



Block C, Plot 11

For

Downing Living
(Manchester) Limited
Partnership Incorporated

Wind Microclimate Report

1690207rep3v2

01 November 2023

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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 Block C, Plot 11 development in Manchester, UK.

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:

- Wind conditions throughout the existing site and surrounds satisfy the safety and comfort criteria for all uses.
- With the introduction of the proposed development, conditions within the site and surrounds remain within the safety and comfort criteria for all uses.
- Cumulative effects are negligible.

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 Downing Living (Manchester) Limited Partnership Incorporated, to assess the wind microclimate for the proposed Block C, Plot 11 development in Manchester, UK.

2 The Project

2.1 Site Location and Surrounding Area

The Block C, Plot 11 development is bounded by Hulme Street to the north, Wilmott Street to the east, Chester Street to the south and Medlock Street to the west. The site sits within the First Street development framework with the Great Jackson Street area is immediately adjacent and further beyond lies the Oxford Road corridor and the Cultural Core.

Further afield the terrain is typical of suburban residential areas. To the north lies Manchester City Centre, with mid-rise to high-rise office and residential developments and buildings typical of a UK city centre.

2.2 The Proposed Development

The proposed development is a residential tower rising to ground+28 storeys.

2.3 Drawing Information Describing the Proposed Development

Assessment models have been constructed on the basis of the following drawings received from Simpson Haugh on the 13th of October 2023:

- 10474-SHP-ZC-A-G251-M3-XX-001.dwg

The existing surrounding area was based upon information from various sources including Ordnance Survey details for the area. Cumulative surrounds were based on a combination of information supplied by Deloitte Limited and held within the Manchester City planning portal.

2.4 Soft Landscaping

The wind microclimate has been assessed for the Proposed Development with the current soft landscaping proposals and surrounding landscaping. This was based on the following drawings which was received from Optimised Environments Limited on the 14th of October 2023:

- M90183.08_Softworks.pdf

Following the completion of the studies, an updated landscaping scheme has been issued on 23rd October 2023:

- M90183.08_GF_0002.pdf
- M90183.08_PD_0100.pdf

The slight changes in the updated scheme are not expected to negatively impact the wind microclimate.

2.5 Cumulative Schemes

A number of cumulative schemes have been considered in the assessment. These schemes are presented in tabular format in Table 2-1 and based on the list received from Deloitte Limited on 18th October 2023. This list is a subset of the full list as any schemes which land on or beyond the perimeter of a 900m diameter disc centred on the Proposed Development have not been modelled and are therefore not included:

Table 2-1 – Cumulative Schemes

Development Name	Planning Reference
Vision	111003/FO/2016/C1
One City Road	128002/FO/2020
Park Place	129273/FO/2021
Travelodge Deansgate Locks	126308/FO/2020
One Medlock Street	135419/FO/2022
Student Castle	121252/FO/2018

The schemes presented in Table 2.2 have been notably included in the existing baseline context. They are either recently completed, or construction has started, and are therefore expected to be completed before work commences on the Proposed Development. These schemes are modelled as though completed. It should be noted that Blocks A, B and D of Plot 11 are included in this list, as construction is in an advanced state at the time of writing.

Table 2-2 – Existing Baseline Schemes

Development Name	Planning Reference
First Street South (Blocks A, B and D only)	125573/FO/2019
Plot 9a, First Street	132600/FO/2021
Metropolitan University Science and Engineering Building	125799/FO/2019
Barclay House	118033/P3OPA/2017
Havelock	129081/FO/2021
Plot 10a, First Street	136043/FO/2023
Plot 10b, First Street	136170/FO/2023
Great Jackson Plot F	132199/FO/2021

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 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 LLDC 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 conditions respectively.

4.1.1 Safety

Within the existing site and surrounds, there are no exceedances of the safety criteria for pedestrian activity throughout the year.

4.1.2 Comfort

Within the existing site and surrounds, wind comfort conditions are suitable for at least strolling or better throughout the year. During summer, most of these areas improve to short-term standing or better.

4.2 Existing Site within Cumulative Surrounds

The results for the existing site within cumulative surrounds are presented graphically within Figure 4.4 for safety, and Figure 4.5 and Figure 4.6 for worst-seasonal and summer conditions respectively.

4.2.1 Safety

Within the existing site and surrounds, there are no exceedances of the safety criteria for pedestrian activity throughout the year.

4.2.2 Comfort

Within the existing site and surrounds, wind comfort conditions are suitable for at least strolling or better throughout the year. During summer, most of these areas improve to short-term standing or better.

4.3 Proposed Development within Existing Surrounds

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

4.3.1 Safety

Within the proposed development and around the site, there are no exceedances of the safety criteria for pedestrian activity throughout the year.

4.3.2 Comfort

4.3.2.1 *Thoroughfares*

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

4.3.2.2 *Entrances*

Wind conditions at all entrances to the development are predicted to be suitable for short-term standing or better throughout the year and thus for comfortable pedestrian ingress/egress.

4.3.2.3 *Recreational Spaces*

Wind comfort conditions at the recreational space between Block C and Block D are suitable for recreational activities from spring to autumn. In winter, the conditions are largely suitable for recreational activities however, there is a small area that is only suitable for strolling which coincides with the main throughfare through the area.

4.3.2.4 *Surrounding Area*

Within the existing site and neighbouring surrounds, wind conditions are substantially suitable for strolling or better, and thus suitable for thoroughfare use; and for short-term standing or better at building fronts, and thus for ingress/egress throughout the year.

4.4 Proposed Development within Cumulative Surrounds

The results for the proposed development within cumulative surrounds are presented graphically within Figure 4.10 for safety, and Figure 4.11 and Figure 4.12 for worst-seasonal and summer conditions respectively.

4.4.1 *Safety*

Within the proposed development and around the site, there are no exceedances of the safety criteria for pedestrian activity throughout the year.

4.4.2 *Comfort*

4.4.2.1 *Thoroughfares*

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

4.4.2.2 *Entrances*

Wind conditions at all entrances to the development are predicted to be suitable for short-term standing or better throughout the year and thus for comfortable pedestrian ingress/egress.

4.4.2.3 *Recreational Spaces*

Wind comfort conditions at the recreational space between Block C and Block D are suitable for recreational activities from spring to autumn. In winter, the conditions are largely suitable for recreational activities however, there is a small area that is only suitable for strolling which coincides with the main throughfare through the area.

4.4.2.4 *Surrounding Area*

Within the existing site and neighbouring surrounds, wind conditions are substantially suitable for strolling or better, and thus suitable for thoroughfare use; and for short-term standing or better at building fronts, and thus for ingress/egress throughout the year.

5 Conclusions

The following conclusions have been drawn:

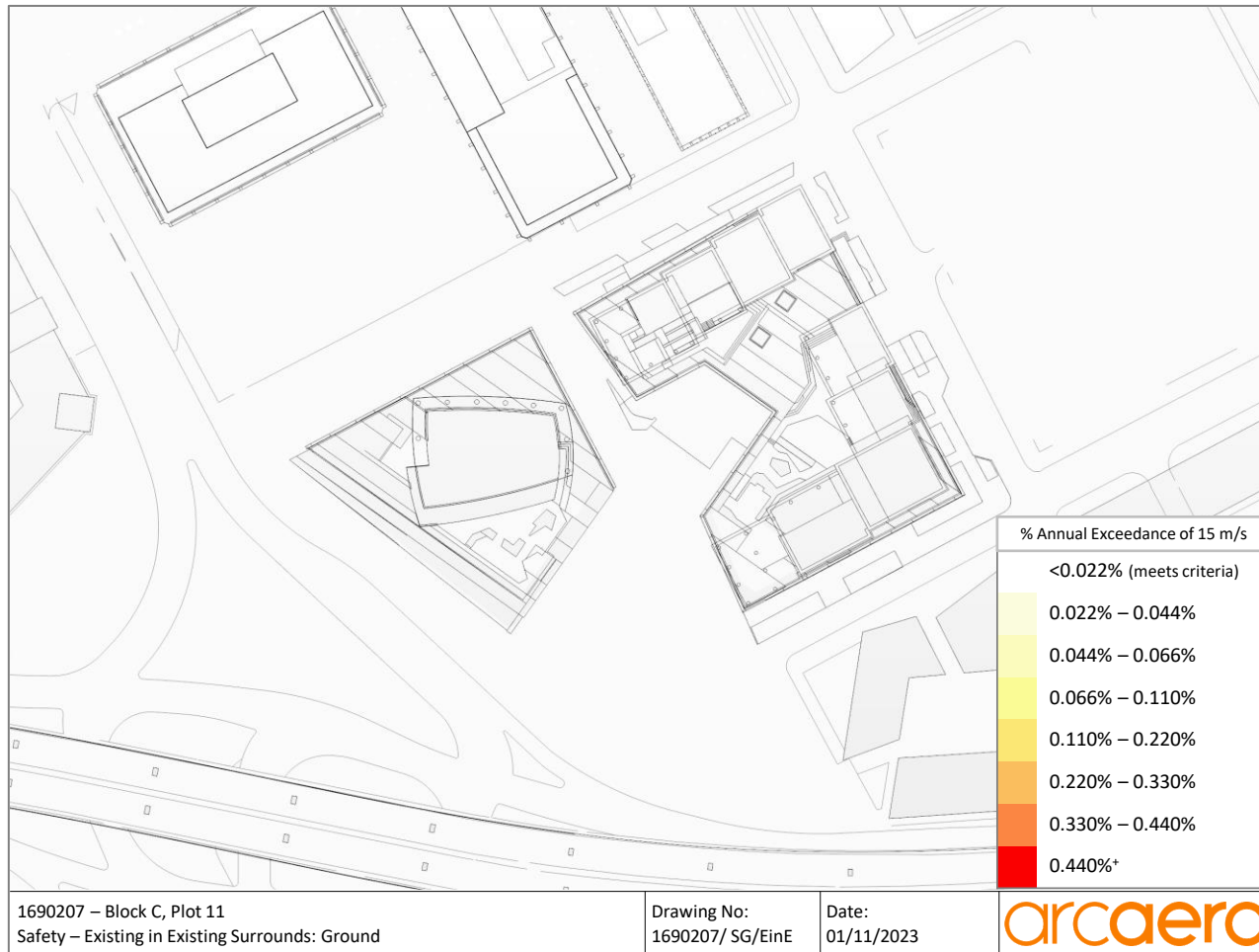
- Wind conditions throughout the existing site and surrounds satisfy the safety and comfort criteria for all uses.
- With the introduction of the proposed development, conditions within the site and surrounds remain within the safety and comfort criteria for all uses.
- Cumulative effects are negligible.

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



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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

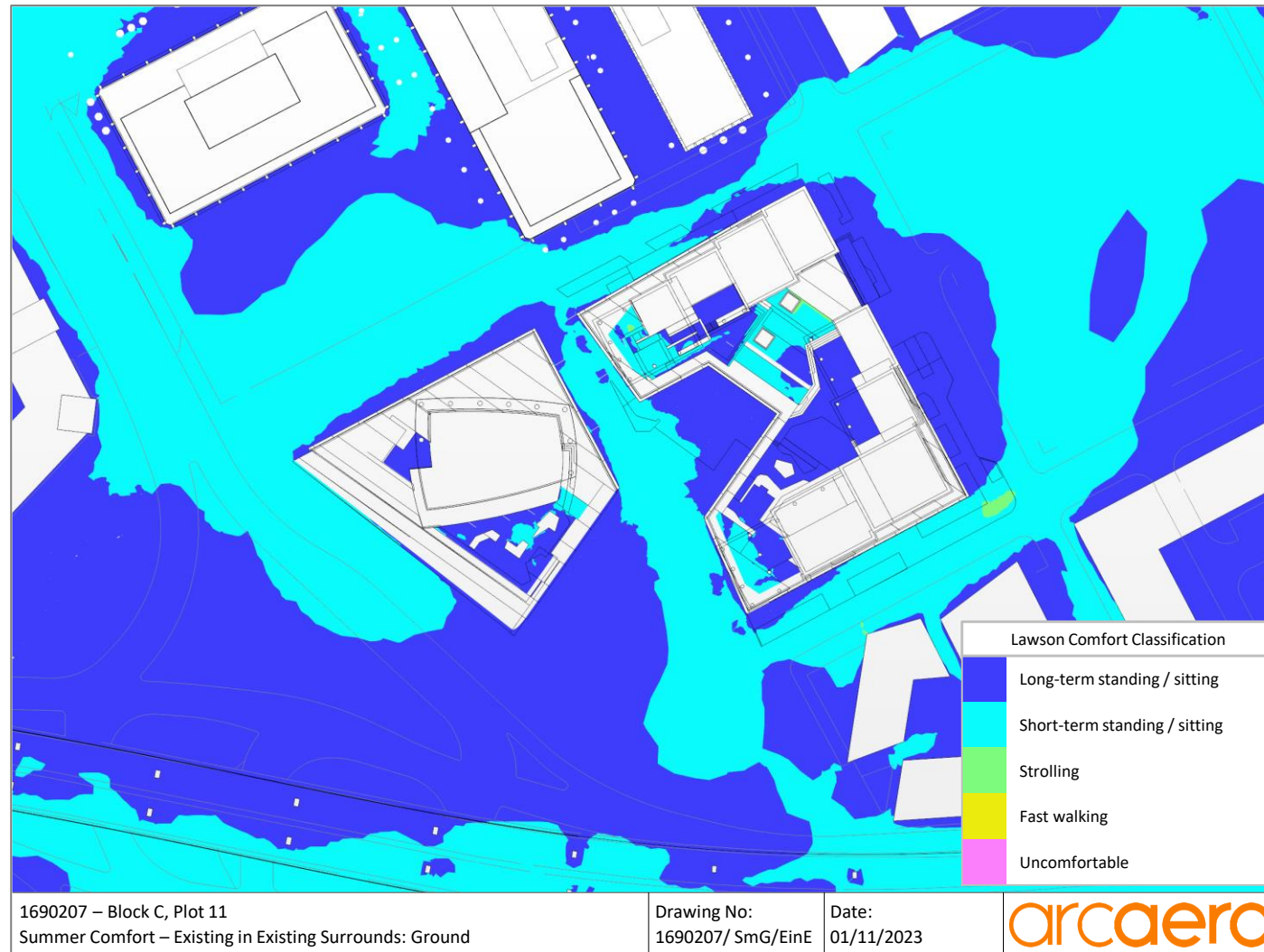


Figure 4.4 – Pedestrian wind conditions, existing site within cumulative surrounds, annual safety

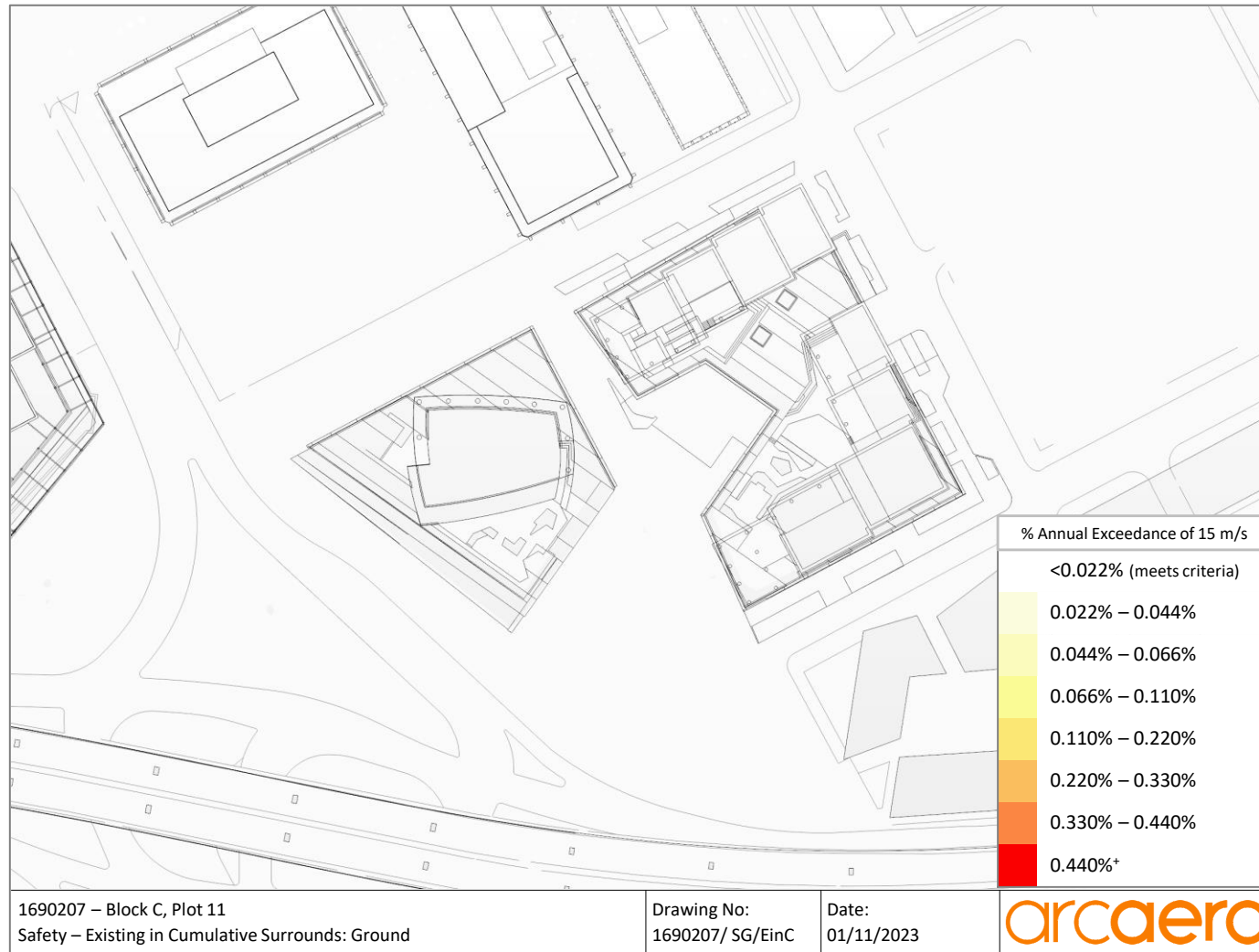


Figure 4.5 – Pedestrian wind conditions, existing site within cumulative surrounds, worst case season

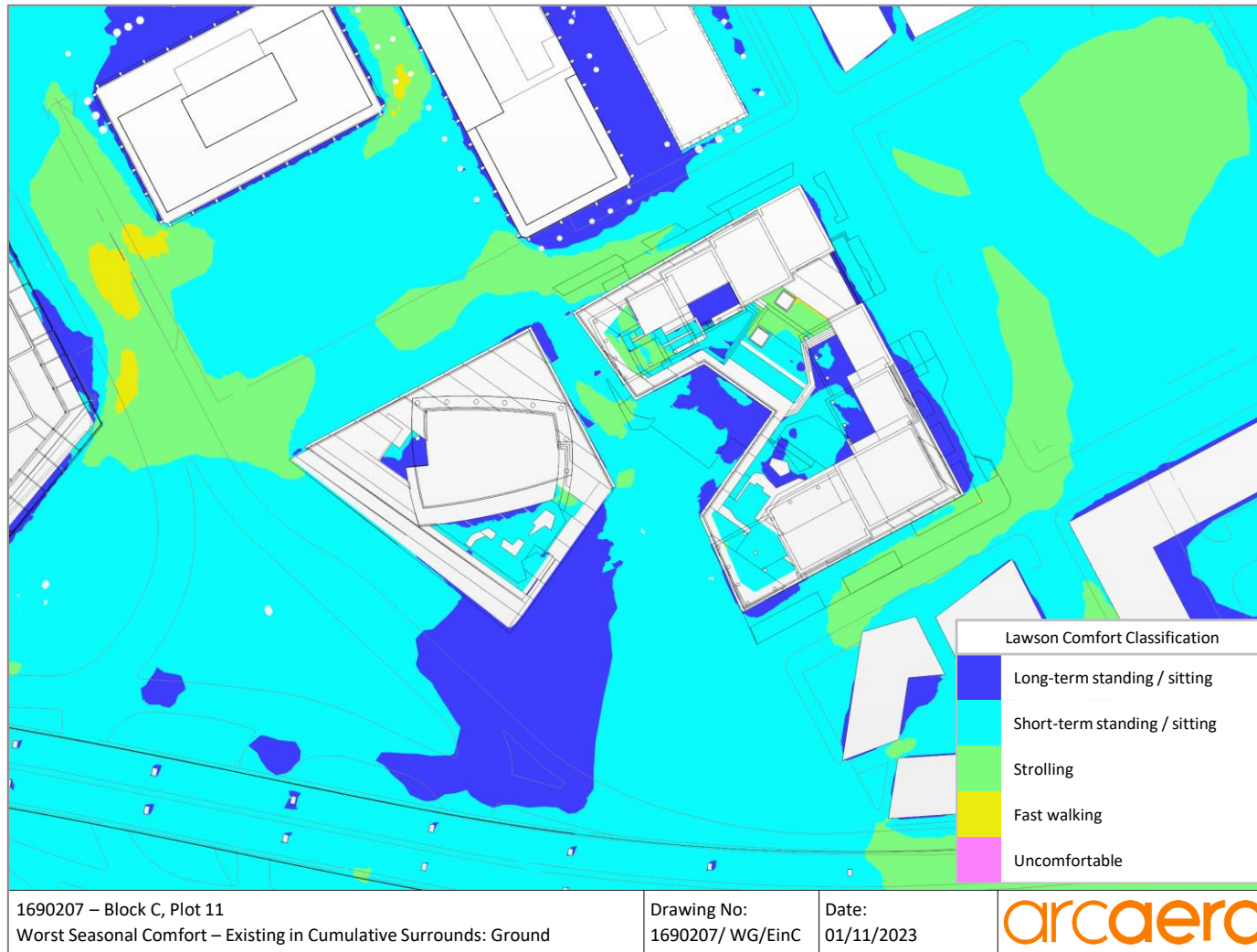


Figure 4.6 – Pedestrian wind conditions, existing site within cumulative surrounds, summer season

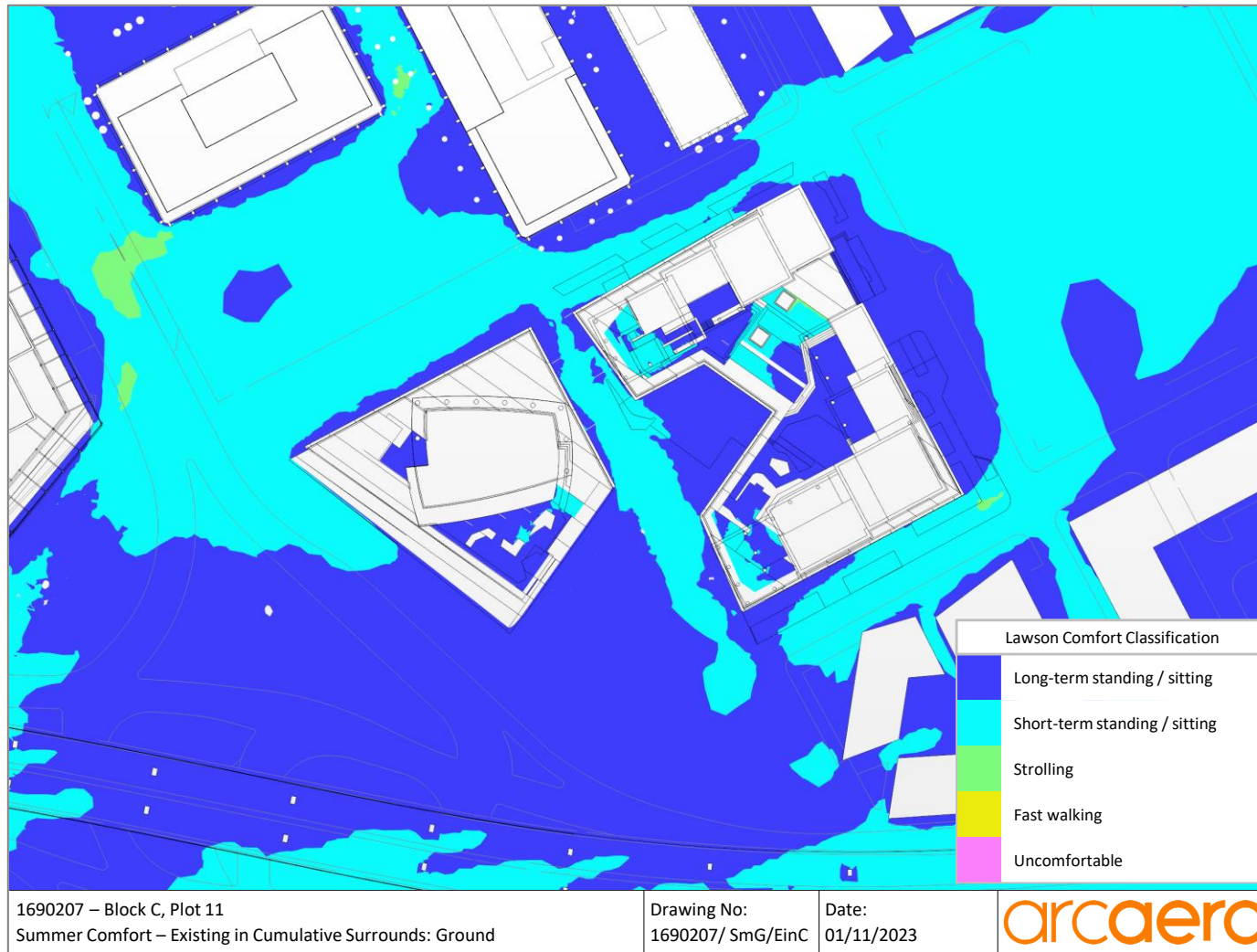


Figure 4.7 – Pedestrian wind conditions, proposed development within existing surrounds, annual safety

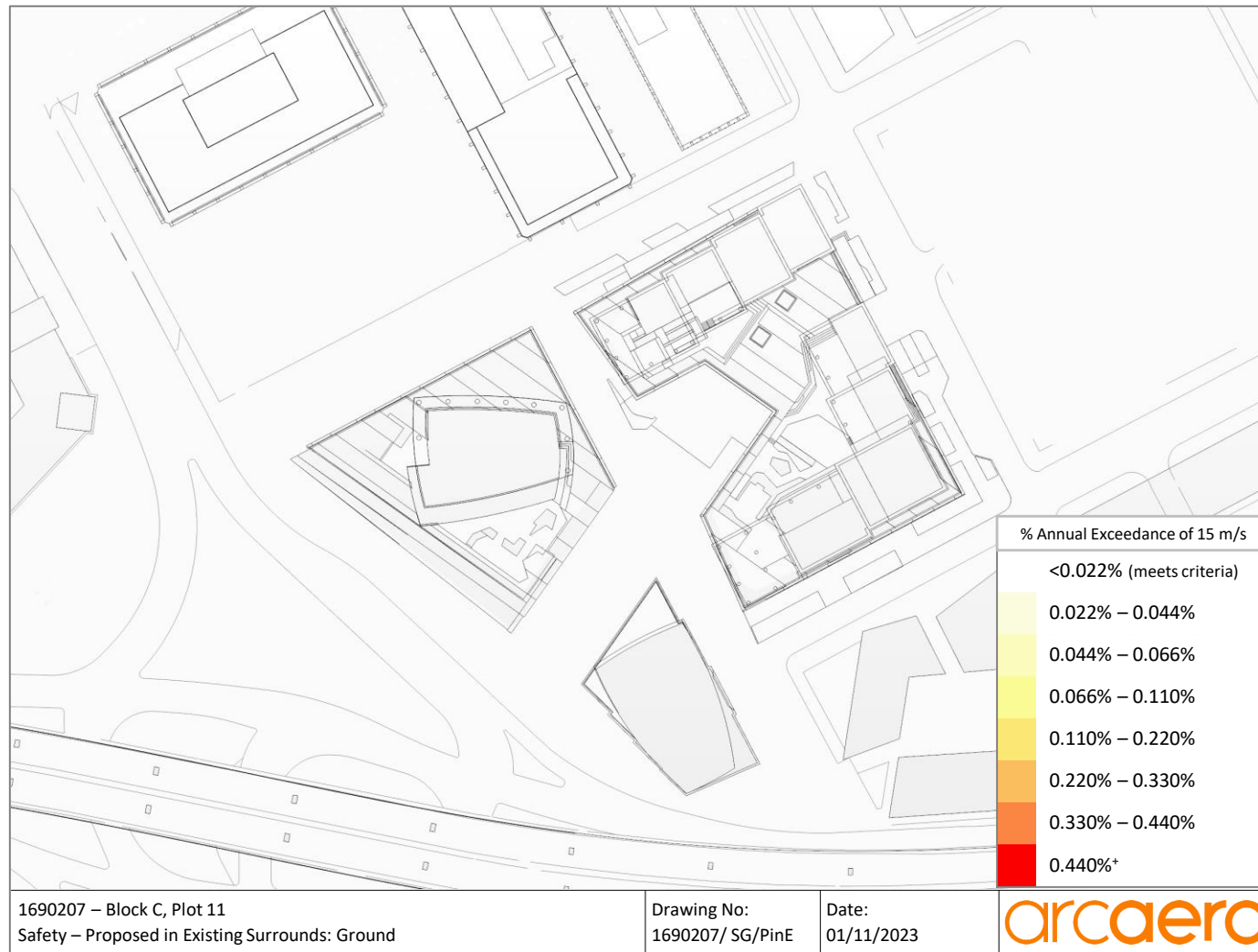


Figure 4.8 – Pedestrian wind conditions, proposed development within existing surrounds, worst case season – ground level

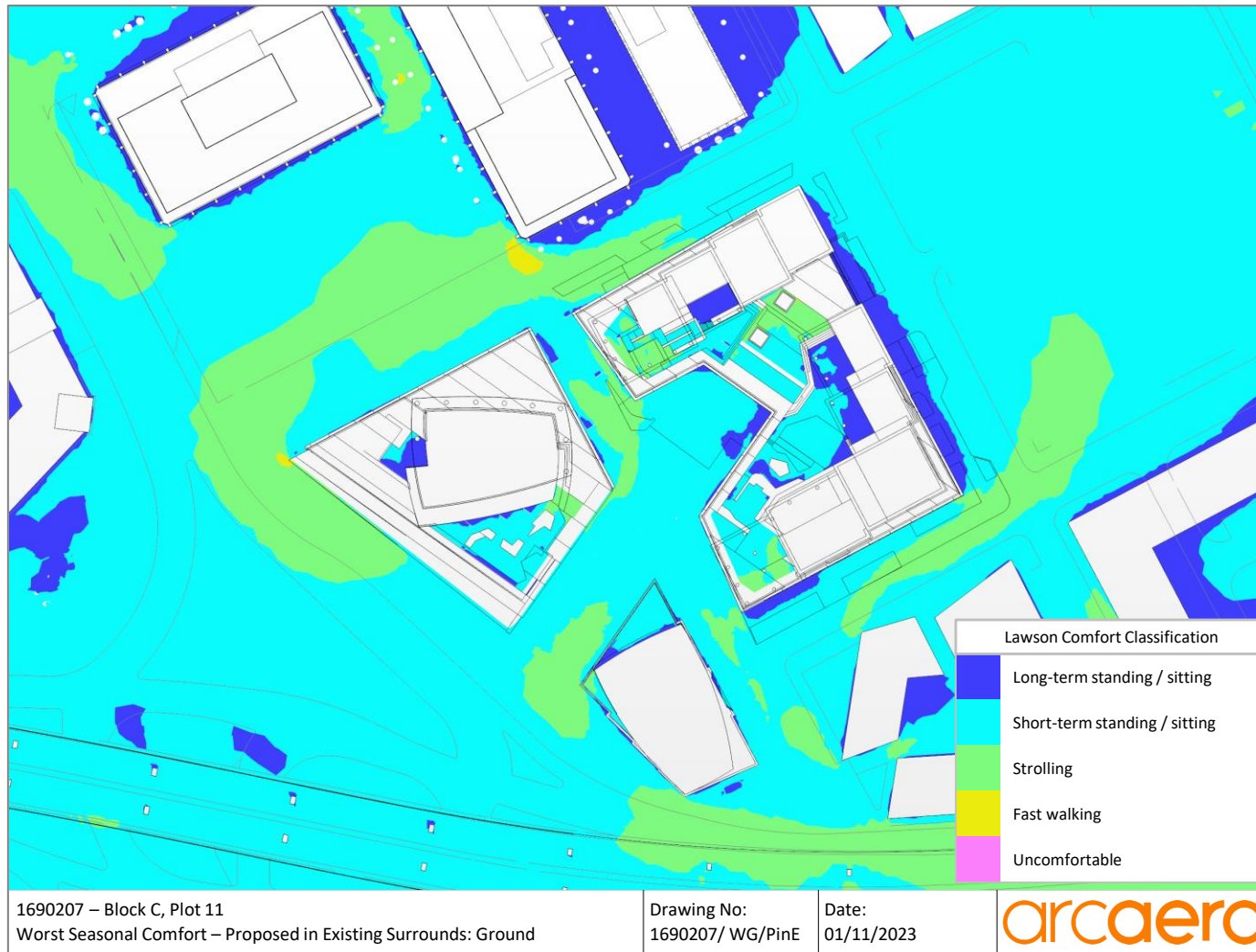


Figure 4.9 – Pedestrian wind conditions, proposed development within existing surrounds, summer season – ground level

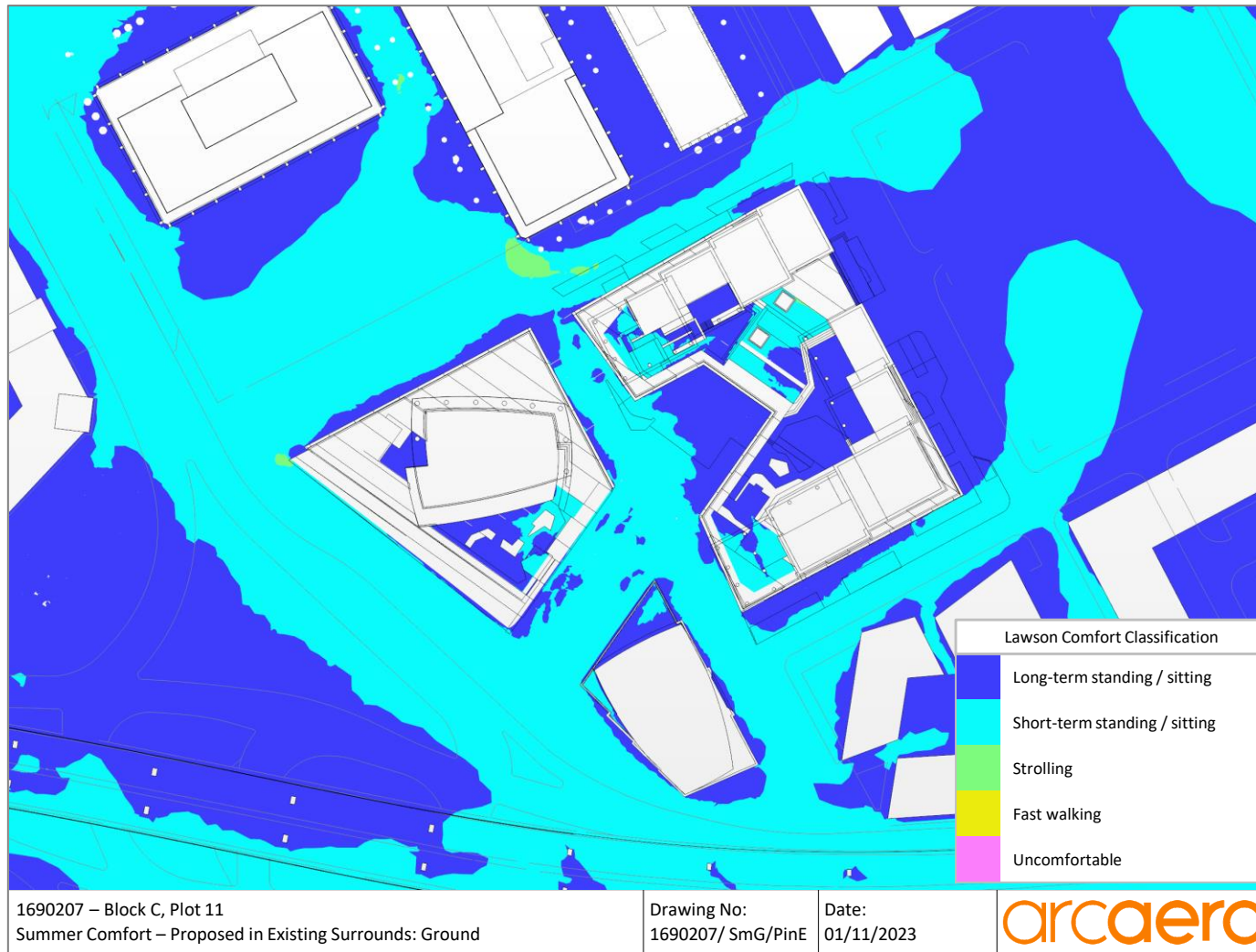


Figure 4.10 – Pedestrian wind conditions, proposed development within cumulative surrounds, annual safety – ground level

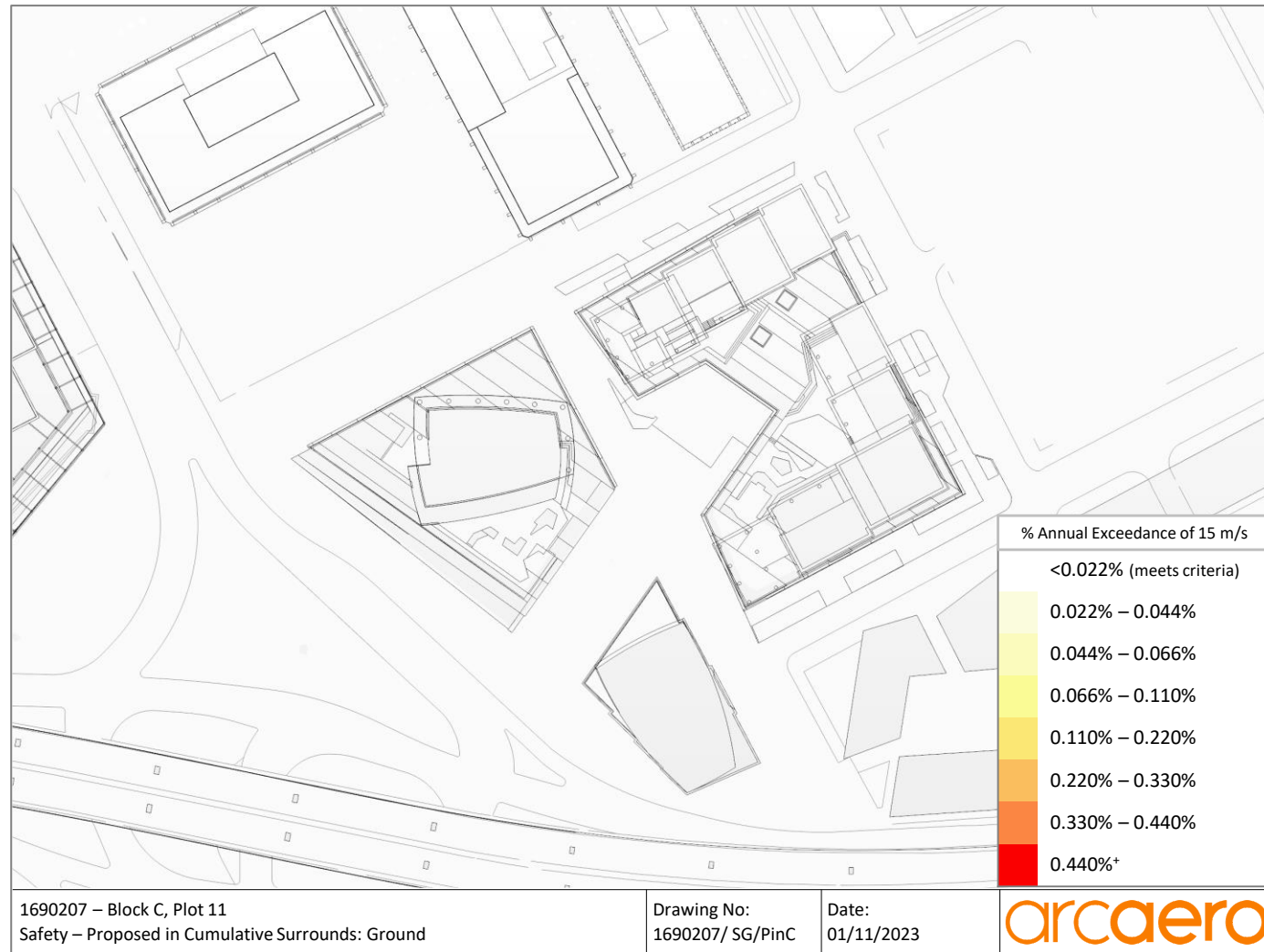


Figure 4.11 – Pedestrian wind conditions, proposed development within cumulative surrounds, worst case season – ground level

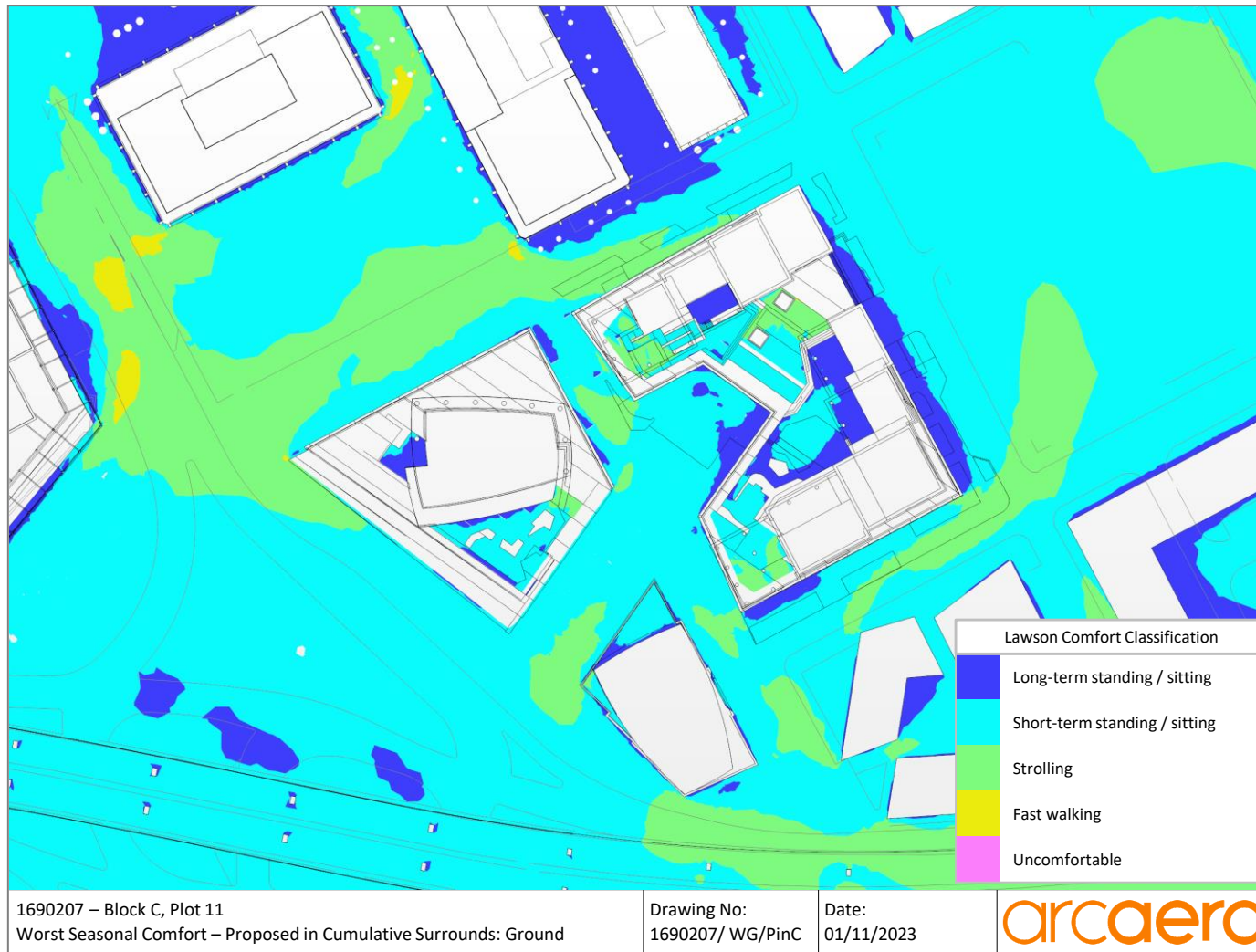
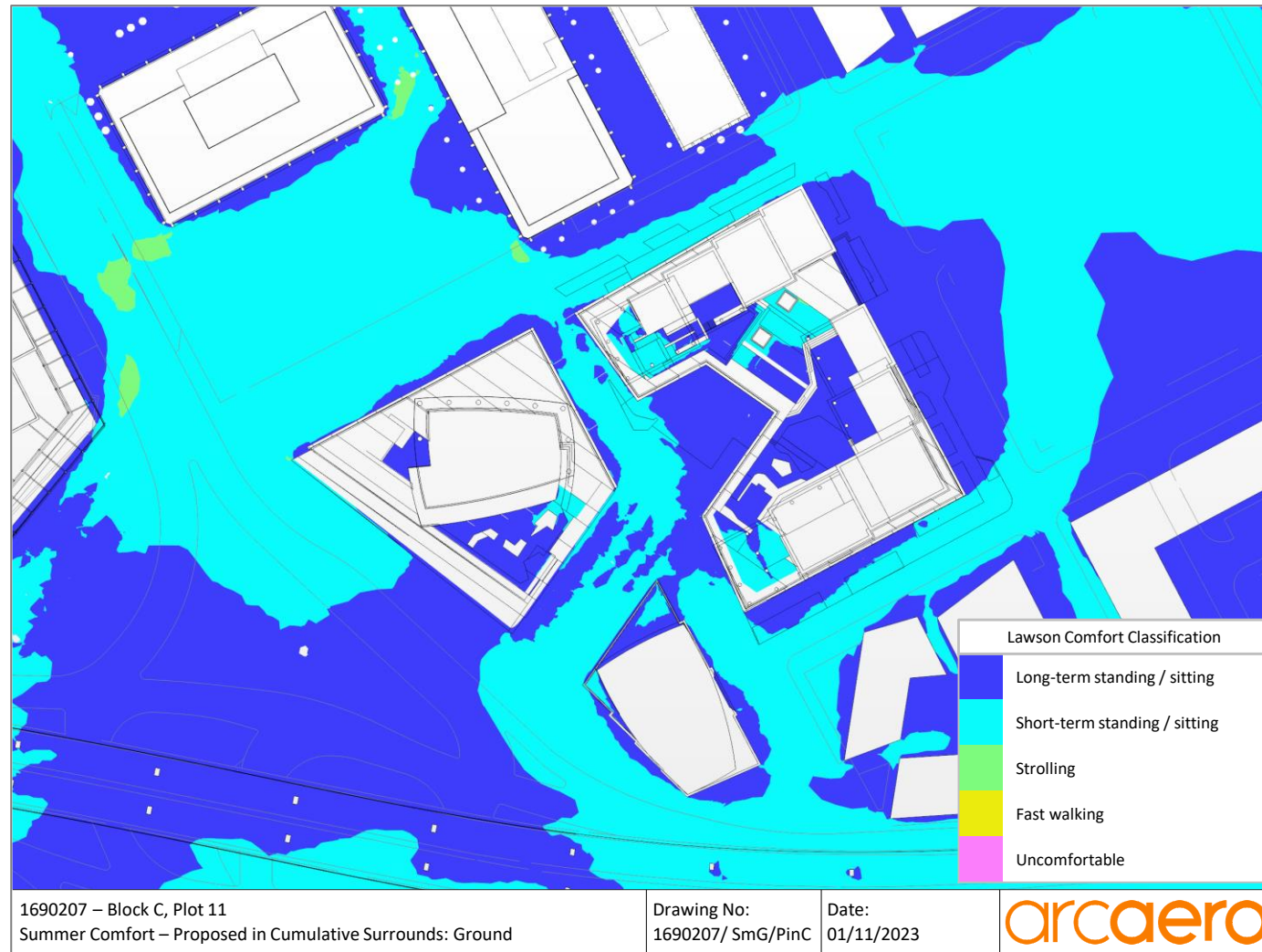


Figure 4.12 – Pedestrian wind conditions, proposed development within cumulative surrounds, summer season – ground level



Appendix A CFD Modelling

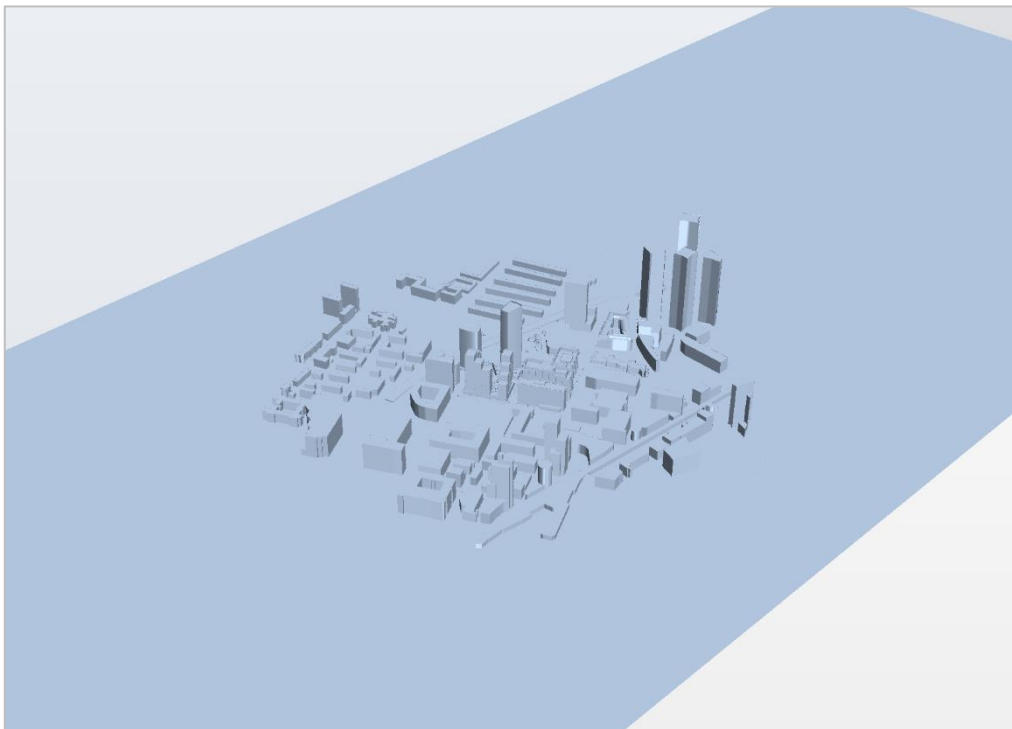
A.1 Spatial discretization

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, 2000m in the across-wind direction, and 1000m 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-ε 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 future surrounds
- Figure B.7 and Figure B.8: Close-ups of the proposed development

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



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

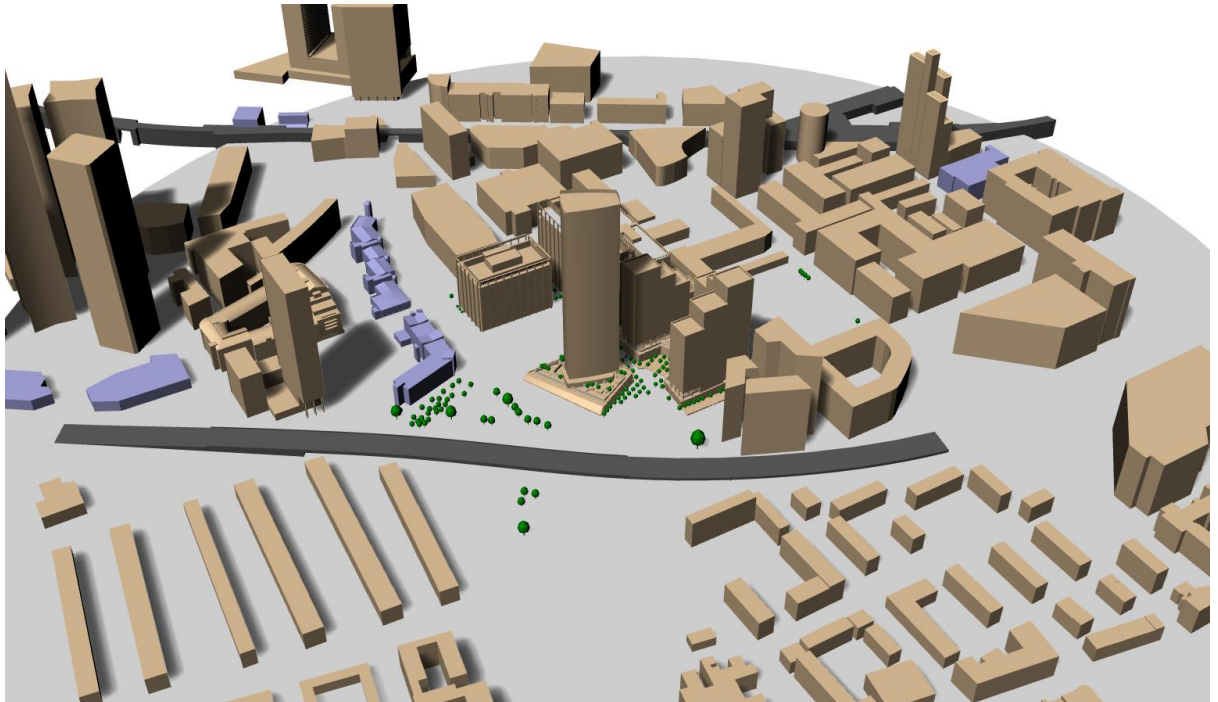


Figure B.3– Proposed development within existing surrounds, viewed from northeast



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

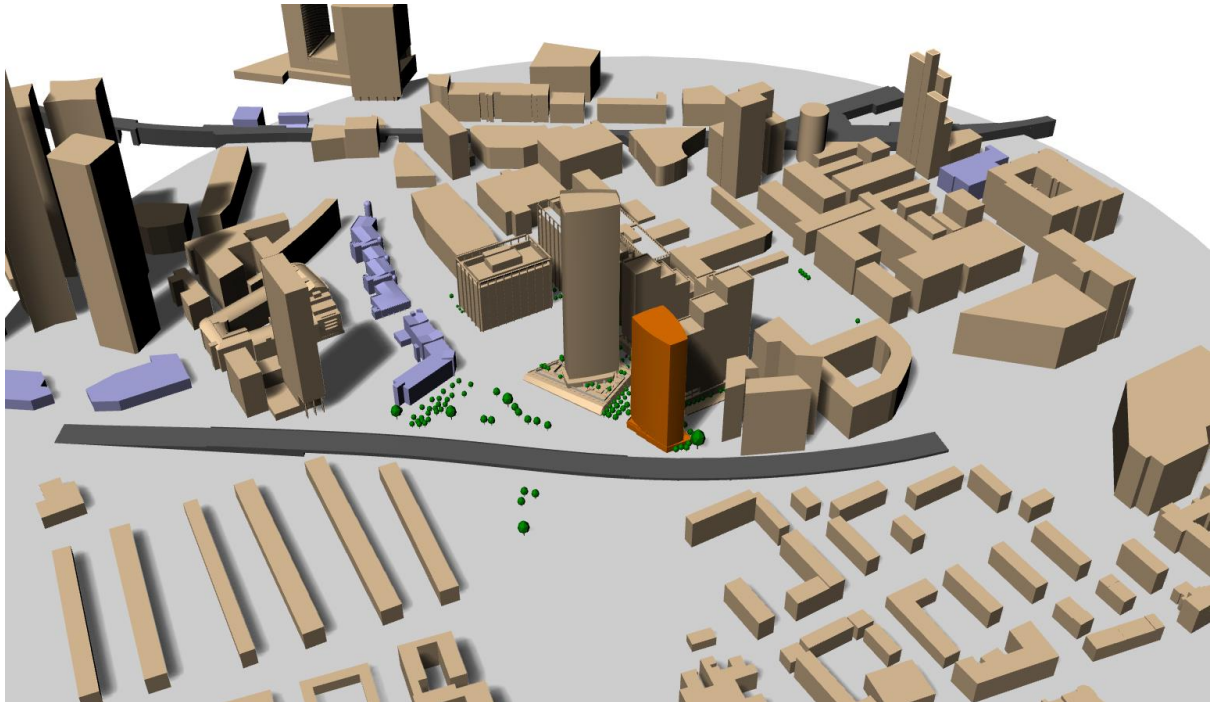


Figure B.5 – Proposed development within cumulative surrounds, viewed from north

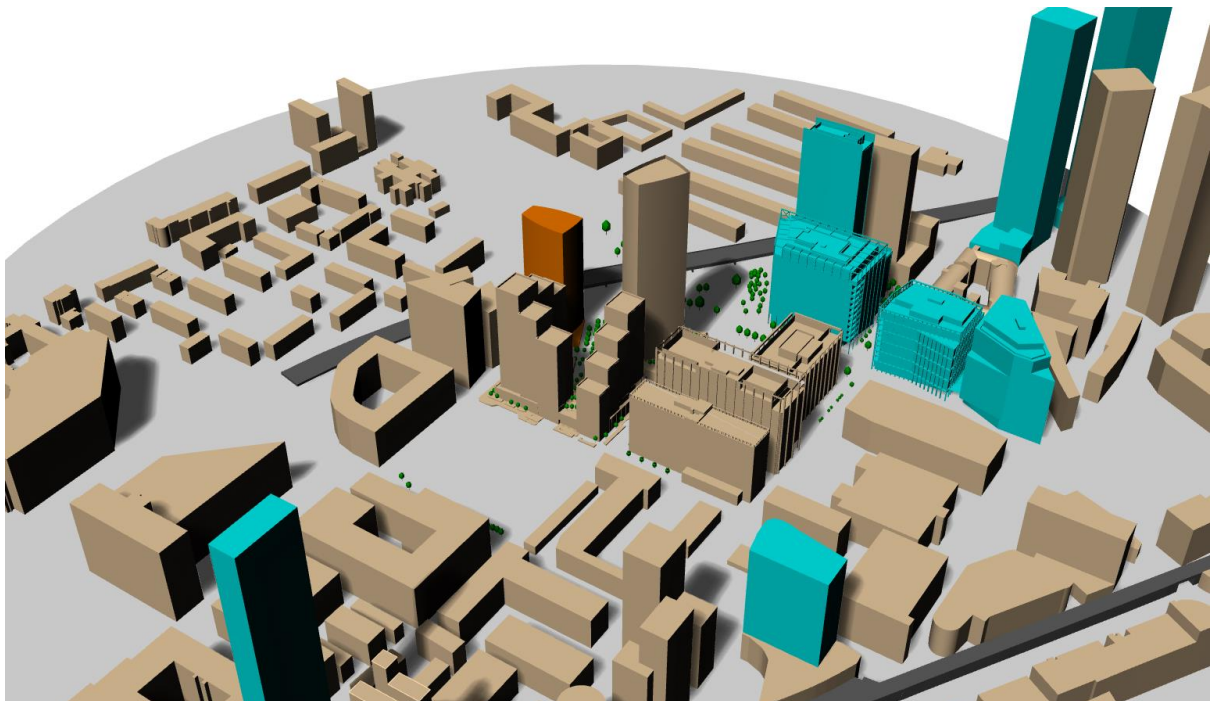


Figure B.6 – Proposed development within cumulative surrounds, viewed from southwest

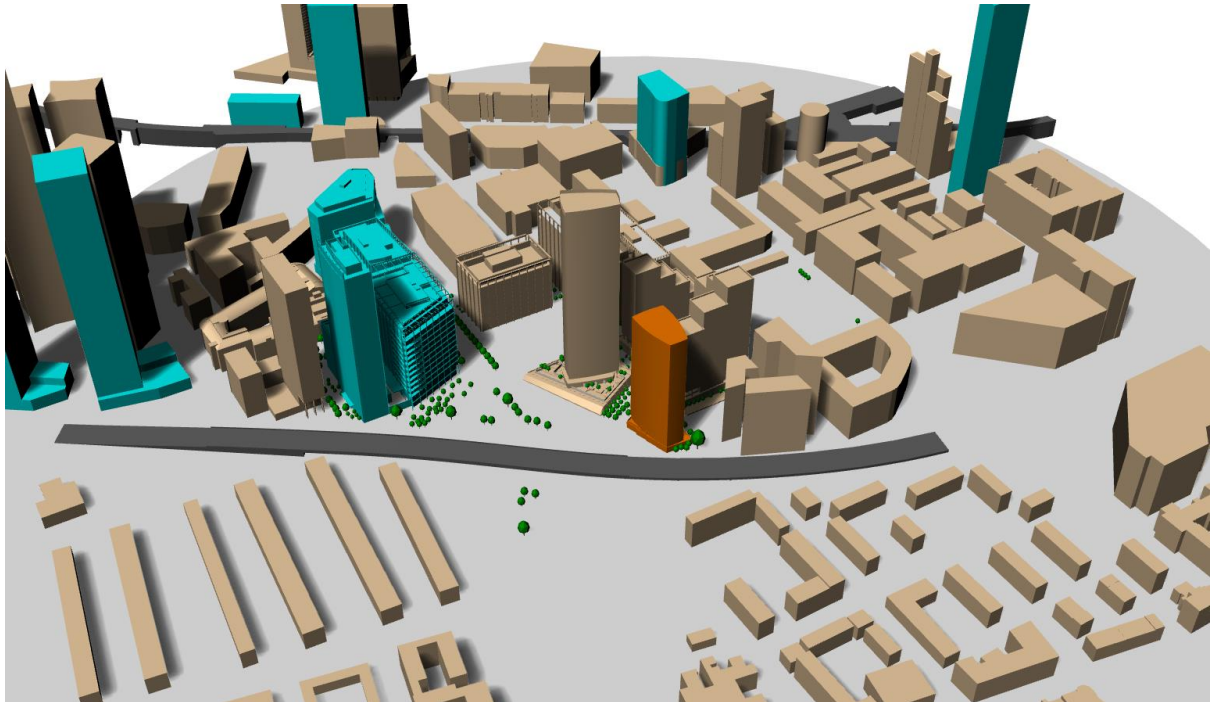


Figure B.7 – Proposed development, close-up from northeast

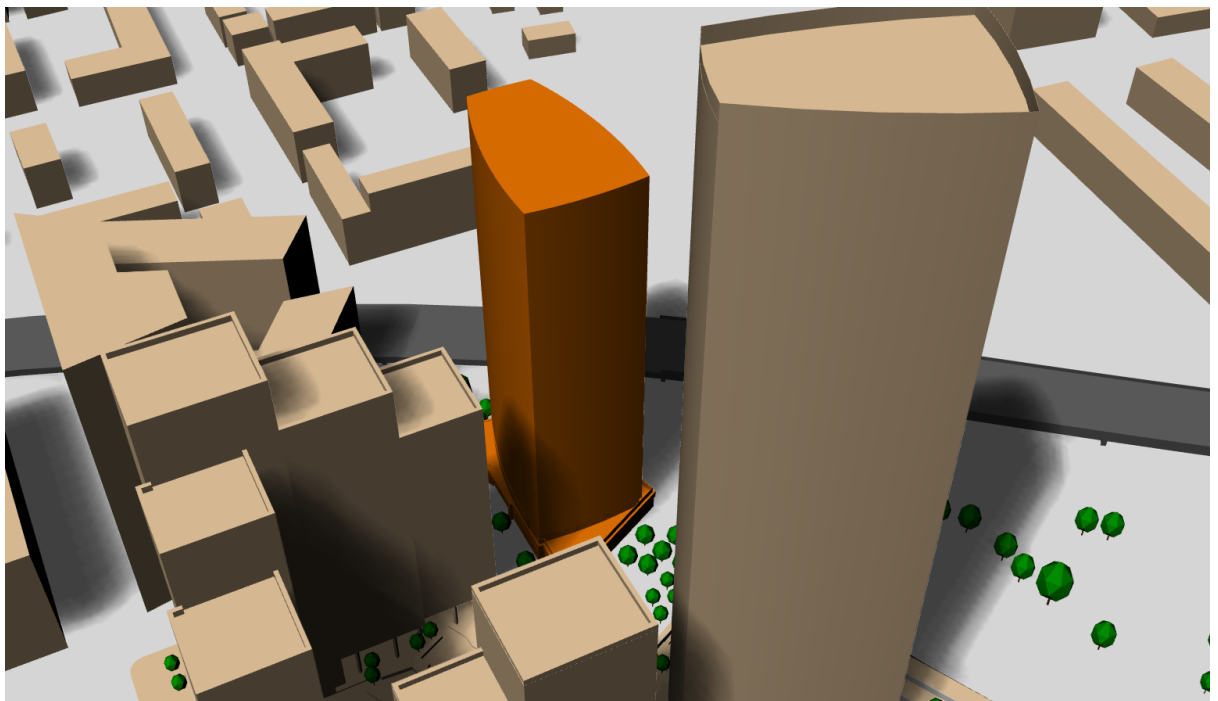


Figure B.8 – Proposed development, close-up from southwest



Appendix C Wind Climate Analysis

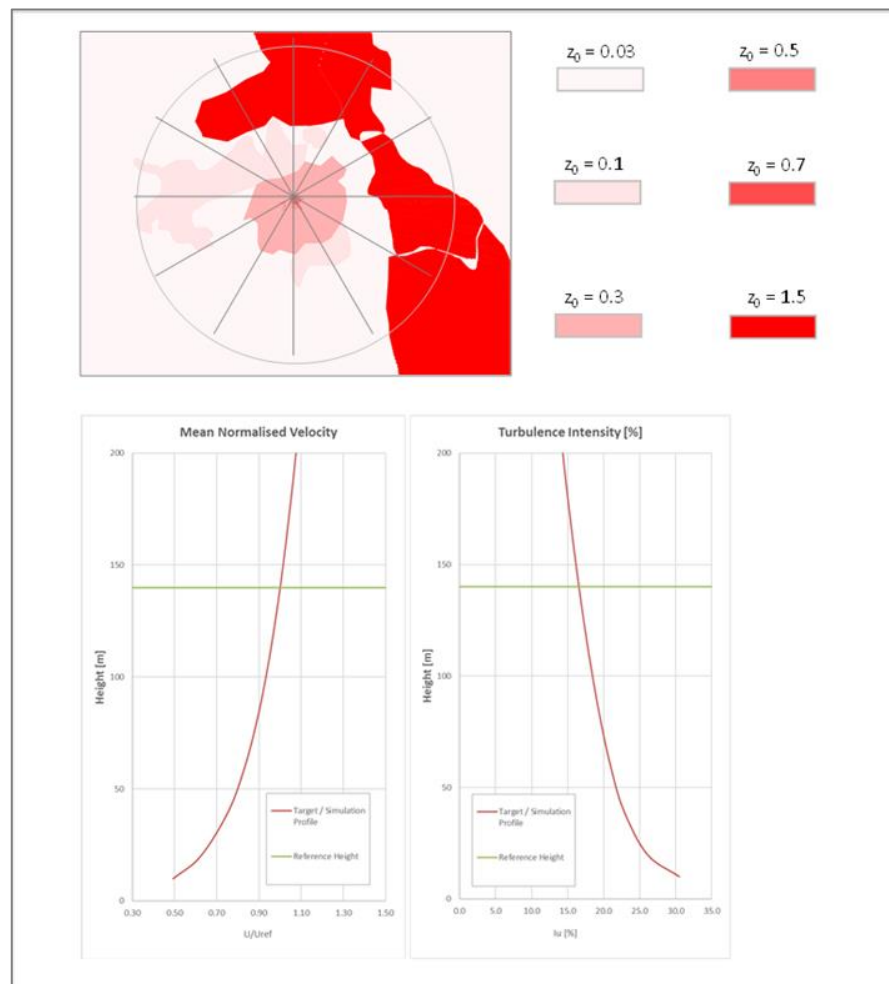
C.1 Surrounding Terrain Assessment

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

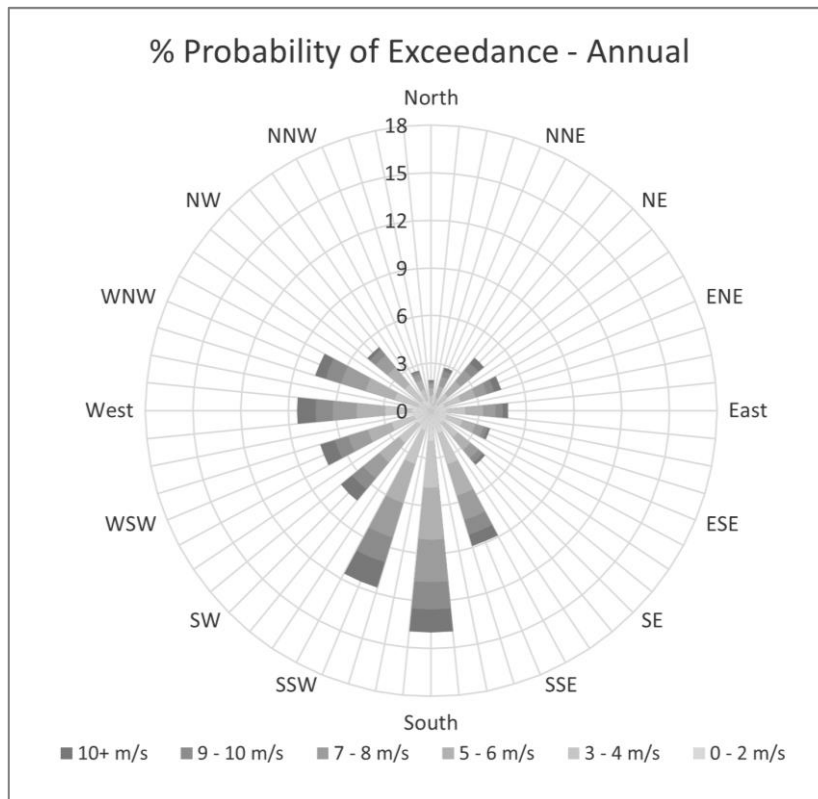


Figure C.3 – Cumulative wind speed probability distribution at site, spring

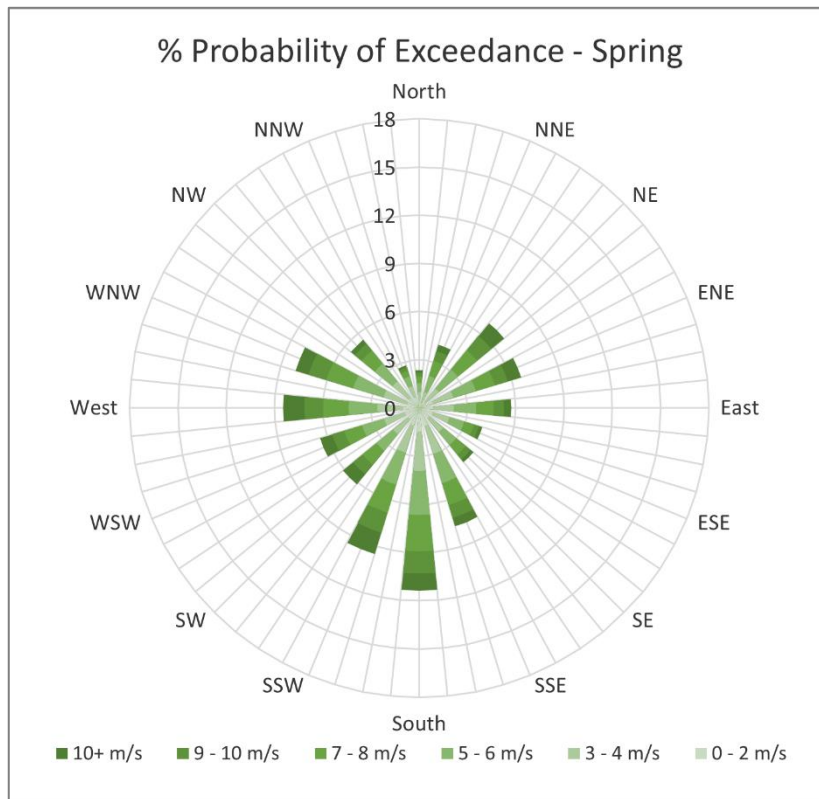


Figure C.4 – Cumulative wind speed probability distribution at site, summer

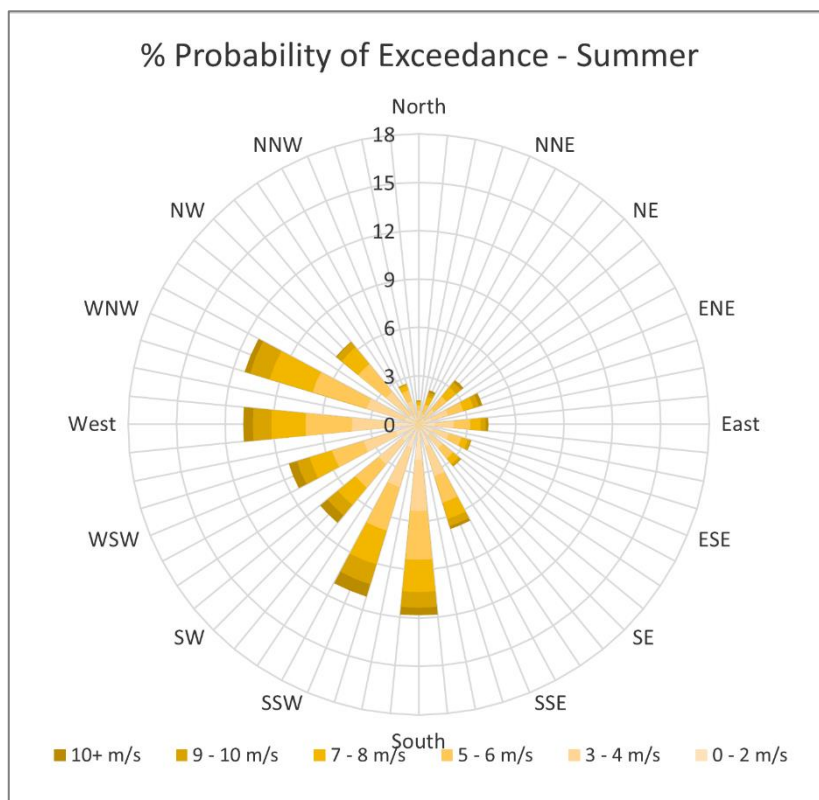


Figure C.5 – Cumulative wind speed probability distribution at site, autumn

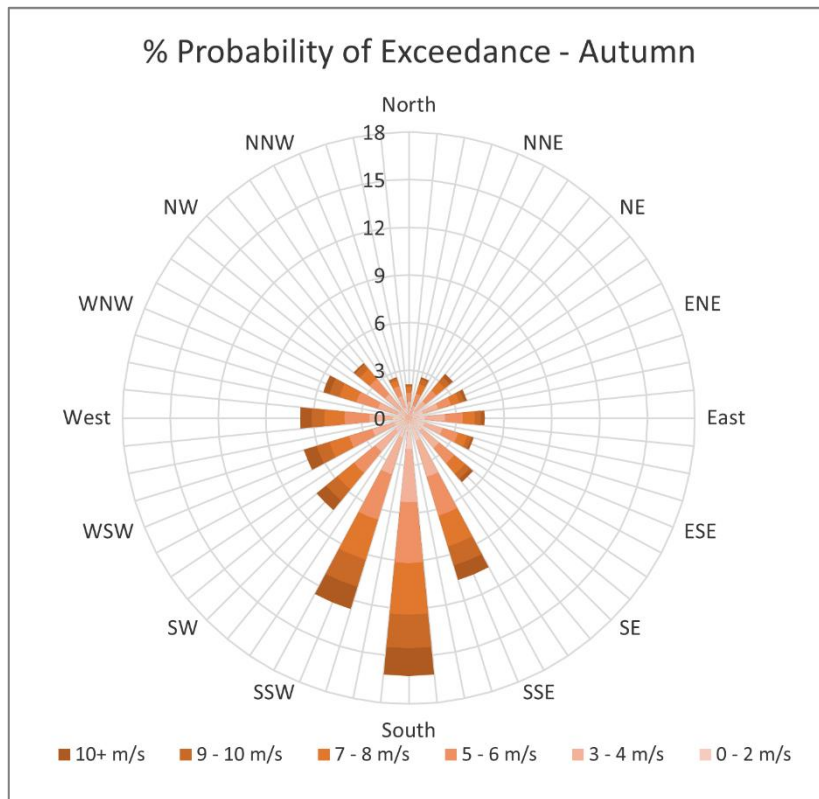


Figure C.6 – Cumulative wind speed probability distribution at site, winter

