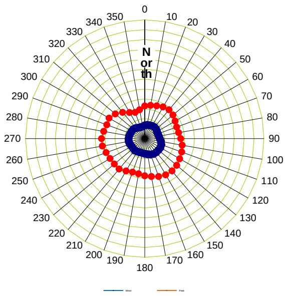

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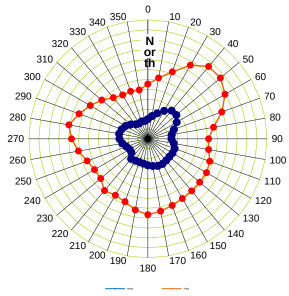

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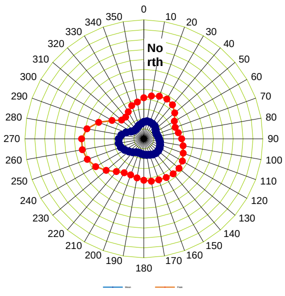

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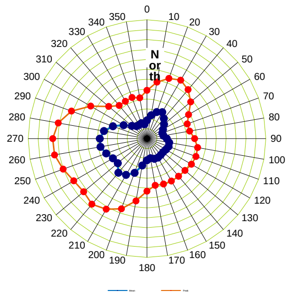

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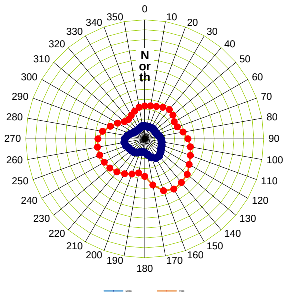

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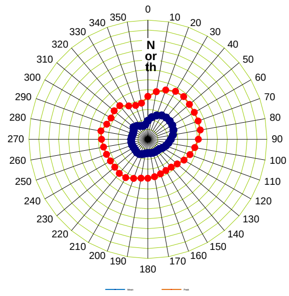

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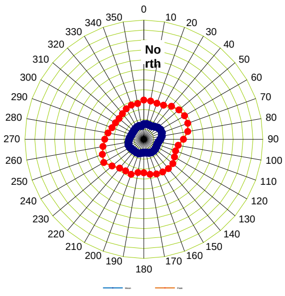

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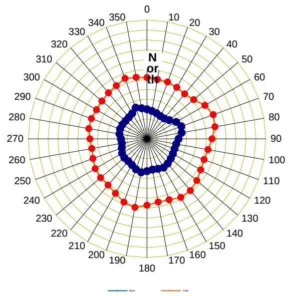

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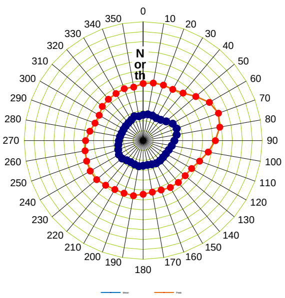

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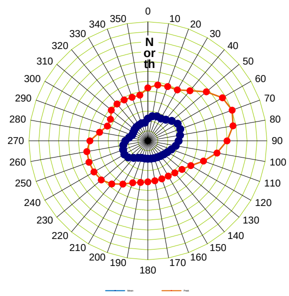

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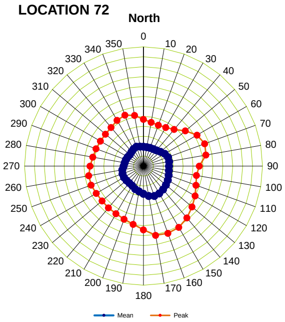

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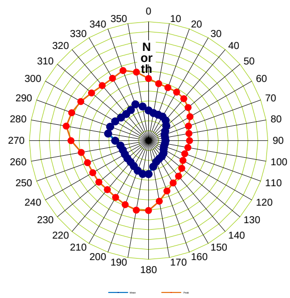

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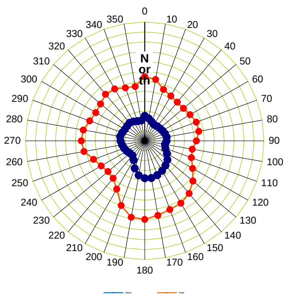

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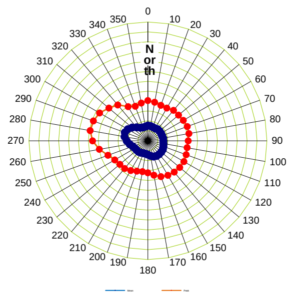

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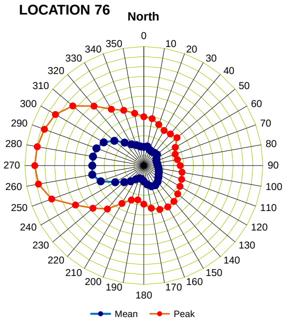

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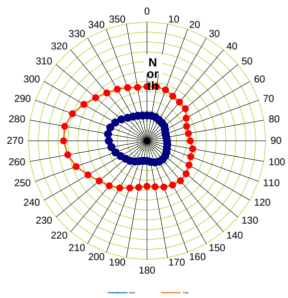

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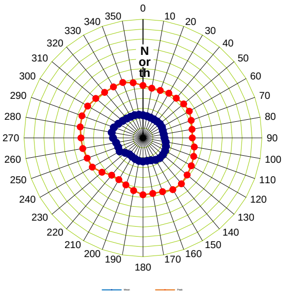

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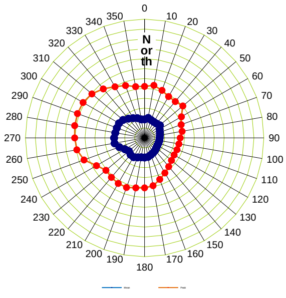

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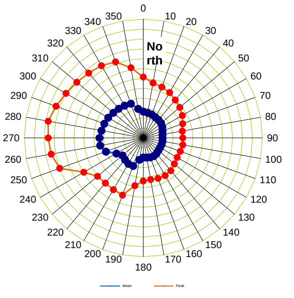

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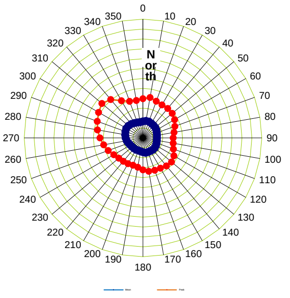

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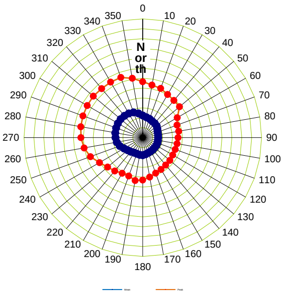

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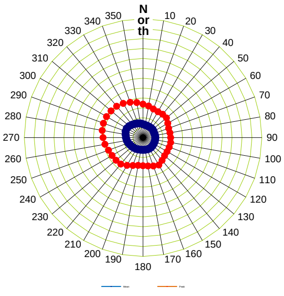

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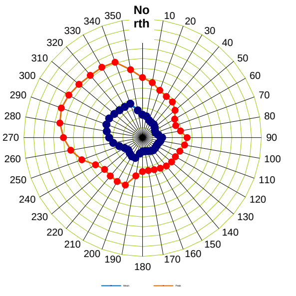

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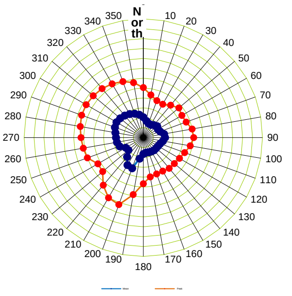

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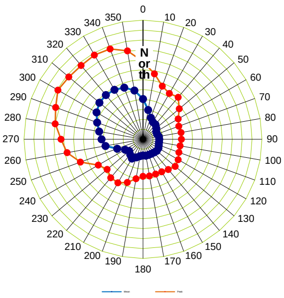

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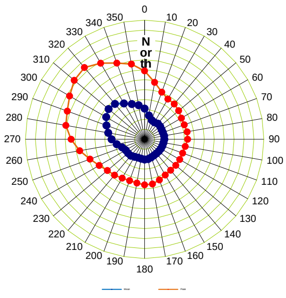

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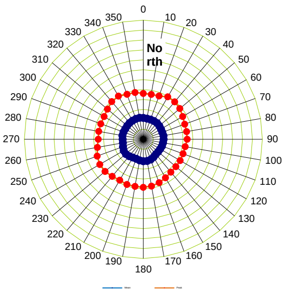

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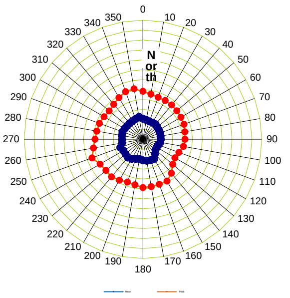

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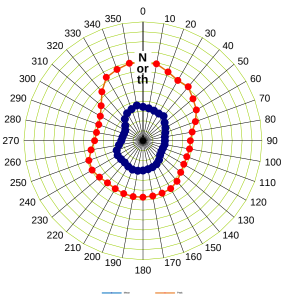

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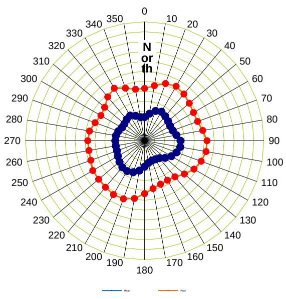

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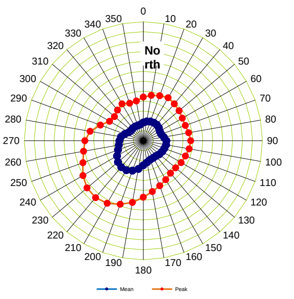

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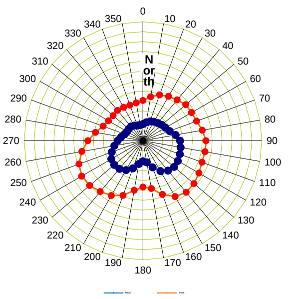

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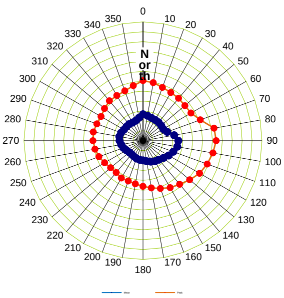

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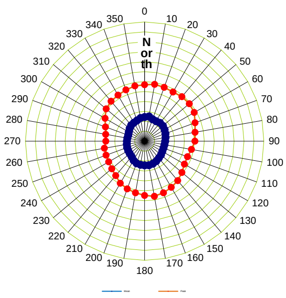

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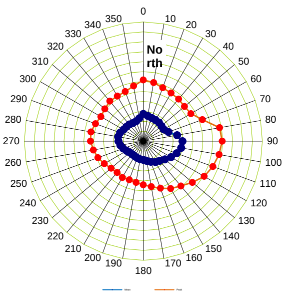

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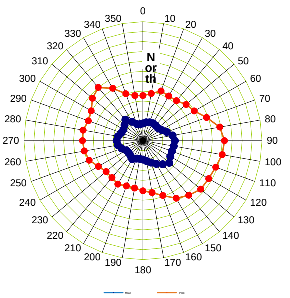

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