

READING METROPOLITAN

READING, UK

PEDESTRIAN LEVEL WIND DESK BASED ASSESSMENT

RWDI #1900850

MAY 17TH, 2019

SUBMITTED TO

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VERSION HISTORY

RWDI Project #1900850 Reading Metropolitan Reading, UK		
Report	Releases	Dated
Reports	Rev A	May 16, 2019
Project Team	Joseph Symes	Project Engineer
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1. EXECUTIVE SUMMARY

The objective of this study was to determine the ground, podium and roof terrace level wind environment within and around the proposed Reading Metropolitan development in Reading, UK.

This report presents a description of the methodology used and the results of four model configurations tested in the wind tunnel, namely:

- Configuration 1: Existing site and Existing Surrounding Buildings;
- Configuration 2: Proposed Development with Existing Surrounding Buildings;
- Mitigation: Proposed Development with landscaping, mitigation and Existing Surrounding Buildings; and
- Configuration 3: Proposed Development with landscaping, mitigation and Cumulative Surrounding Buildings.

Configurations 1 and 2 were initially tested devoid of landscaping in order to present a worst-case (i.e. windy) scenario. Configuration 2 was also tested with landscaping and mitigation measures developed through an iterative test procedure to improve wind conditions and reduce the occurrence of strong winds identified during these initial tests.

Local wind conditions derived from the meteorological data collected at London Heathrow airport indicate prevailing winds from the south-west quadrant throughout the year with secondary winds from the north-east direction which are more prevalent during the spring months.

In the baseline scenario (Configuration 1), thoroughfares in and around the Site have wind conditions suitable for standing use or calmer and entrance locations have conditions suitable for standing use or calmer during the windiest season, acceptable conditions for their intended pedestrian use.

With the Proposed Development in situ (Configuration 2), wind conditions on-site would range from suitable for sitting to walking use during the windiest season, up to two categories windier than suitable for the intended use in some areas. During the summer season wind conditions within amenity spaces would range from suitable for sitting to strolling use, up to two categories windier than suitable in some areas. Off-Site wind conditions would be suitable for the intended pedestrian use. Without landscape or wind mitigation measures, the following locations would be windier than suitable for their intended use:

- The thoroughfare to the North West of the Site (location 84);
- The thoroughfare to the South West of the site, between Tower A and the station, (Locations 11, 201, 202);
- The Eastern entrance to the retail unit and refuse area of Block E (location 55);
- The Northern entrance to the Health Centre (Location 82) and the residential entrances to Block G (locations 83 and 90); and
- The West of the roof terrace of Tower A (locations 235 and 236).

Winds exceeding 15m/s for more than 0.025% of the time (approximately two hours per year) would have the potential to be a safety concern for cyclists and more vulnerable pedestrians. In Configuration 2 – without landscape or wind mitigation measures - there would be instances of winds exceeding this threshold at eight locations (areas represented by measurement locations 77, 83, 84, 90, 201, 202, 235 and 236). Wind mitigation measures have been designed at these locations to reduce the occurrence of winds exceeding 15m/s or restrict pedestrian access to these areas.

Mitigation measures have been developed through an iterative wind tunnel test procedure to improve wind conditions and reduce the occurrence of strong winds. The following mitigation measures, along with the proposed landscaping plan, have been included in the presented mitigation configurations:

- Two staggered 4m high 50% porous screens between Tower A and the station building.
- Two trees near the South corner of Tower A removed.
- The area along South edge of tower A to be made inaccessible with planters.
- 2m deep canopy placed at 5m height on curved facade of health centre, with solid vertical walls at either end and two solid vertical walls in intermediate positions.
- Glass balustrades on all corners of Tower A terrace. 3m high dividers on Tower A terrace.
- 2 m high dividers on private terraces.
- 1.5m hedges on public terraces.

With the implementation of this mitigation strategy, conditions at all ground and podium levels within the site would be acceptable for the intended pedestrian use.

Wind conditions at the entrance to the existing offsite retail unit North East (Location 24) of the Proposed Development would have conditions suitable for strolling use during the windiest season, one category windier than suitable for the intended pedestrian use.

At the Tower A roof terrace level, conditions would remain up to two categories windier than suitable for the intended use during the summer season and instances of strong winds would persist. These conditions could be mitigated by making these areas inaccessible to the public. Alternatively, if the intention is to keep these areas accessible then further mitigation, such as additional dividers at the corners, would need to be considered. All remaining roof terrace locations would have conditions suitable for the intended occupant use during the summer season.

The introduction of cumulative schemes (Configuration 3) would not significantly alter the wind conditions at the Proposed Development. Wind mitigation measures required at the Proposed Development in Configuration 2 would remain valid in the context of the cumulative schemes. With the application of these mitigation measures as per the existing surrounding context scenario, wind conditions would be suitable for the intended use at ground, podium and accessible roof terrace locations with two exceptions:

- The Eastern entrance to the retail unit and refuse area of Block E (location 55) would have conditions one category windier than suitable for the intended use. RWDI would expect that with the implementation of additional mitigation measures, such as recessing the entrances or installing planters/screens either side of the entrances, conditions could be made suitable for the intended use;
- Wind conditions on the Tower A roof terrace level would remain too windy to permit occupant access.

2. INTRODUCTION

RWDI was retained by Chartplan to conduct a microclimate assessment for the proposed mixed-use Reading Metropolitan development (hereafter referred to as the Proposed Development) close to Reading train station in Reading, UK. This report presents the background, objectives, results and recommendations from RWDI's assessment. A summary of the overall recommendations from the study are presented in Section 6, "Conclusions & Recommendations".

3. BACKGROUND AND APPROACH

Wind tunnel tests were conducted on a 1:300 scale model of the Proposed Development, located on Caversham Road (referred to as the "Site" hereafter in this report), in Reading, UK. The investigation quantifies the wind conditions within and around the Site, by comparing the measured wind speed and frequency of occurrence with the Criteria. Meteorological data for Reading has been analysed and adjusted to the Site conditions by modelling the effect of terrain roughness on the wind speeds approaching the Site.

Measurements were taken at up to 240 locations for 36 wind directions, in 10° increments. The measurements covered ground level locations along the building facades and at corners, near main entrances, and on pedestrian routes within and around the Site. In addition, measurements at rooftop and podium terraces were taken for the Proposed Development. Analysis was conducted on a seasonal basis, but the report focuses on the windiest season results (i.e. winter) and those for the summer season, when pedestrian activity generally requires calmer conditions.

Three configurations of the wind tunnel model were tested, as follows:

- Configuration 1: Existing Site with Existing Surrounding Buildings;
- Configuration 2: Proposed Development with Existing Surrounding Buildings;
- Mitigation: Proposed Development with landscaping, wind mitigation and existing surrounding buildings; and
- Mitigation: Proposed Development with landscaping, wind mitigation and Cumulative Surrounding Buildings.

3.1 Site Description and Surroundings

The existing Site consists of an industrial warehouse facility and associated 3-storey office block. This will be demolished before the Proposed Development is built. The Site is located in Reading, and is bounded by Caversham Road to the West, the Great Western main line and Reading Train Station to the South, Trooper Potts Way to the East and The Station Shopping Park to the North. The OS Landranger grid reference for the Site is SU713739.

The surrounding area comprises low- to medium-rise residential and commercial buildings. The surrounding area is characterised by 'suburban' terrain which results in increased turbulence and a lower mean wind speed when compared to open country terrain but a lower turbulence and higher mean wind speeds than in a highly developed urban centre.



Figure 1: Aerial Photograph of the Existing site (Approximate extent of the Site highlighted)

3.2 The Proposed Development

The Proposed Development will be residential led mixed use development which compromises of nine main blocks and two town house blocks, ranging in height from 2 to 27 storeys. The intended uses of the Proposed Development will be a mix of commercial, residential, office, a health centre, public amenity and office amenity use.

Amenity areas are to be provided throughout the development in the form of roof terraces. There will be public amenity spaces provided at ground level, and residential amenity spaces at balcony levels.

4. METHODOLOGY AND ASSESSMENT CRITERIA

Wind tunnel testing is the most well-established and robust means of assessing the pedestrian wind microclimate with the Proposed Development in place. It enables the wind conditions at the Site to be quantified and classified in accordance with the Criteria. To produce the results within the tunnel, a 1:300 scale model of the existing buildings at the Site and the surrounding area within a 360 metre (m) radius of the centre of the Site was constructed.

The basic methodology for quantifying the pedestrian level wind environment is outlined below:

1. Measure the wind speeds at pedestrian level in the wind tunnel relative to a reference wind speed;
2. Adjust standard meteorological data to account for conditions at the Site;
3. Combine these to obtain the expected frequency and magnitude of wind speeds at pedestrian level; and
4. Compare the results with the Criteria to 'grade' conditions around the Site.

4.1 Simulation of Atmospheric Winds

The wind is turbulent, or gusty, and this turbulence varies depending upon the Site. It is necessary to reflect these differences in the wind tunnel test. In addition, the atmospheric boundary layer is a shear flow which means that the mean wind speed increases with height.

Modelling these effects is achieved by a combination of spires and floor roughness elements to create a naturally-grown boundary layer that is representative of urban or open country conditions, as appropriate. The detailed contoured proximity model around the Site is used to fine-tune the flow and create conditions similar to those expected at full scale (as shown in Figure 2).



Figure 2: Image of the Proposed Development with Existing Surrounds in the wind tunnel (view from the south-west).

4.2 Measurement Technique

Wind speed measurements were made using Irwin probes. For pedestrian comfort studies, both the mean wind speed and the peak wind speed are measured at selected locations at the Site and surrounding area to represent sensitive receptors, such as entrances, amenity areas and thoroughfares, at a scaled height of 1.5m above ground level. The typical equivalent full-scale time period for measuring the mean wind speed is around 90 minutes, whereas the peak wind speed is taken as the wind speed exceeded for 1% of the time.

Wind speed at each location was measured for 36 wind directions in 10° increments, with 0° representing wind blowing from the north and 90° wind blowing from the east.

4.3 Scaling

The length scale of the model was 1:300 and the velocity scale was approximately 1:2 for strong winds. Consequently, the time scale for the tests was 1:150, or in other words 1 second in the wind tunnel is equivalent to 150 seconds at full scale.

4.4 Meteorological Data

Meteorological data derived from the meteorological station of London Heathrow Airport have been corrected to standard conditions of 10m above open flat level country terrain. The meteorological station data are then adjusted to the Site conditions using the methodology implemented in the BREVE3 software package.

Approximately 30 years of meteorological data for London Heathrow were used in this report and is presented in Appendix B as wind roses by season (refer to Figure 24). The radial axis indicates the directional distribution of winds. The seasons are defined as summer (June to August) and winter (December to February). Pedestrian level wind speeds at open, flat, level country terrain are typically greater than at an inner city environment with low to medium rise buildings, due to the difference in boundary layer thickness for the vertical wind profile. Hence roughness lengths, a parameter for the wind profile equations that specifies the type of terrain, were estimated in all directions for appropriate upwind distances by use of virtual geographical software, and input into calculations for the wind profiles.

The meteorological data indicate that the prevailing wind direction throughout the year is from the south-west, which is consistent feature of met stations within the London area.

The combination of meteorological data and velocity ratios permits the percentage of time that wind speeds are exceeded on the site to be evaluated. The locations can then be assessed using the Criteria, as described below.

4.5 Pedestrian Comfort

The assessment of the wind conditions requires a standard against which the measurements can be compared. This report uses the Lawson Comfort Criteria, which have been established for over thirty years. The Criteria, which seek to define the reaction of an average pedestrian to the wind, are described in Table 1. If the measured wind conditions exceed the threshold wind speed for more than 5% of the time, then they are unacceptable for the stated pedestrian activity and the expectation is that there may be complaints of nuisance or people will not use the area for its intended purpose.

The Criteria sets out four pedestrian activities and reflect the fact that less active pursuits require more benign wind conditions. The four categories are sitting, standing, strolling and walking, in ascending order of activity level, with a fifth category for conditions that are uncomfortable for all uses. In other words, the wind conditions in an area for sitting need to be calmer than a location that people merely walk past.

The distinction between strolling and walking is that in the strolling scenario pedestrian are more likely to take on a leisurely pace, with the intention of taking time to move through the area, whereas in the walking scenario pedestrians are intending to move through the area quickly and are therefore expected to be more tolerant of stronger winds.

The Criteria are derived for open air conditions and assume that pedestrians will be suitably dressed for the season. Thermal comfort is discussed with reference to acceptable wind environments but not evaluated as part of the assessment.

The coloured key in Table 1 corresponds to the presentation of wind tunnel test results described later in this report.

Table 1: Lawson Comfort Criteria

Key	Comfort Category	Threshold	Description
	Sitting	0-4 m/s	Light breezes desired for outdoor restaurants and seating areas where one can read a paper or comfortably sit for long periods
	Standing	4-6 m/s	Gentle breezes acceptable for main building entrances, pick-up/drop-off points and bus stops
	Strolling	6-8 m/s	Moderate breezes that would be appropriate for window shopping and strolling along a city/town centre street, plaza or park
	Walking	8-10 m/s	Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering
	Uncomfortable	>10 m/s	Winds of this magnitude are considered a nuisance for most activities, and wind mitigation is typically recommended

4.6 Strong Winds

Lawson¹ also specified a lower limit strong wind threshold when winds exceed 15m/s for more than 0.025% of the time (approximately 2 hours of the year). Exceedance of this threshold may indicate a need for remedial measures or a careful assessment of the expected use of that location; e.g. is it reasonable to expect elderly or very young pedestrians to be present at the location on the windiest day of the year.

Wind Speeds that exceed 20m/s for more than approximately 2 hours of the year represent safety issue for all members of the population, which would require mitigation to provide an appropriate wind environment.

¹ Lawson T.V. (April 2001), Building Aerodynamics, Imperial College Press

Strong winds are generally associated with areas which would be classified as acceptable for walking or as uncomfortable. In a mixed-use urban development scheme, walking and uncomfortable conditions would not usually form part of the 'target' wind environment and would usually require mitigation due to pedestrian comfort considerations. This mitigation would also reduce the frequency of, or even eliminate, any strong winds.

If the wind speed exceeds 15m/s for more than 2 hours of the year in a proposed external seating area or outside an entrance, these conditions would be unacceptable and would require mitigation. However, in such cases the area is likely to be classified as acceptable for walking or as uncomfortable and so would require mitigation to satisfy the Criteria in any case.

5. RESULTS

5.1 Details of Analysis

To account for the difference in height and terrain roughness between meteorological conditions at the airports and the Site, it is necessary to apply adjustment factors to the wind tunnel velocity ratios. Adjustment factors (mean factors) were computed for wind directions from 0° through to 360°. The reference height in the wind tunnel was at the equivalent full-scale height of 120 metres. Table 2 presents the mean factors for the Site.

Table 2: BREVe3 mean factors at 120m above ground level

Wind Direction	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Mean Factor at 120 m	1.41	1.42	1.44	1.43	1.39	1.45	1.46	1.51	1.46	1.41	1.41	1.40

5.2 Desired Pedestrian Activity around the Proposed Development

Generally, for a mixed-use development, the target conditions are:

1. Strolling conditions during the windiest season on pedestrian thoroughfares;
2. Standing conditions at main entrances, drop off areas or taxi ranks, station platforms, and bus stops throughout the year; and
3. Sitting conditions at outdoor seating and amenity areas during the summer season when these areas are more likely to be frequently used by pedestrians.

The walking and uncomfortable classifications are usually avoided because of their association with occasional strong winds, unless they are on a minor pedestrian route or a route where pedestrian access could be controlled in the event of strong winds.

Achieving a sitting classification in the summer usually means that the same location would be acceptable for standing in the windiest season because winds are stronger at this time. This is considered an acceptable occurrence for the majority of external amenity spaces because other factors such as air temperature and precipitation influence people's perceptions about the 'need' to use seating in the middle of winter.

5.3 Performance against the Lawson Comfort Criteria

The wind microclimate within and around the Site has been assessed and classified using the Lawson Comfort Criteria defined in Table 1. The results of the assessment for each configuration are described below and presented graphically in Figures 3 to 10.

5.3.1 Configuration 1 – Existing Site with Existing Surrounding Buildings

The wind microclimate results for Configuration 1 are shown in the following figures:

- Figure 3: Windiest Season – Ground Level
- Figure 4: Summer Season – Ground Level

The existing Site was modelled in the context of the existing surrounding buildings devoid of landscaping in order to yield results for a ‘worst-case’ (i.e. relatively ‘windy’) scenario.

5.3.2 Configuration 2 – Proposed Development with Existing Surrounds Buildings

The wind microclimate results for Configuration 2 are shown in the following figures:

- Figure 5: Windiest Season – Ground, Terrace and Roof Levels
- Figure 6: Summer Season – Ground, Terrace and Roof Levels

This configuration includes the Proposed Development modelled with the existing surrounding buildings and devoid of landscaping in order to yield results for a ‘worst-case’ (i.e. relatively ‘windy’) scenario.

5.3.3 Mitigation – Proposed Development with Landscaping, Mitigation and Existing Surrounding Buildings

The wind microclimate results for Configuration 2 with landscaping and wind mitigation measures are shown in the following figures:

- Figure 7: Windiest Season – Ground, Terrace and Roof Levels
- Figure 8: Summer Season – Ground, Terrace and Roof Levels

This configuration includes the Proposed Development modelled in the context of the existing surrounding buildings with the proposed landscaping scheme and wind mitigation measures required to have a suitable wind microclimate with no instances of strong winds likely to be a safety concern for pedestrians.

The following wind mitigation measures were developed in addition to the proposed landscaping scheme (based on plans received March 29th, 2019), and assessed through iterative wind mitigation testing:

- Two staggered 4m high 50% porous screens between Tower A and the station building.
- Two trees near the South corner of Tower A removed.
- The area along South edge of tower A to be made inaccessible with planters.

- 2m deep canopy placed at 5m height on curved facade of health centre, with solid vertical walls at either end and two solid vertical walls in intermediate positions.
- Glass balustrades on all corners of Tower A terrace. 3m high dividers on Tower A terrace.
- 2 m high dividers on private terraces.
- 1.5m hedges on public terraces.

5.3.4 Configuration 3 – Proposed Development with Landscaping, Mitigation and Cumulative Surrounding Buildings

Cumulative schemes within the 360m radius of the site and therefore included on the wind tunnel model are as follows:

- Station Hill
- 29-35 Station Road
- Kings Meadow

Cumulative schemes out with this area have been accounted for in the analysis of the surrounding environment discussed in 5.1 'Details of Analysis'.

The wind microclimate results for the cumulative configuration with landscaping and wind mitigation measures are shown in the following figures:

- Figure 9: Windiest Season – Ground, Terrace and Roof Levels
- Figure 10: Summer Season – Ground, Terrace and Roof Levels

This configuration includes the Proposed Development modelled in the context of the cumulative surrounding buildings with the proposed landscaping scheme and wind mitigation measures required to have a suitable wind microclimate with no instances of strong winds likely to be a safety concern for pedestrians.

Table 3: Expected usage of area represented by individual measurement location

Receptor	Location	Receptor Reference (Probe Measurement Number)
On-Site		
Thoroughfares	Western Buildings	57, 59, 60, 61, 62, 74, 76, 77, 79, 89, 81, 84, 93, 95, 99, 100, 103, 104, 105, 106, 112, 113, 114, 116, 117, 118, 119, 120, 123, 124, 148, 152, 155, 156, 158, 159
	Eastern Buildings	15, 18, 21, 20, 22, 27, 28, 29, 30, 33, 34, 36, 40, 43, 44, 48, 49, 50, 58, 150, 164, 167, 170, 189, 190, 191, 192, 195
Entrances	Western Buildings	55, 75, 78, 82, 83, 90, 96, 98, 115, 121, 122, 125, 126, 127, 129, 131, 133, 138, 142, 149, 153, 154
	Eastern Buildings	12, 17, 19, 35, 41, 42, 52, 53, 169, 171, 178, 183, 184, 186, 187, 188, 193, 194

Ground Level Amenity	11, 10, 13, 14, 51, 54, 56, 128, 130, 132, 134, 135, 136, 137, 139, 140, 141, 143, 144, 145, 146, 147, 151, 166, 167, 168, 172, 173, 174, 175, 176, 177, 179, 180, 181, 182, 185, 196, 197, 198, 199, 200, 201, 202	
Podium Level Amenity	238, 239, 240	
Roof Terrace Amenity	203, 204, 205, 206, 207, 208, 209, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237	
Off-Site		
Thoroughfares	Caversham Road	68, 70, 71, 85, 89, 94, 107, 107 109, 111
	Vastern Road	31, 39, 45, 63, 64
	Other	9, 7, 16, 88
Entrances	4, 24, 26, 32, 37, 67, 72, 73, 86, 92, 97, 102	
Amenity Spaces	6, 8, 66	
Station Platform	1, 2, 3, 160, 161, 162, 163	
Road	Caversham Road	69, 101, 110
	Vastern Road	25, 38, 65
	Trooper Potts way	5
	Northfield Road	87
Crossings	Caversham Road	91
	Vastern Road	46

5.4 Occurrence of Strong Winds

Strong winds exceeding 15m/s for more than 0.025% of the time (approximately two hours per year) are listed below.

Table 4: Annual exceedance of strong winds

Location	Threshold Exceedance	Wind Direction	Hours per Annum
Configuration 1: Existing Site with Existing Surrounding Buildings			
There were no strong winds exceeding 15m/s for more than 0.025% of the time (approximately two hours per year) in this configuration.			
Configuration 2: Proposed Development with Existing Surrounding Buildings			
77	S15	260	2.5
83	S15	260	14
84	S15	270	4

Location	Threshold Exceedance	Wind Direction	Hours per Annum
90	S15	260	7.7
201	S15	200	6.4
202	S15	200	5.6
235	S15	240	3.8
236	S15	220	12.3
Mitigation Run 6: Proposed Development with Existing Surrounding Buildings with Landscaping and Mitigation Measures			
232	S15	290	4.5
235	S15	240	14
Mitigation Run 7: Proposed Development and Cumulative Surrounding Buildings with Landscaping and Mitigation Measures			
232	S15	290	5.2
235	S15	240	13.9

6. DISCUSSION

This discussion compares the measured wind conditions (shown in the dot plots) to the anticipated usage of the site, to provide an assessment of whether the conditions are suitable or too windy for the intended use.

Any locations not specifically mentioned are suitable for or calmer than required for the desired pedestrian usage. Locations that are windier than desired for their intended pedestrian use would require mitigation.

6.1 Configuration 1: Existing Site with Existing Surrounding Buildings

The discussion of the wind microclimate in the Baseline Scenario (Configuration 1) is based on the results shown in Figure 3 for the windiest season and Figure 4 for the summer season at ground level.

6.1.1 Pedestrian Comfort

In the Baseline scenario, conditions are considered to be relatively 'calm' throughout much of the site and surrounding area as the wind conditions at the ground level during the windiest season range from acceptable for sitting use to acceptable for standing use. In the summer season, conditions become even calmer, as most of the site is now classified as suitable for sitting use.

6.1.2 Strong Winds

There are no instances of strong winds exceeding 15m/s for more than 0.025% of the time (approximately 2 hours per year) at any measurement locations at the Site and the surrounding area.

6.2 Configuration 2: Proposed Development with Existing Surrounding Buildings

Discussion of the tested wind conditions for the Proposed Development (Configuration 2) is based on the results shown in Figures 5 for the windiest season and Figures 6 for the summer season at ground level. Wind conditions in Configuration 2 were assessed devoid of landscaping or wind mitigation measures in order to assess a worst-case (i.e. windy) scenario. A wind mitigation strategy developed through iterative wind tunnel testing is presented in the Section 6.3 of this report.

6.2.1 Pedestrian Comfort

In Configuration 2 during the windiest season, with the Proposed Development built out, the conditions across the site would become windier than baseline, with conditions ranging from acceptable for sitting use through to walking use. There are a number of areas which would have conditions windier than suitable for their intended use. During the summer season, wind conditions would generally be one category calmer than the winter season.

Thoroughfares

To the North West of the Site (location 84) and to the South West of the site, between Tower A and the station, (Locations 11, 201, 202) wind conditions would be suitable for walking use during the windiest season (Figure 5). These conditions would be one category too windy for the intended pedestrian use. For the remaining thoroughfares through the Proposed Development and the surrounding area wind conditions would be suitable for strolling use or calmer, which would be acceptable for pedestrian thoroughfares.

Entrances and Station Platforms

Wind conditions at the Eastern entrance to the retail unit and refuse area of Block E (location 55) and the Northern entrance to the Health Centre (Location 82) of the Proposed Development would have strolling use conditions during the windiest season (Figure 5), one category windier than suitable for the intended pedestrian use. At the residential entrances to Block G (locations 83 and 90) the wind conditions would be suitable for walking use, two categories windier than suitable for the intended pedestrian use. Elsewhere during the windiest season (Figure 5), entrances to the proposed development and the existing buildings would be suitable for standing use, or calmer, acceptable for entrance locations. The platforms of the station would have conditions during the windiest season ranging from suitable for sitting use to standing uses, suitable for the intended pedestrian use.

Ground Level Amenity Spaces

During the summer season (Figure 6) wind conditions at the ground level amenity spaces in the proposed development would range from suitable for sitting use to standing use, up to one category windier than suitable for the intended pedestrian use.

Roof Terrace Amenity Spaces

Wind conditions on the West of the roof terrace of Tower A (locations 235 and 236) of the Proposed Development would have strolling use conditions during the summer season (Figure 6), two categories windier than suitable for the intended pedestrian use. During the summer season wind conditions on the roof terraces of Blocks C, D, E and F would range from suitable for sitting use to standing use. As these are private spaces, wind conditions suitable for sitting or standing use would be acceptable, with the spaces expected to only be used when conditions are suitable. For the public terraces, conditions would range from suitable for sitting use to standing use during the summer season (Figure 6). For large terraces, such as these, a combination of sitting or standing conditions during summer would be acceptable on the basis that there would be some sheltered areas suitable for sitting.

6.2.2 Strong Winds

There would be instances of winds exceeding 15m/s for more than 0.025% of the time (approximately two hours per year) at eight measurement locations (77, 83, 84, 90, 201, 202, 235 and 236) in and around the Site which would have the potential to be a safety concern for more vulnerable pedestrians in accessible areas. These results indicate wind conditions that are too windy for use by the general public with implications for pedestrian safety. These conditions would therefore require further wind mitigation measures (as discussed in Section 6.3).

6.3 Mitigation: Proposed Development with Proposed Landscaping, Mitigation Measures and Existing Surrounding Buildings.

Discussion of the tested wind conditions for the Proposed Development with the aforementioned wind mitigation measures incorporated, in the context of the existing surrounding buildings, is based on the results shown in Figures 7 for the windiest season and Figures 8 for the summer season at ground level and terrace level.

6.3.1 Pedestrian Comfort

During the windiest season the conditions across the site would range from acceptable for sitting use through to strolling use. During the summer season, the measurement locations generally record wind conditions that are one category calmer than the winter season.

Thoroughfares

With the addition of the proposed landscaping and the mitigation measures the thoroughfares through the Proposed Development and the surrounding area would have wind conditions suitable for strolling use or calmer during the windiest season, which would be acceptable for pedestrian thoroughfares.

Entrances and Station Platforms

Wind conditions at the entrance to the existing offsite retail unit North East (Location 24) of the Proposed Development would have conditions suitable for strolling use during the windiest season (Figure 7), one category windier than suitable for the intended pedestrian use. Elsewhere during the windiest season (Figure 7), entrances to the proposed development and the existing buildings would be suitable for standing use, or calmer, acceptable for all other entrance locations.

During the windiest season (Figure 7) the Eastern end of the Northern most platform of the train station (Location 3) would have wind conditions suitable for strolling use, one category windier than suitable for the intended use. The remaining platforms of the station would have conditions during the windiest season ranging from suitable for sitting use to standing uses, suitable for the intended pedestrian use.

Ground Level Amenity Spaces

During the summer season (Figure 8) wind conditions at the ground level amenity spaces in the proposed development would range from suitable for sitting use to standing use, with the majority of locations being suitable for sitting. These conditions would be acceptable provided seating provision in areas suitable for standing use has localised screening.

Roof Terrace Amenity Spaces

Wind conditions on the West of the roof terrace of Tower A (locations 235) of the Proposed Development would have strolling use conditions during the summer season (Figure 8), two categories windier than suitable for the intended pedestrian use. During the summer season wind conditions on the roof terraces of Blocks C, D, E and F would range from suitable for sitting use to standing use. As these are private spaces, wind conditions suitable for sitting or standing use would be acceptable, with spaces only expected to be used when conditions are suitable. For the public terraces, conditions would range from suitable for sitting use to standing use during the summer season (Figure 8). For large terraces, such as these, a combination of sitting or standing conditions during summer would be acceptable on the basis that there would be some sheltered areas suitable for sitting.

6.3.2 Strong Winds

There would be instances of winds exceeding 15m/s for more than 0.025% of the time (approximately two hours per year) at two measurement locations (232 and 235) on the roof terrace of Tower A which would have the potential to be a safety concern for occupants. These results indicate wind conditions that are too windy for use by the general public with implications for pedestrian safety. During the mitigation workshop it was agreed with the architects to consider making these areas inaccessible to the public. Alternatively, if the intention is to keep these areas accessible then further mitigation, such as additional dividers at the corners, would need to be considered.



6.4 Configuration 3: Proposed Development with Proposed Landscaping, Mitigation Measures and Cumulative Surrounding Buildings.

Discussion of the tested wind conditions for Configuration 3 is based on the results shown in Figures 9 for the windiest season and Figures 10 for the summer season at ground level and terrace level.

6.4.1 Pedestrian Comfort

During the windiest season the conditions across the site would range from acceptable for sitting use through to strolling use. During the summer season, the measurement locations generally record wind conditions that are one category calmer than the winter season.

Thoroughfares

With the addition of the proposed landscaping and the mitigation measures the thoroughfares through the Proposed Development and the surrounding area would have wind conditions suitable for strolling use or calmer during the windiest season, which would be acceptable for pedestrian thoroughfares.

Entrances and Station Platforms

Wind conditions at the Eastern entrance to the retail unit and refuse area of Block E (location 55) of the Proposed Development would have strolling use conditions during the windiest season (Figure 9), one category windier than suitable for the intended pedestrian use. RWDI would expect that with the implementation of additional mitigation measures, such as recessing the entrances or installing planters/screens either side of the entrances, conditions could be made suitable for the intended use. Elsewhere during the windiest season (Figure 9), entrances to the proposed development and the existing buildings would be suitable for standing use, or calmer, acceptable for entrance locations.

The platforms of the station would have conditions during the windiest season ranging from suitable for sitting use to standing uses, suitable for the intended pedestrian use.

Ground Level Amenity Spaces

During the summer season (Figure 10) wind conditions at the ground level amenity spaces in the proposed development would range from suitable for sitting use to standing use, with the majority of locations being suitable for sitting. These conditions would be acceptable provided seating provision in areas suitable for standing use has localised screening.

Roof Terrace Amenity Spaces

Wind conditions on the West of the roof terrace of Tower A (locations 235) of the Proposed Development would have strolling use conditions during the summer season (Figure 10), two categories windier than suitable for the intended pedestrian use. During the summer season wind conditions on the roof terraces of Blocks C, D, E and F would range from suitable for sitting use to standing use. As these are private spaces, wind conditions suitable for sitting or standing use would be acceptable, with spaces only expected to be used when conditions are suitable. For the public terraces, conditions would range from suitable for sitting use to standing use during the summer season (Figure 10). For large terraces, such as these, a combination of sitting or standing conditions during summer would be acceptable on the basis that there would be some sheltered areas suitable for sitting.

6.4.2 Strong Winds

There would be instances of winds exceeding 15m/s for more than 0.025% of the time (approximately two hours per year) at two measurement locations (232 and 235) on the roof terrace of Tower A which would have the potential to be a safety concern for more vulnerable pedestrians in accessible areas. These results indicate wind conditions that are too windy for use by the general public with implications for pedestrian safety. During the mitigation workshop it was agreed with the architect to consider making these areas inaccessible to the public. Alternatively, if the intention is to keep these areas accessible then further mitigation, such as additional dividers at the corners, would need to be considered.

7. CONCLUDING REMARKS

In conclusion:

1. The meteorological data for the site indicates prevailing winds from the South-West throughout the year, with North-Easterly winds during the spring months.
2. In the baseline scenario (Configuration 1) wind conditions range from suitable for sitting to standing use, acceptable conditions for the current pedestrian uses, as would be expected for low rise buildings in largely suburban area.
3. At the Proposed Development in the context of the existing surrounding buildings (Configuration 2), conditions at the site would be windier than in the baseline scenario, with windier than acceptable conditions at the following locations:
 - The thoroughfare to the North West of the Site (location 84);
 - The thoroughfare to the South West of the site, between Tower A and the station, (Locations 11, 201, 202);
 - The Eastern entrance to the retail unit and refuse area of Block E (location 55);
 - The Northern entrance to the Health Centre (Location 82) and the residential entrances to Block G (locations 83 and 90); and
 - The west of the roof terrace of Tower A (locations 235 and 236).
4. In Configuration 2 there would be instances of winds exceeding this threshold at eight locations (areas represented by measurement locations 77, 83, 84, 90, 201, 202, 235 and 236). Wind mitigation measures would be required at these locations to reduce the occurrence of winds exceeding 15m/s or restrict pedestrian access to these areas.
5. To reduce the occurrence of strong winds and improve wind conditions in these areas, a number of wind mitigation measures have been developed to enhance the proposed landscaping scheme and which would be required to be suitable for the intended pedestrian use. These measures include:
 - Two staggered 4m high 50% porous screens between Tower A and the station building.
 - Two trees near the South corner of Tower A removed.
 - The area along South edge of tower A to be made inaccessible with planters.
 - 2m deep canopy placed at 5m height on curved facade of health centre, with solid vertical walls at either end and two solid vertical walls in intermediate positions.
 - Glass balustrades on all corners of Tower A terrace. 3m high dividers on Tower A terrace.
 - 2 m high dividers on private terraces.
 - 1.5m hedges on public terraces.
6. With the implementation of a mitigation strategy, conditions at ground and podium levels within the site would be acceptable for the intended pedestrian use.
7. Wind conditions at the entrance to the existing offsite retail unit North East (Location 24) of the Proposed Development would have conditions suitable for strolling use during the windiest season, one category windier than suitable for the intended pedestrian use.



8. At the Tower A roof terrace level, with these mitigation measures conditions would remain up to two categories windier than suitable for the intended use and instances of strong winds would persist. During the mitigation workshop the architect agreed to consider making these areas inaccessible to the public. Alternatively, if the intention is to keep these areas accessible then further mitigation, such as additional dividers at the corners, would need to be considered.
9. The introduction of cumulative schemes would not significantly alter the wind conditions at the Proposed Development from those presented for the Proposed Development in the context of the existing surrounding buildings. With the application of the wind mitigation measures required for the Proposed Development in Configuration 2, wind conditions would be suitable for the intended use at ground, podium and accessible roof terrace locations with two exceptions:
 - The Eastern entrance to the retail unit and refuse area of Block E (location 55) would have conditions one category windier than suitable for the intended use. RWDI would expect that with the implementation of additional mitigation measures, such as recessing the entrances or installing planters/screens either side of the entrances, conditions could be made suitable for the intended use;
 - Wind conditions on the Tower A roof terrace level would remain too windy to permit occupant access.



8. REFERENCES

1. Lawson T.V. (April 2001), Building Aerodynamics, Imperial College Press

FIGURES









Roof Level



LEGEND:

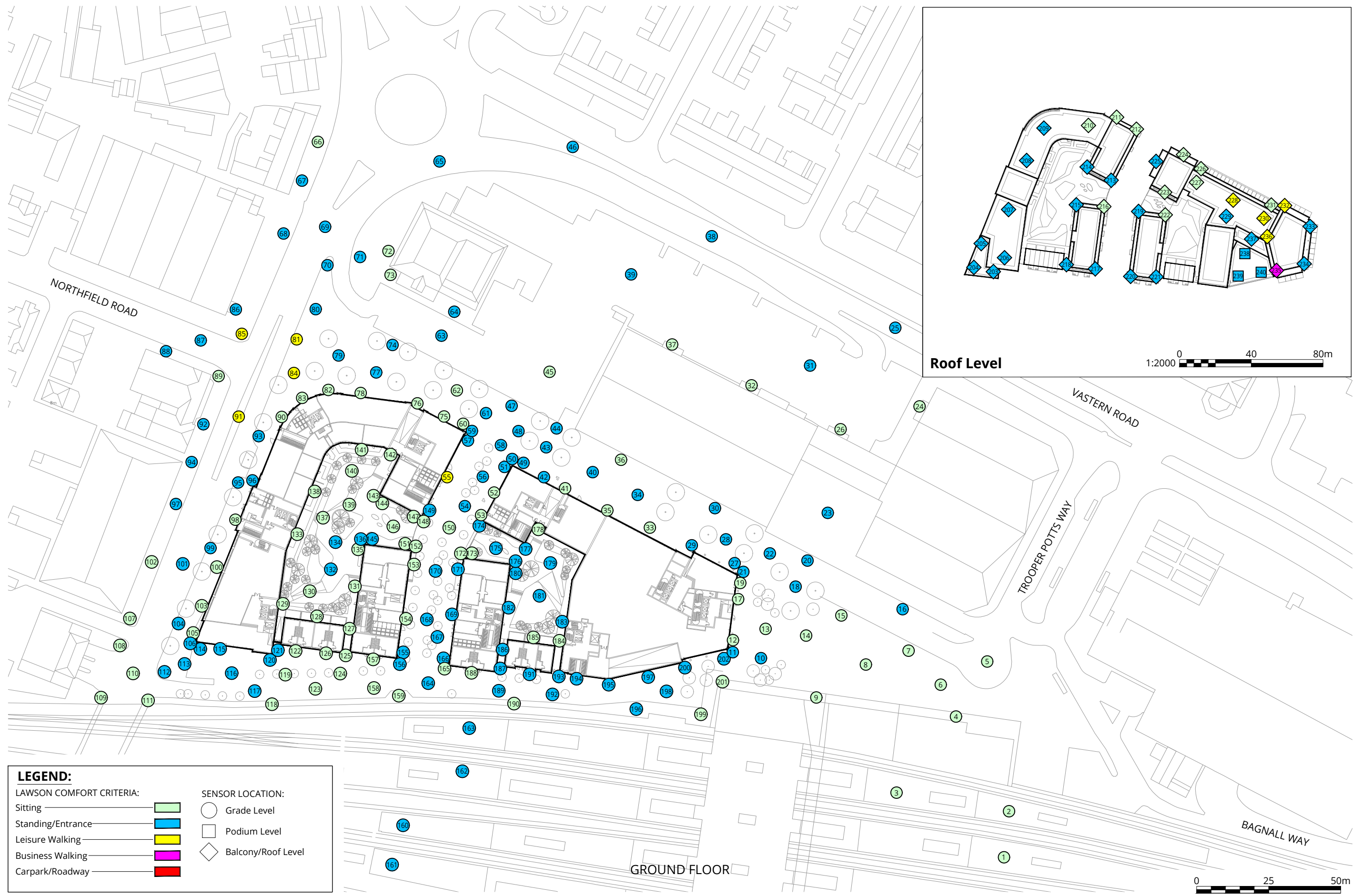
LAWSON COMFORT CRITERIA:

- Sitting
- Standing/Entrance
- Leisure Walking
- Business Walking
- Carpark/Roadway

SENSOR LOCATION:

- Grade Level
- Podium Level
- Balcony/Roof Level





LEGEND:

LAWSON COMFORT CRITERIA:

Sitting	Light Green
Standing/Entrance	Blue
Leisure Walking	Yellow
Business Walking	Magenta
Carpark/Roadway	Red

SENSOR LOCATION:

Grade Level	Circle
Podium Level	Square
Balcony/Roof Level	Diamond

Pedestrian Wind Comfort Conditions - Ground Floor and Roof Level
Configuration 3: Proposed Development with Proposed Landscaping, Wind Mitigation Measures and the Cumulative Surrounding Buildings Windiest Season

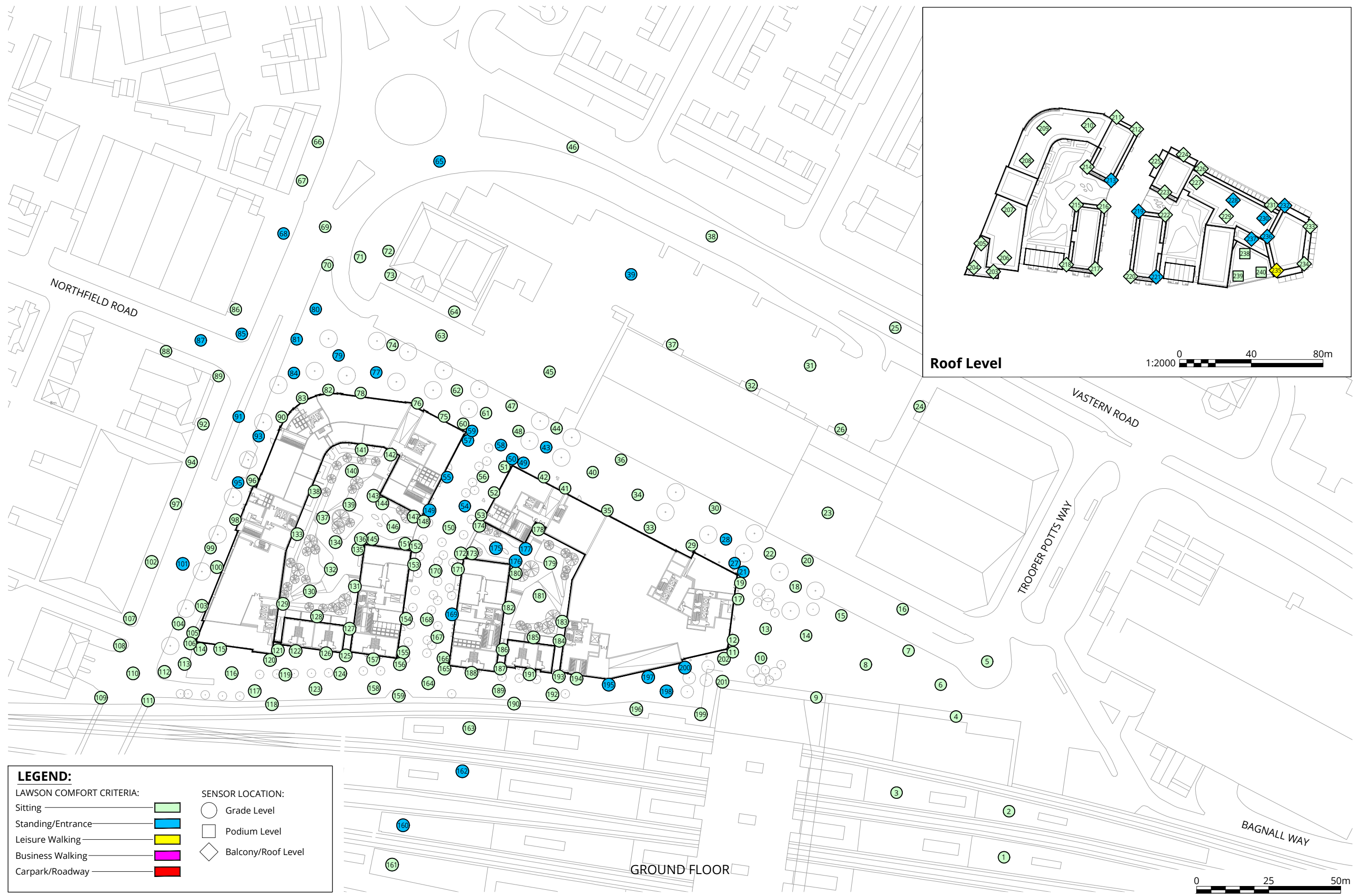
Reading Metropolitan - London, UK



Project #1900850

Drawn by:	JLF	Figure:	9
Approx. Scale @A3:	1:1250		
Date Revised:	May. 14, 2019		





Roof Level

1:2000 0 40 80m

LEGEND:

LAWSON COMFORT CRITERIA:

- Sitting
- Standing/Entrance
- Leisure Walking
- Business Walking
- Carpark/Roadway

SENSOR LOCATION:

- Grade Level
- Podium Level
- Balcony/Roof Level

Pedestrian Wind Comfort Conditions - Ground Floor and Roof Level
Configuration 3: Proposed Development with Proposed Landscaping, Wind Mitigation Measures and the Cumulative Surrounding Buildings Summer Season

Reading Metropolitan - London, UK



Project #1900850

Drawn by: JLF	Figure: 10
Approx. Scale @A3: 1:1250	
Date Revised: May. 14, 2019	



APPENDIX A



APPENDIX A: WIND TUNNEL PHOTOS

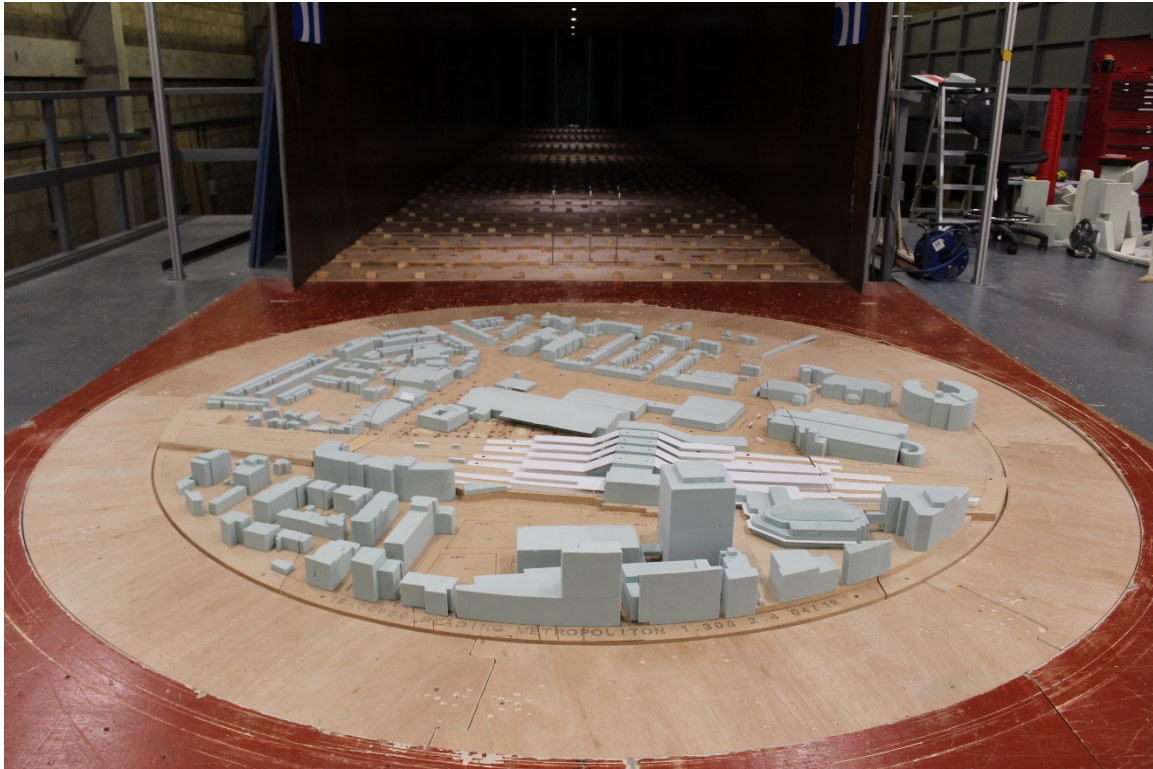


Figure 11: Configuration 1: Existing Site with Existing Surrounding Buildings – View in the Wind Tunnel (from the South).

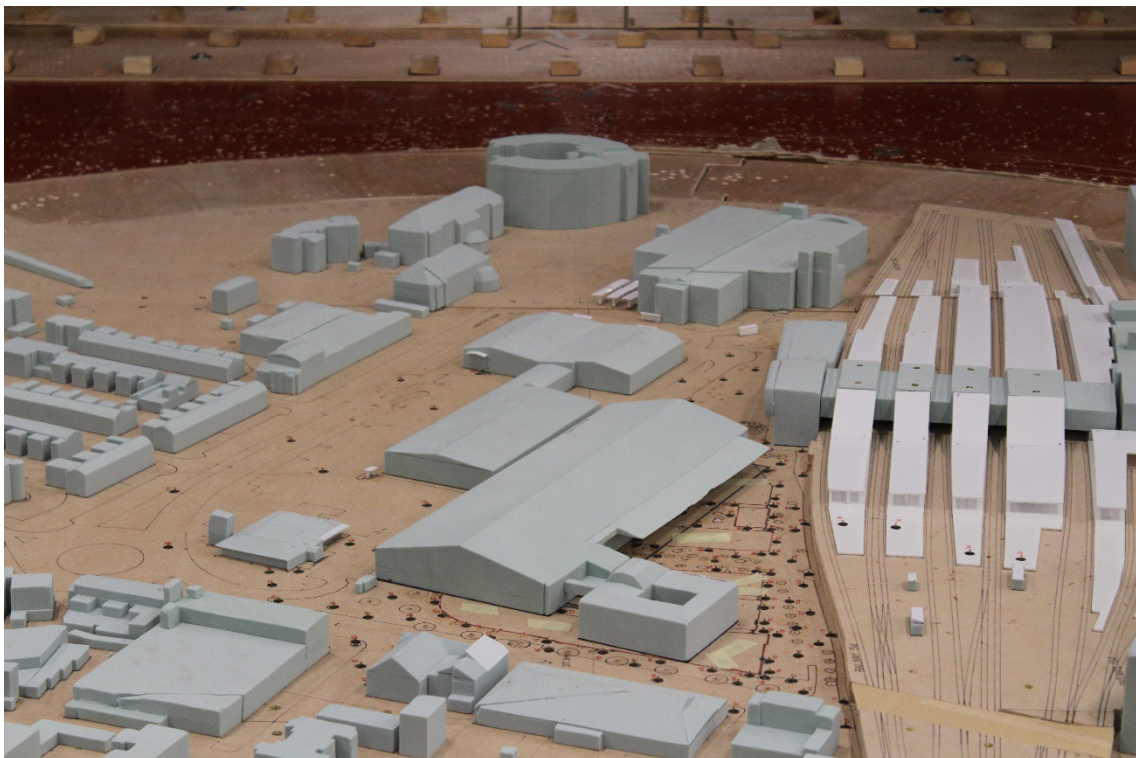


Figure 12: Configuration 1: Existing Site with Existing Surrounding Buildings – View in the Wind Tunnel (from the West).

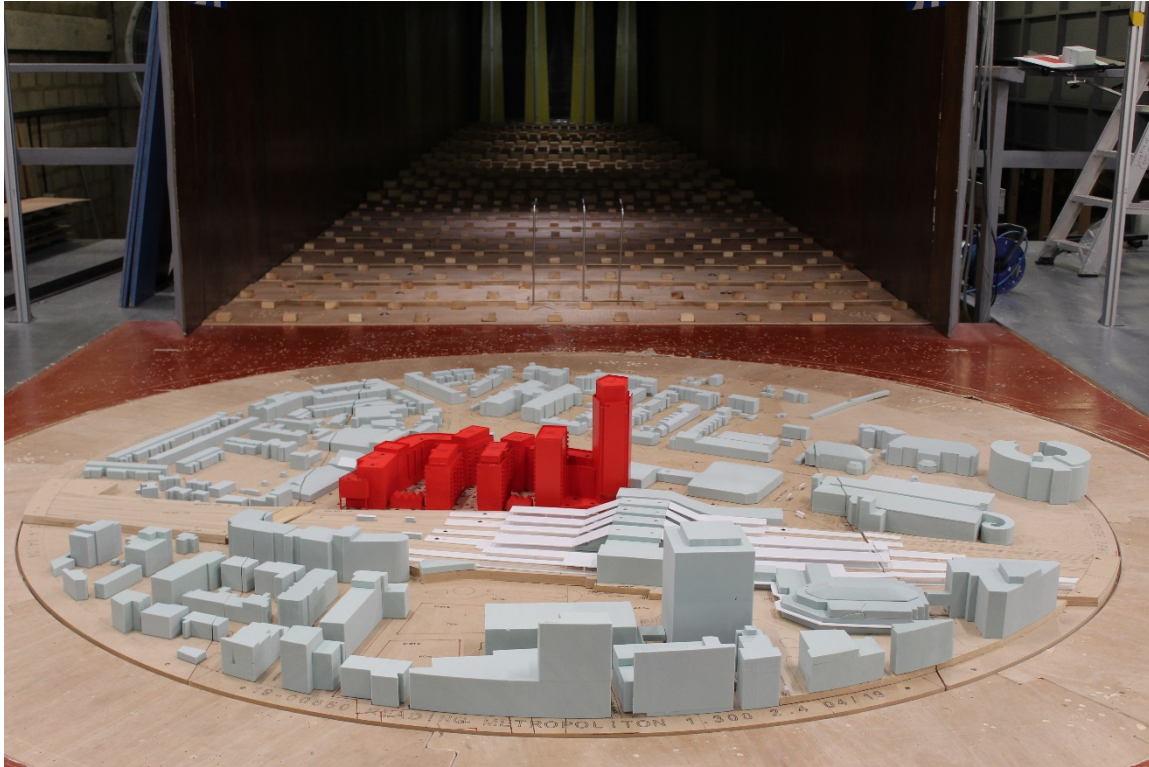


Figure 13: Configuration 2: Proposed Development with existing surrounding buildings – View in the Wind Tunnel (from the South).

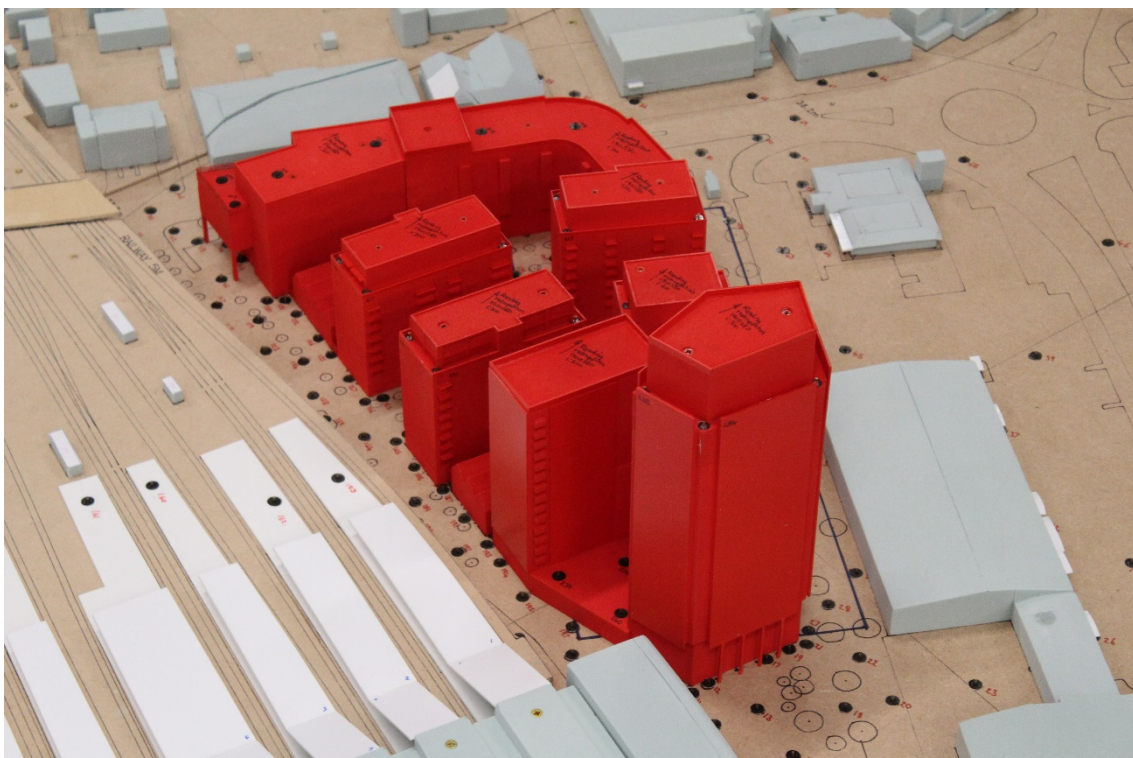


Figure 14: Configuration 2: Proposed Development with existing surrounding buildings – View in the Wind Tunnel (from the East).



Figure 15: Mitigation: Proposed Development with landscaping, mitigation and existing surrounding building – View in the Wind Tunnel (from the North).

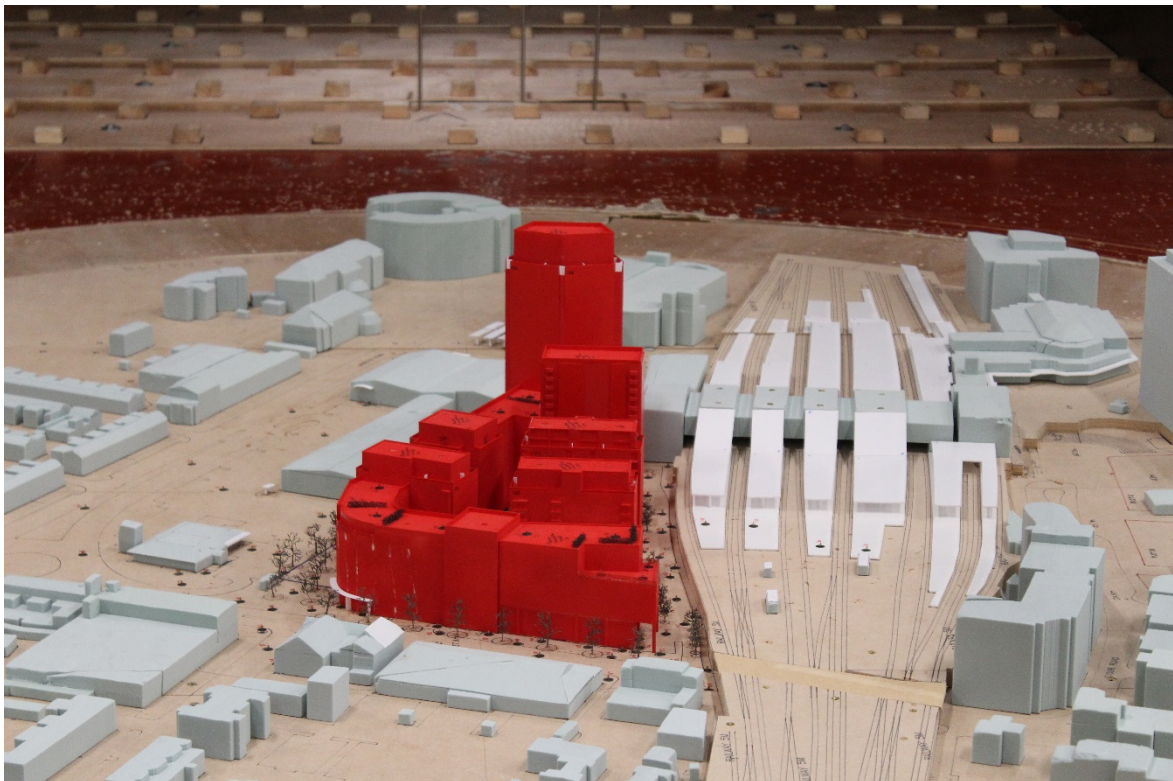


Figure 16: Mitigation: Proposed Development with landscaping, mitigation and existing surrounding building – View in the Wind Tunnel (from the West).

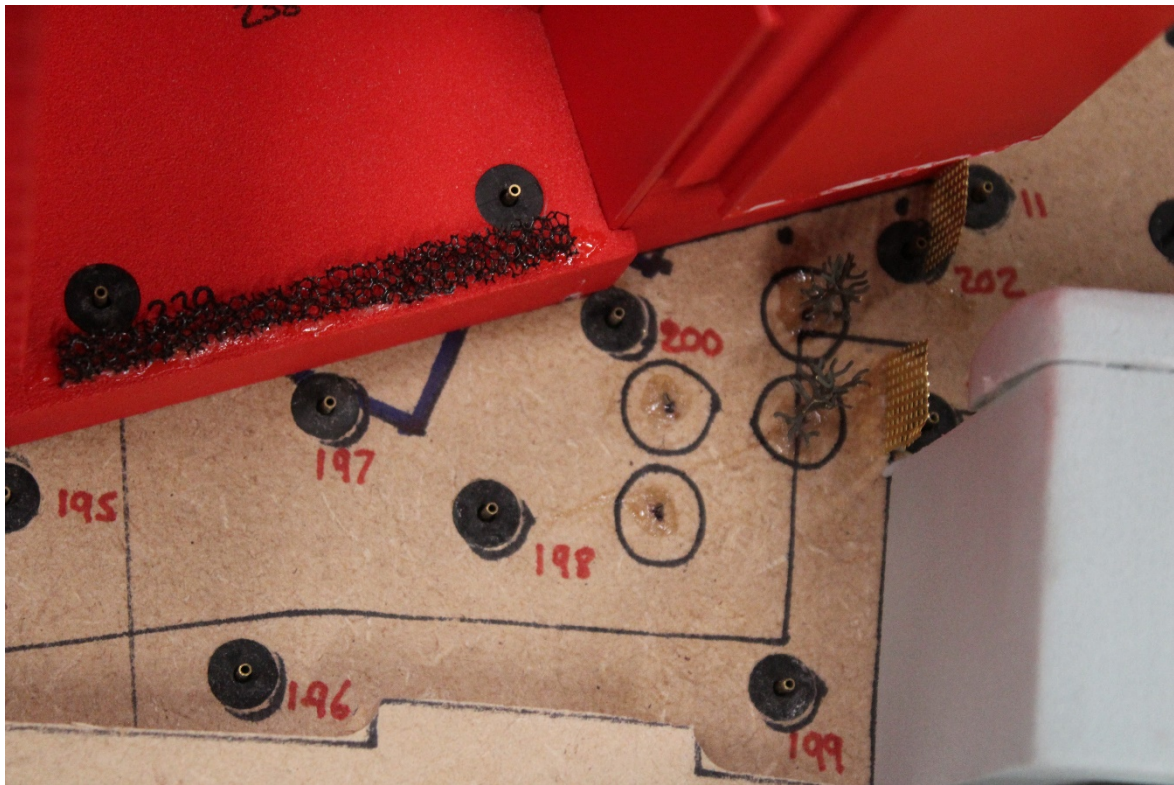


Figure 17: Mitigation Measures: Two staggered 4m high 50% porous screens between Tower A and the station building. Two trees near the South corner of Tower A removed.

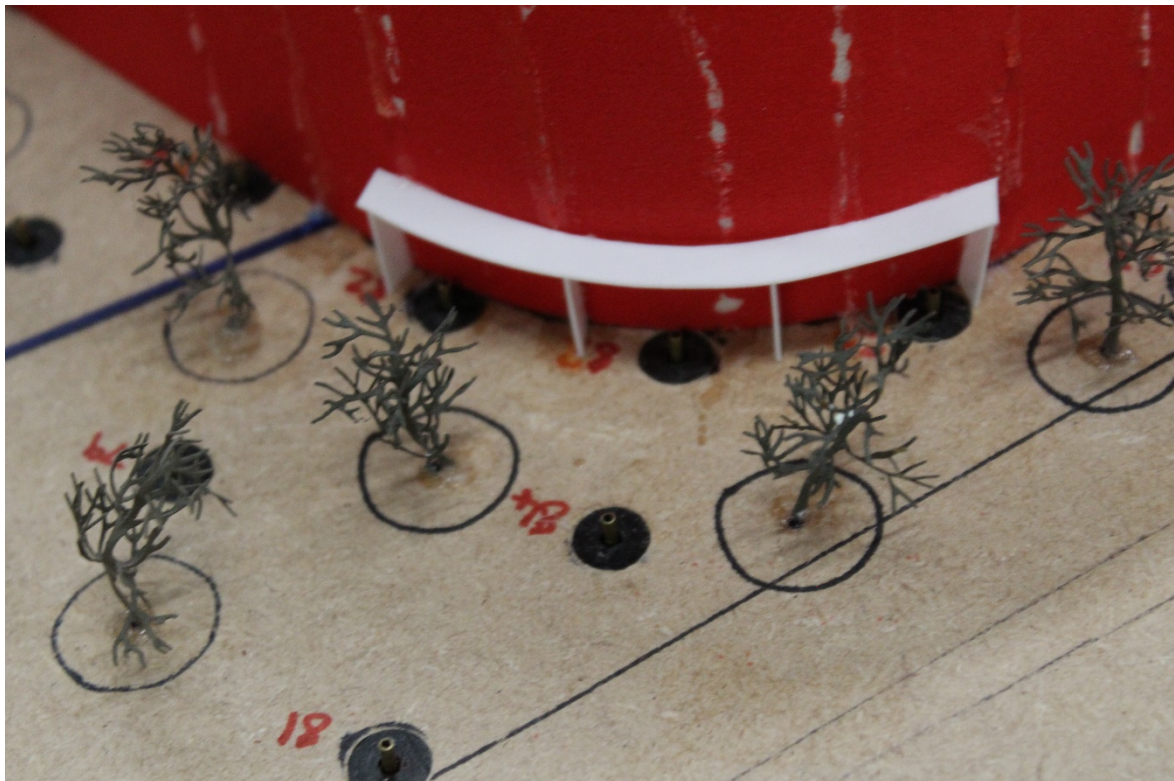


Figure 18: Mitigation Measures: 2m deep canopy placed at 5m height on curved facade of health centre, with solid vertical walls at either end and two solid vertical walls in intermediate positions.

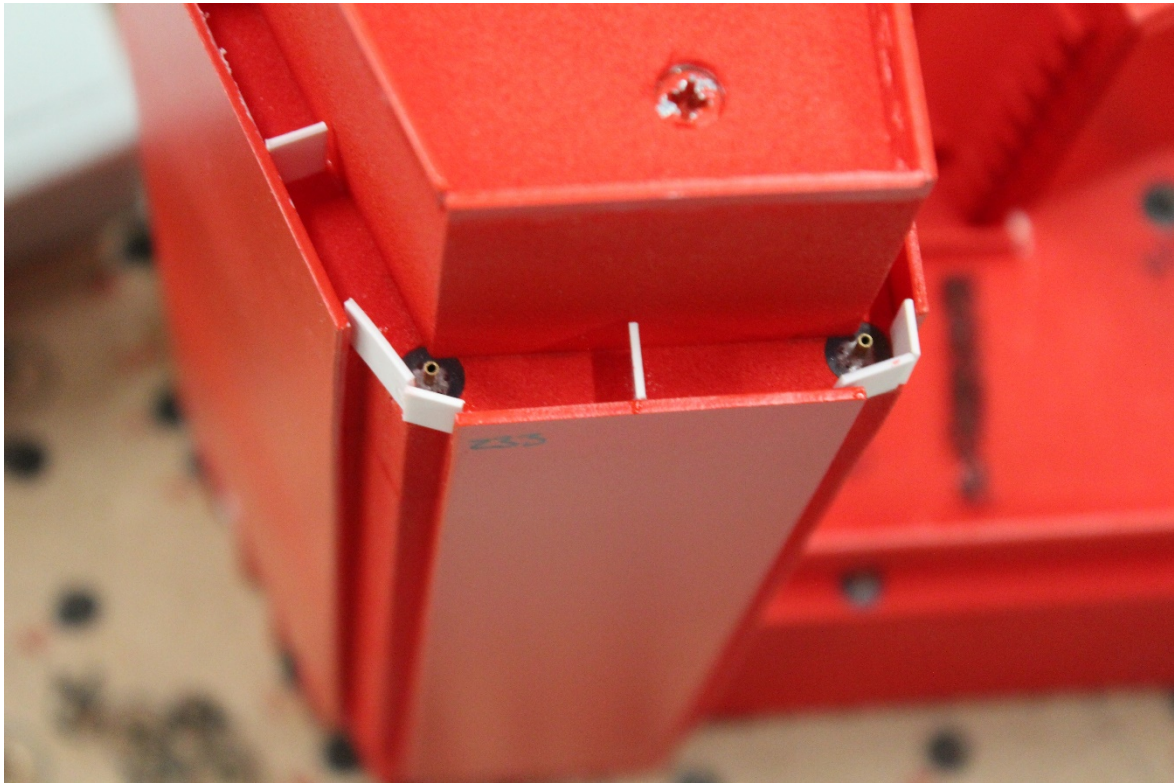


Figure 19: Mitigation Measures: Glass balustrades on all corners of Tower A terrace. 3m high dividers on Tower A terrace.

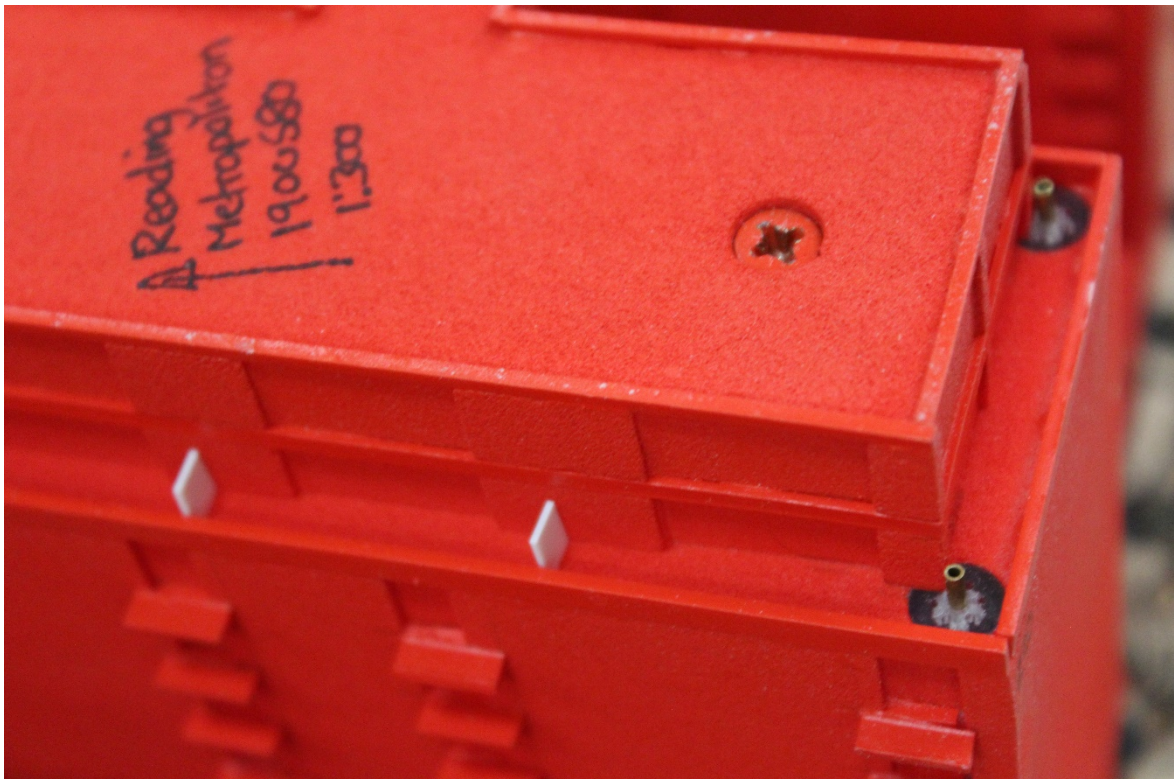


Figure 20: Mitigation Measures: 2 m high dividers on private terraces.



Figure 21: Mitigation Measures: 1.5m hedges on public terraces.

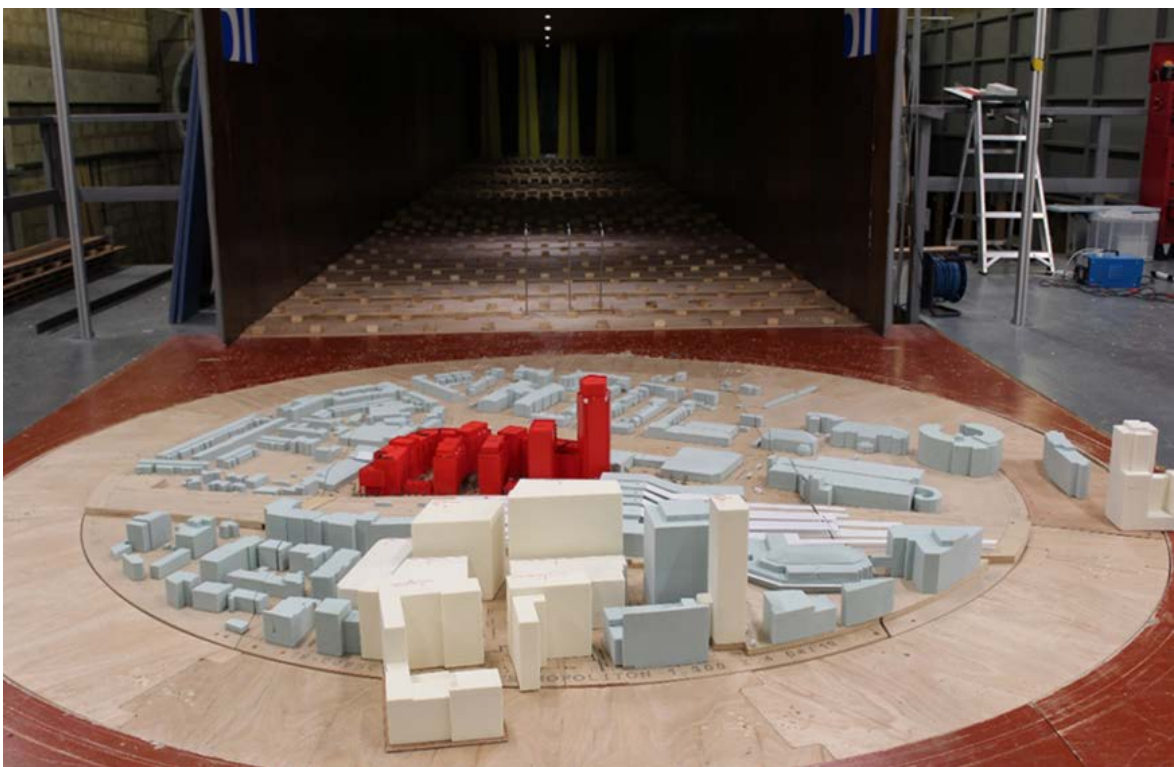


Figure 22: Configuration 3: Proposed Development with landscaping, mitigation and cumulative surrounding buildings – View in the Wind Tunnel (from the South).

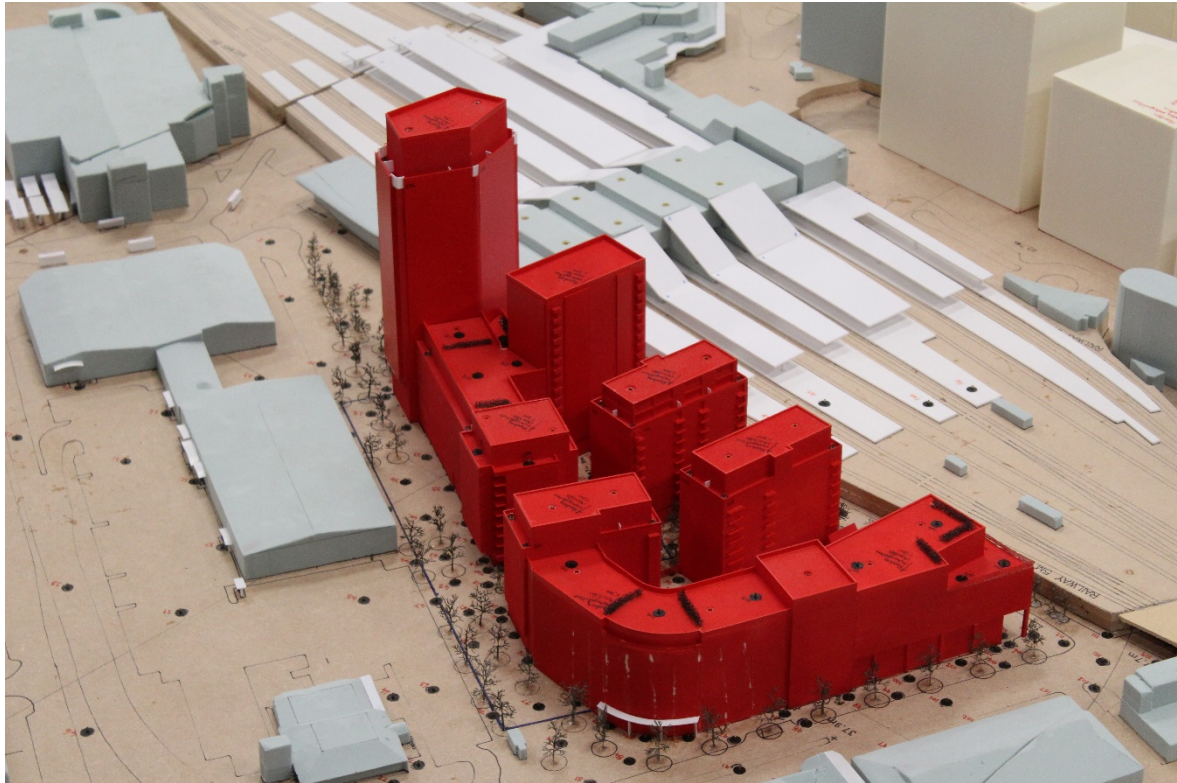


Figure 23: Configuration 3: Proposed Development with landscaping, mitigation and cumulative surrounding buildings – View in the Wind Tunnel (from the West).

APPENDIX B



APPENDIX B: METEOROLOGICAL DATA

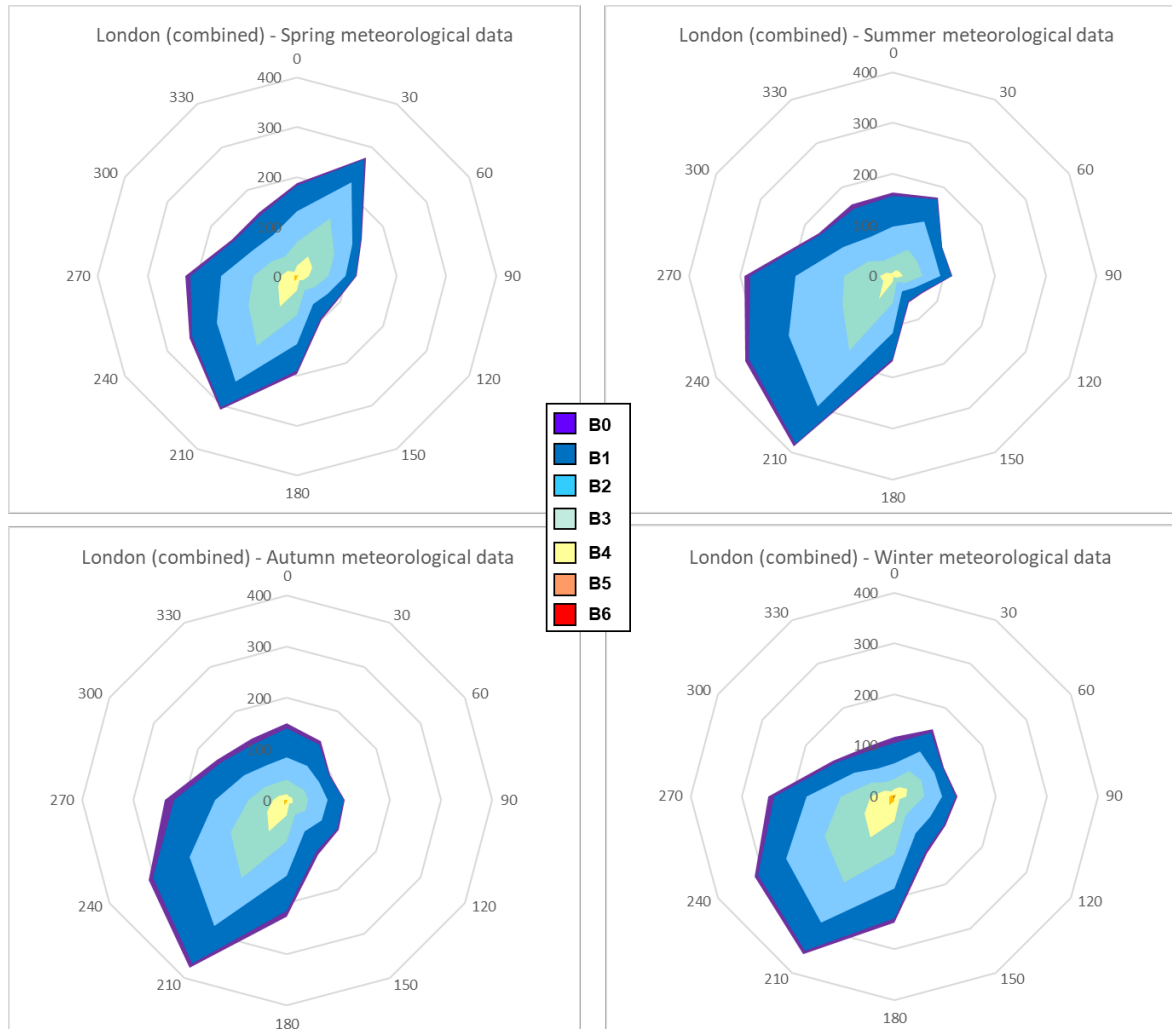


Figure 24: Seasonal wind roses for London (in Beaufort Force)
(Radial axis indicates the hours for which the stated Beaufort Range is exceeded)