



33-41 Cheetham Hill Road

For

ZX Cheetham Hill Developments Limited

Wind Microclimate Report

2910468rep1v5

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Executive Summary

Background

A study has been carried out by Architectural Aerodynamics Ltd. (ArcAero) to assess the wind microclimate for the proposed 33-41 Cheetham Hill Road development in Manchester, United Kingdom.

The study has employed computational modelling (CFD) to predict the strength of wind speeds that will occur following the introduction of the proposed development.

This suitability of wind conditions is determined using the widely accepted industry standard Lawson criteria to determine the suitability of wind conditions on site and the impact of the proposed development on the surrounding area.

Conclusions

The following conclusions have been drawn:

- Upon the introduction of proposed development within existing surrounds:
 - On ground and terrace level, wind conditions are expected to remain safe and suitable for intended uses within and around the site.
- Upon the introduction of the cumulative surrounds, wind safety and comfort conditions remain materially similar to that of the proposed development within existing surrounds.

1 Introduction

A microclimate is defined as the distinctive climate of a small-scale area. The weather variables in a microclimate, such as wind, may be different to the conditions prevailing over the area as a whole. Wind microclimate assessments consider the wind conditions that would result upon the introduction of a new development into an existing space.

Such assessments predict the proportion of time an area will experience wind speeds in excess of threshold values associated with safe and comfortable use by pedestrians and occupants once the development is introduced. It can therefore be shown within the various parts of a new proposal and neighbouring properties whether wind conditions are suitable or unsuitable, and whether design adjustment or mitigation measures are required. It is for this purpose that wind microclimate assessments are undertaken.

This report summarises the results of a CFD study, commissioned by ZX Cheetham Hill Developments Limited, to assess the wind microclimate for the proposed 33-41 Cheetham Hill Road development in Manchester, United Kingdom.

2 The Project

2.1 Site Location and Surrounding Area

The 33-41 Cheetham Hill Road development is bounded by Carnarvon Street to the north, Cheetham Hill Road to the east and Gibson Place to the west. To the south there is an existing commercial property.

Further afield, the development is largely characterised by medium to high rise developments to the east and northeast, with low-rise buildings more prevalent from southwest round to north.

2.2 The Proposed Development

The proposed development will comprise a ground plus 23 storey tower, rising to approximately 80m above the ground.

2.3 Drawing Information Describing the Proposed Development

Assessment models have been constructed on the basis of the following updated drawings received from Hawkins Brown Architects on 24th October 2023:

- CHR-HBA-01-ZZ-M3-A-0001.dwg

The existing surrounding area was based upon information supplied Hawkins Browns Architects and supplemented by Ordnance Survey details for the area. Cumulative surrounds were based upon information contained within the Manchester City Council open access system.

2.4 Soft Landscaping

The simulations have been run in the absence of soft landscaping. The effect of the soft landscaping proposals is assessed qualitatively, and based on the following received from Smeeden Foreman Ltd (via Ks4) on 29th November 2023:

- 1003 - Landscape Plan - Roof Terrace_A1 (PLANNING).pdf

2.5 Changes to Proposed Development

In May 2024 and following completion of the CFD assessment, the proposed development underwent minor changes based on the drawings received on 13th May 2024. These changes are summarized as follows:

- Expressed corner windows removed and façade setting out updated to position masonry at the corners on all facades.
- In lieu of corner windows, slot windows are introduced to maintain dual aspect living spaces where possible.
- Setting out of piers touching the ground at Cheetham Hill Rd and the southern boundary updated to align with updates on levels above.

- Perforated aluminium spandrel panels to upper levels of facade are replaced with masonry. The slab edge and soffit ventilation details are replicated from typical lower levels.
- Perforated aluminium spandrel panels to parapet are replaced with masonry This is articulated with a recessed panel in line with the horizontal bands below and stack bonded soldier course brickwork to improve the legibility as a crowning element.

The changes above are not expected to materially impact the local wind microclimate and therefore the findings of this report remain unchanged.

2.6 Cumulative Schemes

A number of cumulative schemes have been considered in the assessment. These schemes are presented in tabular format in Table 2-1.

Table 2-1 – Cumulative Schemes

Development Name	Planning Reference
Former Boddingtons Brewery	132416/FO/2021
Old Brewery Gardens	118831/FO/2018
Land Bounded by Cheetham Hill Road, Lord Street & Fernie Street Manchester	113914/FO/2016
1 Park Place	138302/FO/2023

3 Assessment Methodology

3.1 Overview

CFD modelling has employed a steady-state RANS approach. This method employs turbulence models to approximate the magnitude of velocity fluctuations about the average wind speeds predicted, in order to derive an estimation of the effect of gusts.

Full details on this approach are provided in Appendix A of this report - salient highlights of this approach are:

- The Shear Stress Transport k- ω turbulence model has been employed.
- Architectural features of 0.5 metres or more have been captured within the geometry modelled.
- Cell sizes of as small as 0.2 metres were utilised to capture flow behaviour in critical locations.
- The region of interest closest to the ground (1.5 metres) incorporated 5 layers of cells.

Modelling has derived mean and gust equivalent mean wind speeds, in accordance with best industry practice. In doing so 16 wind directions were assessed, in 22.5° increments.

The industry standard criteria for wind microclimate assessments, the LDDC variant of the Lawson criteria (1), has been employed for the study.

3.2 Computational Model

A digital model of the site and surrounds was used for the study. The surrounding area was modelled up to a distance of 450 m and all features which are likely to impact the wind flow to and through the site have been replicated. Details of the model, including the configurations tested, are presented within Appendix B of this report.

3.3 Wind Climate Analysis

Wind microclimate studies require that meteorological data is transposed from a nearby weather station with sufficient wind data to produce accurate wind frequency statistics. The current study uses data from Manchester International Airport.

Full details of the wind climate relevant to the site, the wind properties approaching the site and the modelling of those wind properties in the CFD models are provided in Appendix C of this report. All analysis of wind data and the atmospheric boundary layer has employed the methods of ESDU item 01008 (2), in accordance with best industry practice.

3.4 The LDDC Lawson Criteria

The industry standard criteria for such assessments are commonly referred to as the Lawson criteria. Architectural Aerodynamics use the London Docklands Development Corporation (LDDC) variant of the Lawson Criteria (1).

The LDDC variant of the Lawson criteria applies a single percentage probability of exceedance of a range of wind speeds related to different pedestrian uses.

3.4.1 Safety

A wind speed of 15 metres-per-second occurring once per year is rated as unsafe, with the potential to de-stabilise the less able members of the public including the elderly, cyclists and children.

3.4.2 Comfort

The LLDC variant of the Lawson criteria (1) dictates that wind conditions are suitable for a given activity when the threshold is exceeded no more than 5% of the time in seasons relevant to the activities that will take place in a given area. The value of 5% has been established as giving a reasonable allowance for extreme and relatively infrequent winds that are tolerable within each category. These threshold wind speed values are presented in Table 3-1.

Table 3-1 – LLDC Wind Comfort Thresholds

Threshold Wind Speed [m/s]	Comfort Rating / Activity	
4	C4	Long-term sitting
6	C3	Standing / short-term sitting
8	C2	Strolling
10	C1	Walking
> 10	C0	Uncomfortable

4 Results

4.1 Existing Site Conditions

The results for the existing site conditions are presented graphically within Figure 4.1 for safety, and Figure 4.2 and Figure 4.3 for worst-seasonal and summer comfort conditions respectively.

4.1.1 Safety

Wind conditions within and around the existing site satisfy the criteria for pedestrian safety.

4.1.2 Comfort

Wind conditions within the site and immediate surrounding areas are generally suitable for at least short-term standing or better with small pockets of strolling conditions further to the east & northeast of the site. Thus, wind conditions are comfortable for intended uses as pedestrian ingress / egress at all entrances, and comfortable throughfare use in and around the site.

4.2 Proposed Development within Existing Surrounds

The results for the proposed development within existing surrounds are presented graphically within Figure 4.4 and Figure 4.5 for safety, Figure 4.6 and Figure 4.7 for worst-seasonal comfort and Figure 4.8 and Figure 4.9 for summer comfort respectively.

4.2.1 Safety

Following the introduction of proposed development, wind conditions within the site and surrounding areas satisfy the safety criteria for wind at ground level.

The simulations executed for this report were carried out in the absence of any soft landscaping proposals on the level 17 terrace, and are therefore over-conservative in this area. A small exceedance of the safety criteria is predicted near the western edge of the terrace. The baseline soft landscaping scheme provided to Architectural Aerodynamics on 29-11-2023 is sufficient to ameliorate any potential exceedances of the safety criteria.

4.2.2 Comfort

4.2.2.1 *Thoroughfares*

Wind conditions on thoroughfares within the site remain suitable for pedestrian strolling or better and are thus comfortable for pedestrian access to and passage through the site.

4.2.2.2 *Entrances*

Wind conditions at all entrances to the proposed development remain suitable for short-term standing or better and thus comfortable for pedestrian ingress / egress.

4.2.2.3 *Recreational Spaces*

The simulations executed for this report were carried out in the absence of any soft landscaping proposals on the level 17 terrace, and are therefore over-conservative in this area. As shown, the conditions on the terrace are largely suitable for strolling during the Winter and short-term sitting during the Summer. The baseline soft landscaping scheme provided to Architectural Aerodynamics on 29-11-2023 is sufficient to ameliorate any potential exceedances of the comfort criteria on the level 17 terrace and ensure conditions are acceptable.

4.2.2.4 Surrounding Area

Within the surrounding areas, wind conditions remain generally suitable for at least short-term standing or better all year round, with localised region of strolling conditions present along the Cheetham Hill Road, Gibson Pl, and Carnarvon Street. This still meets comfort criteria for a leisure thoroughfare through the area.

Thus, all entrances and thoroughfares in the surrounding area are comfortable for their intended uses.

4.3 Proposed Development within Cumulative Surrounds

The results for the proposed development within future surrounds are presented graphically within Figure 4.10 and Figure 4.11 for safety, Figure 4.12 and Figure 4.13 for worst-seasonal comfort and Figure 4.14 and Figure 4.15 for summer comfort respectively.

Following the introduction of cumulative surrounds, wind conditions from both a safety and a comfort perspective remain materially similar as the proposed development within the existing surrounds scenario. Correspondingly, acceptable wind conditions exist at ground level and the Level 17 roof terrace.

4.4 Soft Landscaping

The soft landscaping proposals have been assessed qualitatively following the execution of the simulations runs for the building massing and will be sufficient to ameliorate any potential exceedances of the comfort or safety criteria. The soft landscaping scheme is presented in Figure 4.16.

5 Conclusions

The following conclusions have been drawn:

- Upon the introduction of proposed development within existing surrounds:
 - On ground and terrace level, wind conditions are expected to remain safe and suitable for intended uses within and around the site.
- Upon the introduction of the cumulative surrounds, wind safety and comfort conditions remain materially similar to that of the proposed development within existing surrounds.

6 References

1. **Lawson, T.V.** *The determination of the wind environment of a building complex before construction*. Bristol : University of Bristol, Department of Aeronautical Engineering, 1990.
2. **ESDU (Engineering Science Data Unit).** *Item 01008. Computer Program for wind speeds and turbulence properties: flat or hilly sites in terrain with roughness*. 2001.
3. **F, Menter.** *Zonal Two Equation $k-\omega$ Turbulence Models for Aerodynamic Flows*. 1993. AIAA Paper 93-2906.
4. **F, Menter.** *Turbulence Modelling for Engineering Flows*. s.l. : ANSYS Inc., 2011.
5. **Richards, P.J. and Hoxey, R.P.** *Appropriate boundary conditions for computational wind engineering models using the $k-\epsilon$ turbulence model*. s.l. : Journal of Wind Engineering and Industrial Aerodynamics, 1993. vol. 46 & 47, pg. 145 - 153.
6. **Blocken, B. and Carmeliet, J.** *Pedestrian wind environment around buildings: Literature review and practical examples*. s.l. : Journal of Thermal Envelope and Building Science, 2004.

7 Figures

Figure 4.1 – Pedestrian wind conditions, existing site within existing surrounds, annual safety

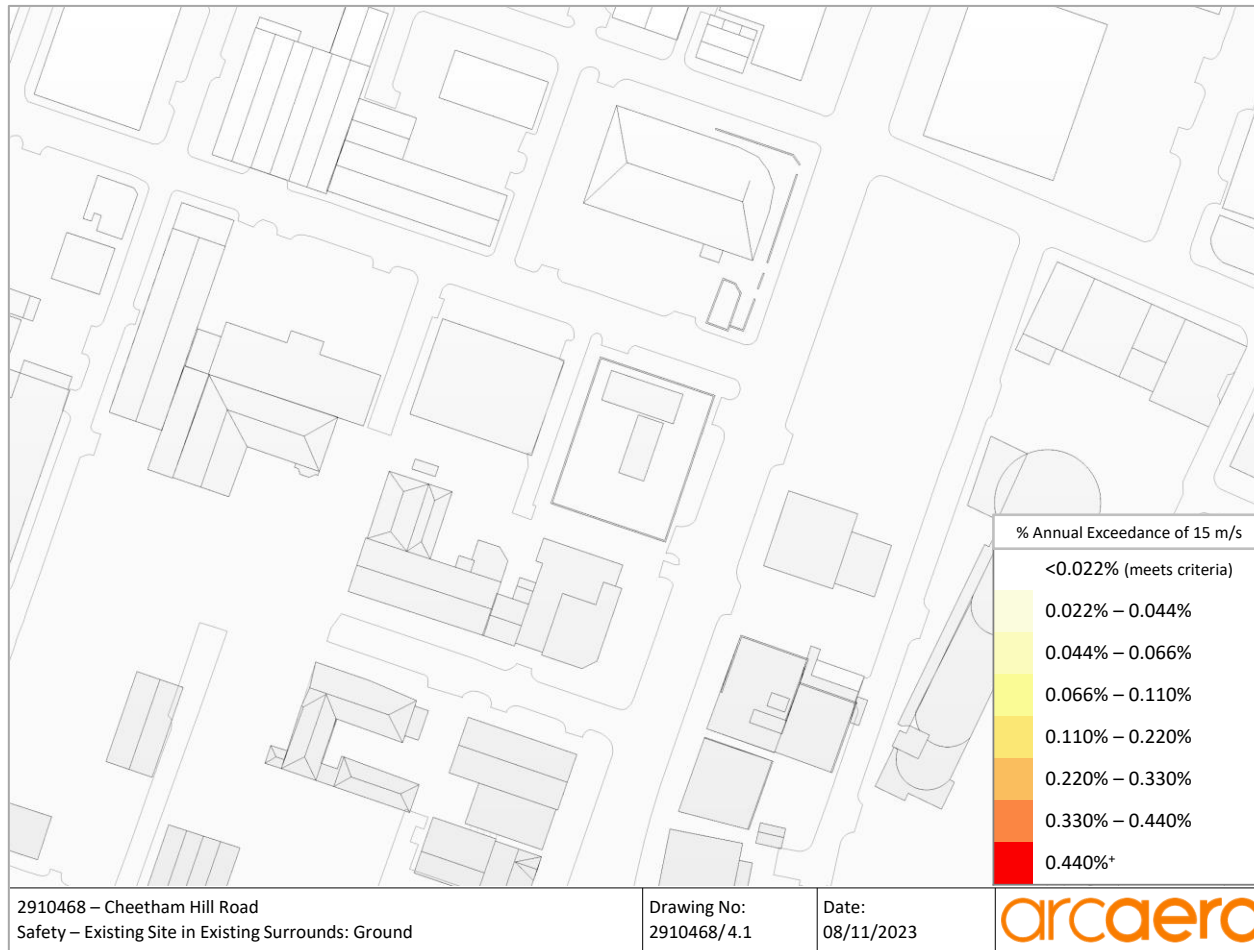


Figure 4.2 - Pedestrian wind conditions, existing site within existing surrounds, worst case season



Figure 4.3 – Pedestrian wind conditions, existing site within existing surrounds, summer season

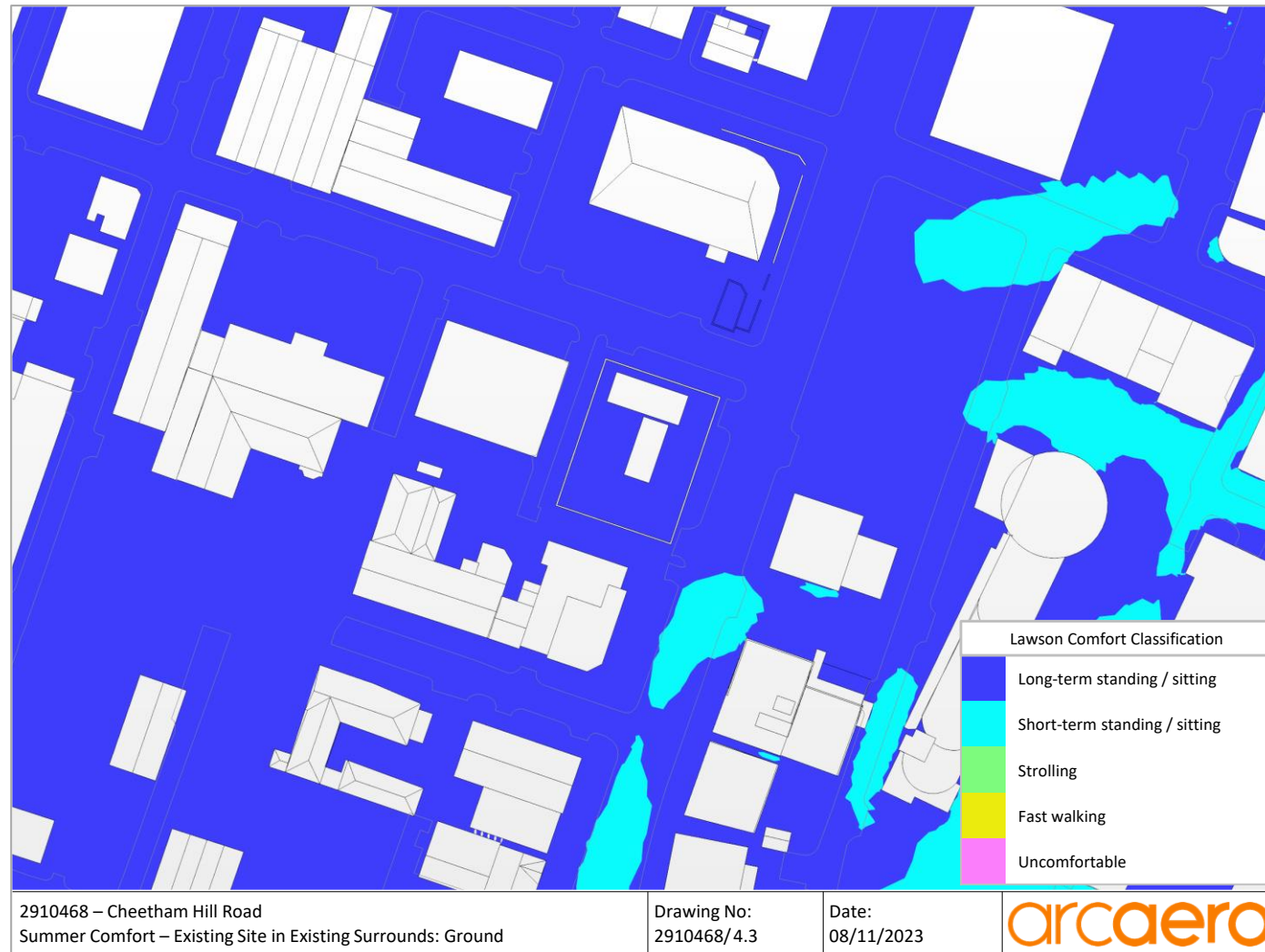


Figure 4.4 – Pedestrian wind conditions, proposed development within existing surrounds, annual safety – ground level

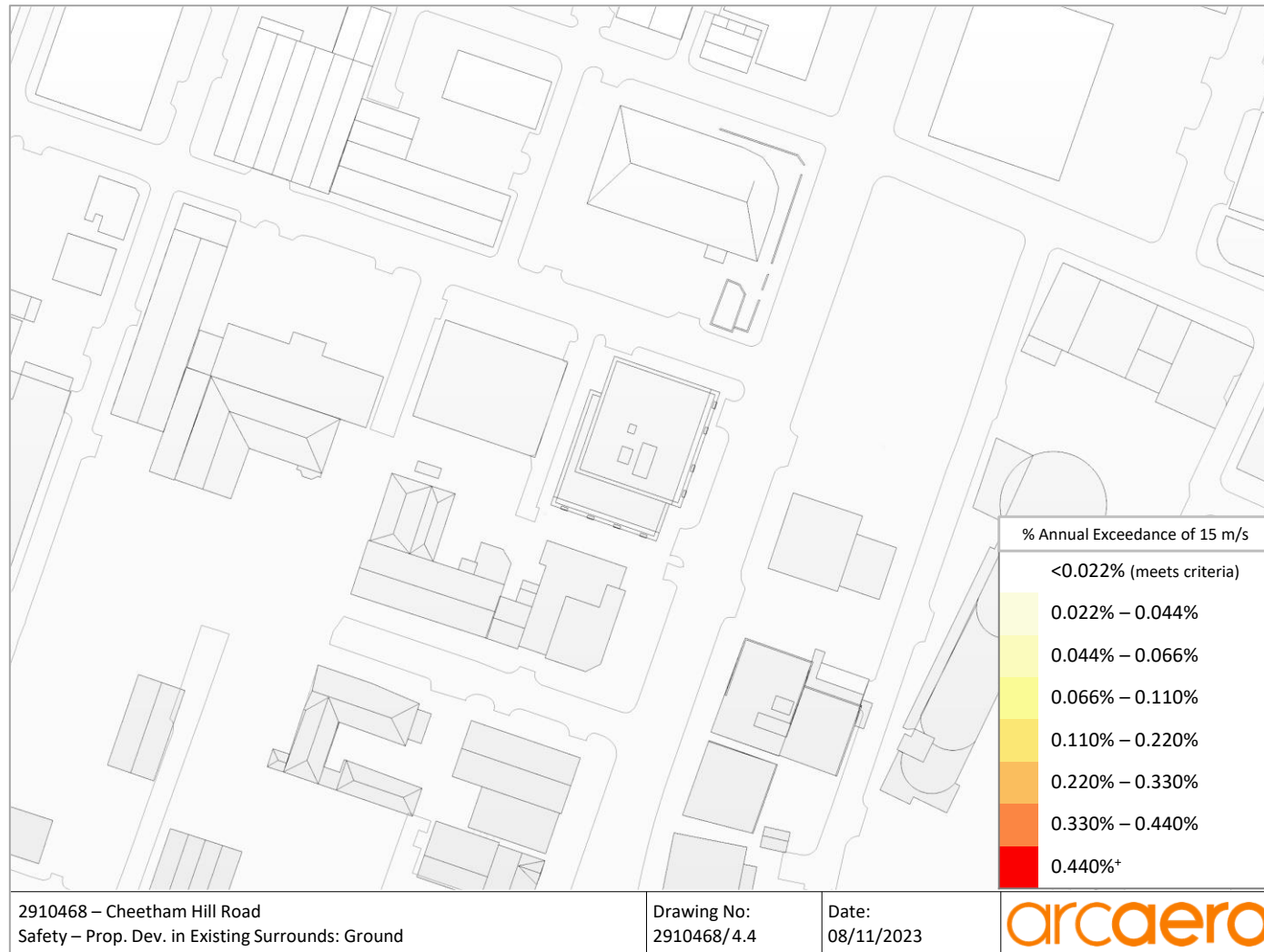


Figure 4.5 – Pedestrian wind conditions, proposed development within existing surrounds, annual safety – terrace level

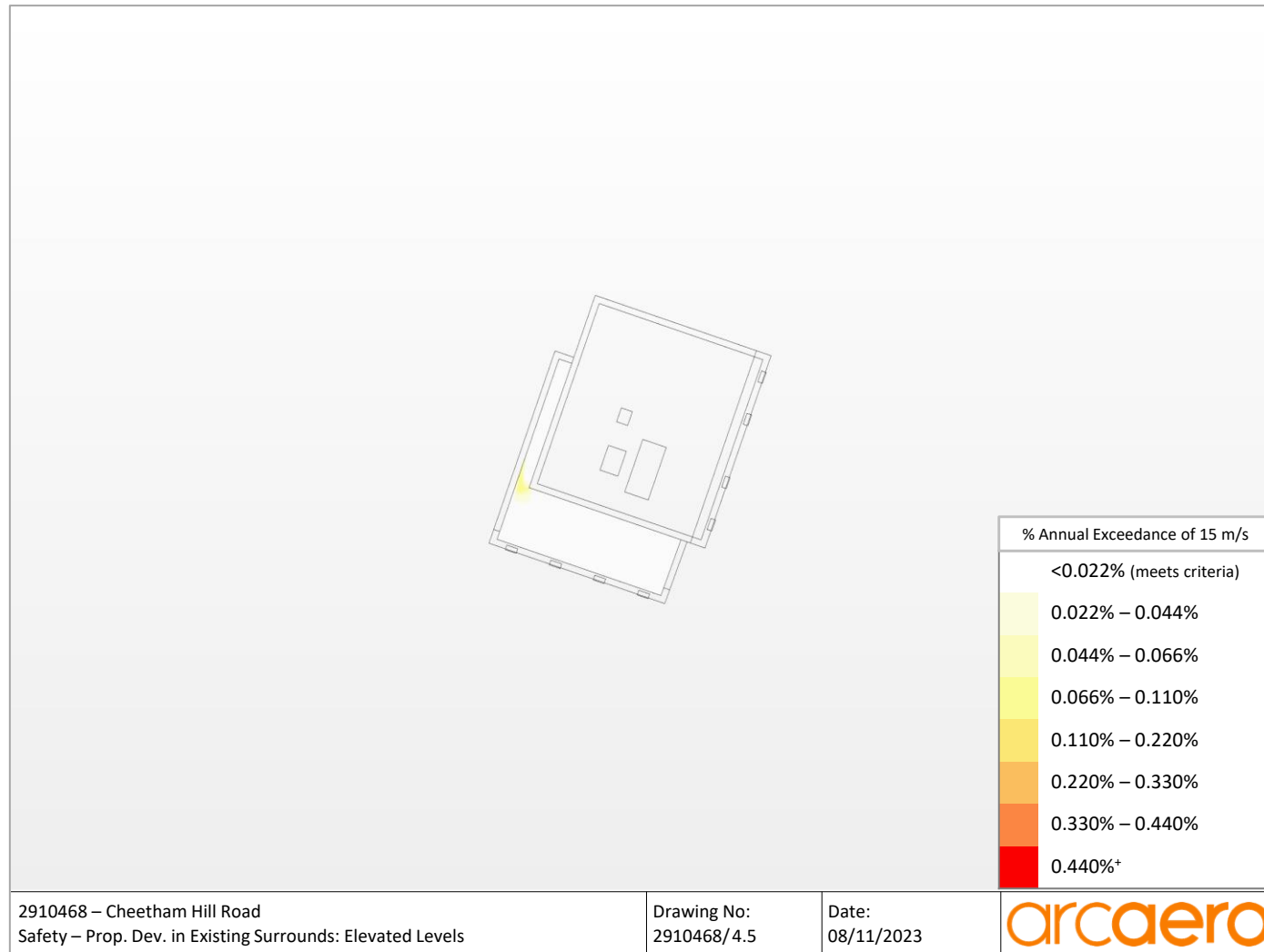


Figure 4.6 – Pedestrian wind conditions, proposed development within existing surrounds, worst case season – ground level

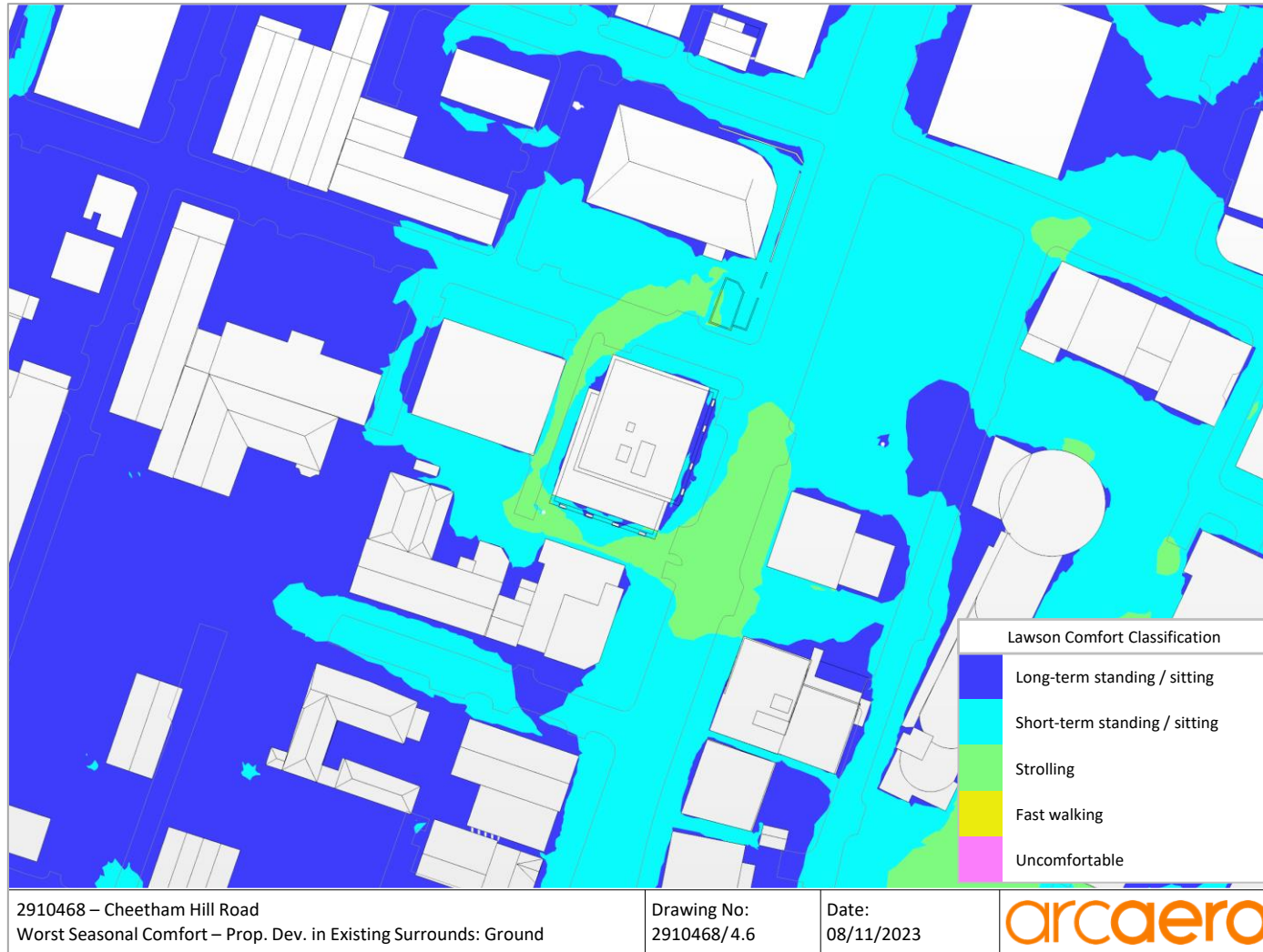


Figure 4.7 – Pedestrian wind conditions, proposed development within existing surrounds, worst case season – terrace level

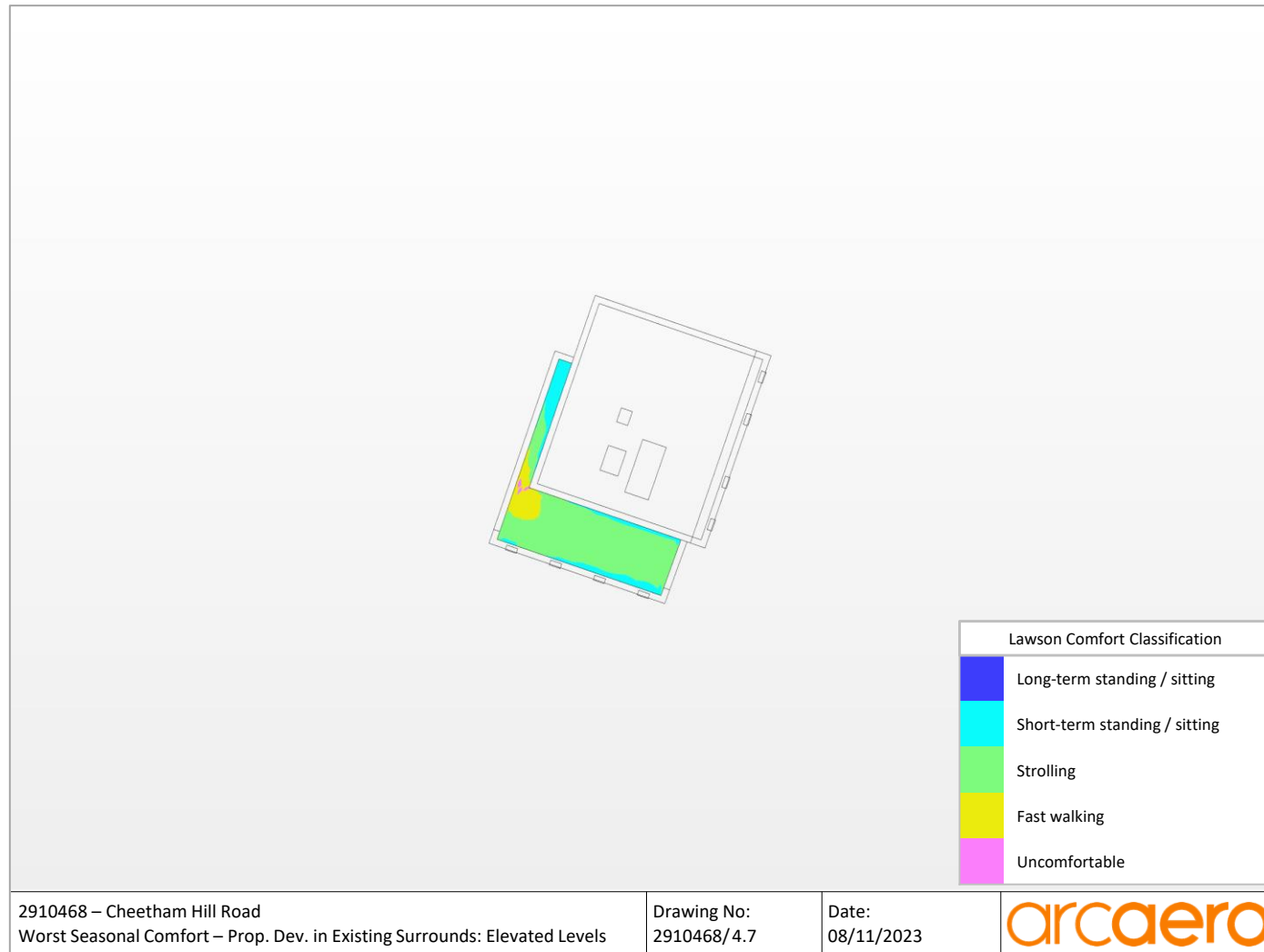


Figure 4.8 – Pedestrian wind conditions, proposed development within existing surrounds, summer season – ground level

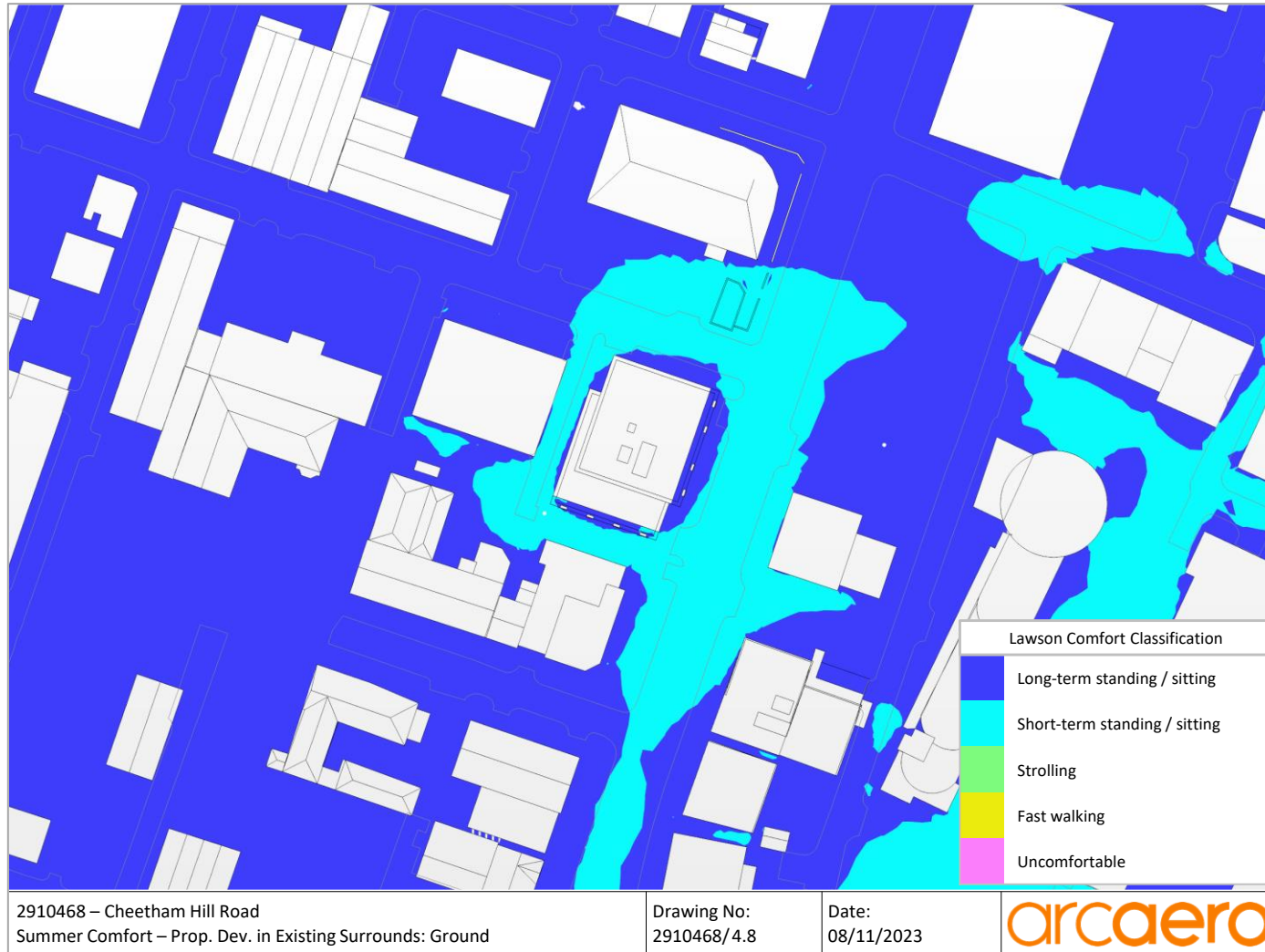


Figure 4.9 – Pedestrian wind conditions, proposed development within existing surrounds, summer season – terrace level

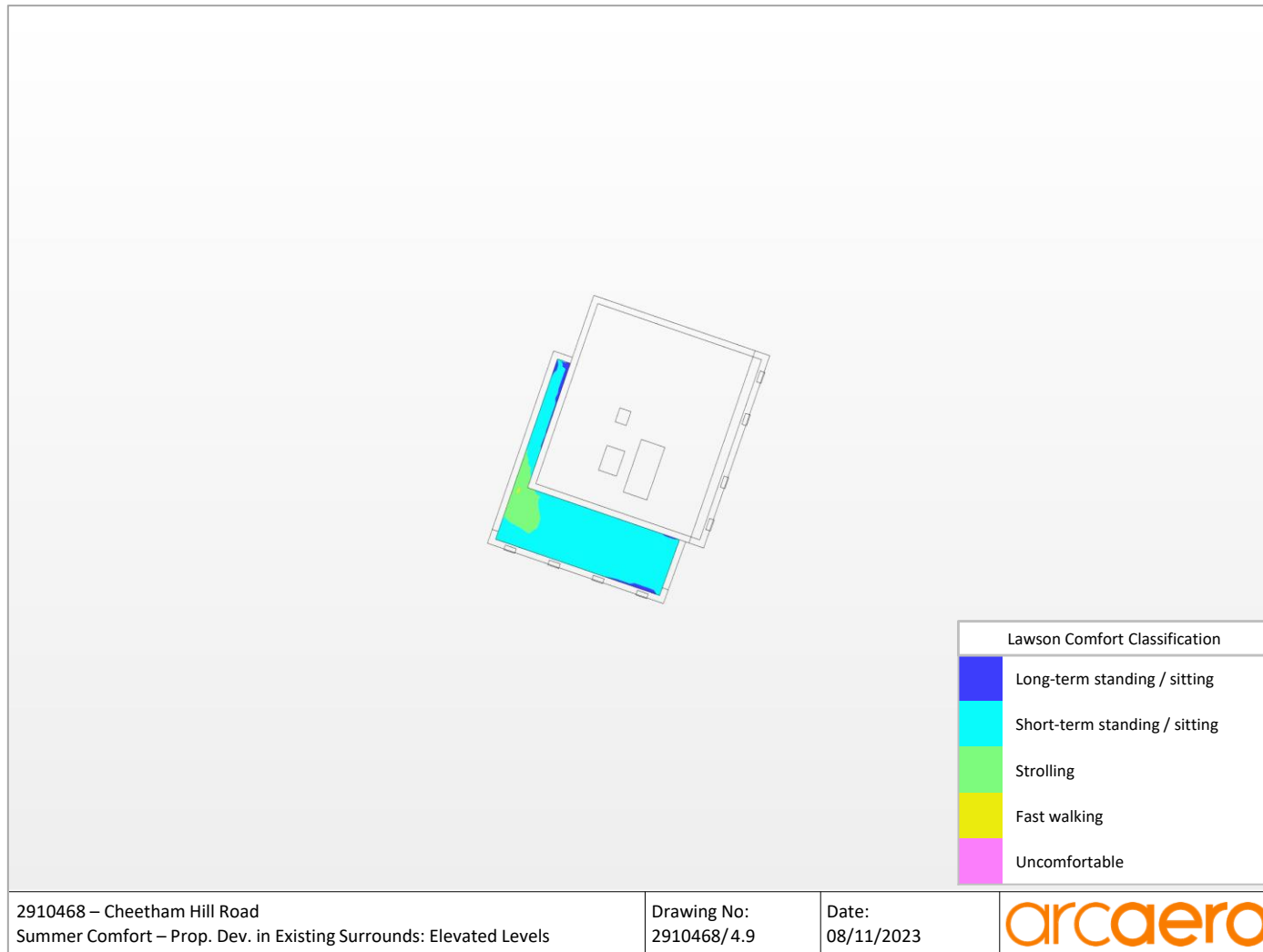


Figure 4.10 – Pedestrian wind conditions, proposed development within cumulative surrounds, annual safety – ground level

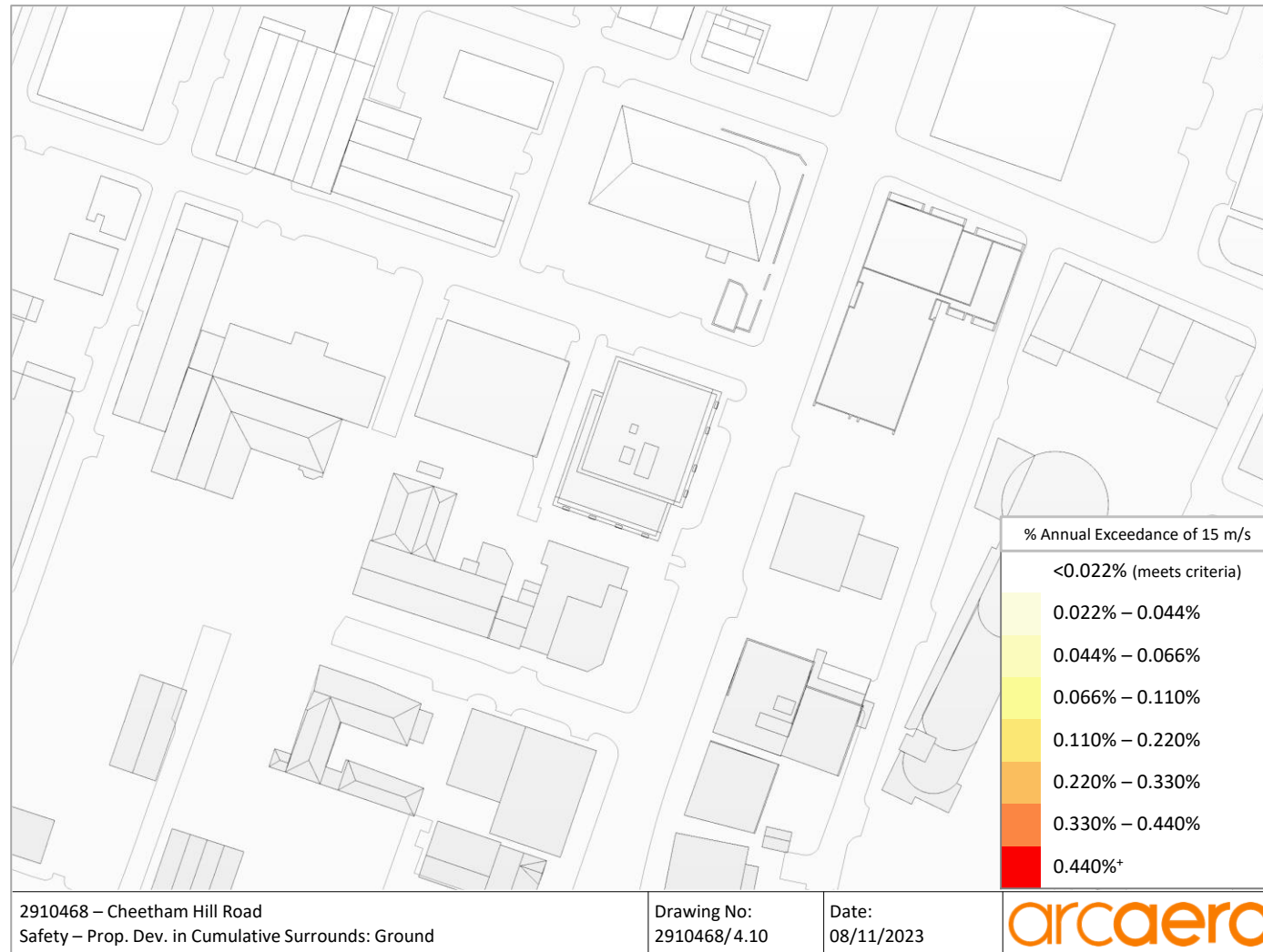


Figure 4.11 – Pedestrian wind conditions, proposed development within cumulative surrounds, annual safety – terrace level

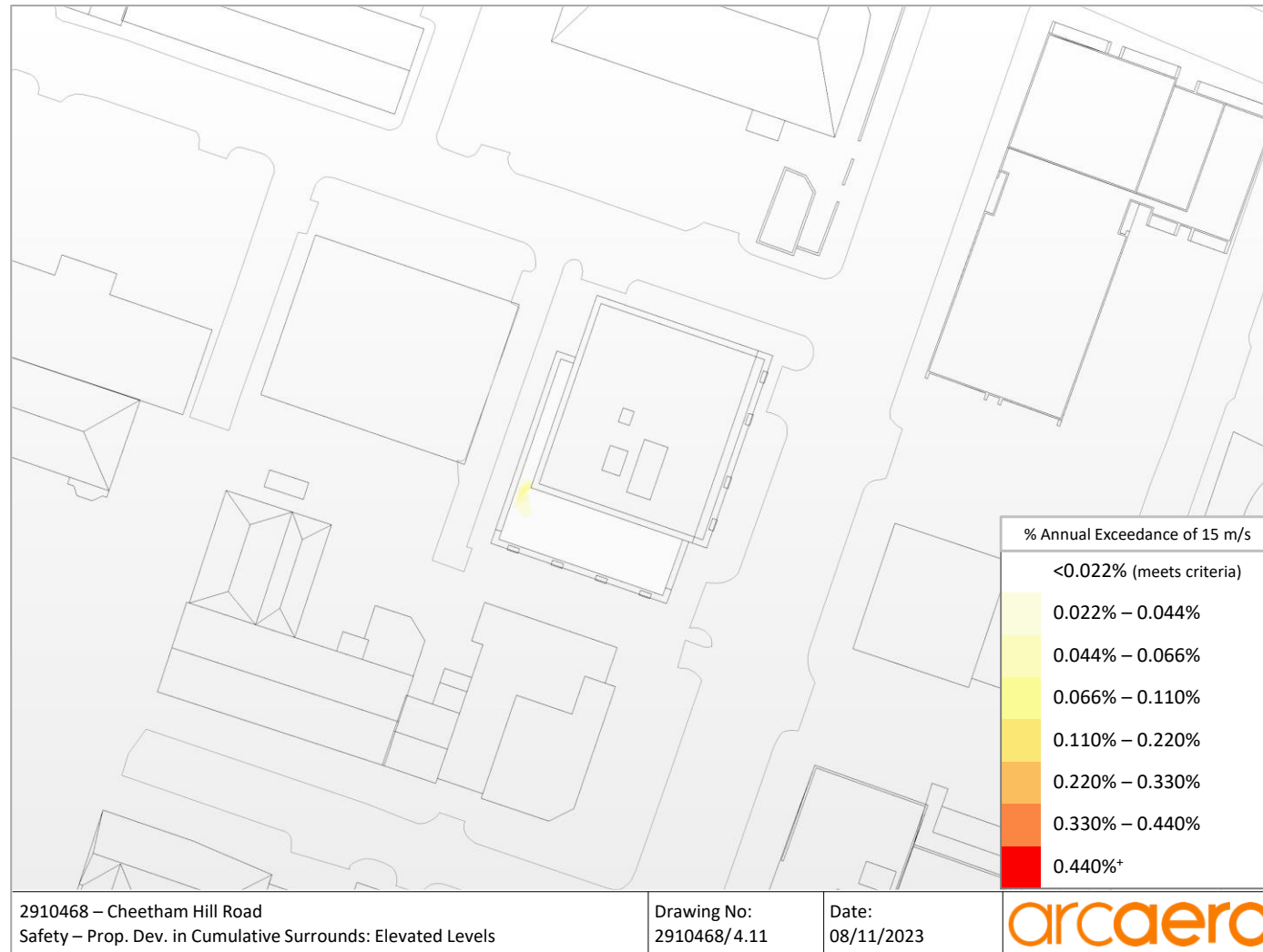


Figure 4.12 – Pedestrian wind conditions, proposed development within cumulative surrounds, worst case season – ground level

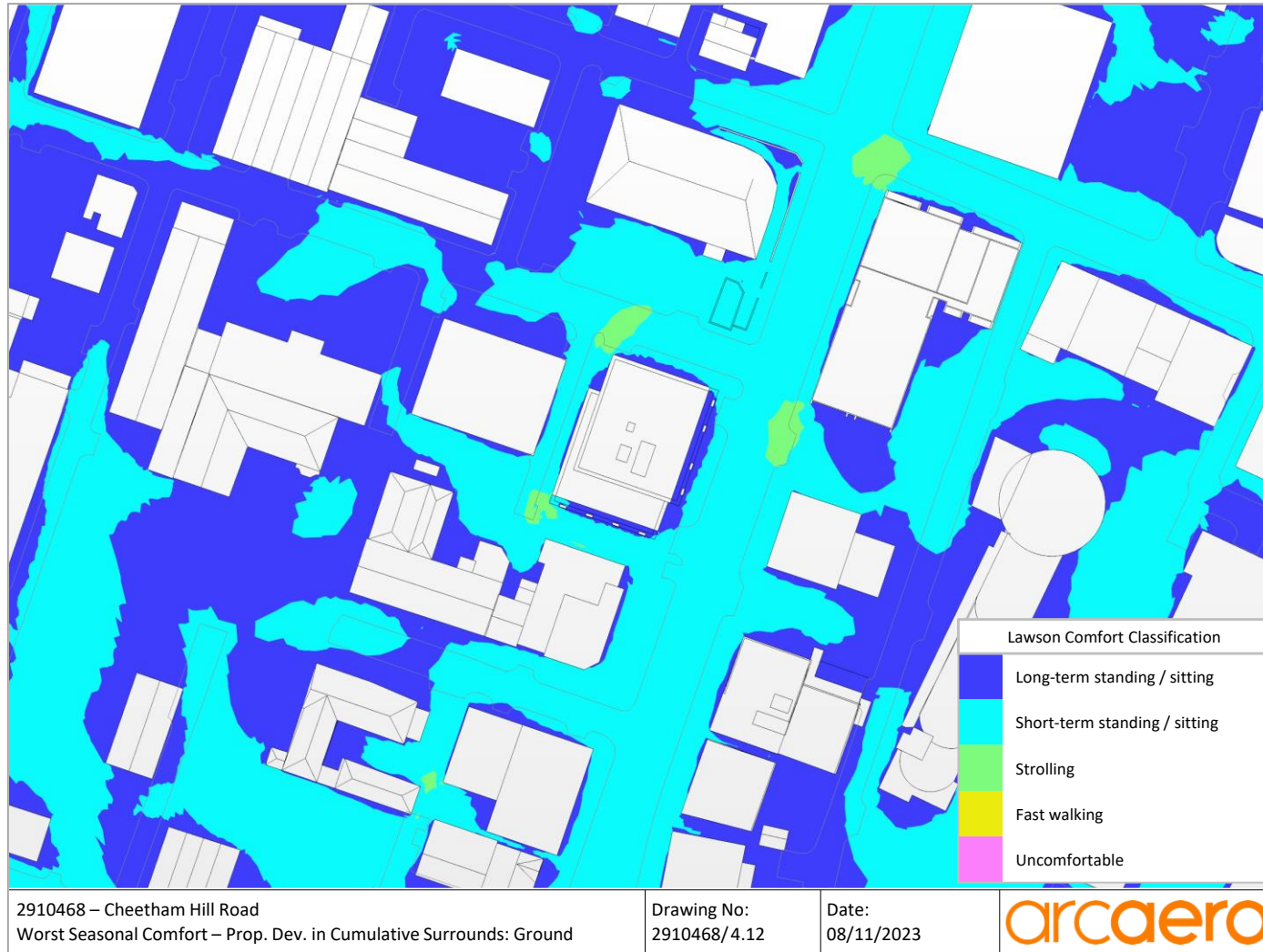


Figure 4.13 – Pedestrian wind conditions, proposed development within cumulative surrounds, worst case season – terrace level



Figure 4.14 – Pedestrian wind conditions, proposed development within cumulative surrounds, summer season – ground level



Figure 4.15 – Pedestrian wind conditions, proposed development within cumulative surrounds, summer season – terrace level



Figure 4.16 – Soft Landscaping Proposals – Level 17 Terrace



Appendix A CFD Modelling

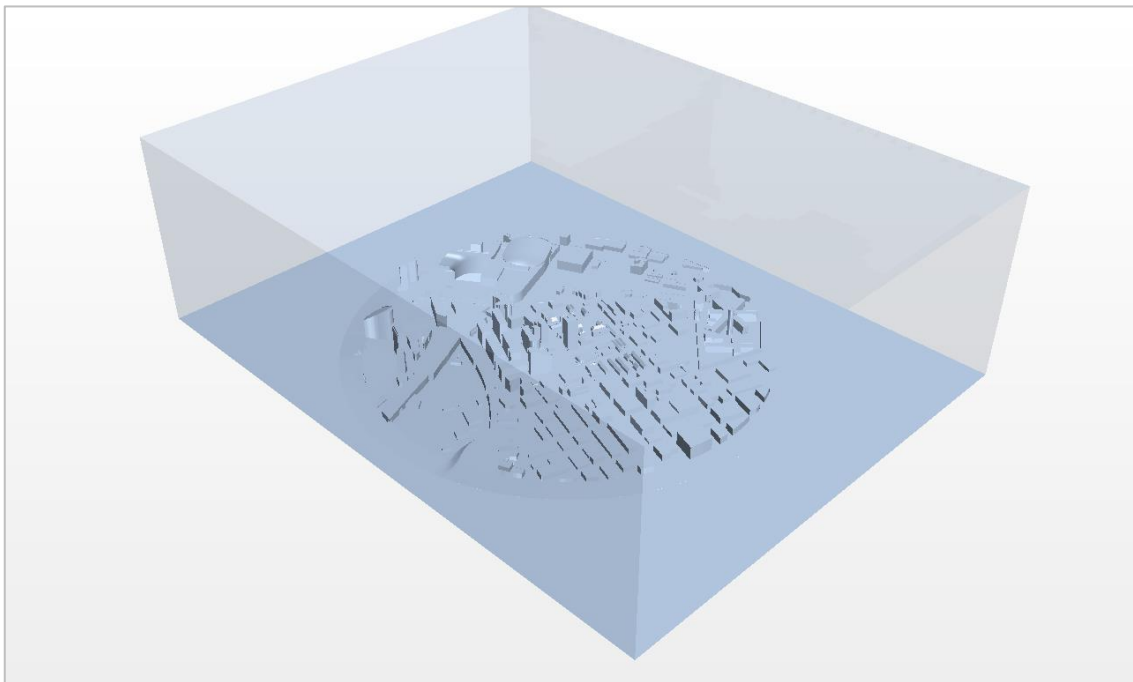
A.1 Spatial discretization

The computational domain was discretised using polyhedral cells for the core mesh, and low aspect-ratio prism cells adjacent to walls and the ground. Computational meshes were constructed for each of the three different study configurations.

The computational domain includes the proposed development site, with surrounding buildings and topographical features within a 450m radius represented explicitly. The full computational domain extends to 1500m in the along-wind direction, 1100m in the across-wind direction, and 450m vertically.

The proposed development and immediate vicinity were meshed down to a cell size of 0.2m in order to capture the detailed geometric features and resulting flow artefacts. The pedestrian ground level surfaces were meshed with a prism layer mesh of 5 layers, which, in the vicinity of the building rise up to a total height of 1.5m above the ground.

Figure A.1 – Computational Domain



A.2 Solution Method

The modelling of an incompressible fluid flow was completed with combinations of semi-implicit method for pressure-linked equations (SIMPLE) algorithms. The resulting flow turbulent features were modelled with introduction of the Shear Stress Transport (SST) $k-\omega$ turbulence model. This model was suggested by Menter (3) and is based on a two-equation eddy-viscosity approach, where the SST model formulation combines the use of a $k-\omega$ in the inner parts of the boundary layer, but also switches to a $k-\epsilon$ behaviour in the free-stream regions of the solutions. Further details for the selected turbulence model are provided in the work of Menter (4).

A.3 Initial and Boundary Conditions

The atmospheric boundary layer flow was simulated by implementing a logarithmic velocity profile model presented by Richards and Hoxey (5), with the following main assumptions:

- The vertical velocity component at the domain boundary is negligible
- The pressure gradient and shear stress are constant

The model implies the following equation for the mean inlet velocity at the CFD domain:

$$U(z) = \frac{U^*}{\kappa} \cdot \ln\left(\frac{z + z_0}{z_0}\right)$$

where:

- κ - is the von Karman's constant
- z - is the distance from the ground surface in vertical direction
- z_0 - is the ground surface roughness length in meters

The friction velocity U^* is calculated by the following equations:

$$U^* = \kappa \cdot \frac{U_{ref}}{\ln\left(\frac{z_{ref} + z_0}{z_0}\right)}$$

where:

- z_{ref} – is the reference height in metres
- U_{ref} - is the reference velocity in m/s measured at z_{ref}

The turbulent velocity fluctuations at the domain inlet are induced by the constant shear stress with height, maintained by the turbulent kinetic energy k equation below:

$$k(z) = \frac{(U^*)^2}{\sqrt{C_\mu}}$$

where:

- $C_\mu = 0.03$ - is a k - ϵ turbulence model constant

All surface boundary conditions were modelled as smooth walls with a no-slip condition. A no-slip wall boundary condition with a varying roughness length height based on the terrain analysis for the site was applied on the ground surface outside the explicit surrounds area of the domain.

A.4 Gust Equivalent Mean Calculation

The gusts in the wind flow is a major component that may lead to additional danger and discomfort to that caused by the mean wind flow. Thus, the gust wind speed is accounted by a calculation of the equivalent mean wind speed, considering the standard deviation of the mean wind speed, in particular the turbulent kinetic energy, k :

$$\sigma = \sqrt{(k * 2/3)}$$

The GEM is then calculated as:

$$U_{GEM} = \frac{U_{Mean} + 3.5\sigma}{k_g}$$

Where gust factor, $k_g = 1.85$

The final speedup used in the Lawson criteria is the worst case from U_{GEM} and U_{Mean} .

Appendix B Computational Model

A digital model of the site and surrounds was used for the study. The surrounding area was modelled up to a distance of 450m and all features which are likely to impact the wind flow to and through the site have been replicated. The model was reviewed and approved by the design team prior to the study.

B.1 Model Images

Images of the computational model are presented as follows:

- Figure B.1 and Figure B.2: Existing site and surrounds
- Figure B.3 and Figure B.4: Proposed development within existing surrounds
- Figure B.5 and Figure B.6: Proposed development within cumulative surrounds
- Figure B.7 and Figure B.8: Close-ups of the proposed development

Figure B.1 - Existing site and surrounds, viewed from south



Figure B.2 - Existing site and surrounds, viewed from west

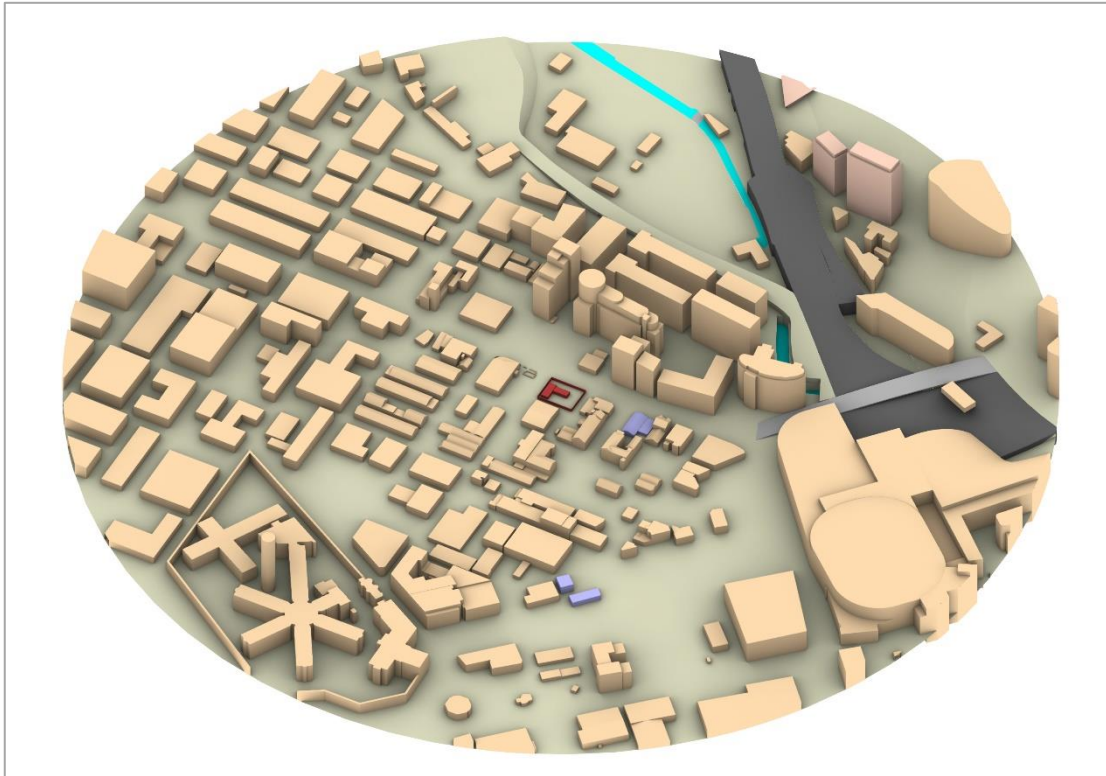


Figure B.3– Proposed development within existing surrounds, viewed from south

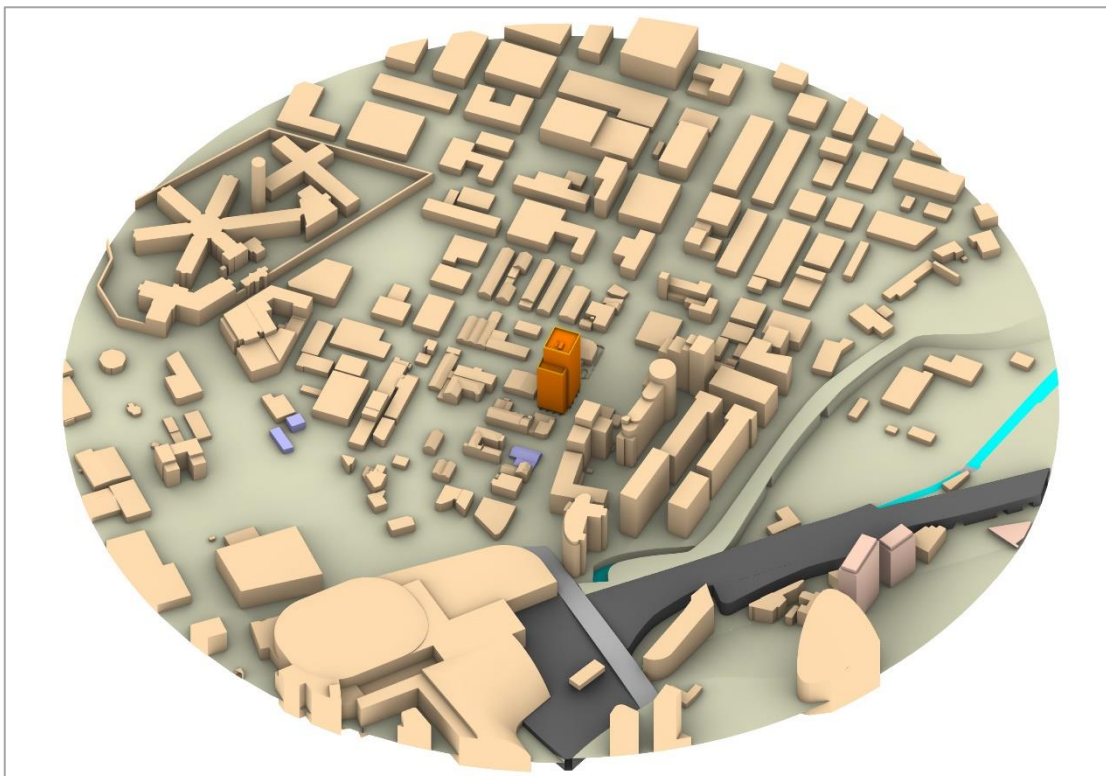


Figure B.4 – Proposed development within existing surrounds, viewed from west



Figure B.5 – Proposed development within cumulative surrounds, viewed from south

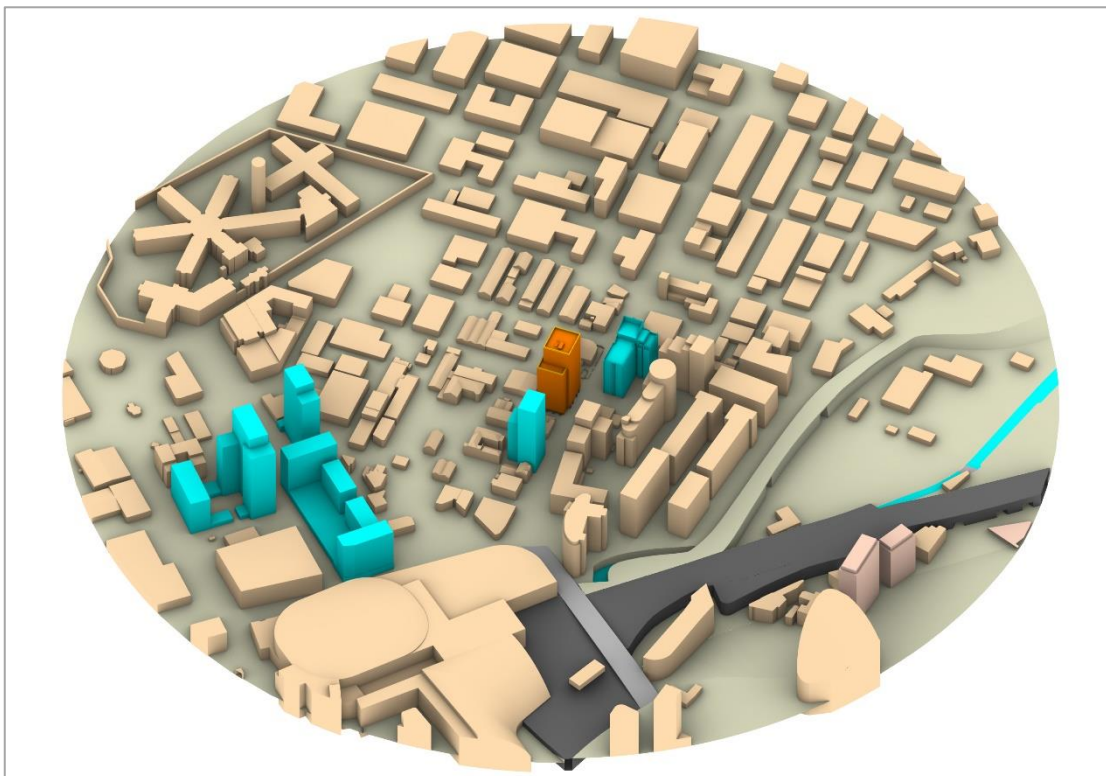


Figure B.6 – Proposed development within cumulative surrounds, viewed from west

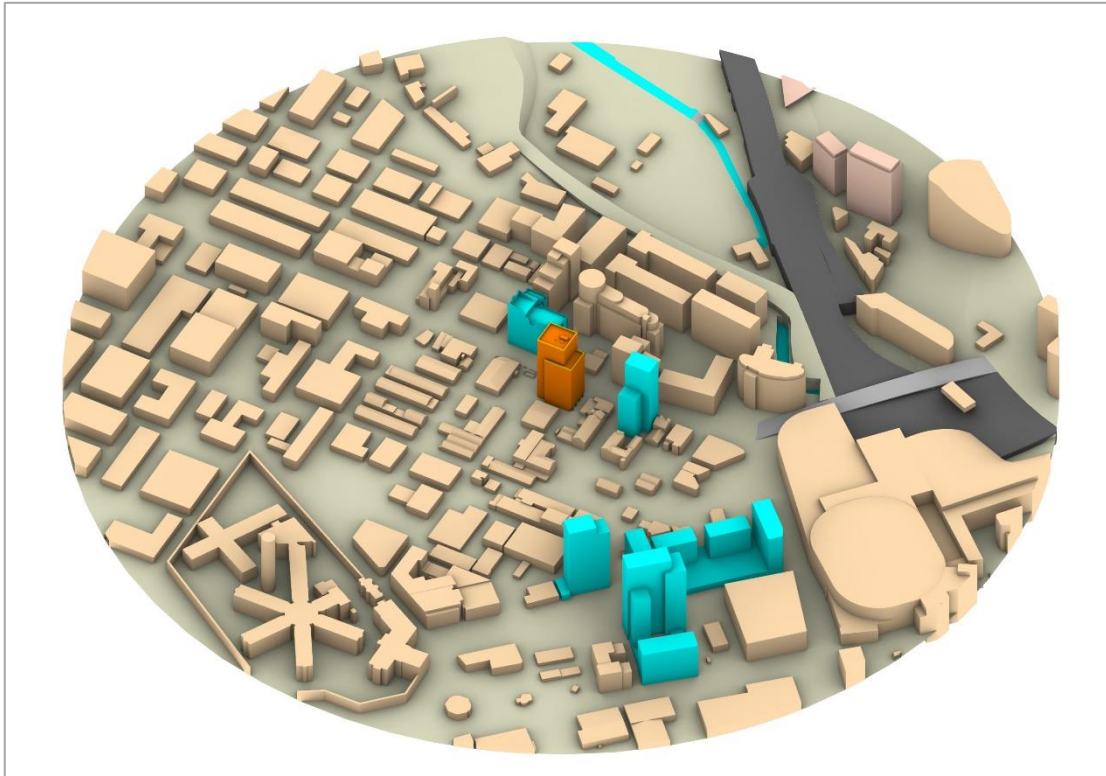


Figure B.7 – Proposed development, close-up from south

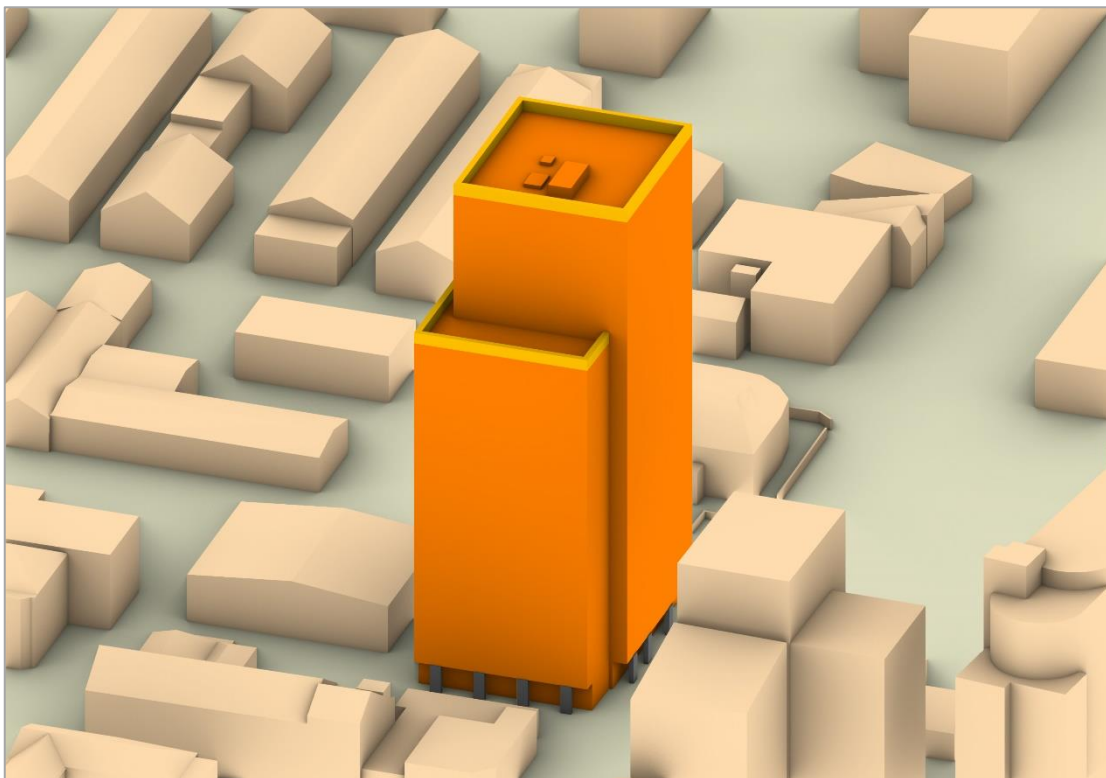
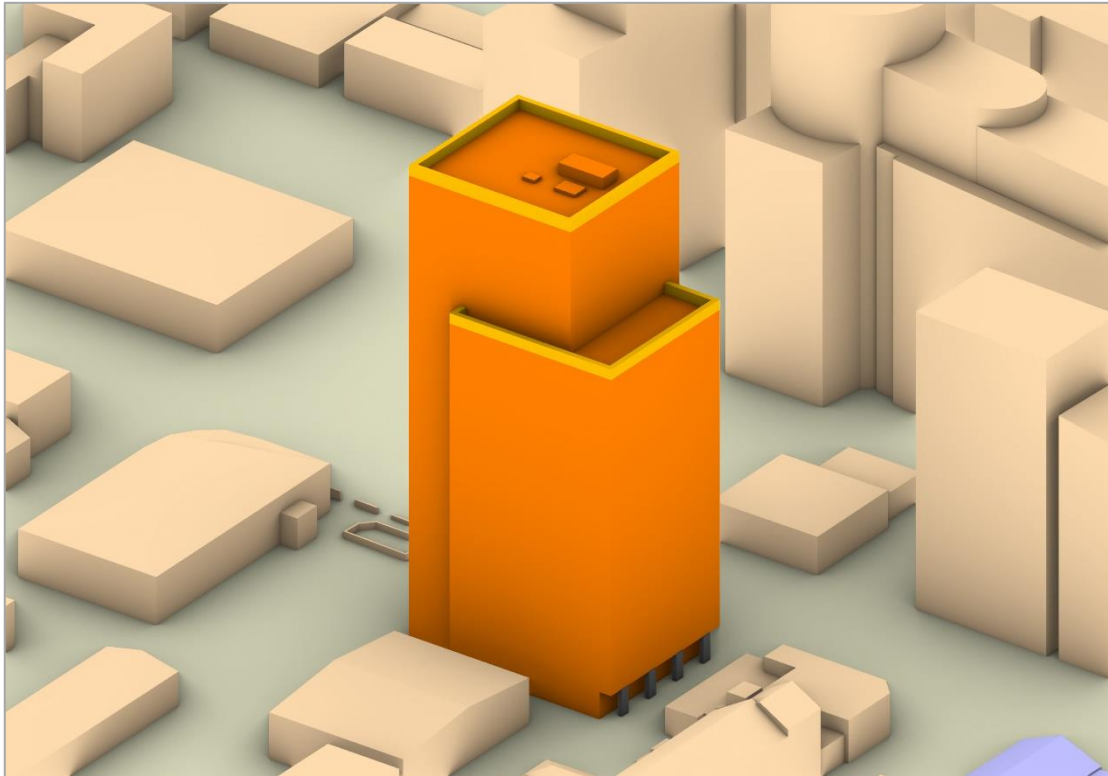


Figure B.8 – Proposed development, close-up from west



Appendix C Wind Climate Analysis

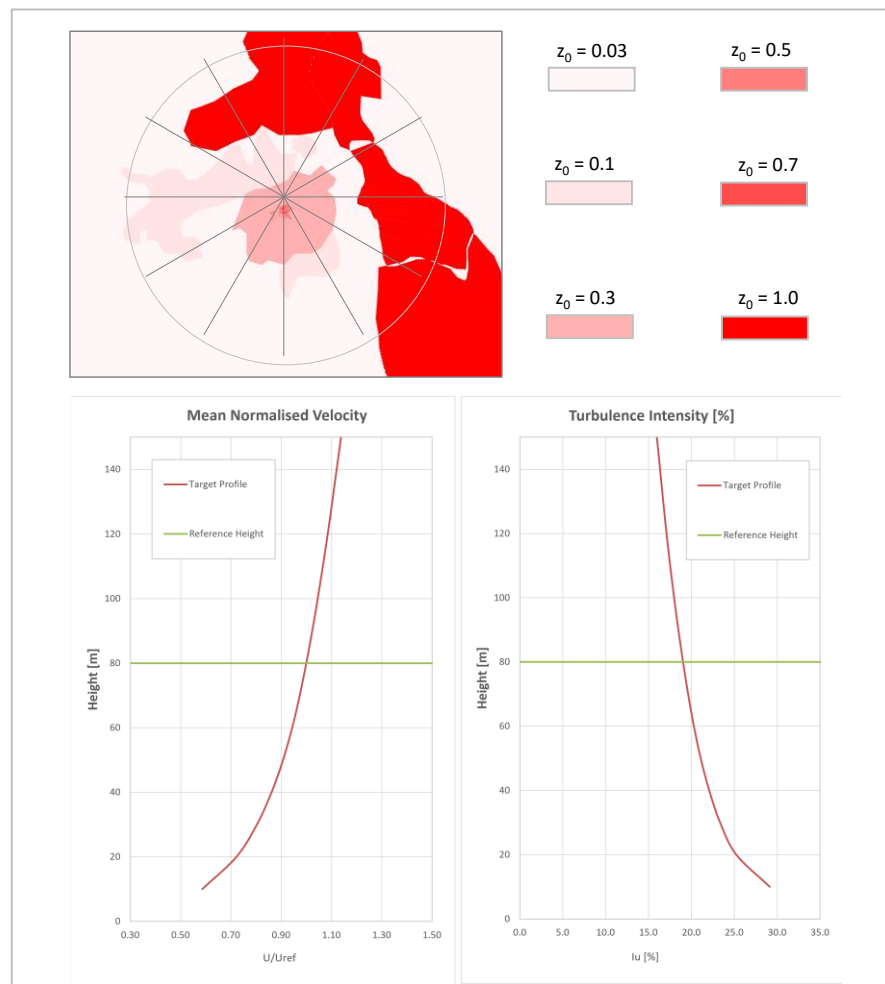
C.1 Surrounding Terrain Assessment

A detailed analysis, based on the widely accepted Deaves and Harris model of the atmospheric boundary layer, as defined in ESDU Item 01008 (2), has been carried out to determine the wind properties at the site. From this analysis, a representative profile was defined as a target profile for the CFD simulations.

C.2 Wind Properties at the Site

Upon conducting the ESDU analysis, each angle was replicated within the CFD model. As each angle exhibited very similar wind profiles, a generic wind profile used in the study is presented within Figure C.1.

Figure C.1 – Mean wind speed and turbulence intensity profiles



C.3 Wind Frequency Data

Wind microclimate studies require that meteorological data is transposed from a nearby weather station with sufficient wind data to produce accurate wind frequency statistics. The current study uses data from Manchester Airport. The cumulative wind speed probability distributions, transposed to building height at site are provided in Figure C.2 to Figure C.6.

Figure C.2 – Cumulative wind speed probability distribution at site, annual

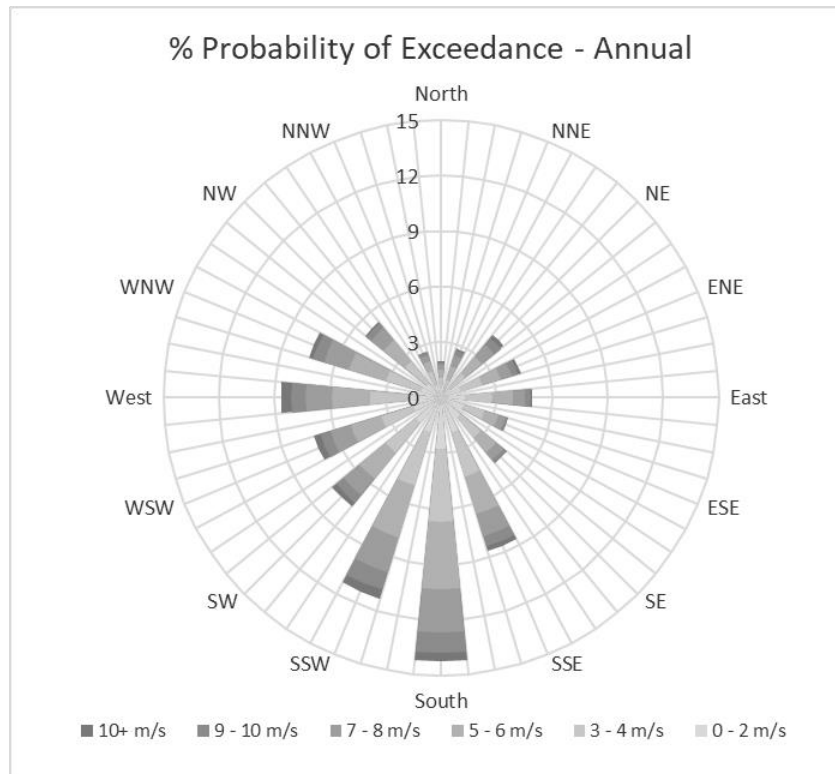


Figure C.3 – Cumulative wind speed probability distribution at site, spring

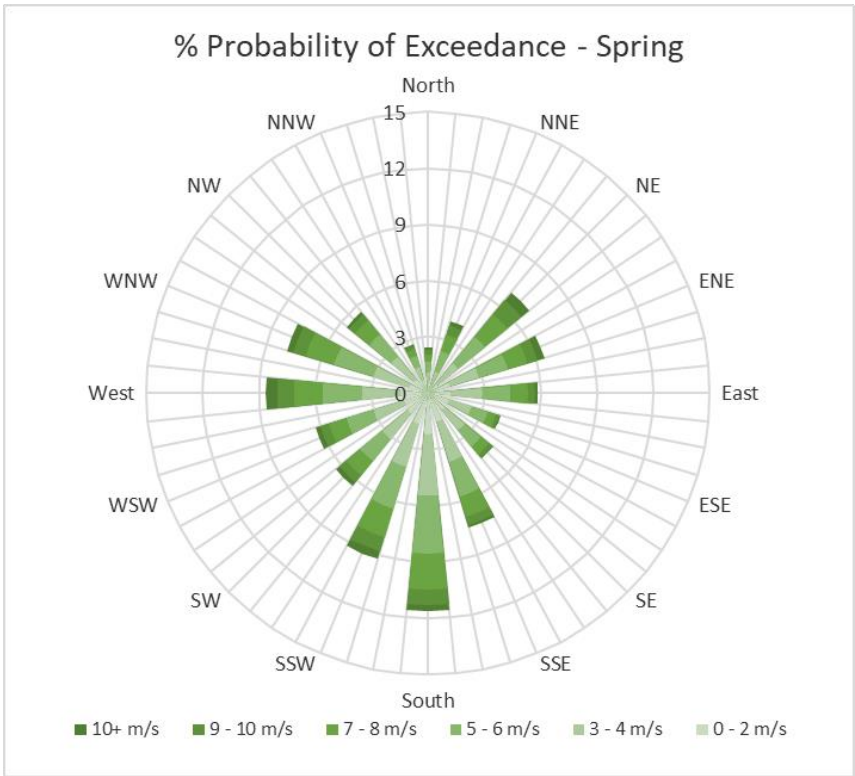


Figure C.4 – Cumulative wind speed probability distribution at site, summer

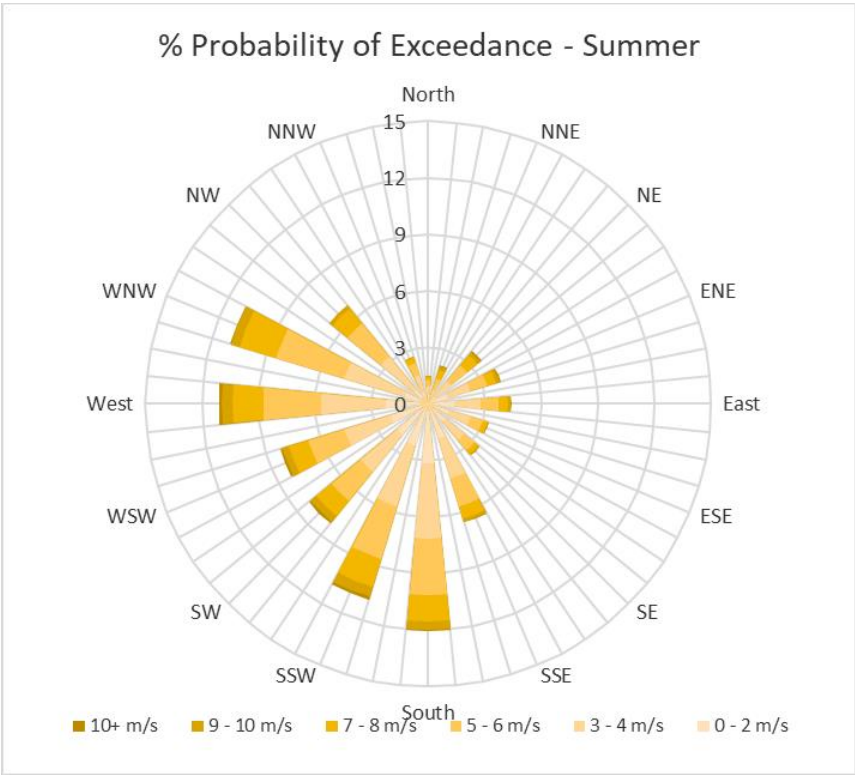


Figure C.5 – Cumulative wind speed probability distribution at site, autumn

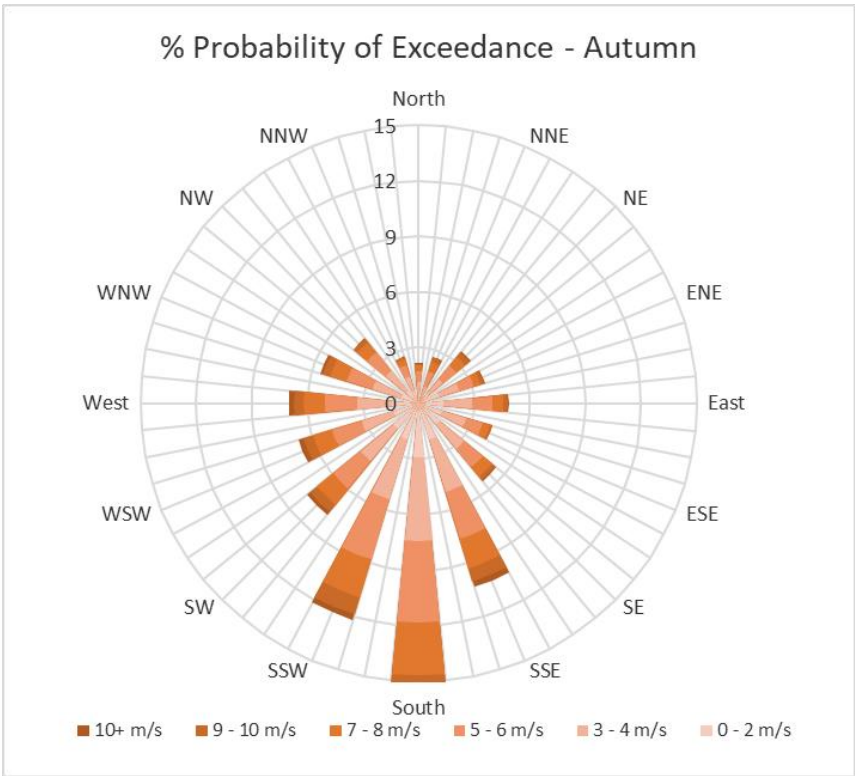


Figure C.6 – Cumulative wind speed probability distribution at site, winter

