

29 – 35 Station Road (Union Tower)
Reading, UK

Draft Report

Pedestrian Level Wind Microclimate Assessment

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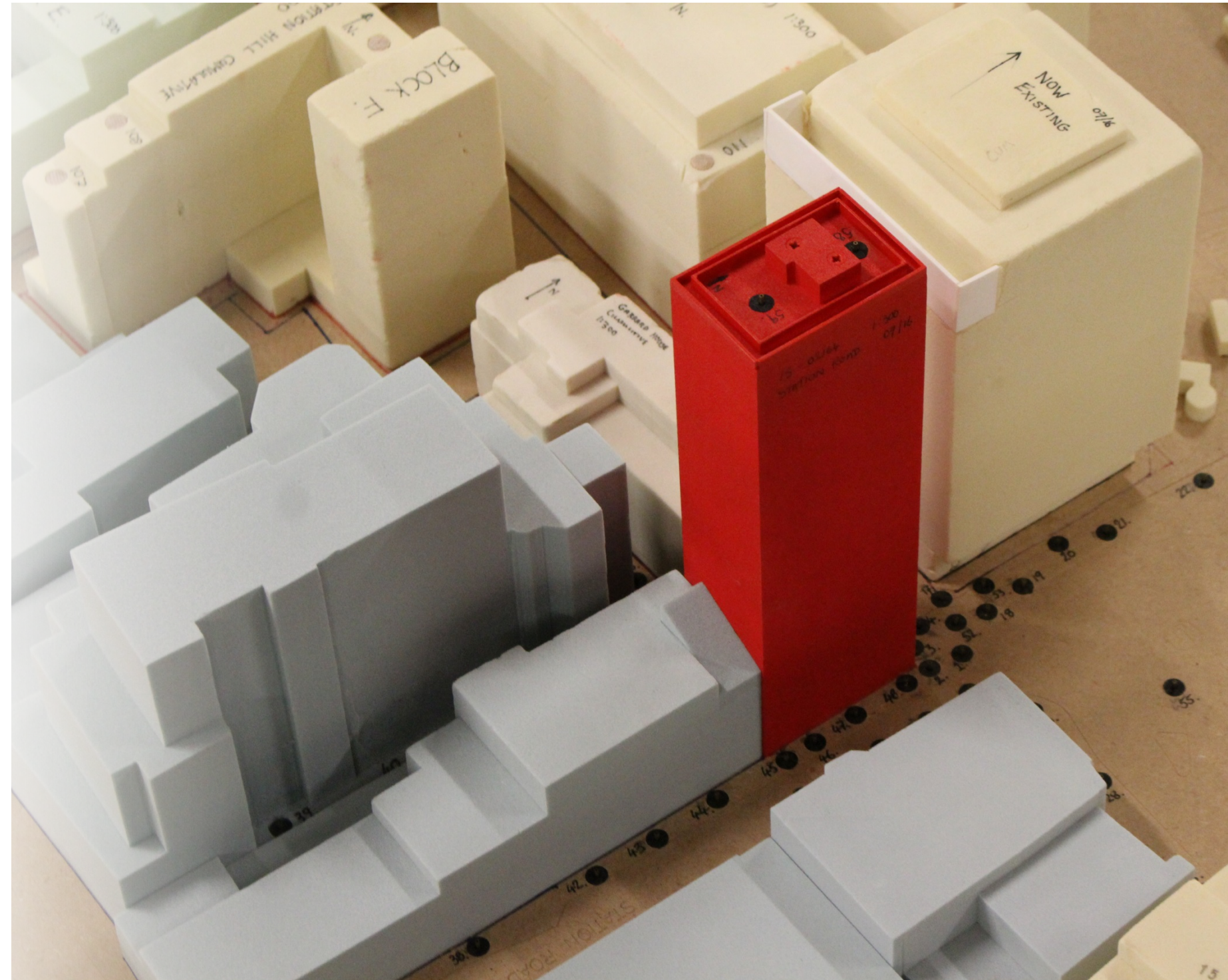
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VERSION HISTORY

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EXECUTIVE SUMMARY

The objective of this study was to provide a ground and roof-top terrace level wind microclimate assessment, based on a series of wind tunnel tests, for the Union Tower development at 29-35 Station Road in Reading, UK.

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

- C1: Existing Site with existing surrounding buildings;
- C2: Proposed Development with existing surrounding buildings; and
- C3: Proposed Development with cumulative surrounding buildings.

Results are presented in terms of the Lawson Comfort Criteria with the main focus on the windiest season (generally winter) and summer season.

The wind microclimate at the Existing Site (Configuration 1) is suitable for a range of activities from sitting use to leisure walking use during the windiest season. Six locations have windy conditions suitable for leisure walking use clustered on thoroughfares between the Site and Thames Tower to the north.

The Proposed Development with existing surrounding buildings (Configuration 2) was found to result in a slight increase in 'windiness' overall relative to Configuration 1, particularly on Garrard Street to the north of the Proposed Development. The greater massing of the Proposed Development relative to the existing Site increases the speed of the flow being channelled along Garrard Street and between the Proposed Development and the neighbouring Thames Tower. As such there is an increase in the number of locations in this area with conditions suitable for leisure walking and business walking conditions are found in the vicinity of measurement location (54). As these conditions are located on thoroughfares and a roadway respectively these are expected to be suitable for the intended pedestrian activity. Mitigation measures have been suggested to provide beneficial shelter to bike racks at the northern façade of the Proposed Development which are currently a windier than considered suitable for the intended pedestrian use.

With cumulative schemes in place (Configuration 3) wind conditions around the Proposed Development were generally found to be calmer relative to Configuration 2. North of the Site, measurement location 54 decreased in windiness from being suitable for business walking to being suitable for leisure walking. Additionally, the shelter from the north-easterly winds afforded by cumulative schemes results in conditions at the bike racks located at the northern façade of the Proposed Development (measurement location 6) decreasing in windiness to be suitable for the intended pedestrian use. All other ground floor measurement locations are expected to be suitable for the intended pedestrian use.

For both Configuration 2 and for Configuration 3 during the summer season, at ground level, all locations are suitable for the intended pedestrian use. The roof terrace located on the 23rd floor is expected to be one category of the Lawson Comfort Criteria windier than desired. Mitigation measures have been recommended in order to reduce the local wind speeds in this area.

The construction of the Proposed Development is expected to induce strong winds in excess of Beaufort Force 6 for more than one hour per year in both Configuration 2 and in Configuration 3 at seven locations immediately north of the Proposed Development (up to 5.8 hours per year in the worst case) as a result of flow being channelled between the Development and the neighbouring Thames Tower. As these occur at measurement locations located on thoroughfares and a roadway it is not expected that occasional B6 winds will present a nuisance to pedestrians.

The number of locations with winds in excess of the B6 threshold for more than one hour per year reduces to three in Configuration 3. These measurement locations (17, 18 and 54) have up to 1.6 hours of strong winds in

excess of B6, however, as they are located on thoroughfares and roadways occasional strong winds of this magnitude would not be expected to cause a nuisance to pedestrians.

Measures have been suggested to provide beneficial shelter to pedestrians where windy conditions have been highlighted. Bracketing the bike rack area on Garrard Street with porous screens 1500mm in height would be expected to provide beneficial shelter to pedestrians during the windiest season. If seating is intended across the entirety of the roof terrace soft landscaping in the form of trees or shrubs in planters no less than 2000mm in height should be employed throughout the terrace to disperse the wind and reduce mean wind speeds..

1. Introduction

Wind tunnel tests were conducted on a 1:300 scale model of the proposed Union Tower development at 29 – 35 Station Road (referred to as the 'Proposed Development' hereafter in this report) in Reading. The investigation quantifies the wind conditions within and around the Site, by comparing the measured wind speed and frequency of occurrence with the well-established Lawson Comfort 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 65 locations for 36 directions at 10° intervals. The measurements covered ground level locations along the building façades and at corners, near main entrances, within open amenity spaces and on pedestrian routes within and around the Site. In addition, measurements on the roof top terrace were taken.

Analysis was conducted on a seasonal basis but the report focuses on the windiest season results (generally 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:

1. Existing Site with existing surrounding buildings;
2. Proposed Development with existing surrounding buildings; and
3. Proposed Development with cumulative surrounding buildings.

Results are presented in a series of 'dot-plots' which indicate the measured comfort criteria for the windiest season and summer season for each configuration.

The assessment was conducted without landscaping or other mitigation measures so as to provide a worst-case (i.e. relatively 'windy') set of results.

2. Site Description

2.1 Site Location and Surroundings

The Site of the Proposed Development is located in the centre of Reading, UK at OS Landranger grid reference SU714736. The Site is located on the western side of Station Road, south of the junction with Garrard Street and is currently occupied by an unoccupied five storey retail and office block.

To the east the site is bounded by Station Road, to the south by an existing six storey retail and office block, the west by Garrard House, and the north by Garrard Street and the 16 storey renovated Thames tower. The immediate surrounding environment is urban in nature with existing and proposed developments of similar and greater height to the north and north-west and low rise existing structures to the south, east and west. Suburban conurbation dominates to the north, east, south and west after approximately 1km with channels of farm and parkland to the north-west and north-east.

Figure 1 shows an aerial view of the Site and surrounding area, with the approximate Site location highlighted in yellow.

2.2 The Proposed Development

The Proposed Development is a mixed use retail and residential tower of 24 storeys and approximately 84m total height. Retail and residential access will be located at ground level along Station Road, with additional retail access and outdoor bicycle parking on Garrard Street. A communal roof terrace is located on the 23rd floor featuring green roof and seating areas.

The wind tunnel model is shown in Figure 2. Further photographs of the various test configurations are included in Appendix A.

3. Wind Tunnel Testing: Procedure and Methodology

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

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

3.1 Simulation of Atmospheric Winds

The wind is gusty, which is to say it is a turbulent flow and as this turbulence varies depending upon the Site it is necessary to reflect site specific conditions in the wind tunnel test. Additionally, as the fluid in the atmospheric boundary layer is viscous mean wind speed will increase with height as the layers within the atmospheric boundary layer shear against each other. 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 proximity model around the Site is used to fine-tune the flow and create conditions similar to those expected at full scale.

3.2 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 each location 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 speeds at each location were measured for 36 wind directions in 10° intervals, with 0° representing a wind blowing from the north and 90° a wind blowing from the east.

3.3 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. The sampling frequency for the data acquisition equipment is therefore adjusted for the time scale.

3.4 Meteorological Data

Combined meteorological data from London Heathrow airport was corrected to standard conditions of 10m above open flat level country terrain. The meteorological station data was then adjusted to the Site conditions using the methodology implemented in the BREVe3.2 software package.

This report made use of approximately 30 years of meteorological data for London Heathrow airport which is presented in Appendix B as wind roses by season (refer to Figure 15) with the wind speed divided into Beaufort Force ranges (see Table 4, Appendix C). The radial axis indicates the cumulative number of hours per season that the wind speed exceeds the particular Beaufort Force. The seasons are defined as spring (March, April and May), summer (June, July and August), autumn (September, October and November) and winter (December, January and February).

The meteorological data indicates that the prevailing wind direction throughout the year is from the south-west, which is consistent feature of many areas in southern England. There is also a secondary peak from north-easterly winds, especially during the spring.

The combination of meteorological data, Site altitude and velocity ratios permits the percentage of time that wind speeds are exceeded at ground level on the Site to be evaluated. The locations can then be assessed using the 'Lawson Comfort Criteria', as described below.

3.5 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 and have been widely used on building Developments throughout the United Kingdom. The comfort criteria, which seek to define the reaction of an average pedestrian to the wind, are described in Table 1 and illustrated in Figure 16 in Appendix C. If the measured wind conditions exceed the threshold 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 set out six pedestrian activities and reflect the fact that less active pursuits require more benign wind conditions. The six categories are sitting, standing, entering/leaving a building, leisure walking, business walking and roadway/car-park, in ascending order of activity level. 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 leisure walking and business walking is that in the business scenario, where pedestrians are on Site because their livelihood depends upon it, they will 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 not part of the assessment.

The coloured key in Table 1 corresponds to the presentation of wind tunnel test results described in Section 4 of this report.

Table 1: Lawson Comfort Criteria

Key	Comfort Category	Threshold	Description
	Sitting	1% > B3	Light breezes desired for outdoor restaurants and seating areas where one can read a paper or comfortably sit for long periods
	Standing/Entrance Use	6% > B3	Gentle breezes suitable for main building entrances, pick-up/drop-off points and bus stops
	Leisure Walking	4% > B4	Moderate breezes that would be appropriate for strolling along a city/town centre street, plaza or park
	Business Walking	2% > B5	Relatively high speeds that can be tolerated if one's objective is to walk, run or cycle without lingering
	Roadway/Car-park	6% > B5	Winds of this magnitude are considered a nuisance for most activities, and wind mitigation is typically recommended

3.6 Strong Winds

Lawson also specified a strong wind threshold when winds exceed Beaufort Force 6 (B6). 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?

In the UK, stronger winds are associated with areas which would be classified as suitable for business walking or roadway use. In a mixed-use, urban Development scheme, business walking and roadway conditions would not usually form part of the 'target' wind environment and taking consideration of pedestrian comfort would normally require mitigation. This mitigation would also reduce the frequency of, or even eliminate, any strong winds.

For locations on a pedestrian thoroughfare, where the wind speed occasionally exceeds Beaufort Force 6 wind speed threshold, the wind is unlikely to generate nuisance to pedestrians. However, we would expect pedestrians to experience difficulty in walking when the wind speed exceeds Beaufort Force 7 (B7) or 8 (B8).

If the wind speed exceeds B6 wind speed threshold 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 suitable for leisure walking, business walking or roadway use and so would require mitigation to satisfy the Lawson Comfort Criteria in any case.

In accordance with Lawson's methodology it is RWDI's practice to report incidence when the B6, B7 and B8 thresholds are exceeded for more than 1 hour per annum. The results for this study are presented in Table 3, which also shows the wind direction that contributes most to the strong winds.

4. Results

4.1 Details of the 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 a full range of 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 120m	1.41	1.42	1.44	1.43	1.39	1.45	1.46	1.51	1.46	1.41	1.41	1.40

4.2 Desired Pedestrian Activity around the Development

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

- Leisure walking during the windiest season on pedestrian thoroughfares;
- Standing/entrance conditions at main entrances, drop off areas or taxi ranks, and bus stops throughout the year; and
- 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 business walking and roadway 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 same location would be suitable 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.

4.3 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 Figure 3 to Figure 8

4.3.1 Configuration 1: Existing Site with existing surrounding buildings

Results for the existing Site with existing surrounding buildings are presented in Figures 3 and 4 for the windiest season and the summer season respectively at ground level.

It should be noted that relative to later configurations a reduced number of measurement locations were utilised during this scenario as several probes were located on the roof terrace of the Proposed Development.

4.3.2 Configuration 2: Proposed Development with existing surrounding buildings

Results for ground and roof top level measurement locations during the windiest season for the Proposed Development with existing surrounding buildings are presented in Figure 5.

Ground and roof top level measurement locations summer season results for the Proposed Development with existing surrounding buildings are shown in Figure 6.

The change in the number of measurement locations utilised during this, and the previous configuration relative to Configuration 3 is due to several probes being located on the Proposed Development roof terrace.

4.3.3 Configuration 3: Proposed Development with cumulative surrounding buildings

Results for ground and roof top level measurement locations during the windiest season for the Proposed Development with existing surrounding buildings are presented in Figure 7.

Ground and roof top level measurement locations summer season results for the Proposed Development with existing surrounding buildings are shown in Figure 8.

The change in the number of measurement locations utilised during this, and the baseline configuration is due to several probes being located on the Proposed Development roof terrace.

4.4 Occurrence of Strong Winds

Areas with occasional strong winds exceeding Beaufort Force 6 (referred to as B6) are listed in Table 3 together with the primary wind direction and the number of hours per annum for which the threshold wind speed is exceeded. No exceedances of the Beaufort Force 7 criteria were recorded for more than 1 hour per annum in the three tested configurations.

Table 3: Annual Exceedance of Strong Winds

Location	Beaufort Force Exceedance	Wind Direction	Hours per Annum
Configuration 1: Existing Site with existing surrounding buildings			
No strong winds in excess of B6 for more than one hour per year were recorded during the baseline configuration.			
Configuration 2: Proposed Development with existing surrounding buildings			
17	B6	230	4.5
18	B6	220	4.1
40	B6	230	1.0
52	B6	230	1.2
54	B6	290	5.8
55	B6	220	1.0
60	B6	10	1.4
Configuration 3: Proposed Development with cumulative surrounding buildings			
17	B6	200	1.1
18	B6	200	1.6
54	B6	200	1.3

5. Discussion

This discussion compares the measured wind conditions (shown as dot plots in Figure 3 through Figure 8) to the anticipated usage of the Site, to provide an assessment of whether conditions are suitable or too 'windy' for the intended use.

Locations that are 'windier' than desired for their intended pedestrian use would require implementation of mitigation measures to provide a suitable wind environment for use of these areas. The Proposed Development was modelled devoid of landscaping in order to yield results for a 'worst-case' (i.e. relatively 'windy') scenario. It is expected that introducing landscaping would improve the local wind microclimate of the area it occupies from a pedestrian perspective. Potential mitigation options, including landscaping, are discussed in the mitigation section of this report.

5.1 Configuration 1: Existing Site with existing surrounding buildings (Figure 3 and Figure 4)

The discussion of the wind microclimate in 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.

5.1.1 Pedestrian Comfort

During the windiest season, wind conditions immediately surrounding the 29 – 35 Station Road Site are suitable for a range of activities ranging from sitting to leisure walking during the windiest season. All locations are therefore suitable for the expected pedestrian use with leisure walking conditions confined to thoroughfares about the Garrard Street and Station Road junction, represented by measurement locations 1, 4, 17-18, 52 and 54.

In summer, wind conditions are either consistent with the winter season or one category 'calmer' than the windiest season resulting in conditions suitable for standing/entrance use or sitting activities.

5.1.2 Strong Winds

As shown in Table 3, no strong winds exceeding of the B6 criteria (for more than one hour per annum) were recorded for the Configuration 1 environment.

5.2 Configuration 2: Proposed Development with existing surrounding buildings (Figure 5 and Figure 6)

The discussion of the wind microclimate in Configuration 2 is based on the results shown in Figure 5 for the windiest season, with Figure 6 showing the summer season results. The wind environment of Configuration 2 generally ranges from acceptable for sitting use to acceptable for business walking use, during the windiest season (as shown in Figure 5).

5.2.1 Pedestrian Comfort

Wind conditions around the Development were generally windier by one category or remained constant relative with conditions during the Configuration 1. The increased massing of the Proposed Development over the existing structure results in a greater channelling effect between the Proposed Development and the neighbouring Thames Tower on the northern side of Garrard Street. This has resulted in an increase in the number of locations with leisure walking conditions and business walking in the vicinity of measurement location

54 during the windiest season. Additionally there has been an increase in the number of associated B6 strength strong winds.

5.2.2 Thoroughfares

The presence of the Proposed Development increases the massing and height of the structure on the Site relative to the baseline scenario. This is expected to result in greater low channelling between the Proposed Development and Thames Tower as the volume of air being forced between the buildings has increased. As such wind conditions at measurement locations 6, 16, 54 and 60 sited to the north of the Proposed Development are windier than the baseline conditions by one category while downstream measurement locations 30, 31 and 55 increase in windiness from being suitable for standing/entrance use to being suitable for leisure walking use.

Measurement location 54 is expected to be suitable for business walking use during the windiest season, however as this location is sited in a roadway, mitigation measures are not considered necessary.

5.2.3 Entrances

Entrances to the Proposed Development at measurement locations 3, 8, 45, 47-48 and 63 and surrounding buildings (7, 34, 36, 42, 44) are expected to experience wind conditions acceptable for the intended pedestrian use with standing/entrance calmer conditions during the windiest season.

5.2.4 Transport Stops

Bus stops represented by measurement locations 19 and 47 are expected to be suitable for standing/entrance use during the windiest season. As it is reasonable for pedestrians to be standing at these locations, standing/entrance use conditions are considered suitable.

Bike racks situated in the vicinity of measurement locations 5 and 6 would require standing/entrance use conditions or calmer to be considered suitable for the intended pedestrian use. During configuration 2, location 6 is expected to have conditions suitable for leisure walking use. Mitigation measures intended to produce calmer conditions are discussed in Section 6.

5.2.5 Amenity Spaces

The Proposed Development features a roof terrace amenity space on the 23rd floor which is represented by measurement locations 58 and 59. During the summer season, when occupants expect amenity spaces to be available for use, conditions are suitable for a mix of sitting and standing. This mix of conditions is potentially suitable depending on how the terrace is designed and used (i.e. if seating areas are predominantly located in the vicinity of measurement location 59, then the conditions would be suitable). We would also expect occupants to be more tolerant of windier conditions at higher elevations, due to the expectation of higher wind speeds at this height. On this basis, we would conclude that mitigation would only be required if the entire terrace area is designated for use as outdoor seating (e.g. a café-spill out area, or sun lounge deck), otherwise the conditions as currently assessed are likely to be appropriate.

Suggested mitigation measures are discussed in Section 6, which could be used to optimise the use of the roof terrace if required.

5.2.6 Strong Winds

Strong winds, (that is winds of Beaufort Force 6 (B6) or greater occurring more than one hour per year) are recorded at seven ground level measurement locations. At locations 17, 18, 40, 52, 54, 55 and 60 up to 5.8 hours of B6 winds per annum were recorded. However, as locations 17, 18, 54 and 60 are located on

roadways or thoroughfares, where pedestrians are expected to be moving from one point to another, occasional B6 strong winds are not expected to cause a nuisance to pedestrians. Locations 40 and 55 observe an hour of B6 winds per year and are not expected to be accessed by pedestrians and therefore are not considered to be of concern.

5.3 Configuration 3: Proposed Development with cumulative surrounding buildings (Figure 7 and Figure 8)

The discussion of the wind microclimate around the Proposed Development with cumulative surrounding schemes in place is based on the results shown in Figure 7 for the windiest season; and Figure 8 for the summer season at both ground and rooftop terrace.

5.3.1 Pedestrian Comfort

With the inclusion of cumulative schemes wind conditions around the north of the Proposed Development have become calmer or remained consistent with Configuration 2. To the south and to the east of the Development wind conditions have remained suitable for a mixture of sitting and standing/entrance use with no impact on the suitability for the intended pedestrian use. Measurement location 54, which was suitable for business walking use in Configuration 2, is suitable for leisure walking use in Configuration 3 due to the greater shelter provided to the south-west of the Proposed Development by cumulative schemes. Surrounding measurement locations (1, 4, 6 and 16) have also become calmer or have reduced occurrences of B6 strong winds (17 and 18) during the windiest season.

5.3.2 Thoroughfares

In Configuration 3, during the windiest season thoroughfares around the Proposed Development are suitable for the intended pedestrian use throughout the year with suitability for standing/entrance use on Station Road locations and standing/entrance conditions predominant on pedestrian routes immediately north of the Development. Conditions suitable for leisure walking use remain on the Garrard Street roadway and northern pavement as a result of flow being channelled along the street and creating relatively windy conditions at measurement locations 17, 18, 52 and 54. Flow acceleration will also occur at the north western corner of the Proposed Development, resulting in conditions suitable for leisure walking use at location 60.

These results represent a general improvement over the conditions presented for Configuration and most significantly, measurement location 54 is expected to be suitable for leisure walking during the windiest season.

During the summer season, all the thoroughfares in and around the Site are expected to have conditions suitable for sitting and standing use with the exception of localised leisure walking conditions (at measurement location 54) located in the roadway of Garrard Street. As such, wind conditions will be suitable for the intended pedestrian use at all measurement locations.

5.3.3 Entrances

During testing of Configuration 3 entrances to the proposed development and surrounding buildings observed standing/entrance and sitting suitable conditions during the windiest season. These conditions are suitable or calmer than required for the intended pedestrian use.

5.3.4 Transport Stops

Bus stops represented by measurement locations 19 and 47 are expected to be suitable for standing/entrance use during the windiest season. As it is reasonable for pedestrians to be standing at these locations for extended periods, standing/entrance use conditions are considered suitable.

Bike racks situated in the vicinity of measurement locations 5 and 6 would require standing/entrance use conditions or calmer to be considered suitable for the intended pedestrian use. During configuration 3, location 5 and location 6 are expected to observe conditions suitable for standing/entrance use and as such would be considered suitable for the intended pedestrian use.

5.3.5 Amenity Spaces

The Proposed Development features a roof terrace amenity space on the 23rd floor and is represented by measurement locations 58 and 59. During the summer season, when occupants expect amenity spaces to be available for use, wind conditions are suitable for a mix of sitting and standing use.

This is consistent with the results detailed in Section 5.2.4 for Configuration 2 and as such if seating is predominantly in the vicinity of measurement location 59 then conditions would be considered suitable. If seating is intended throughout the terrace measures to reduce windiness north of the lift overrun block at location 58 have been suggested in Section 6 to optimise wind conditions to the intended use.

5.3.6 Strong Winds

The number of locations observing B6 winds for an hour or more per year and the frequency of strong winds at these locations has reduced relative to Configuration 2. Measurement locations 17, 18 and 54 have up to 1.6 hours of B6 winds per year. Measurement location 54 is located on the roadway of Garrard Street while measurement location 17 and 18 are located at the junction with Station Road, adjacent to the south-eastern corner of Thames Tower. As these locations are all thoroughfares with no nearby entrances to Thames Tower, occasional strong winds of this magnitude would not be expected to cause a nuisance to pedestrians transiting from one location to another.

6. Mitigation Measures

The wind tunnel tests were conducted on models where there was no landscape planting included, in order to generate a conservative (i.e. relatively 'windy') microclimate. The following areas of the development required mitigation in order to achieve their respective comfort criteria to provide a suitable wind environment for the intended use.

6.1 Bike Racks

Bike racks located at measurement location 6, against the northern façade of the Development on Garrard Street have leisure walking conditions during Configuration 2 which are one category windier than desired for the intended use. It is expected that the use of a porous or solid screens 1500mm in height located to the east and west of the bike racks would be beneficial in providing shelter to the affected area. Alternatively, the use of soft landscaping such as trees or shrubs in planters placed on the southern Garrard Street pavement in the vicinity of measurement locations 1 through 6 (Figure 7) would be expected to provide beneficial shelter to users of the bike rack.

6.2 Roof Terrace

During the summer season the 23rd floor roof terrace is expected to have conditions one category higher than desirable for an amenity space. It seating is the primary occupant use throughout the terrace it is recommended that soft landscaping, such as 2000mm trees or shrubs in planters, or 1500mm porous screens be installed within the terrace in order to 'break up' the flow and calm conditions on the terrace. This would be expected to be beneficial to the occupant's perception of wind on the terrace. Otherwise the entirety of the terrace is currently suitable for standing use.

7. Concluding Remarks

In conclusion:

1. The meteorological data for the Site indicates prevailing winds from the south-west quadrant throughout the year with secondary winds from the north-easterly direction, particularly during winter and spring.
2. The wind microclimate at the Existing Site (Configuration 1) is suitable for a range of activities from sitting use to leisure walking use during the windiest season. Six locations suitable for leisure walking use are clustered on thoroughfares between the Site and Thames Tower.
3. Configuration 2 was found to result in a slight increase in windiness relative to Configuration 1. There is an increase in the number of locations north of the Proposed Development having conditions suitable for leisure walking and localised business walking conditions are expected in the vicinity of measurement location 54. As these conditions are located on thoroughfares and a roadway respectively, these conditions are expected to be acceptable for the intended pedestrian use.
4. In Configuration 3, wind conditions were generally found to be calmer than Configuration 2. North of the Site, location 54 decreased in windiness from being suitable for business walking to being suitable for leisure walking. Additionally, conditions north of the Proposed Development decrease in windiness to be suitable for the intended pedestrian use. All other ground floor measurement locations are expected to be suitable for the intended pedestrian use.
5. During the summer season at ground level in both Configuration 2 and Configuration 3 all entrance, thoroughfare and transport locations are suitable for the intended pedestrian use. The 23rd floor roof terrace is expected to be windier than desired and while occupants would be expected to be more tolerant of higher wind speeds at high altitude locations, measures have been recommended to improve wind conditions.
6. Localised instances of strong winds in excess of Beaufort Force 6 are expected to occur for more than one hour per year in both Configuration 2 and in Configuration 3. Seven locations are expected to experience B6 winds (up to 5.8 hours per year in the worst case) in Configuration 2. As these occur at measurement locations located on thoroughfares and a roadway it is not expected that winds of this magnitude will present a nuisance to pedestrians in these areas.
7. The number of locations having winds in excess of the B6 threshold for more than one hour per year reduces to three in Configuration 3. These measurement locations (17, 18 and 54) are expected to have up to 1.6 hours of B6 winds; however, as they are located on thoroughfares or roadways occasional strong winds of this magnitude would not be expected to cause nuisance to pedestrians in these areas.
8. Measures have been suggested to provide beneficial shelter to pedestrians where windy conditions have been highlighted. Bracketing the bike rack area on Garrard street with porous screens 1500mm in height would be expected to provide beneficial shelter to pedestrians during the windiest season. If seating is intended across the entirety of the roof terrace soft landscaping in the form of trees or shrubs in planters no less than 2000mm in height should be employed throughout the terrace to disperse the wind and reduce mean wind speeds.

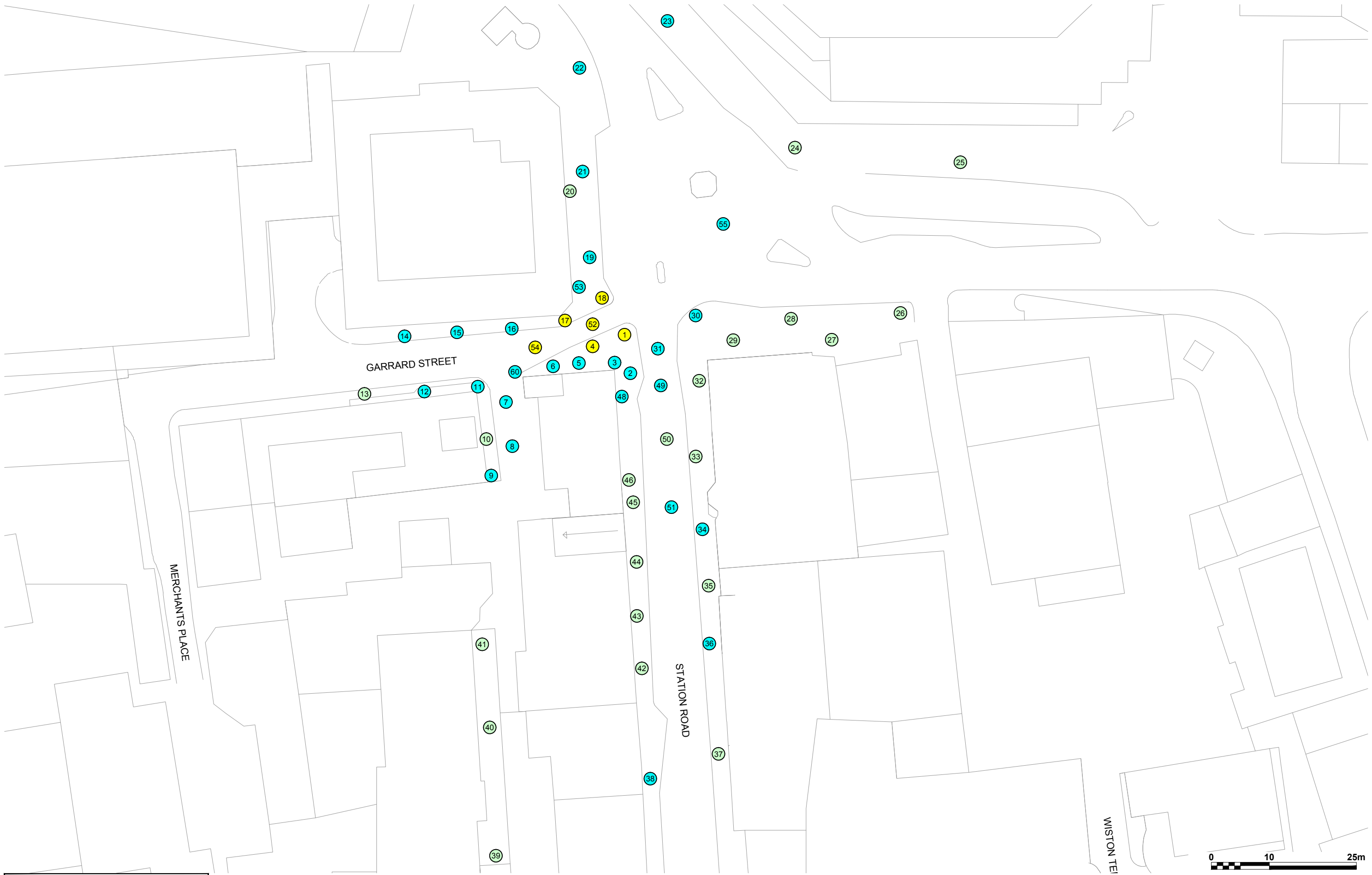
8. Figures



Figure 1: Aerial view of the Site highlighted in yellow



Figure 2: Wind tunnel model viewed from the south-west with Union Tower highlighted in red



LEGEND:

LDDC COMFORT CATEGORIES:

- Sitting
- Standing
- Strolling
- Walking
- Uncomfortable

SENSOR LOCATION:

- Grade Level
- Podium Level
- Roof Level

Pedestrian Wind Comfort Conditions – Existing site with existing surroundings

Windiest Season

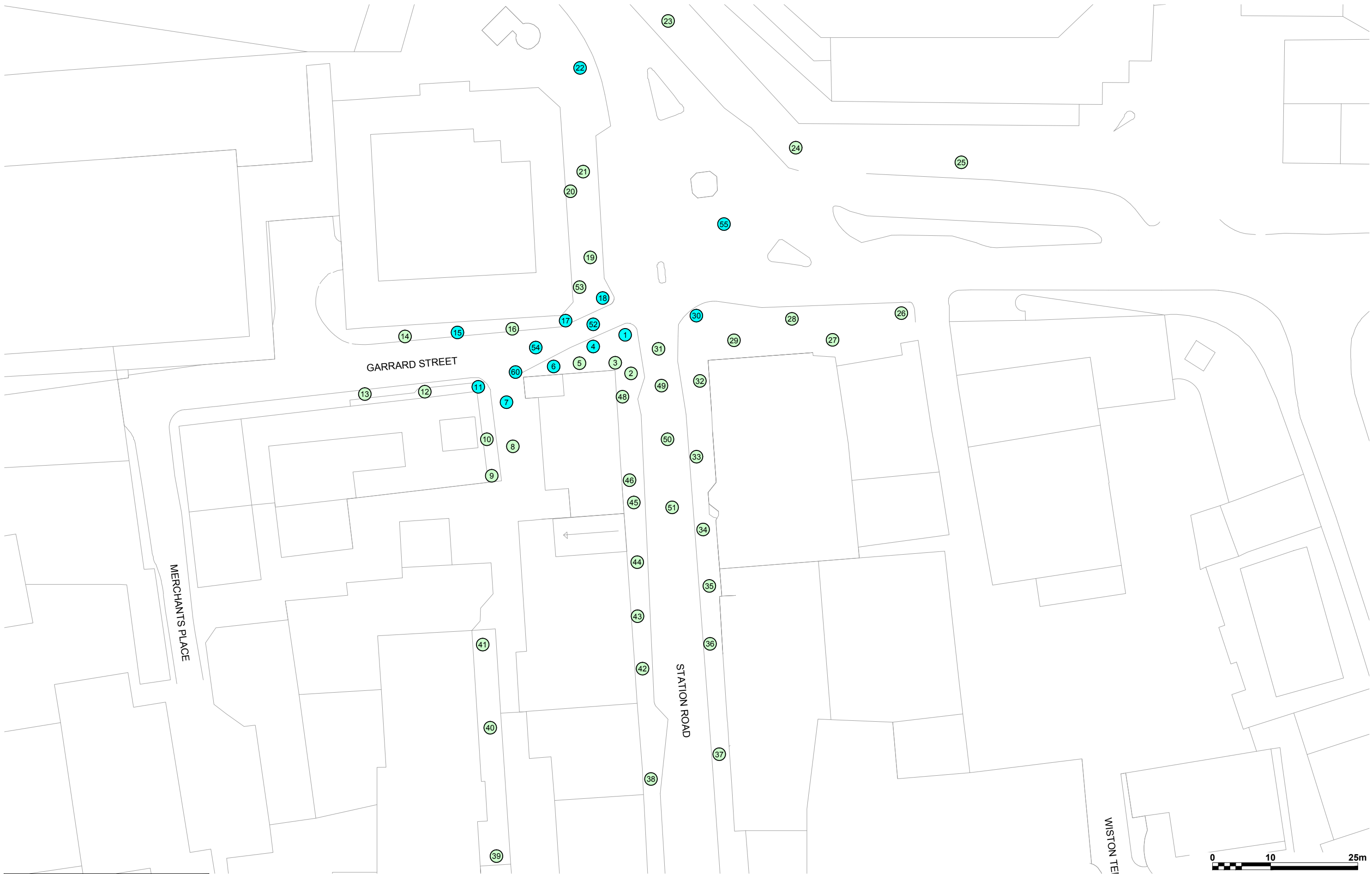
29-35 Station Road-Reading-UK

True North 

Project #1502164

Drawn by: SM	Figure: 3
Approx. Scale: 1:600	
Date Revised: July 29, 2015	





LEGEND:

LDDC COMFORT CATEGORIES:

- Sitting
- Standing
- Strolling
- Walking
- Uncomfortable

SENSOR LOCATION:

- Grade Level
- Podium Level
- Roof Level

Pedestrian Wind Comfort Conditions – Existing site with existing surroundings

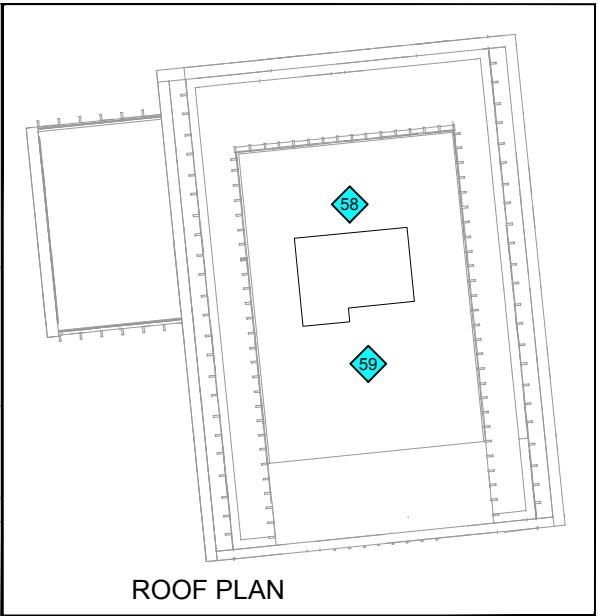
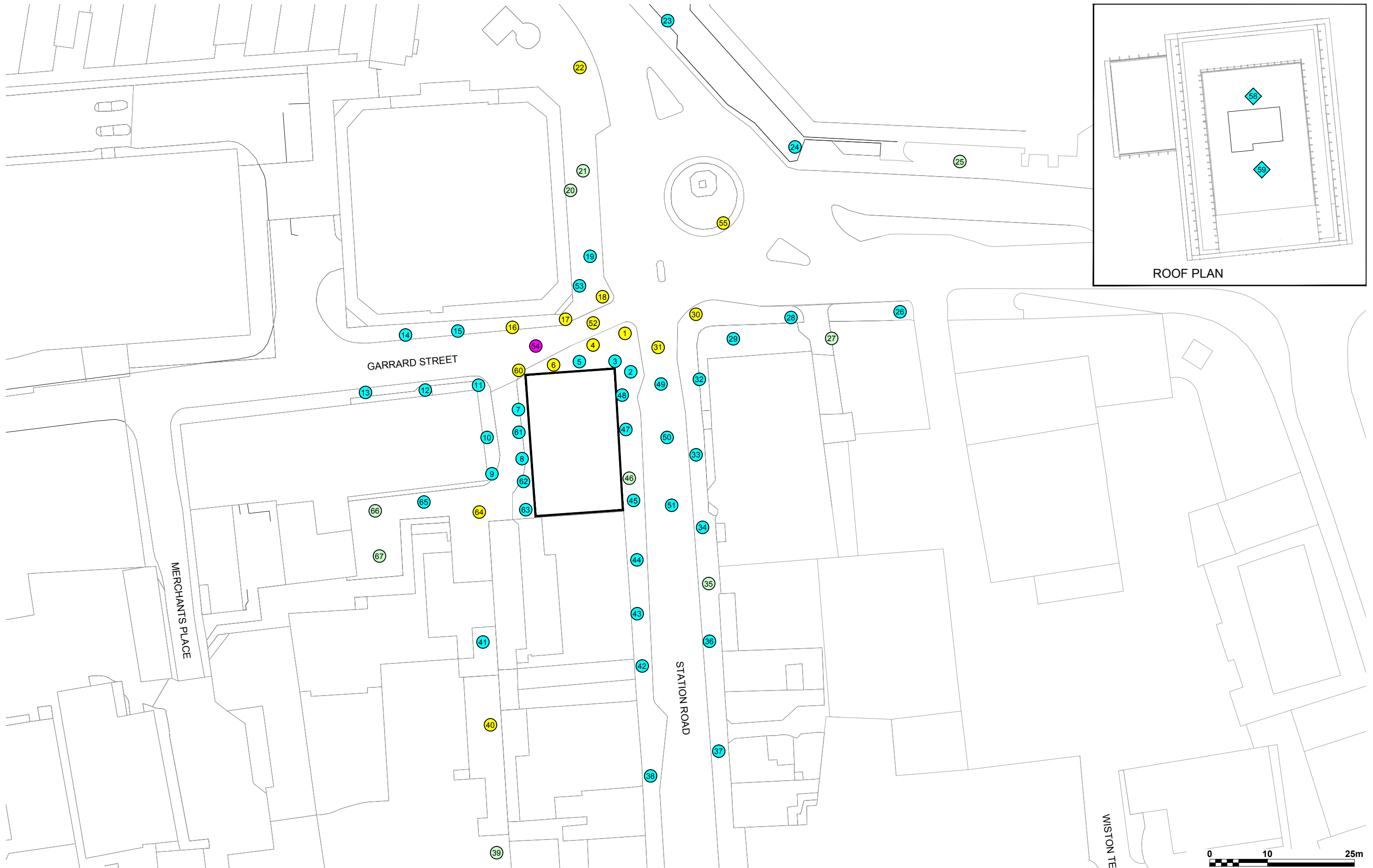
Summer Season

29-35 Station Road-Reading-UK

True North

Project #1502164

Drawn by: SM	Figure: 4
Approx. Scale: 1:600	
Date Revised: July 29, 2015	



ROOF PLAN

LEGEND:

LDDC COMFORT CATEGORIES:

- Sitting
- Standing
- Strolling
- Walking
- Uncomfortable

SENSOR LOCATION:

- Grade Level
- Podium Level
- Roof Level

Pedestrian Wind Comfort Conditions - Configuration 2: Proposed development with existing surrounding buildings

Windiest Season

1502164 - #29-35 Station Road-Reading-UK

True North

0 10 25m

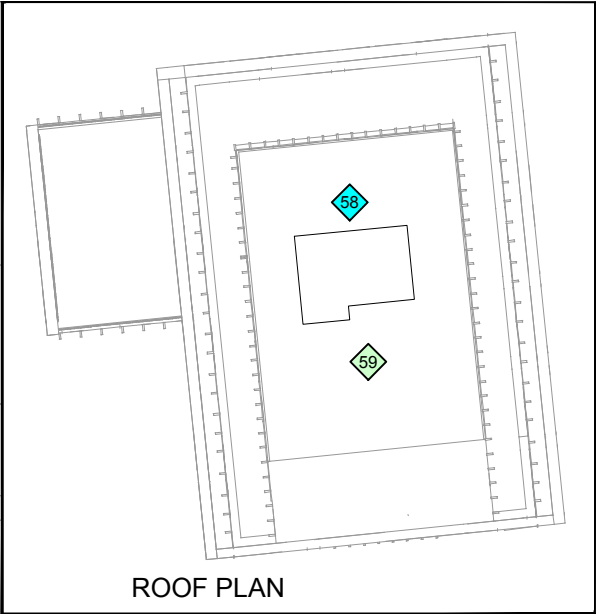
Drawn by: CAX Figure: 5

Approx. Scale: 1:600

Date Revised: Aug. 3, 2016

Project #1502164

RWDI



LEGEND:

LDDC COMFORT CATEGORIES:

- Sitting ————
- Standing ————
- Strolling ————
- Walking ————
- Uncomfortable ————

SENSOR LOCATION:

- Grade Level
- Podium Level
- ◇ Roof Level

Pedestrian Wind Comfort Conditions - Configuration 2: Proposed development with existing surrounding buildings

Summer Season

1502164 - #29-35 Station Road-Reading-UK

True North

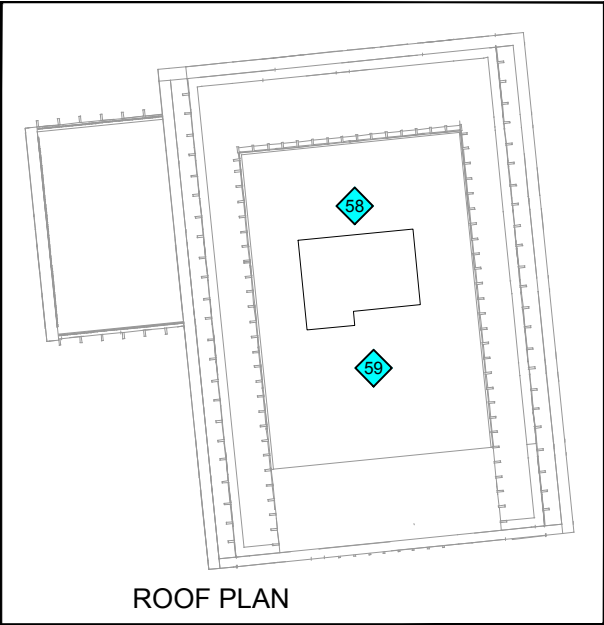
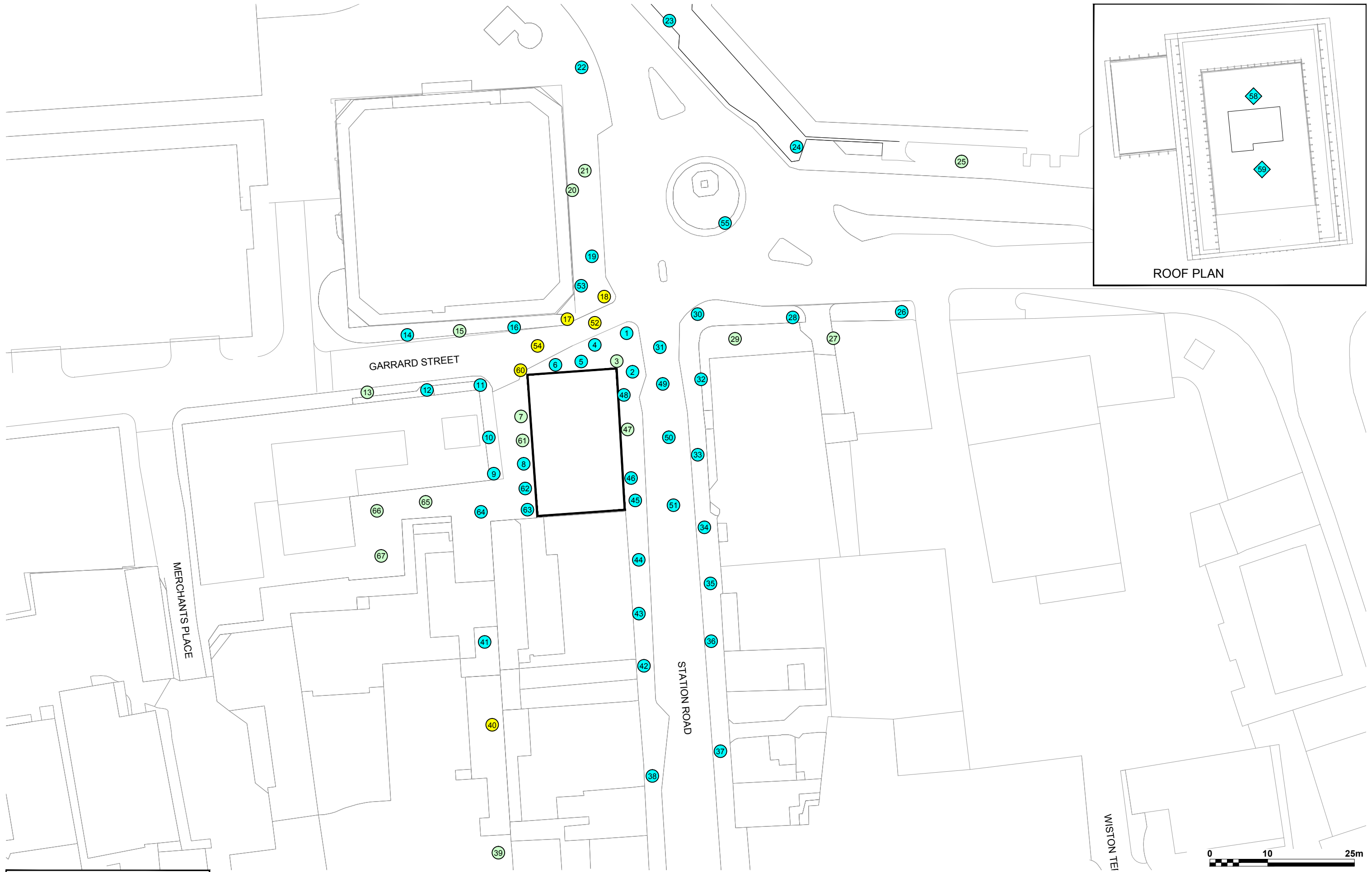
Drawn by: CAX

Approx. Scale: 1:600

Date Revised: Aug. 3, 2016

Figure: 6

0 10 25m



LEGEND:

LDDC COMFORT CATEGORIES:

Sitting	Green
Standing	Blue
Strolling	Yellow
Walking	Pink
Uncomfortable	Red

SENSOR LOCATION:

○	Grade Level
□	Podium Level
◇	Roof Level

Pedestrian Wind Comfort Conditions - Configuration 3: Proposed development with cumulative surrounding buildings
Windiest Season

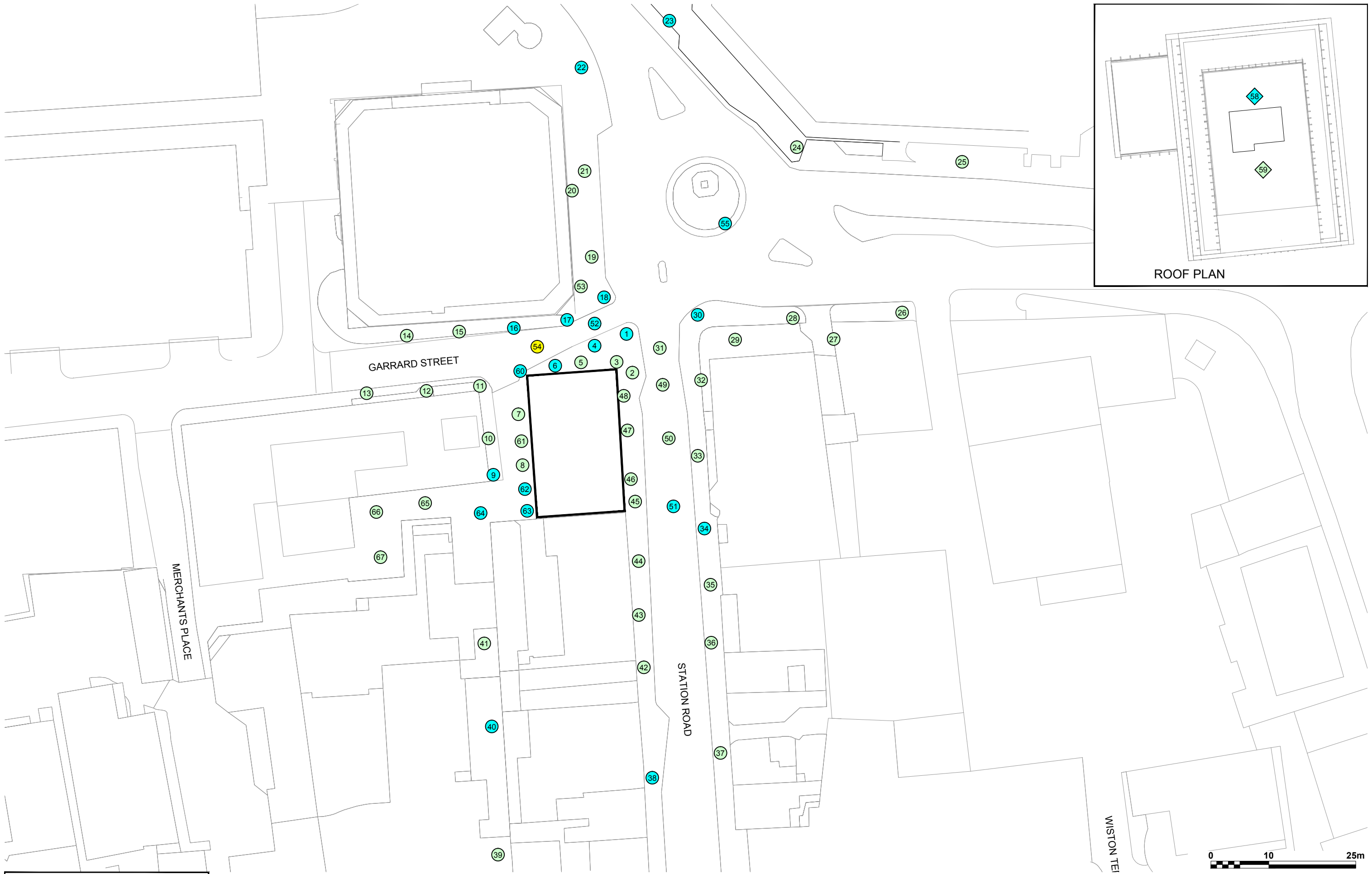
29-35 Station Road-Reading-UK



Project #1502164

Drawn by: CAX	Figure: 7
Approx. Scale: 1:600	
Date Revised: Aug 3, 2016	





LEGEND:

LDDC COMFORT CATEGORIES:

Sitting

Standing

Strolling

Walking

Uncomfortable

SENSOR LOCATION:

Grade Level

Podium Level

Roof Level

Pedestrian Wind Comfort Conditions - Configuration 3: Proposed development with cumulative surrounding buildings
Summer Season

29-35 Station Road-Reading-UK

True North

Drawn by: CAX

Figure: 8

Approx. Scale: 1:600

Date Revised: Aug 3, 2016

Project #1502164

RWDI

Appendix A: Photographs of the Wind Tunnel Model

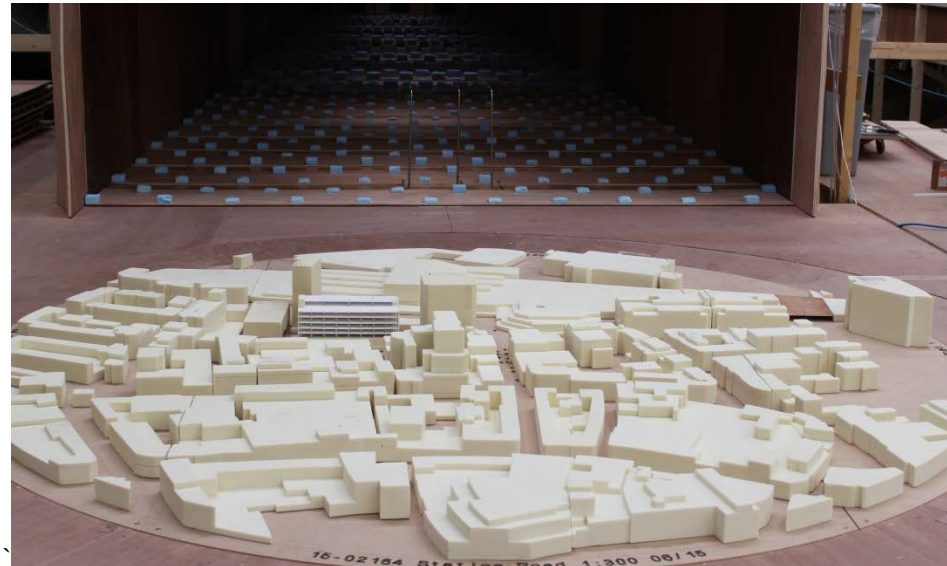


Figure 9: Existing Site with existing surrounds (Configuration 1) – View in the Wind Tunnel (from the south)



Figure 10: Existing Site with existing surrounds (Configuration 1) – View in the Wind Tunnel (from the south, overhead)

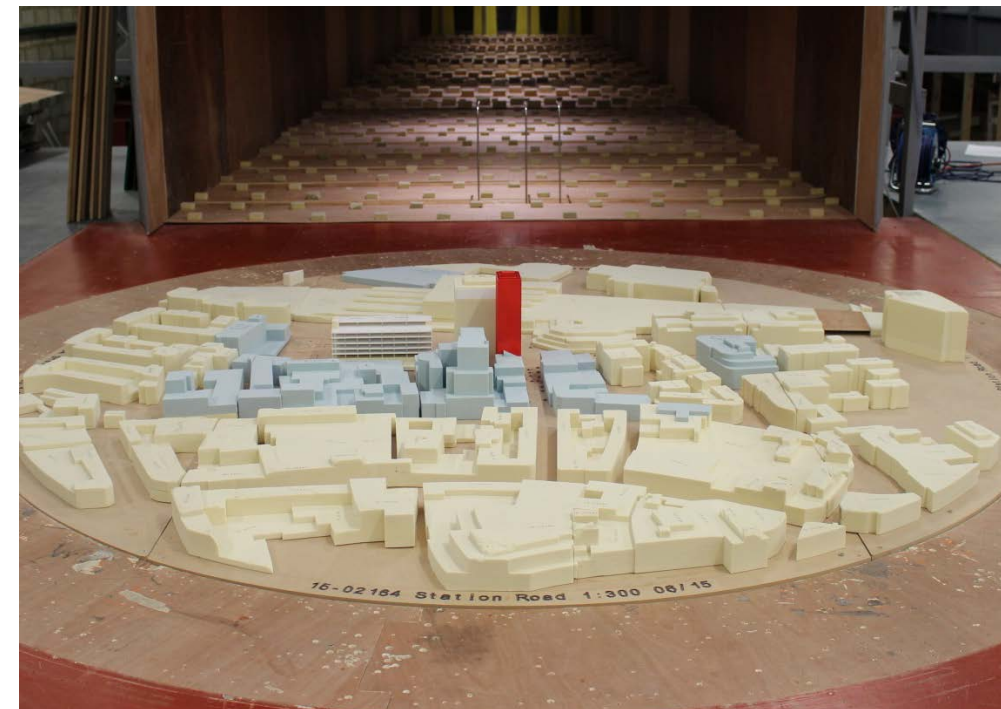


Figure 11: Proposed Development with existing surrounds (Configuration 2) – View in the Wind Tunnel (from the south)



Figure 12: Proposed Development with existing surrounds (Configuration 2) – View in the Wind Tunnel (from the south-west, overhead)



Figure 13: Proposed Development with cumulative surrounds (Configuration 3) – View in the Wind Tunnel (from the south)

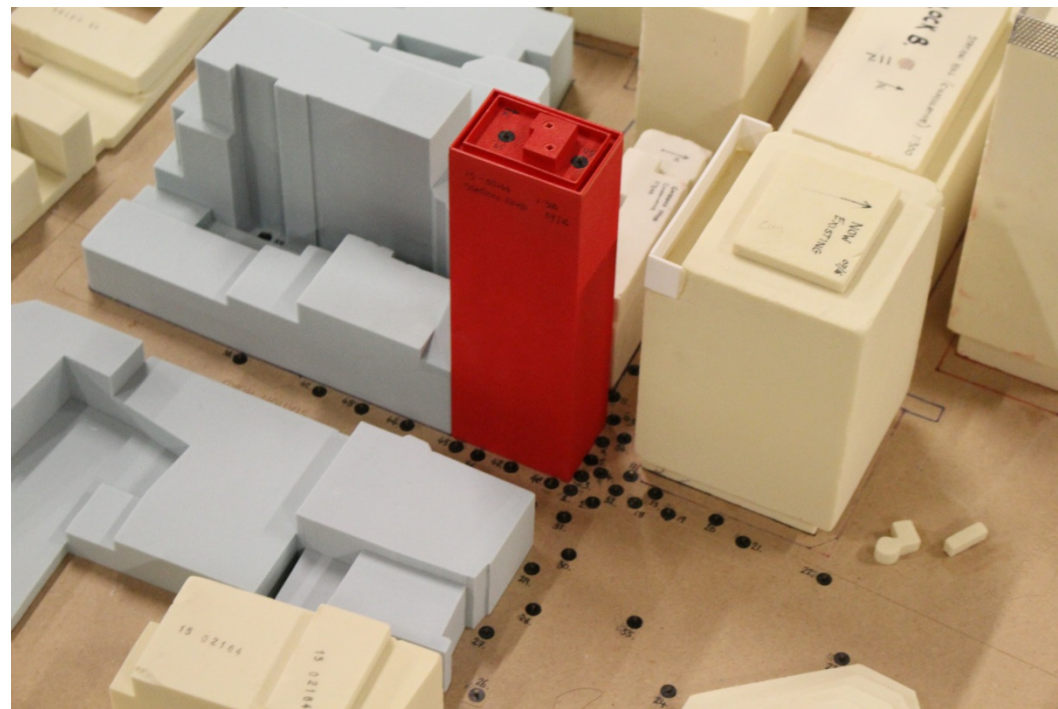


Figure 14: Proposed Development with Cumulative Surrounds (Configuration 3) – View of target building from north-east

Appendix B: Meteorological Data

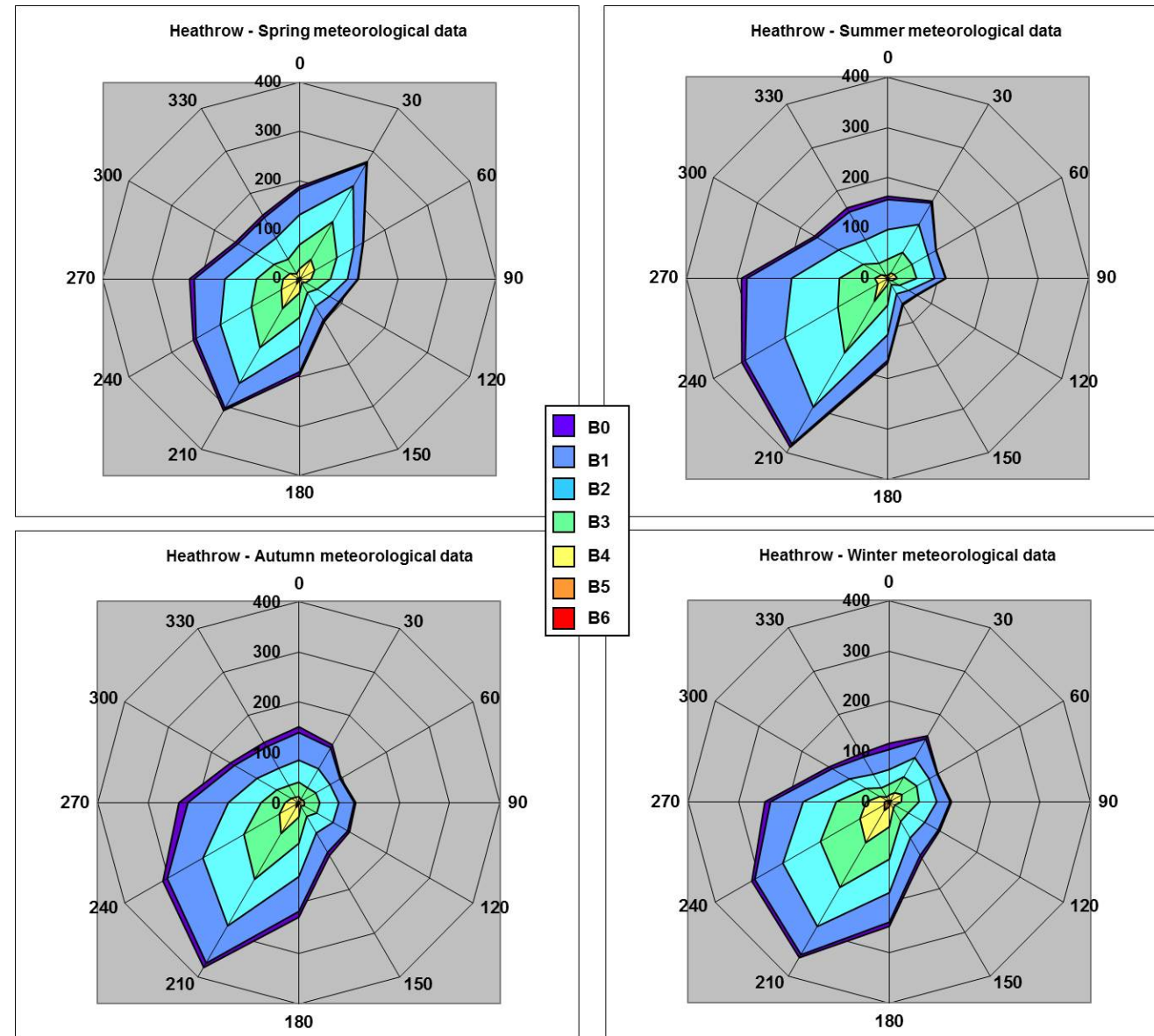


Figure 15: Directional Distribution (%) of Wind, London Heathrow Airport (Spring, Summer, Autumn, Winter)

Appendix C: Lawson Comfort Criteria

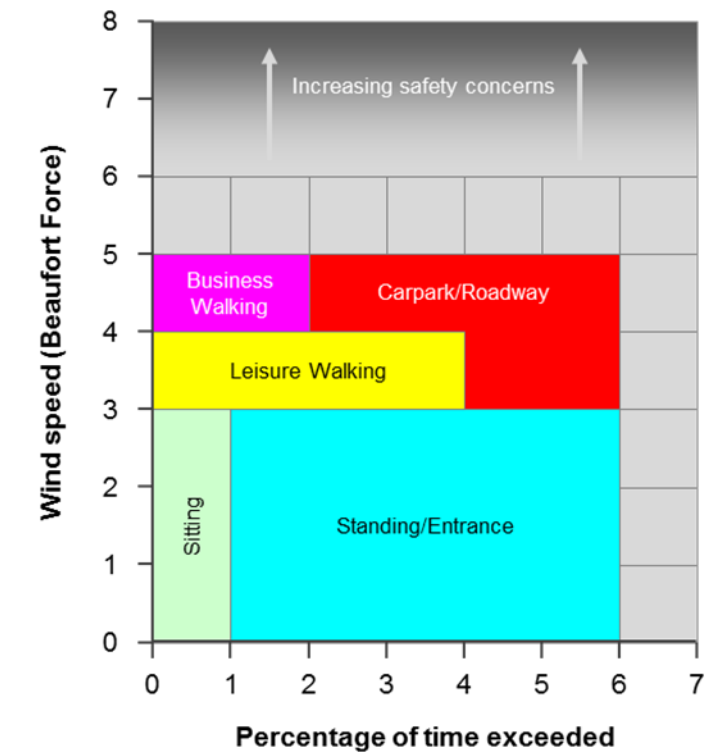


Figure 16: Graphical representation of the Lawson Comfort Criteria

Beaufort Force	Hourly Average Wind Speed (m/s)	Description of Wind	Noticeable Wind Effect
0	< 0.45	Calm	Smoke rises vertically.
1	0.45 – 1.55	Light Air	Direction shown by smoke drift but not by vanes.
2	1.55 – 3.35	Gentle Breeze	Wind felt on face; leaves rustle; wind vane moves.
3	3.35 – 5.60	Light Breeze	Leaves & twigs in motion; wind extends a flag.
4	5.60 – 8.25	Moderate Breeze	Raises dust and loose paper; small branches move.
5	8.25 – 10.95	Fresh Breeze	Small trees, in leaf, sway.
6	10.95 – 14.10	Strong Breeze	Large branches begin to move; telephone wires whistle.
7	14.10 – 17.20	Near Gale	Whole trees in motion.
8	17.20 – 20.80	Gale	Twigs break off; personal progress impeded.
9	20.80 – 24.35	Strong Gale	Slight structural damage; chimney pots removed.
10	24.35 – 28.40	Storm	Trees uprooted; considerable structural damage.
11	28.40 – 32.40	Violent Storm	Damage is widespread; unusual in the U.K.
12	> 32.40	Hurricane	Countryside is devastated; only occurs in tropical countries.

Table 4: Beaufort Land Scale