



Plot 10a First Street

For

Ask Real Estate Ltd

Wind Microclimate Report

21 September 2022

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Issue History

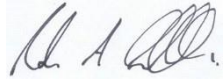
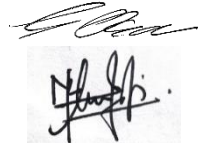
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Executive Summary

Background

A study has been carried out by Architectural Aerodynamics Ltd. (ArcAero) to assess the wind microclimate for the proposed Plot 10a First Street 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:

- Upon introduction of the proposed development wind conditions are expected to meet the safety criteria for all users.
- Wind conditions at the ground level within and around the proposed development are expected to be suitable for planned pedestrian activities.
- Wind conditions on the Level 12 roof terrace are expected to be suitable for a mixture of long-term and short-term sitting during summer. Where suitable for long-term sitting, these conditions would be suitable for an area with permanent seating that would expect considerable use in summer. Where less benign, conditions would be appropriate for a more general amenity space.

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 methods employed in carrying out a CFD study, commissioned by Ask Real Estate Ltd, to assess the wind microclimate for the proposed Plot 10a First Street development in Manchester, UK.

2 The Project

2.1 Site Location

The Site is bound by River Street to the north and east, Hulme Street to the south, and Newcastle Street to the west. There are no permanent structures on the Site. There are no trees on or adjacent to the Site.

Two separate planning applications for Plot 10a and Plot 10b are being brought forward for planning at the same time. These sites can be described as follows:

- Plot 10a: bound by River Street to the north, development Plot 10b to the east, Hulme Street to the south, and Medlock Street to the west.
- Plot 10b: bound by River Street to the north and east, Hulme Street to the south, and development Plot 10a to the west.

2.2 The Proposed Development

The redevelopment of Plot 10 would involve a change to the previously envisaged layout of Plot 10 (as detailed in the 2018 First Street SDF) to deliver two parallel linear blocks, Plot 10a and Plot 10b:

- Plot 10a would be progressed to deliver a sustainable office building fronting onto First Street.
- Plot 10b would be progressed by Vita to deliver a purpose-built student accommodation scheme, with a ground floor food market hall.

2.3 Soft Landscaping

The wind microclimate has been assessed for the proposed development with current soft landscaping proposals for Plot 10a and surrounding landscaping. Soft landscaping proposals for Plot 10a were supplied by Planit, the landscape architects for Plot 10a, in the form of the following drawing:

- PL1471.1-PLA-ZZ-00-DR-L-000002, dated 11th July 2022.

2.4 Committed Developments

A number of committed developments have been considered in the assessment, either within the baseline (existing) surrounding context, or as cumulative developments that have been granted planning consent. These schemes are presented in tabular format in Table 2-1 and Table 2-2.

Table 2-1 – Developments considered within the baseline context

Development Name	Planning Reference
Plot 11, First Street	125573/FO/2019
John Dalton West Building	125799/FO/2019
Barclay House	118033/P3OPA/2017
70 Great Bridgewater Street	129081/FO/2021
Vision, Whitworth Street West	111003/FO/2016/C1
Viadux	115871/FO/2017
Plot 9a First Street	132600/FO/2021

Table 2-2 – Developments considered within the cumulative context

Development Name	Planning Reference
One City Road	128002/FO/2020
Hotspur House	120635/FO/2018
Park Place	129273/FO/2021
GJS Plot F	132199/FO/2021
Student Castle	121252/FO/2018
Travelodge Deansgate Locks	126308/FO/2020
Apex Tower	133172/FO/2022
Transition	116850/FO/2017

2.5 Assessment Scenarios

The scenarios assessed within the current study are as follows:

- Baseline conditions
- Baseline + Plot 10a
- Baseline + Plot 10a + cumulative

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 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, wind conditions meet the criteria for pedestrian safety.

4.1.2 Comfort

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

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 for worst-seasonal and Figure 4.7 and Figure 4.8 for summer comfort respectively.

4.2.1 Safety

With the introduction of the proposed development within existing surroundings, wind conditions meet the criteria for pedestrian safety.

4.2.2 Comfort

The introduction of the proposed development generally yields an improved wind microclimate, relative to the conditions that exist for the existing site.

4.2.2.1 Thoroughfares

Wind conditions at all thoroughfares within the site are predicted to be suitable for at least strolling throughout the year and thus suitable for pedestrian access to and passage through the site.

4.2.2.2 Entrances

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

4.2.2.3 Recreational Spaces

Wind conditions within the landscaped area between Plots 9 and 10a are suitable for short-term standing during summer, suitable therefore, for general recreational uses in summer.

Wind conditions within the level 12 roof terrace are suitable in part, for long-term sitting, during summer, and otherwise suitable for short-term sitting. Where suitable for long-term sitting, these conditions would be suitable for an area with permanent seating that would expect considerable use in summer. Where less benign, conditions would be appropriate for a more general amenity space.

4.2.2.4 *Surrounding Area*

Wind conditions within the surrounding area are expected to remain substantially suitable for strolling or better, and thus for thoroughfare use; and for short-term standing or better at building fronts, and thus for ingress / egress.

4.3 Proposed Development within Future Surrounds

The results for the proposed development within future surrounds are presented graphically within Figure 4.9 and Figure 4.10 for safety, Figure 4.11 for worst-seasonal and Figure 4.12 and Figure 4.13 for summer comfort respectively.

4.3.1 *Safety*

With the introduction of the proposed development within cumulative surroundings, wind conditions meet the criteria for pedestrian safety.

4.3.2 *Comfort*

4.3.2.1 *Thoroughfares*

Wind conditions on thoroughfares within the site are predicted to be substantially suitable for strolling throughout the year and thus suitable 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 standing or better throughout the year and thus comfortable for pedestrian ingress / egress.

4.3.2.3 *Recreational Spaces*

Wind conditions within the landscaped area between Plots 9 and 10a are suitable for short-term standing during summer, suitable therefore, for general recreational uses in summer.

Wind conditions within the level 12 roof terrace are quite substantially suitable for long-term sitting, during summer, and otherwise suitable for short-term sitting.

4.3.2.4 *Surrounding Area*

Wind conditions within the surrounding area are expected to remain substantially suitable for strolling or better, and thus for thoroughfare use; and for short-term standing or better at building fronts, and thus for ingress / egress.

5 Conclusions

The following conclusions have been drawn:

- Upon introduction of the proposed development wind conditions are expected to meet the safety criteria for all users.
- Wind conditions at the ground level within and around the proposed development are expected to be suitable for planned pedestrian activities.
- Wind conditions on the Level 12 roof terrace are expected to be suitable for a mixture of long-term and short-term sitting during summer. Where suitable for long-term sitting, these conditions would be suitable for an area with permanent seating that would expect considerable use in summer. Where less benign, conditions would be appropriate for a more general amenity space.

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-seasonal comfort

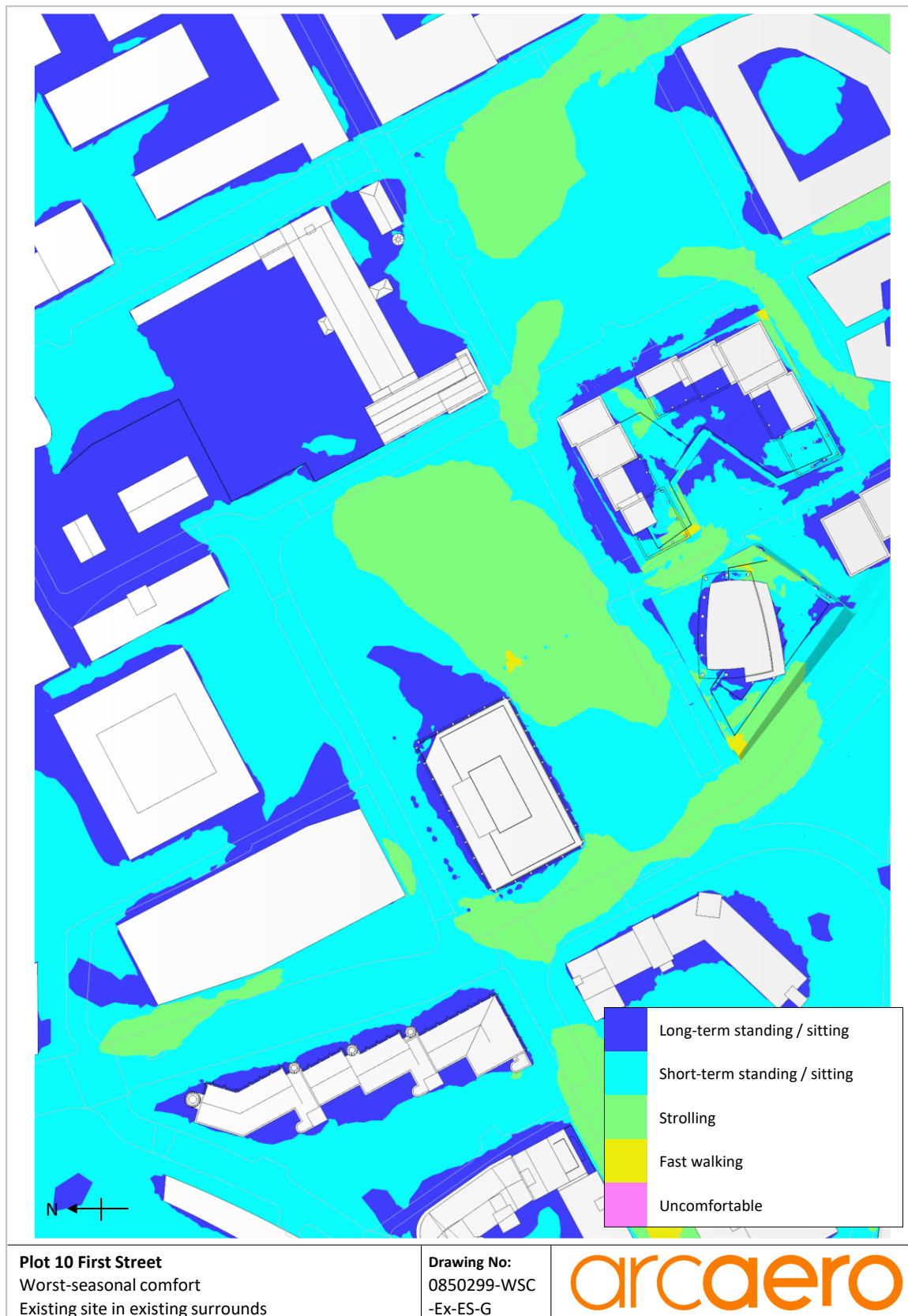


Figure 4.3 – Pedestrian wind conditions, existing site within existing surrounds, summer comfort

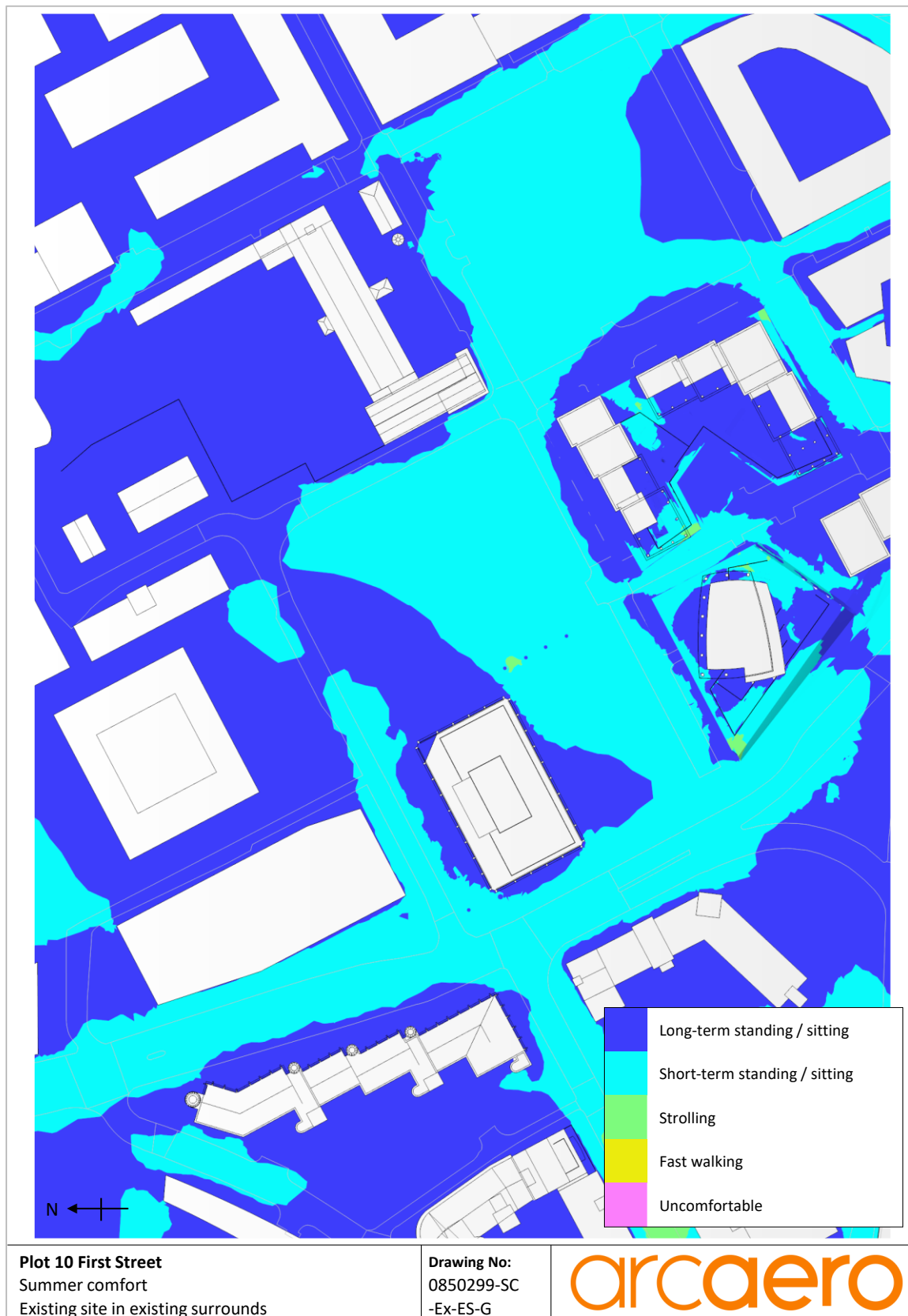


Figure 4.4 – Proposed development within existing surrounds, annual safety, ground



Figure 4.5 – Proposed development within existing surrounds, terrace-level safety

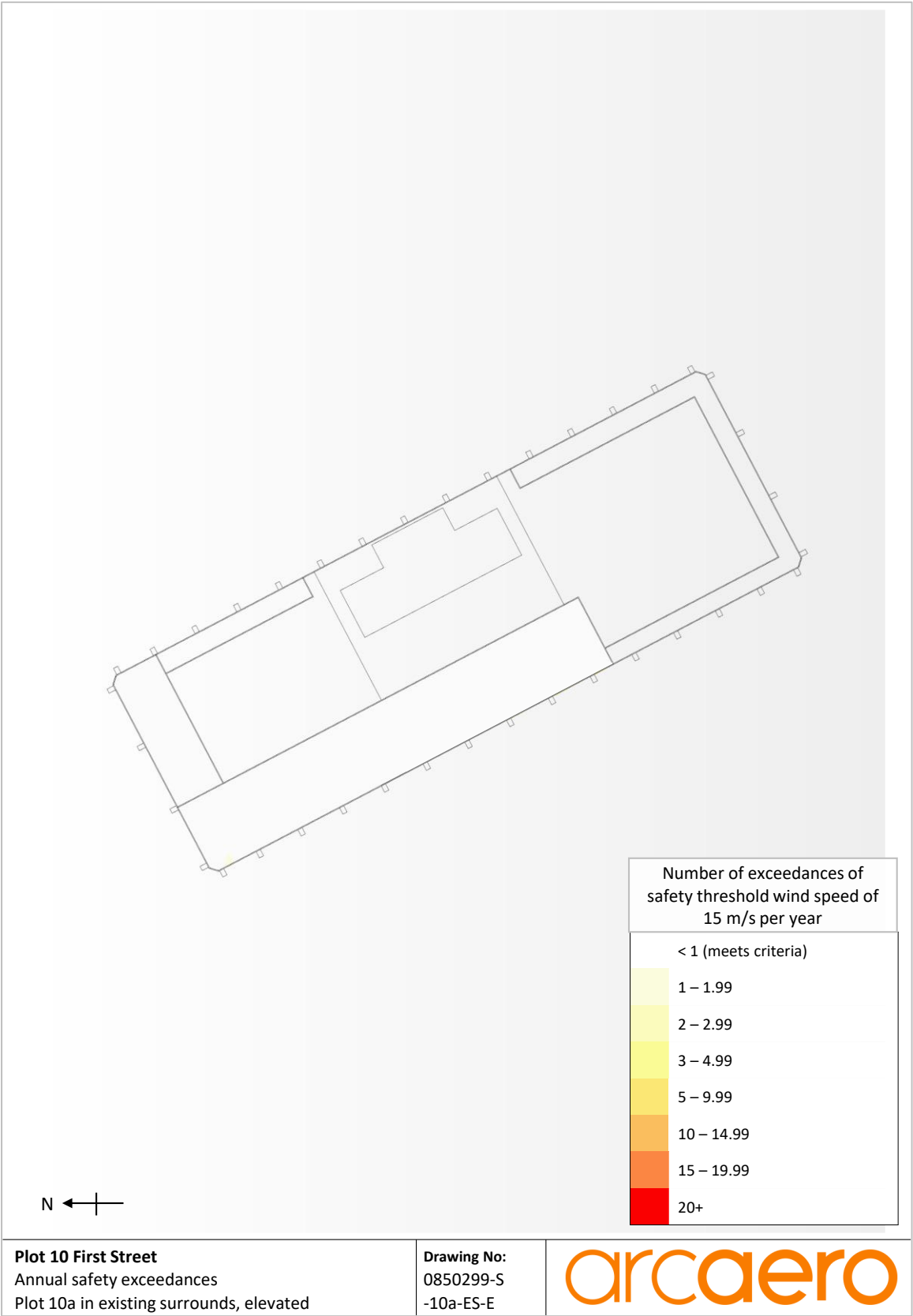


Figure 4.6 – Proposed development within existing surrounds, worst-seasonal comfort, ground

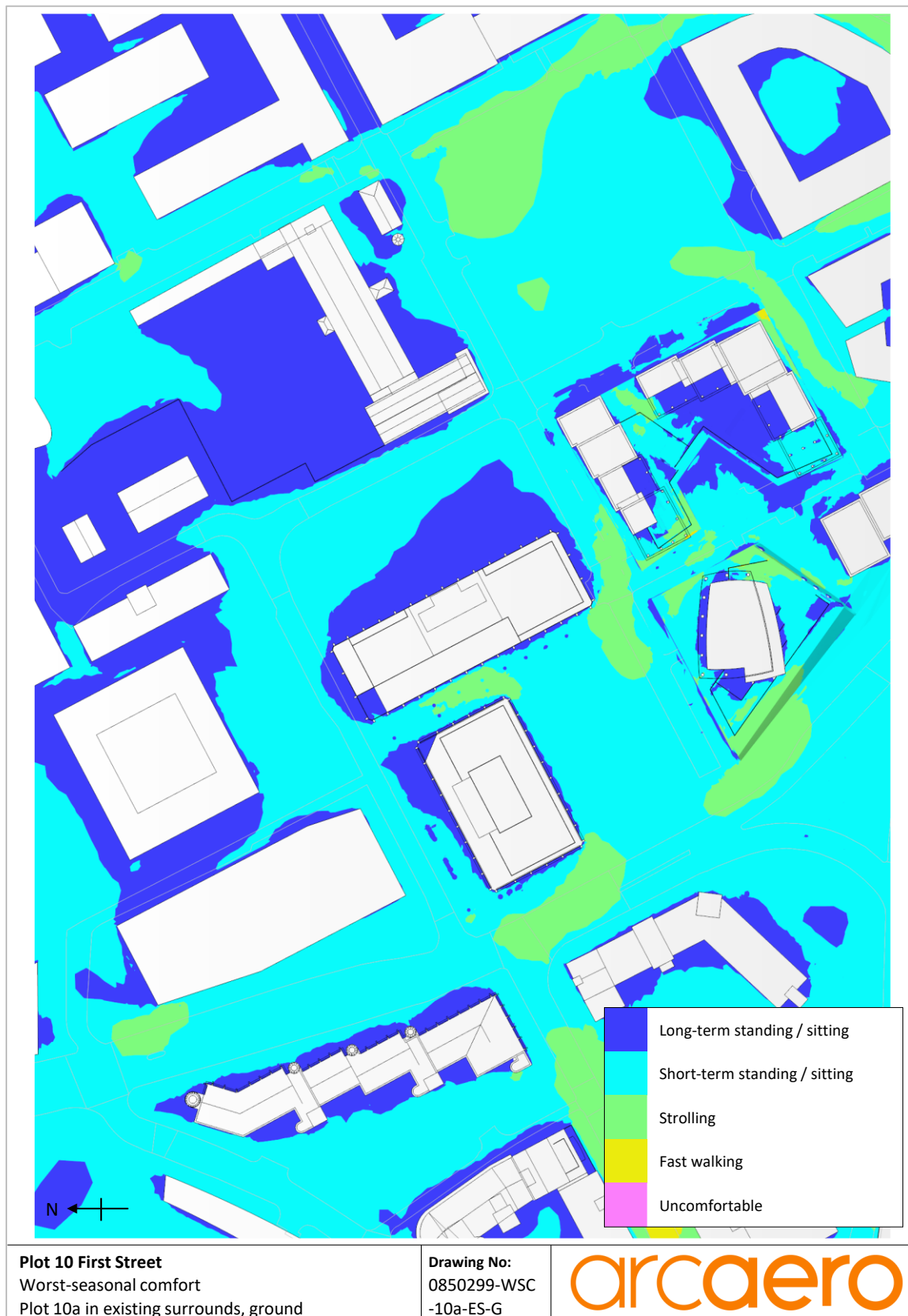


Figure 4.7 – Proposed development within existing surrounds, summer comfort, ground

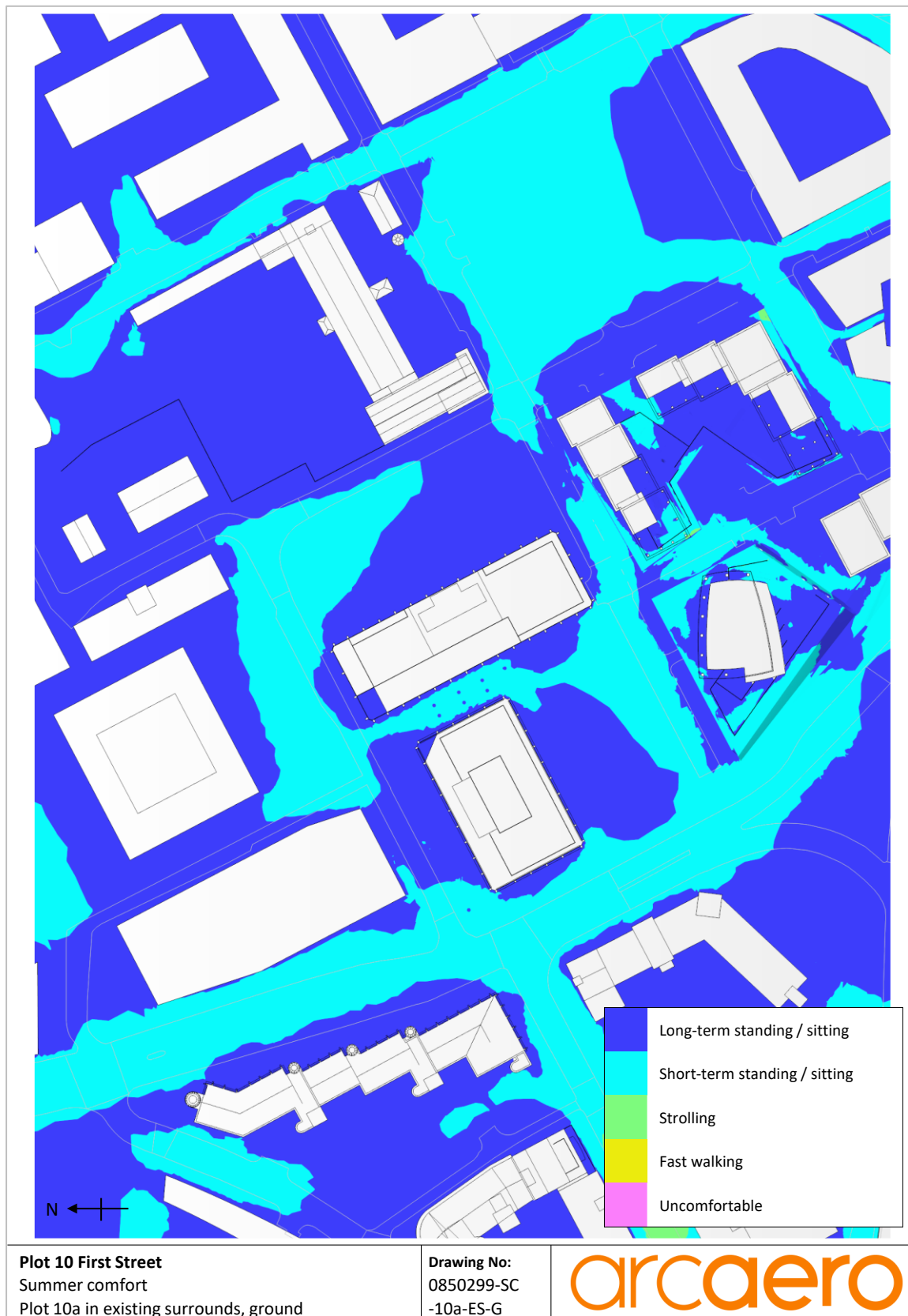


Figure 4.8 – Proposed development within existing surrounds, summer comfort, terrace level

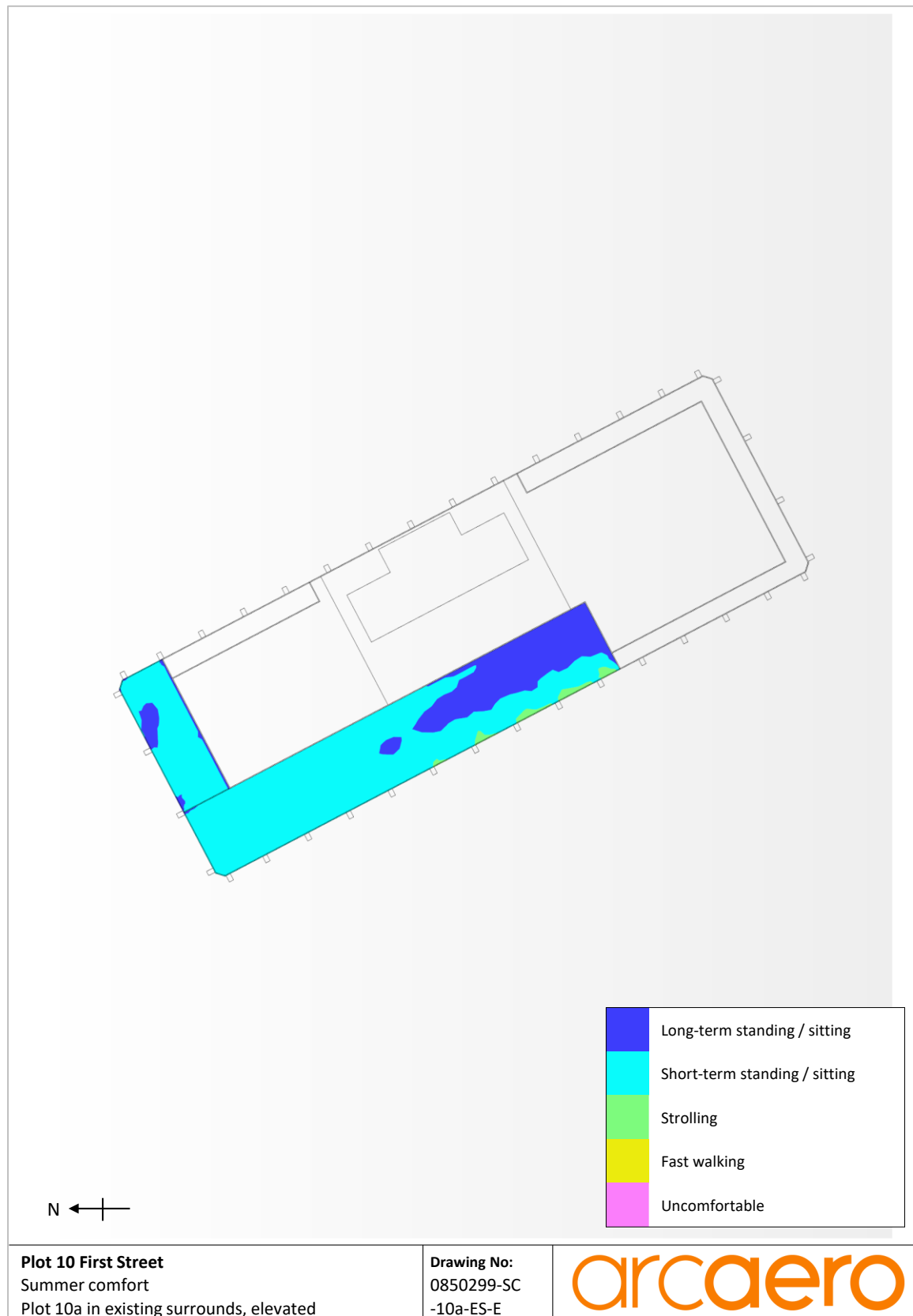


Figure 4.9 – Proposed development within cumulative surrounds, annual safety, ground



Figure 4.10 – Proposed development within cumulative surrounds, annual safety, terrace level

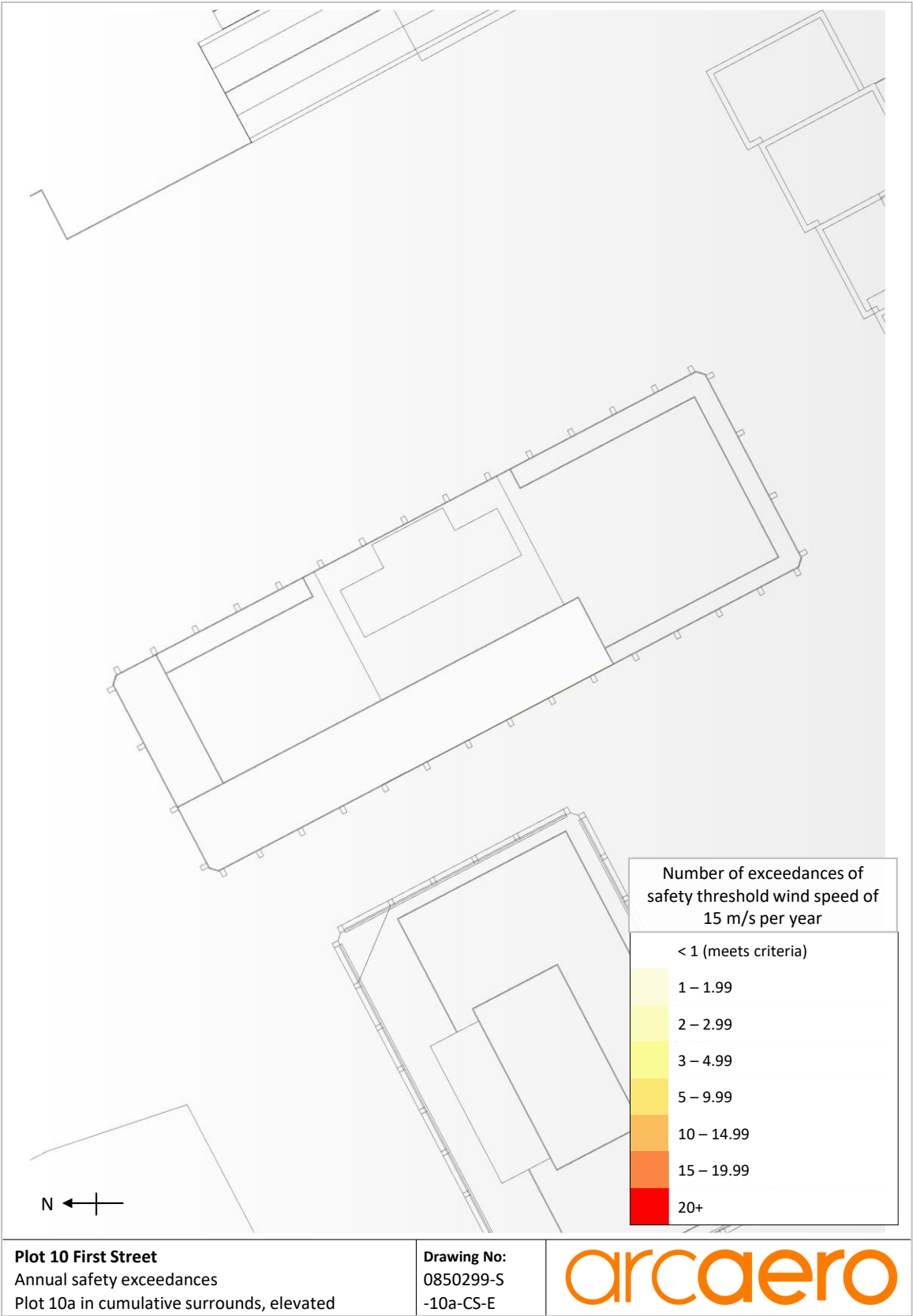


Figure 4.11 – Proposed development within cumulative surrounds, worst-seasonal comfort, ground

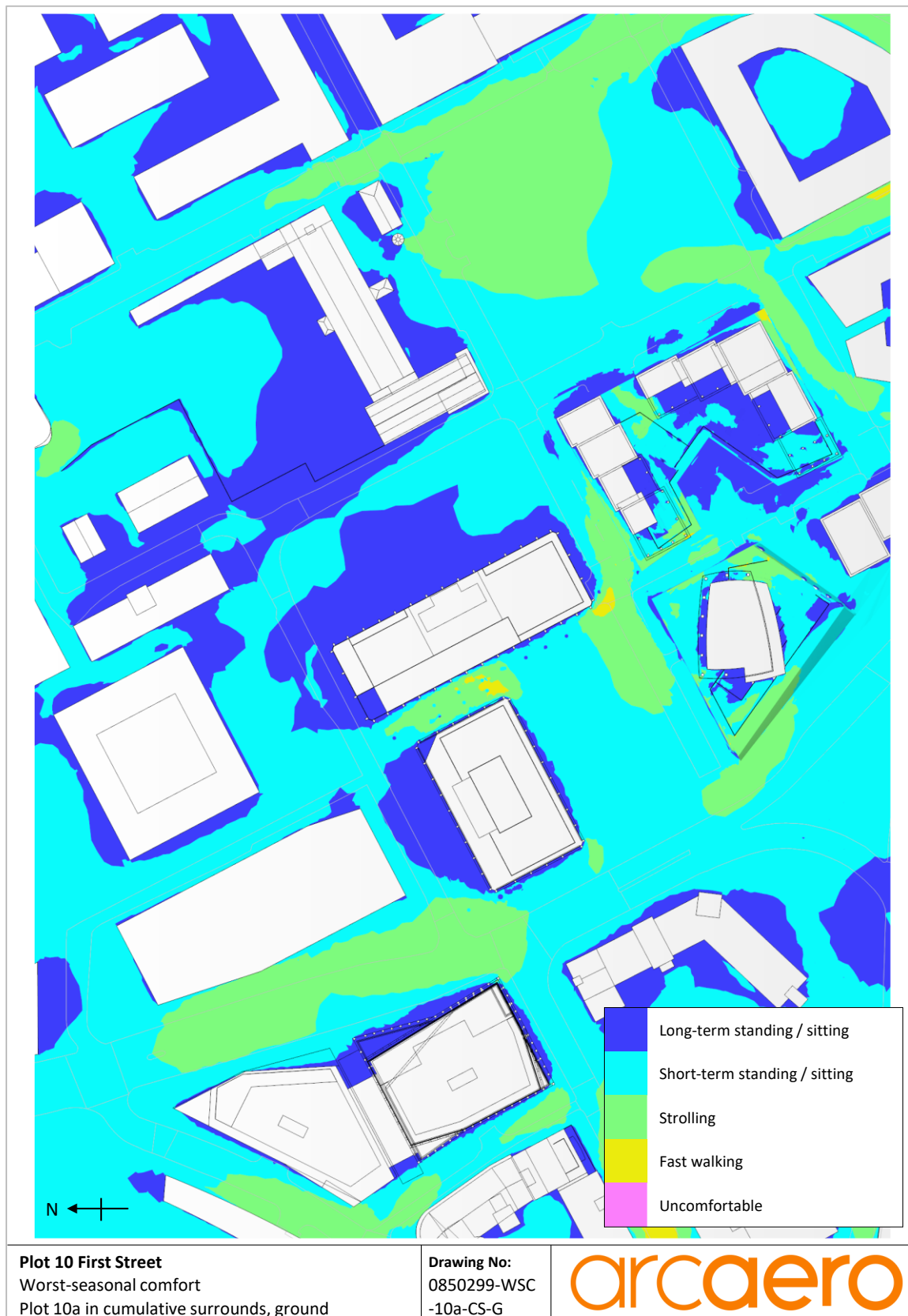


Figure 4.12 – Proposed development within cumulative surrounds, summer comfort, ground

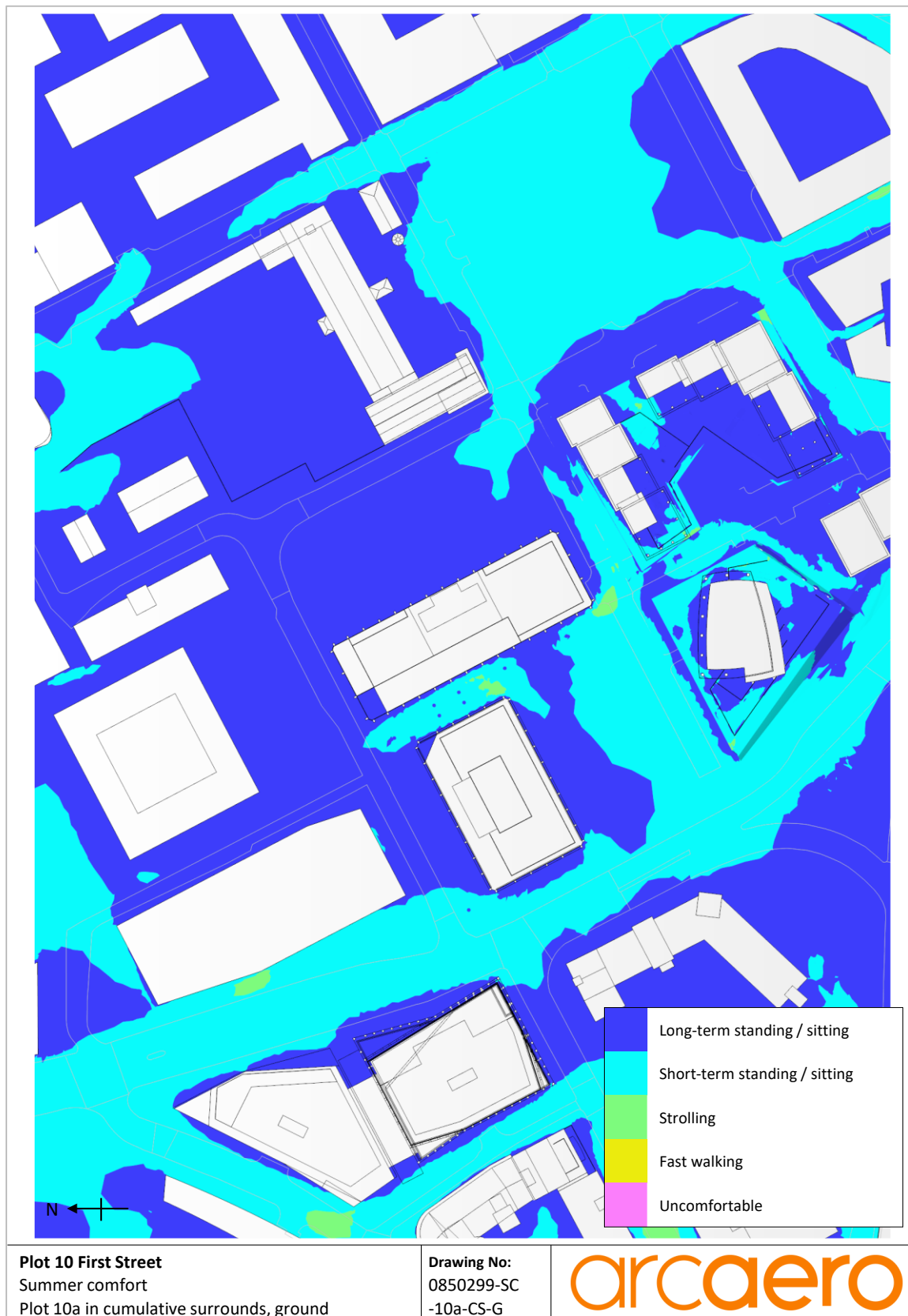
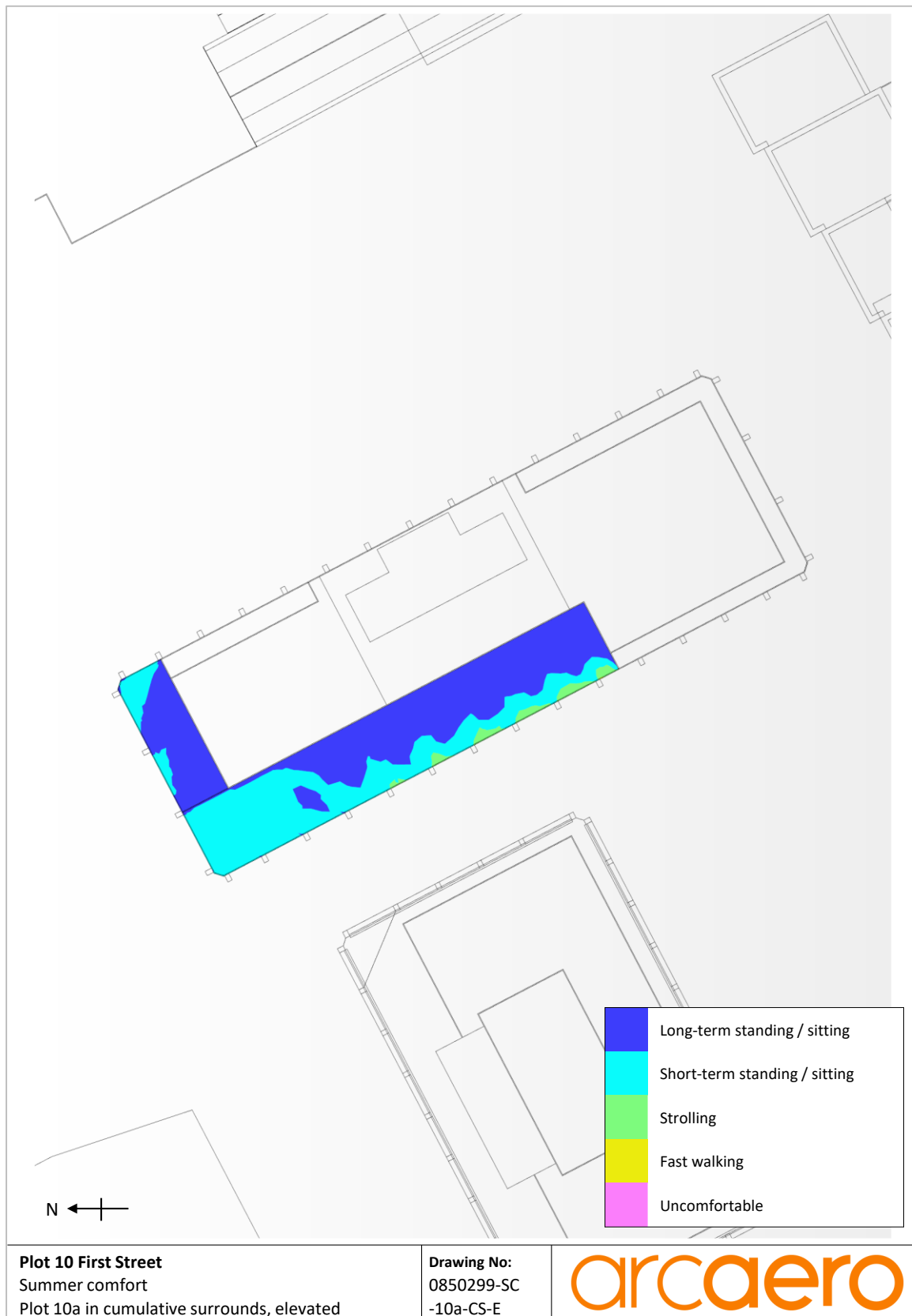


Figure 4.13 – Proposed development within cumulative surrounds, summer comfort, terrace level



CFD Modelling

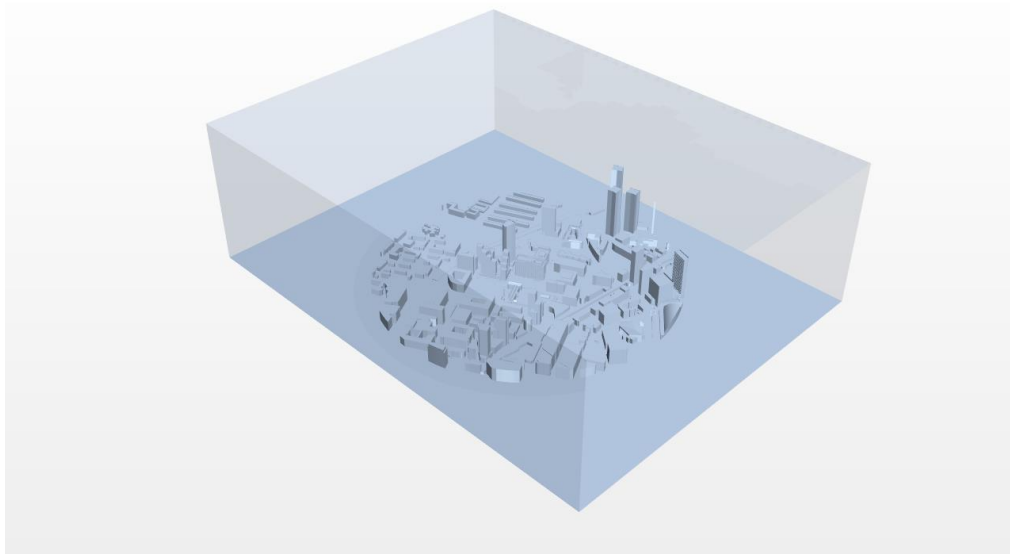
A.1 Spatial discretization

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:

- $C_\mu = 0.09$ - 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: Baseline conditions
- Figure B.2: Baseline + Plot 10a
- Figure B.3: Baseline + Plot 10a + cumulative

Figure B.1 - Baseline conditions, viewed from northeast

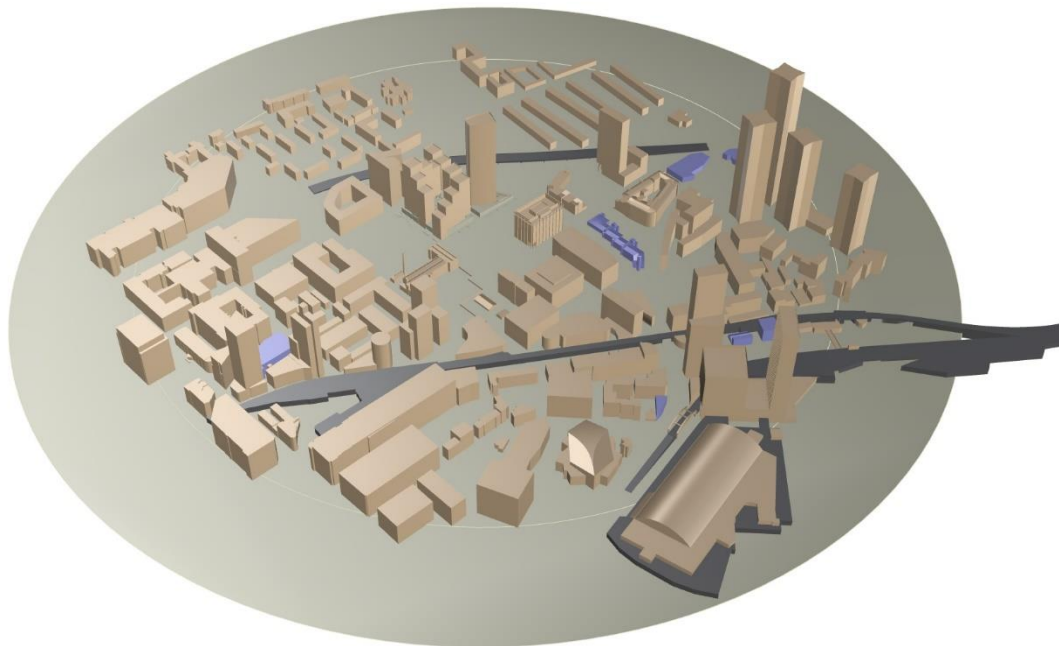


Figure B.2 - Baseline + Plot 10a, viewed from northeast

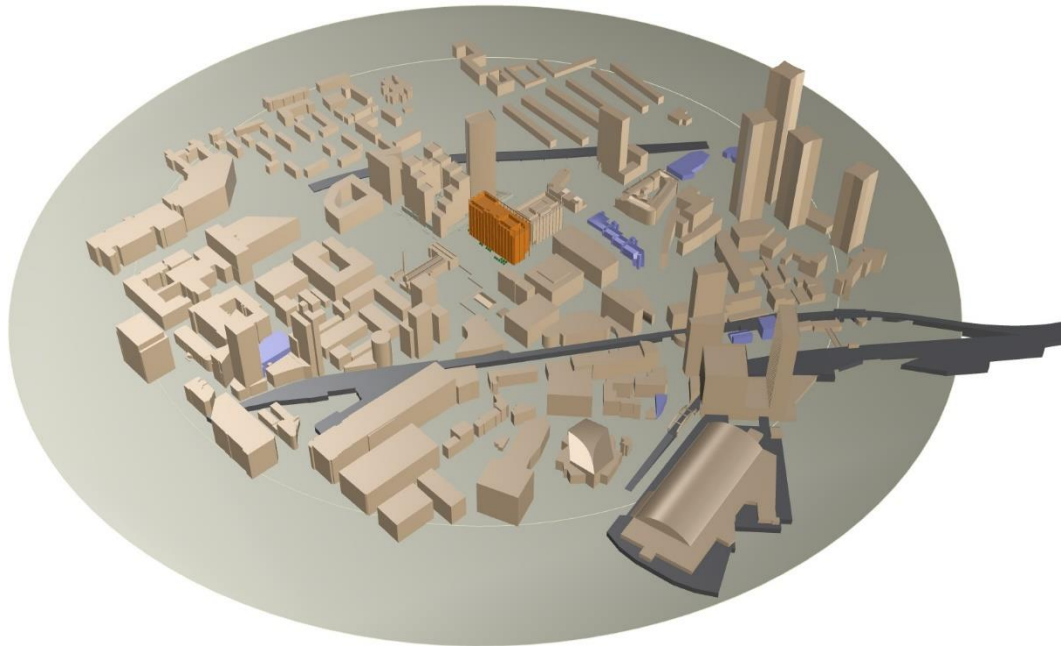
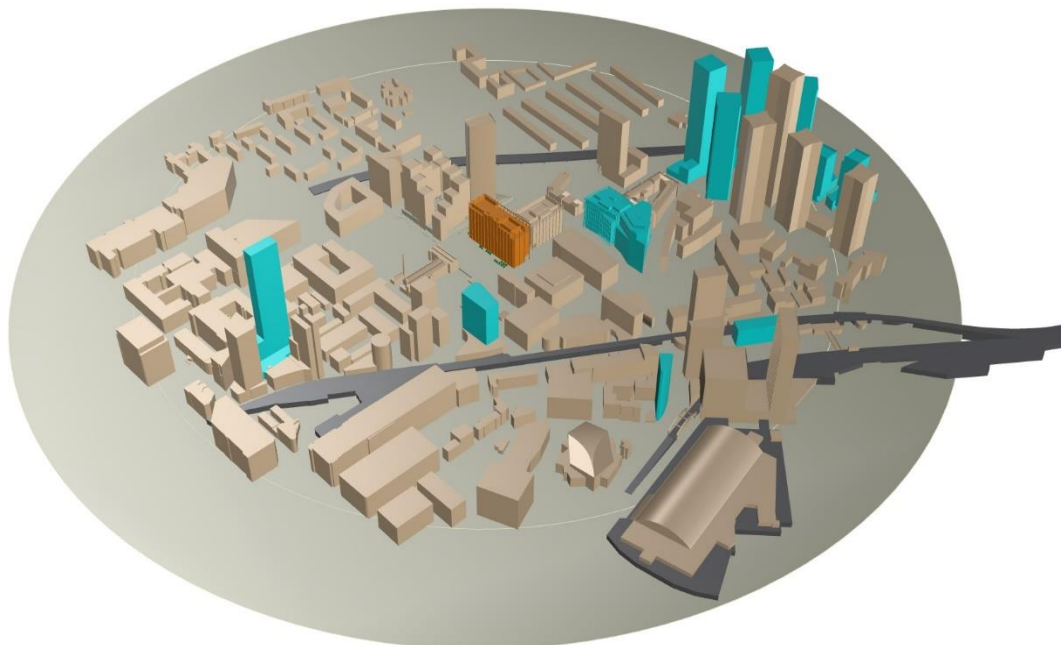


Figure B.3— Baseline + Plot 10a + cumulative, viewed from northeast



Appendix C Wind Climate Analysis

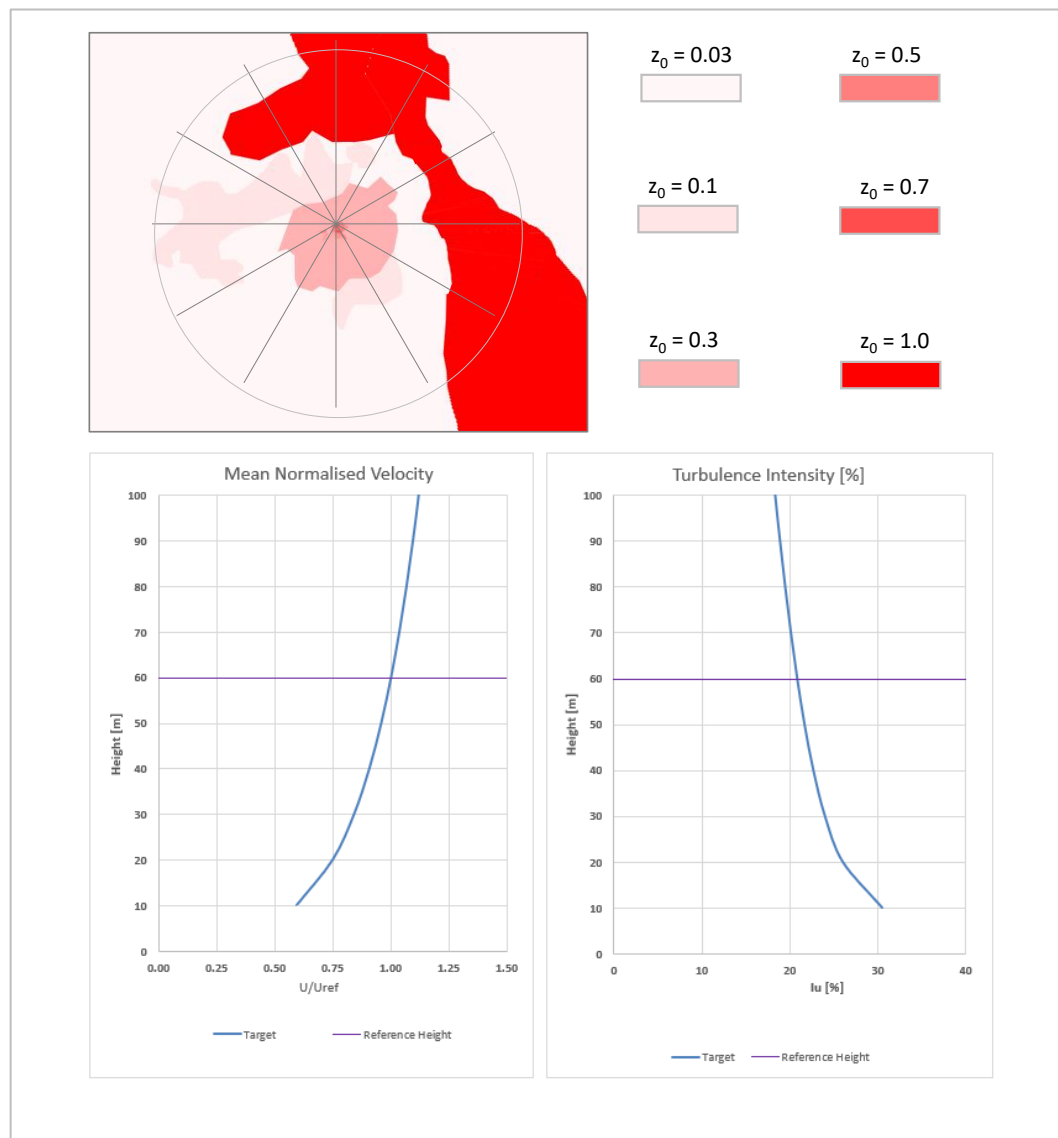
C.1 Surrounding Terrain Assessment

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 – Terrain roughness, 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 International 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

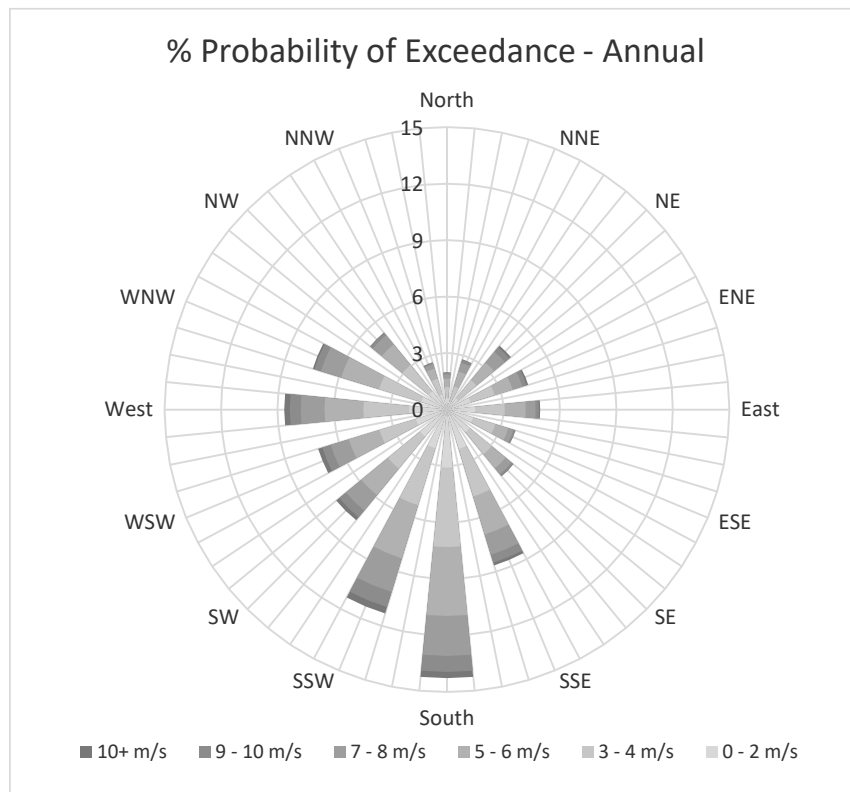


Figure C.3 – Cumulative wind speed probability distribution at site, spring

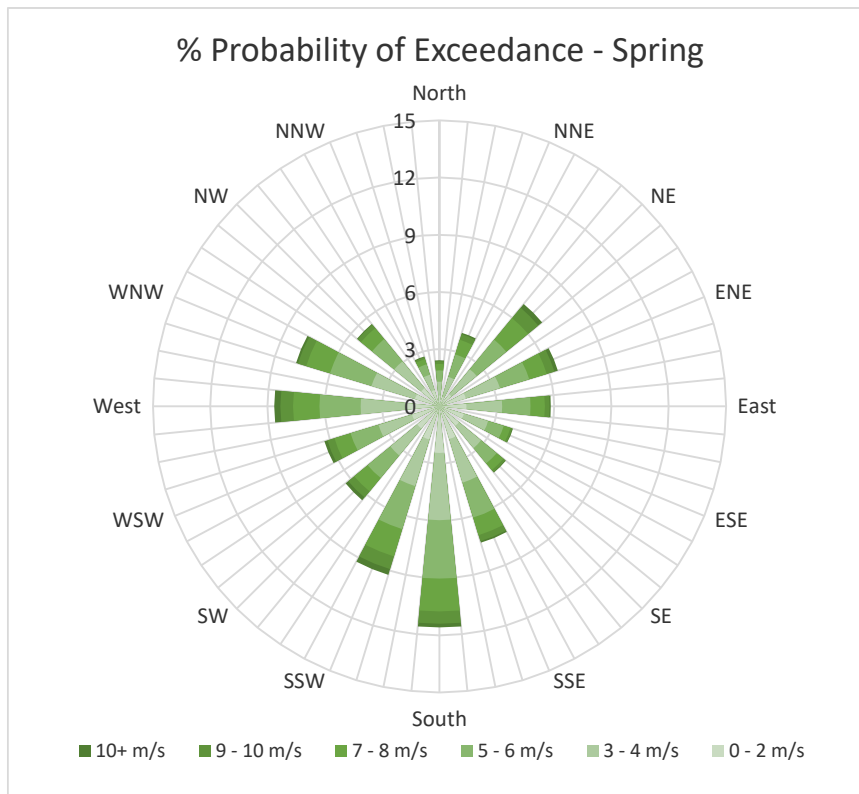


Figure C.4 – Cumulative wind speed probability distribution at site, summer

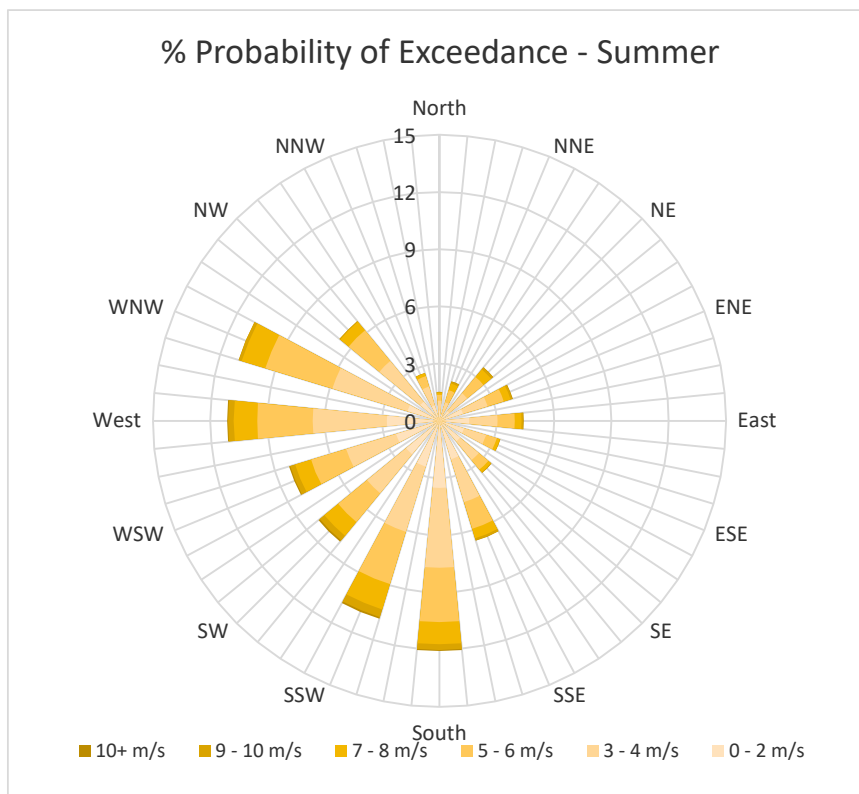


Figure C.5 – Cumulative wind speed probability distribution at site, autumn

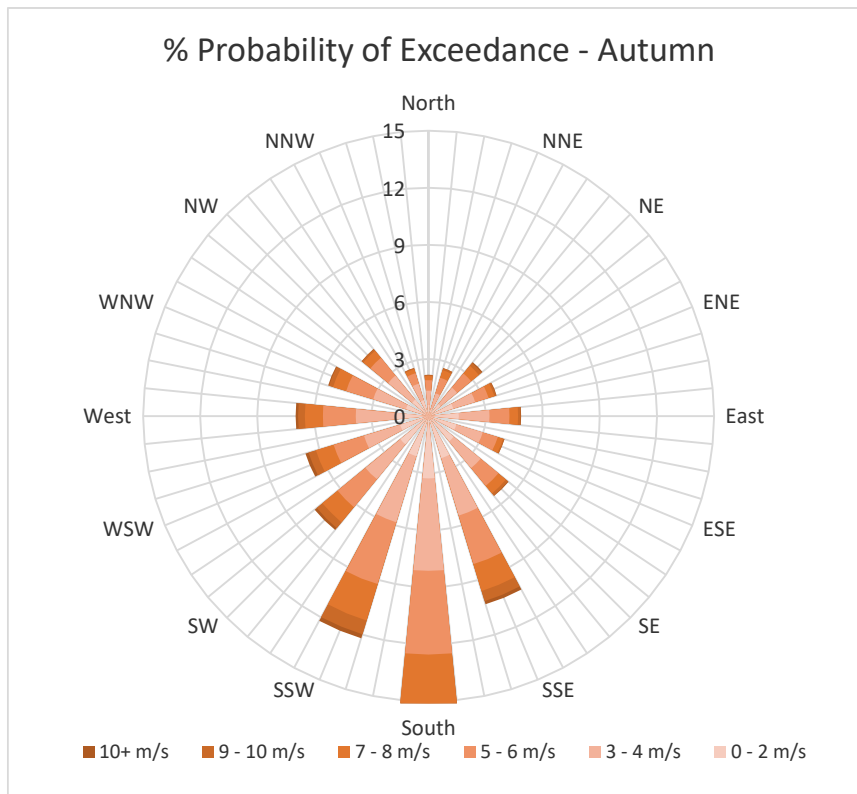


Figure C.6 – Cumulative wind speed probability distribution at site, winter

