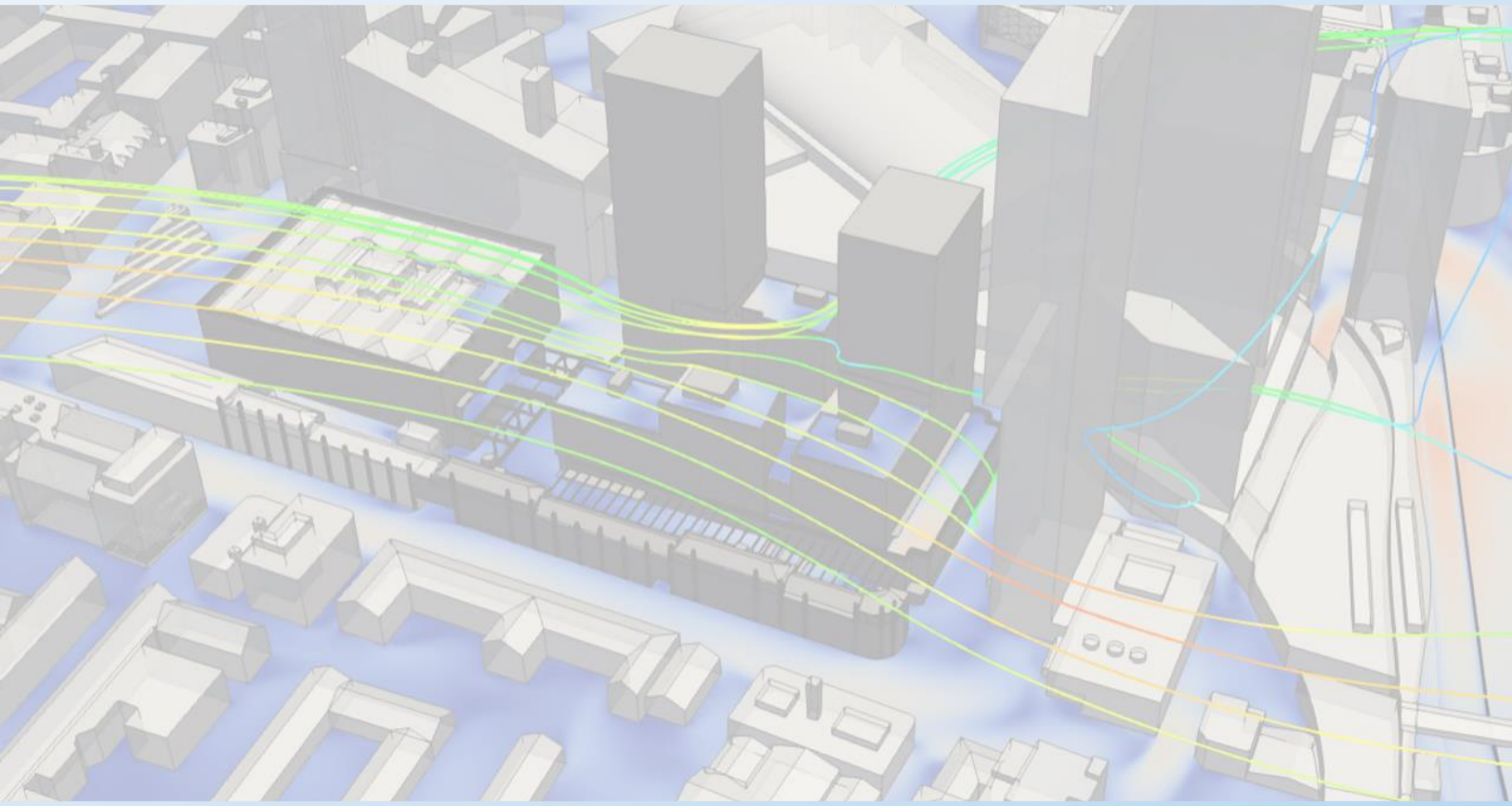
Trilogy Real Estate

GREAT NORTHERN WAREHOUSE

Wind Microclimate Study



NOVEMBER 2022

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Wind Microclimate Study

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EXECUTIVE SUMMARY

A wind microclimate study has been performed for the proposed Great Northern Warehouse project in Manchester. The analysis used computational fluid dynamics (CFD) simulations to determine the aerodynamic effect that the proposed buildings have on the wind patterns around the site. This was combined with long-term wind speed data to provide a statistical representation of the wind conditions, which were then compared against pedestrian comfort and distress criteria.

Results show that the introduction of the proposed development results in wind conditions that rate as safe for all users, except for an area on Great Bridgewater Street to the north of Beetham Tower and some small areas on Windmill Street to the north-east of the site. These areas exist in the baseline and therefore do not require mitigation.

With the introduction of cumulative surrounds, wind conditions remain similar to those recorded in the proposed scenario.

Elevated levels and private balconies across the proposed development rate as safe for all users and are mostly suitable for sitting and standing during summer across all scenarios. Private balconies have been modelled with balustrades corresponding to Section 2.6.

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1 INTRODUCTION

1.1.1. WSP have been appointed by Trilogy Real Estate to perform a wind microclimate study around the proposed Great Northern Warehouse development in Manchester. The development is an 800,000 square-foot mixed-use new quarter of Manchester's civic centre.

1.1.2. This study aims to compare the pedestrian-level wind environment around the proposed development against comfort and distress criteria and to the conditions of the existing site. The study pays particular attention to pedestrian access routes, seating areas, as well as building drop-offs and entrances.

1.2 URBAN WIND EFFECTS

1.2.1. The wind microclimate around an urban environment is affected by terrain, buildings, and other obstructions. The introduction of a new building development can affect the local wind flow patterns, which can produce an uncomfortable and/or unsafe wind environment at pedestrian level.

1.2.2. This is particularly important for buildings which are taller than their surroundings. Fast-moving high-level winds can downdraft to street level along windward faces of buildings. As air then moves into the low-pressure wake of the building, it can accelerate around corners and/or through restrictions, causing localised regions of relatively high wind speed.

1.2.3. The assessment of environmental wind flows in the built environment lies outside the scope of BS EN 1991-1-4:2005[1], the current UK code of practice for the assessment of wind effects on buildings, which focuses on wind loading. Also, there are no handbooks or engineering methods from which reliable assessments of the complex environmental wind flows that shape the pedestrian level wind conditions can be derived. A detailed Computational Fluid Dynamics (CFD) study was therefore used to provide a reliable quantification of the pedestrian level and high-level terrace wind environment at locations such as pedestrian access routes, building entrances and high-level terraces. The study combines numerically obtained pedestrian level wind speeds at key areas within and around the site of the proposed development with long-term wind frequency statistics transposed from the nearest suitable weather station to determine the probability of local wind speeds exceeding comfort and safety thresholds for a range of common pedestrian activities. The assessment is based on the LDDC version of the Lawson criteria which represents best industry practice in the UK.[2]

2 METHODOLOGY

2.1 ASSESSMENT METHODOLOGY

2.1.1. The pedestrian-level wind environment in an urban setting will depend on the general wind conditions, as well as on the effects of the urban environment itself. Therefore, the assessment consists of three main parts: calculation of the urban environment's **aerodynamic effect on the wind**; which is then **combined with historical wind data;** and, finally, **compared against criteria** to quantify the discomfort and/or level of distress caused by the wind.

2.1.2. CFD has been used to compute the aerodynamic effect for four scenarios:

- Baseline: the existing site conditions
- Future baseline: the existing site within the context of future/consented surrounds
- Proposed: the proposed development within the context of existing surrounds
- Cumulative: the proposed development within the context of future/consented surrounds

2.2 SITE AND STUDY AREA

2.2.1. The project site is bound by Deansgate to the west, Great Bridgewater Street to the south, Watson Street to the east and Peter Street to the north. The area in the vicinity consists of predominantly medium-rise buildings, with some high-rise buildings to the north-west, east and south.

2.2.2. A three-dimensional CAD model of the site and surrounding buildings has been constructed using the following information:

Table 2-1 – Information used to construct the model.

Date issued (dd/mm/yy)	Title	Filename	Usage
27/10/22	10422-SHP-ZZ-A-G000-XX-002-Massing_Site	10422-SHP-ZZ-A-G000-XX-002-Massing_Site.dwg	Construction of the proposed development
08/09/2022	Cumulative Impact – Applications within a c.500m radius of the site	Cumulative Developments Sep 2022.doc	Construction and categorisation of surrounding developments

2.2.3. The model includes the site and all buildings within an approx. 500m radius of the site as shown in Figure 2-1. The flow around these buildings and terrain is explicitly modelled within this radius, whilst outside this region obstructions are accounted for using mathematical models which assign a 'roughness' depending on the terrain type.

2.2.4. The detail of the CAD model increases from approximately 1m for the surrounding buildings to 0.2m around the site, as shown in **Figure 2-2**.

Figure 2-1 - The 3D CAD model, showing the explicitly-modelled surrounding buildings and terrain.

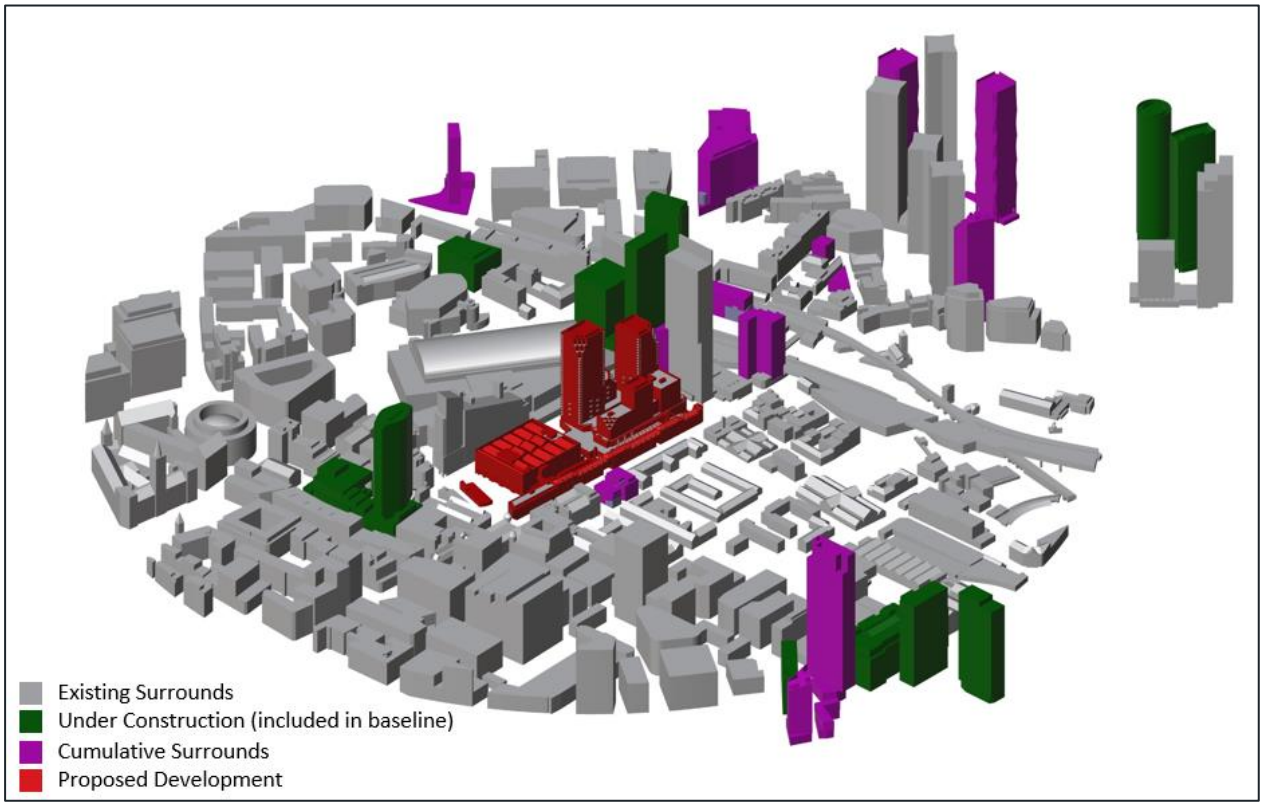
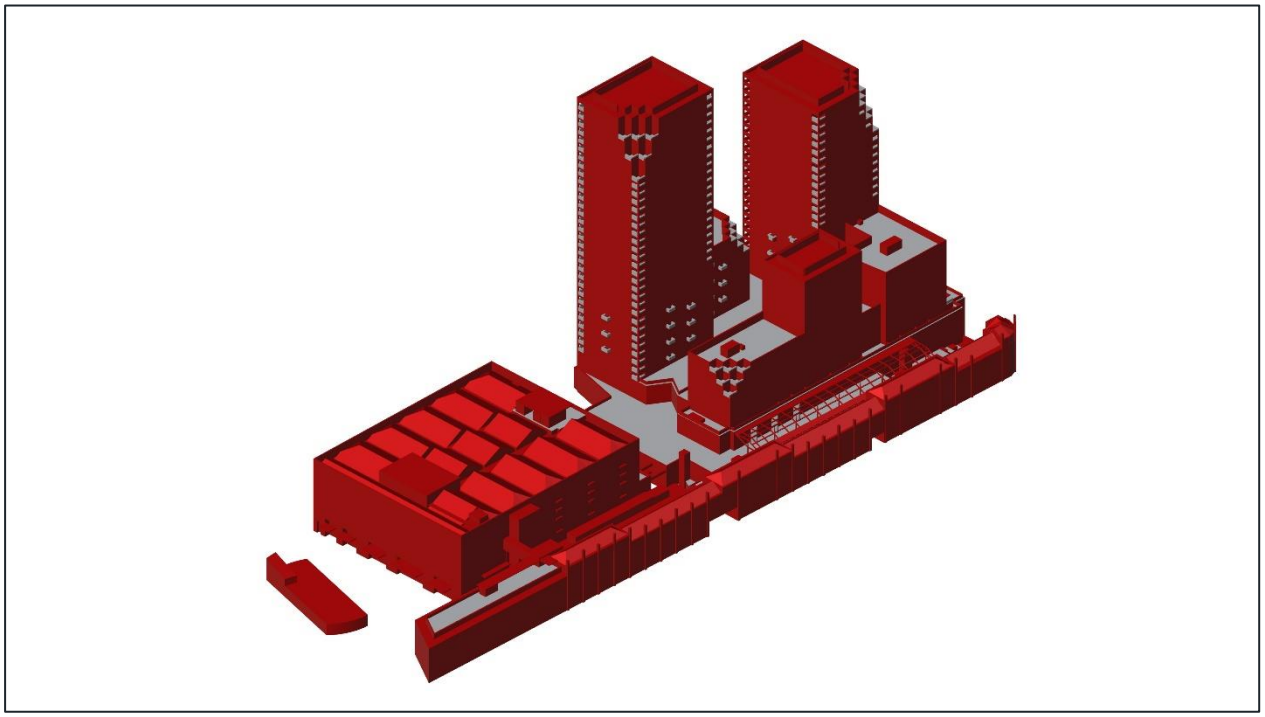


Figure 2-2 - Screenshot of the CAD model for the proposed case showing the level of detail in the model.



2.3 ASSESSMENT CRITERIA

2.3.1. The criteria used in this study were developed by Lawson (2001)[2], and have been reproduced in Table 2-2. Like most criteria used in assessments of pedestrian wind conditions, they relate a threshold wind speed and a threshold frequency to the suitability of an activity.

2.3.2. The frequency threshold for each criterion is 5% - or about three weeks per year. It is also useful to assess frequency on a seasonal basis. For example, an outdoor seating area may require wind conditions suitable for sitting or standing in summer, but not in winter when the seating is unlikely to be used. For season-specific results, the criteria are based on 5% of hours across the months in that season.

Table 2-2 – Comfort criteria used in this study.

Criteria	Suitability	Threshold mean wind for 5% of hours [ms^{-1}]
Pedestrian sitting	Outdoor seating and areas one can occupy comfortably for long periods	4
Pedestrian standing	Main building entrances, pickup/drop-off points	6
Pedestrian walking	Appropriate for strolling	8
Business walking	Can be tolerated if one's objective is to walk, run or cycle without lingering	10
Unsuitable	Nuisance for most pedestrian activities	>10

2.3.3. Additionally, criteria for distress have been defined based on 2.2 hours' exceedance per year. These are areas where someone could find walking difficult or even lose their footing. These criteria are reproduced in Table 2-3. An additional warning "criterion" has been introduced which shows areas which are close to exceeding the S15 criteria.

Table 2-3 – Distress criteria used in this study.

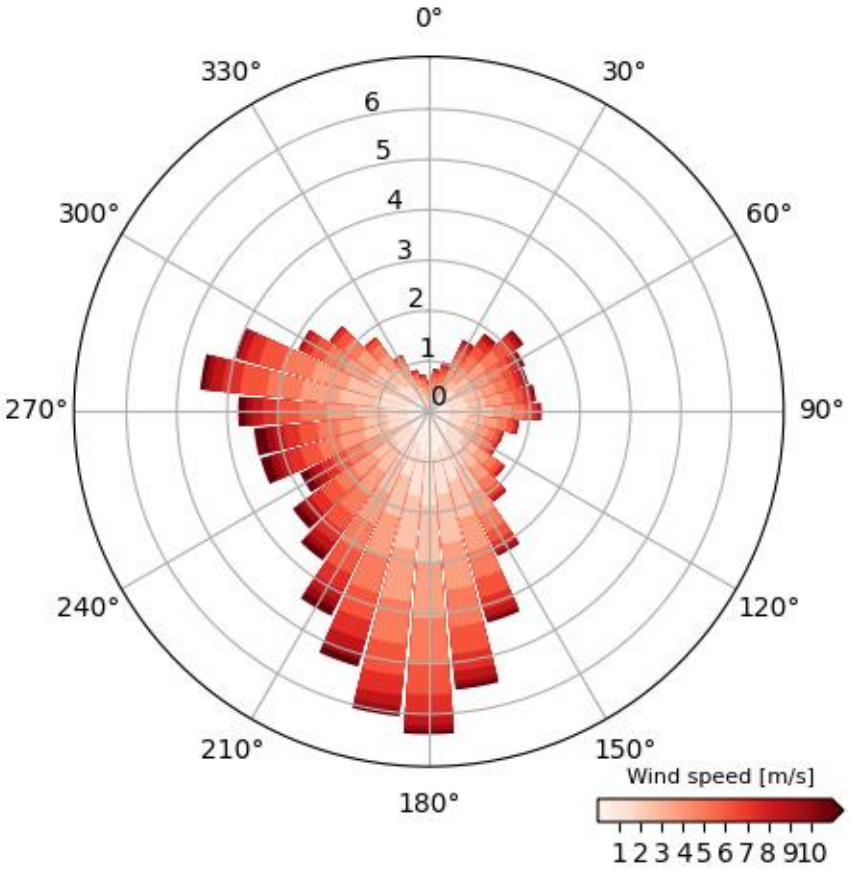
Criteria	Description	Threshold mean wind speed for 2.2hr/year [ms^{-1}]
S15	Unsuitable for frail persons, cyclists etc	15
S20	Unsuitable for all pedestrians	20

2.4 WIND CLIMATE ANALYSIS

2.4.1. Wind data was collected from the nearby meteorological station at Manchester airport, which is approximately 13km south of the site. The data consisted of mean hourly wind speeds and directions over the last 20 years. The data was discretised into 36 bins, representing 10° sectors. The nomenclature adopted in this report assigns 0° to winds coming from north, and increases clockwise such that 90° refers to winds blowing from east, 180° from south and 270° from west.

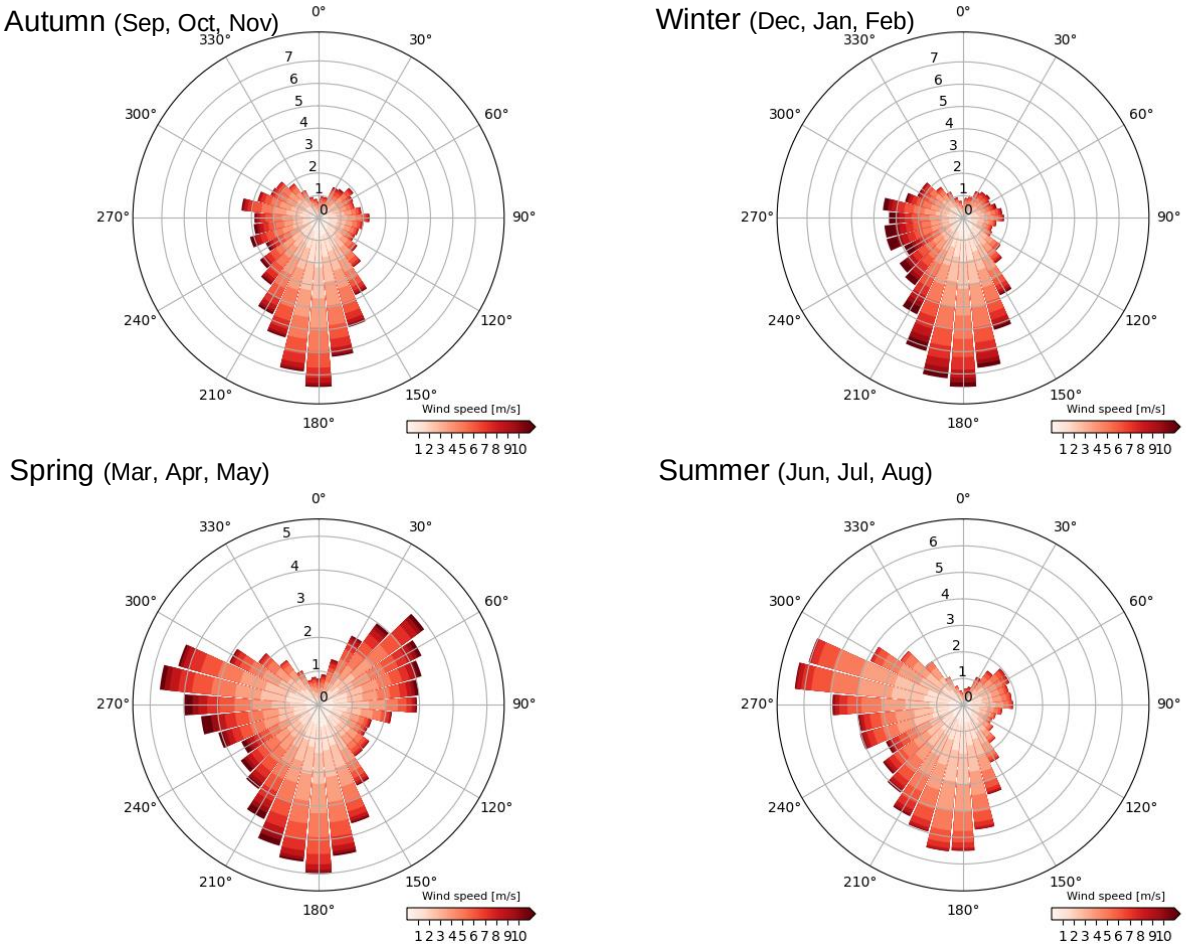
2.4.2. Figure 2-3 shows a summary of the wind data at the project site for the whole year in the form of a wind rose. Wind direction is shown on the angular axes, with percentage of hours on the radial axes. From this plot, it is possible to observe that southerly winds are the prevailing wind direction, with these and westerly winds also representing the largest proportion of higher wind speeds.

Figure 2-3 - Annual wind rose at the Manchester airport, showing the frequency and magnitude of mean-hourly wind speeds.



2.4.3. Figure 2-4 shows similar wind roses split into three-month seasons. It shows that during spring and summer, the westerly component becomes more dominant compared to autumn and winter.

Figure 2-4 - Wind roses for each season.



2.4.4. Linear regression methods were used to fit the data to a Weibull probability distribution, i.e.:

$$P(U) = pe^{-\left(\frac{U}{c}\right)^{k}}$$

where the p, c and k coefficients are the probability of the wind direction occurring, the dispersion parameter and the shape parameter respectively.

2.4.5. To account for the differences in terrain surrounding the weather station at Manchester airport and the project site, adjustments were made using the wind model proposed by ESDU, an engineering advisory organisation based in the UK (ESDU 2010)[3]. This method assigns transposition factors to the *c* term in the Weibull distribution of the data at the meteorological site, based on upwind aerodynamic roughness of the terrain. The weather centre data was initially transposed to open country terrain and subsequently transposed to a reference height of 120m at the site of the proposed development, accounting for upwind terrain and topographical features. This terrain analysis was based on the CORINE Land Cover (CLC) dataset[5] which is shown in Figure 2-5. This resulted in the transposition factors shown in Table 2-4.

Figure 2-5 - Categorisation of the terrain surrounding the site.

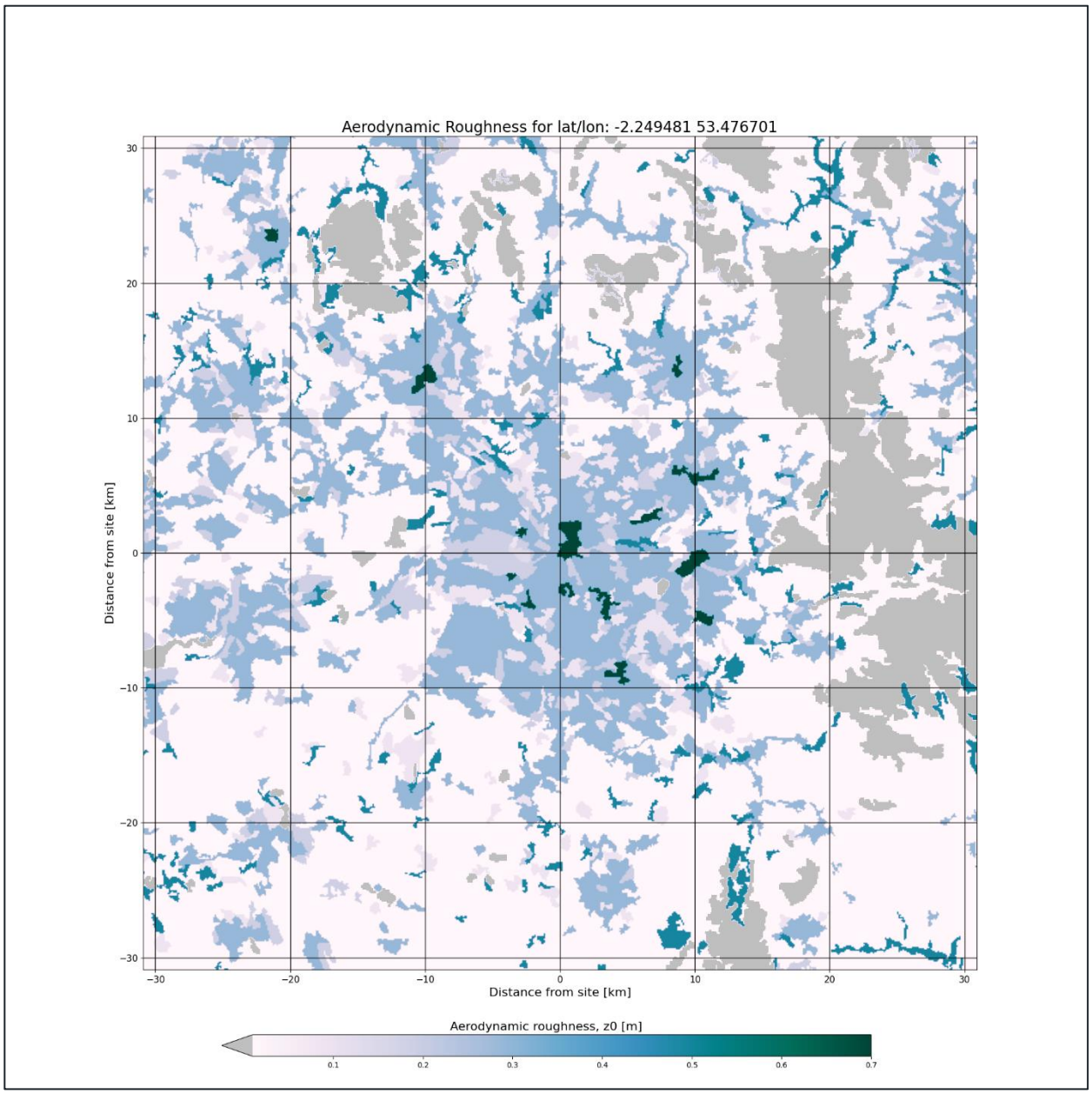


Table 2-4 – Transposition factors from 10m open country to 120m reference height at the project site

0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
1.28	1.27	1.28	1.29	1.28	1.28	1.28	1.28	1.31	1.31	1.30	1.31

2.4.6. The aerodynamic effect from all wind directions must be accounted for and, as the weather data has an azimuthal resolution of 10°, 36 simulated directions will provide the best possible resolution. However, this can be computationally expensive and infrequent wind directions will not contribute significantly to the final outcome. Therefore, some adjacent infrequent directions have been grouped together such that each simulated direction has a similar frequency of occurrence. The grouping

methodology is such that the frequency of grouped wind directions should generally not exceed that of the most frequent (prevailing) wind directions.

2.4.7. In this case, 22 wind directions were explicitly simulated (see Table 2-5).

Table 2-5 – Wind directions simulated.

Simulated direction [°]	Bins included [°]	Combined frequency [%]
0	350,0,10	2.22
30	20,30,40	4.51
55	50,60	4.42
75	70,80	4.19
95	90,100	4.03
120	110,120,130	4.92
145	140,150	5.37
160	160	4.35
170	170	5.54
180	180	6.40
190	190	6.07
200	200	5.25
210	210	4.49
220	220	3.63
230	230	3.32
245	240,250	6.30
260	260	3.48
270	270	3.78
280	280	4.56
290	290	3.99
305	300,310	5.28
330	320,330,340	3.91

2.5 SIMULATION DETAILS AND ASSUMPTIONS

2.5.1. A CFD numerical simulation has been performed for each of the directions shown in Table 2-5. Relative wind speeds were sampled at a plane 1.5m from the ground. These values were then combined with the weather data shown in 2.4 and compared against criteria discussed in section 2.3.

2.5.2. Each simulation uses numerical methods to solve the governing equations of fluid mechanics around the site of interest. The site of interest in this case is the geometry discussed in section 2.2, surrounded by a volume which extends 2.8km in the horizontal directions and 500m in the vertical direction. The CFD method employed requires this volume to be split into smaller volumes or 'cells'. These cells are nominally hexahedral and reduce in size from approximately 25m in the far field to 0.1m near the building in order to sufficiently resolve the fluid flow. Thin prismatic layers of cells were added to the ground and buildings to resolve the large gradients in the flow near the solid obstructions. In this case, the total number of cells ranged between 49-58 million for the four scenarios.

2.5.3. As time-averaged results are of interest, the equations in the model have been time-averaged using Reynolds averaging to produce the Reynolds-Averaged Navier-Stokes (RANS) equations. The realizable version of the $k-\epsilon$ model (Shih et. al., 1995)[4] has been used to describe the statistical effect of turbulence by solving transport equations for the turbulent kinetic energy (k) and turbulent dissipation rate (ϵ).

2.5.4. The velocity magnitude output from the CFD is a mean velocity defined as

$$\bar{U} = (\bar{u}^2 + \bar{v}^2 + \bar{w}^2)^{\frac{1}{2}}$$

where the overbar represents a time-averaged quantity and u, v, w are the velocity components in the x, y, z directions, respectively. However, a pedestrian's perception to the wind does not depend on direction; a wind from any direction is equally as uncomfortable. Therefore, the velocity of interest is actually

$$\bar{U} = \overline{(u^2 + v^2 + w^2)^{\frac{1}{2}}}$$

these scalar values are different because $u = \bar{u} + u'$ and $\overline{u'}^2 = 0$ but $\overline{u'^2} \neq 0$, where u' is the fluctuating part of the instantaneous velocity, u. Using the fact that $k = \frac{1}{2}\left(\overline{u'^2} + \overline{v'^2} + \overline{u'^2}\right)$, the velocity used of interest from the RANS equations is

$$\bar{U}_{scalar} = (\bar{U}^2 + 2k)^{\frac{1}{2}}$$

2.5.5. Additionally, a 'gust' wind speed has been estimated as:

$$U_{gust} = \bar{U}_{scalar} + g\sqrt{\frac{2}{3}k}$$

Where g is a peak gust factor that was set to 3.0. This gust wind speed was divided by 1.85 to give a gust equivalent mean (GEM) value. The maximum of the GEM and the scalar mean wind speed at each sampled cell was the quantity used in the analysis.

2.5.6. A non-slip condition was applied to the ground and buildings. Buildings and ground within the 500m radius had a rough wall function with an assigned roughness of $z_0 = 0.02m$; the far-field (>500m radius) ground had a rough wall function with varying roughness heights depending on their terrain classification (ESDU). The outlet had a zero-gradient boundary condition, side and top walls had free slip conditions. A logarithmic velocity profile was applied to the inlet whereby the velocity varies with height through:

$$U(z) = \frac{u_\tau}{\kappa} \ln\left(\frac{z + z_0}{z_0}\right)$$

where

$$u_\tau = \frac{\kappa U_{ref}}{\ln\left(\frac{z_{ref} + z_0}{z_0}\right)}$$

and $\kappa = 0.41$ is the Von Karman constant, z is the height above the ground, $z_{ref} = 120m$, z_0 is the upstream roughness which varies by direction and $U_{ref} = 10m/s$.

2.5.7. The SIMPLE algorithm as implemented in OpenFOAM (Engys version Helyx Core-3.0.0) was used to iteratively solve the equations. The solution was considered to be converged when the residuals (i.e. the relative change from one iteration to the next) were 10^{-5} for momentum and 10^{-4} for pressure.

2.5.8. Trees and other aerodynamically porous elements were treated as porous regions in the CFD model. For trees, the momentum loss in the transport equations is modelled through the inertial term in the Darcy-Forchheimer law for porous media which has the form $\Delta P = C\, U^2$, where ΔP is the pressure drop across the volume of the tree, U is the air velocity and C is the inertial term, which can be related to a drag coefficient for various tree types. Drag coefficients, obtained experimentally, were chosen for various tree species from *Bitog et al (2011)*[6].

2.6 MITIGATION MEASURES

2.6.1. Wind mitigation measures were iteratively designed and tested through regular mitigation workshops between WSP, SimpsonHaugh, 2110 Consult and Trilogy Real Estate. The mitigation measures were included in all simulations which considered the proposed development, shown in Figure 2-6, and are as follows:

- On the south-east corner of the development:
    - 1x 2m deep, 11m tall, 50% porous façade fin (~3m clearance from the ground).
    - 2x 1m wide, 1.5m tall, 50% porous screens above/within the planters.
    - 2x freestanding 1.5m wide, 2m tall, 50% porous screens along the pavement on Watson Street.
    - Trees as per the proposed landscaping scheme. No trees in other areas have been included in the computational model.

On the private balconies within the proposed development, a parameter study was undertaken to test the effectiveness of varying balustrade heights and porosities. The following solution was achieved and is depicted in Figure 2-7:

- 1.1m 50% porous balustrades are sufficient for all private balconies except for the following requirements on the towers:
    - 1.1m solid balustrades, within an additional 0.4m 50% porous balustrade on the western-facing elements on the towers.
    - 1.5m 50% porous balustrades on north- and south-facing elements on the towers.

Figure 2-6 - Wind mitigation measures developed as part of regular mitigation workshops, which have been included in the simulations.

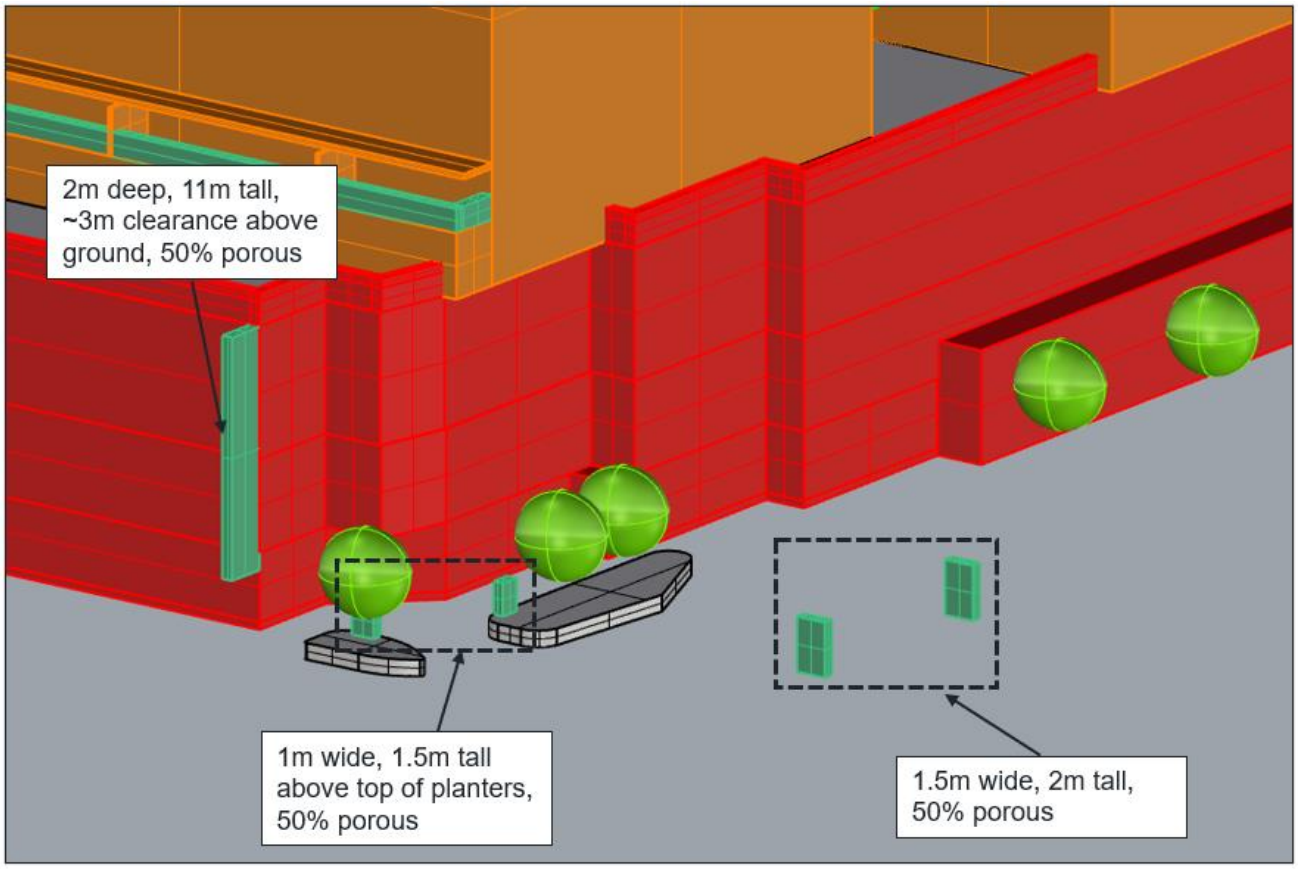
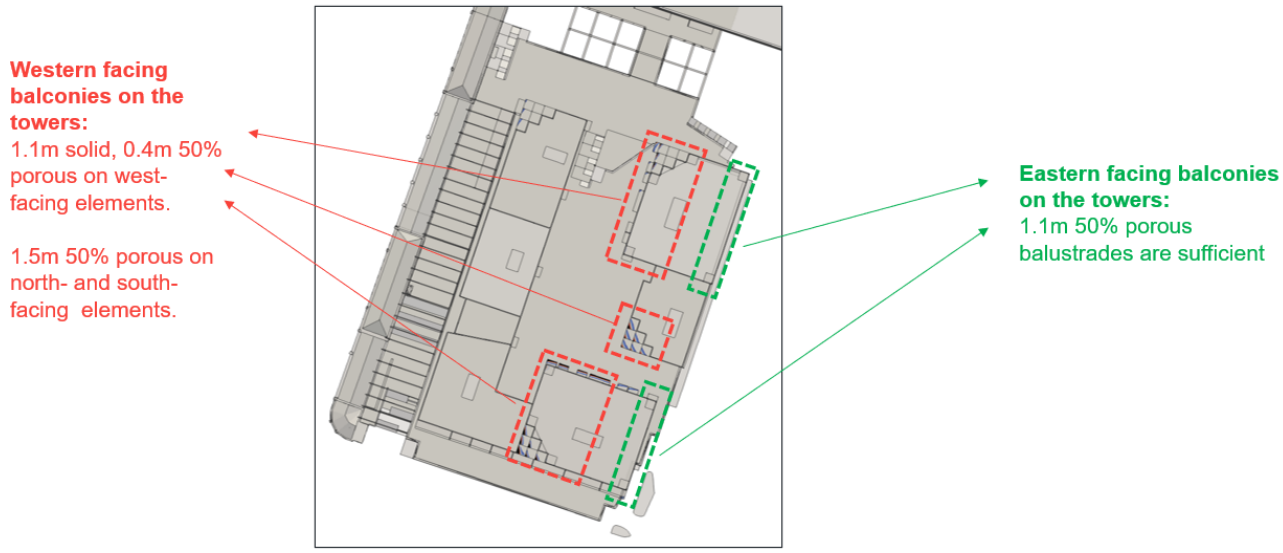


Figure 2-7 - Balustrade designs on the private balconies, informed by a study on balustrade height and porosity.



2.6.2. WSP understands that the wind mitigation measures presented in Section 2.6.1 will be incorporated into the design and landscaping scheme.

3 RESULTS – SCENARIO 1: BASELINE

This section analyses the results of the existing site within the context of existing surrounds.

SAFETY CRITERIA ANALYSIS

3.1.1. Figure 3-1 shows contours of comfort criteria on a plane 1.5m above the ground for Scenario 1. It shows that for the existing site in existing surrounds ground level wind conditions are mostly rated as safe for all users, except for an area on Great Bridgewater Street to the north of Beetham Tower and some small areas on Windmill Street to the north-east of the site.

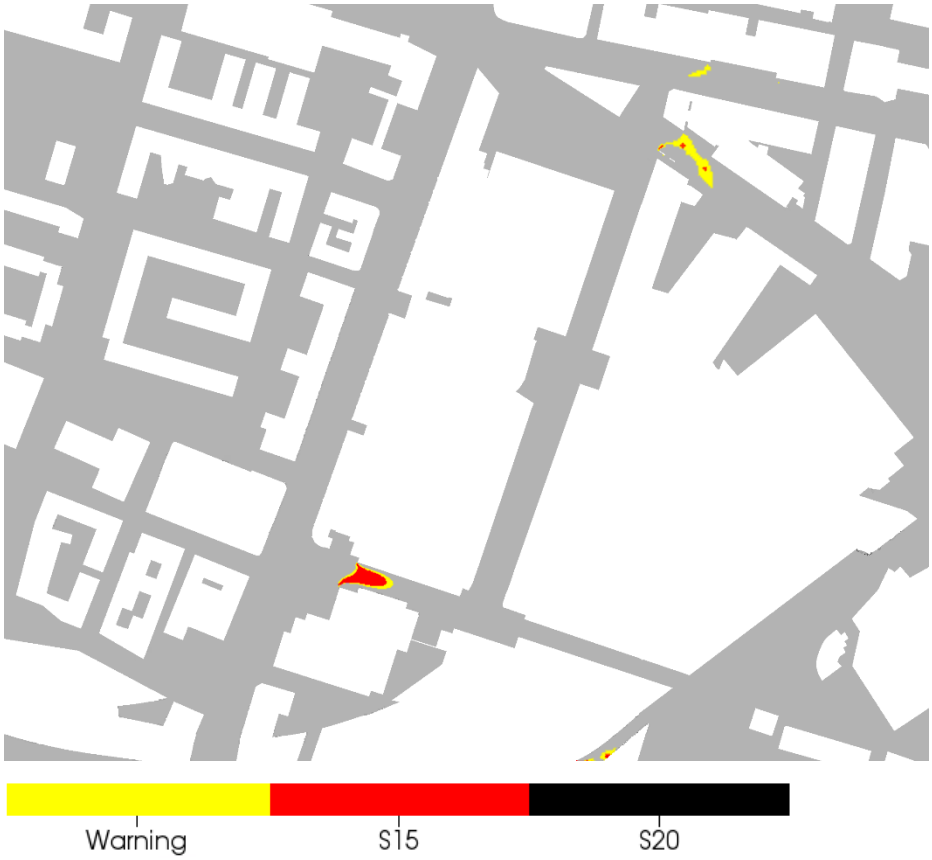


Figure 3-1 - Contours of safety criteria for Scenario 1.

COMFORT CRITERIA ANALYSIS

3.1.2. Figure 3-2 and Figure 3-3 show contours of comfort criteria on a plane 1.5m above the ground for the worst-case season (winter) and summer seasons respectively for Scenario 1.

3.1.3. Figure 3-2 shows that wind conditions within and around the existing site rate as suitable for walking, standing and sitting during winter. There is a small region of business walking recorded on Great Bridgewater Street.

3.1.4. Figure 3-3 shows that wind conditions within and around the existing site rate as suitable for standing and sitting during summer. There is a small region of walking recorded on Great Bridgewater Street.

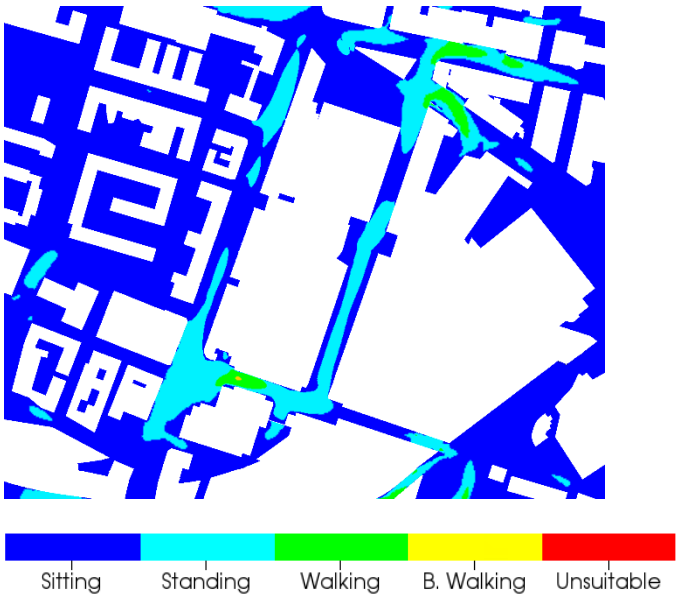


Figure 3-2 - Contours of comfort criteria in winter for Scenario 1.

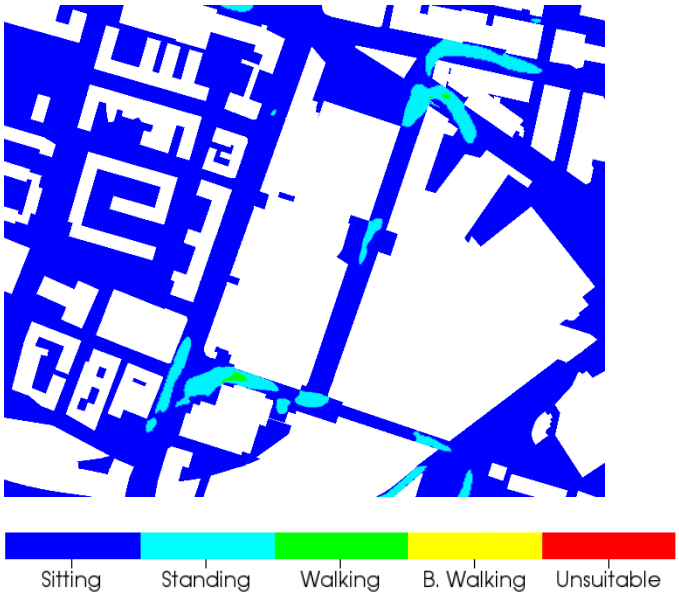


Figure 3-3 - Contours of comfort criteria in summer for Scenario 1.

4 RESULTS – SCENARIO 2: FUTURE BASELINE

This section analyses the results of the existing site within the context of consented surrounds.

SAFETY CRITERIA ANALYSIS

4.1.1. Figure 4-1 shows contours of comfort criteria on a plane 1.5m above the ground for Scenario 2, directly compared against the baseline conditions (Scenario 1). It shows that the introduction of consented surrounds results in ground level wind conditions that are similar to the baseline. The areas of exceedance on Great Bridgewater Street and Windmill Street remain.



Figure 4-1 - Contours of safety criteria (left: Scenario 1, right: Scenario 2).

COMFORT CRITERIA ANALYSIS

4.1.2. Figure 4-2 and Figure 4-3 show contours of comfort criteria on a plane 1.5m above the ground for the worst-case season (winter) and summer seasons respectively, directly compared against the baseline conditions (Scenario 1).

4.1.3. Figure 4-2 shows that, with the introduction of consented developments, wind conditions within the site remain suitable for business walking, leisure walking, standing and sitting during winter.

4.1.4. Figure 4-3 shows that, with the introduction of consented developments, wind conditions within the site remain suitable for walking, standing and sitting during summer.

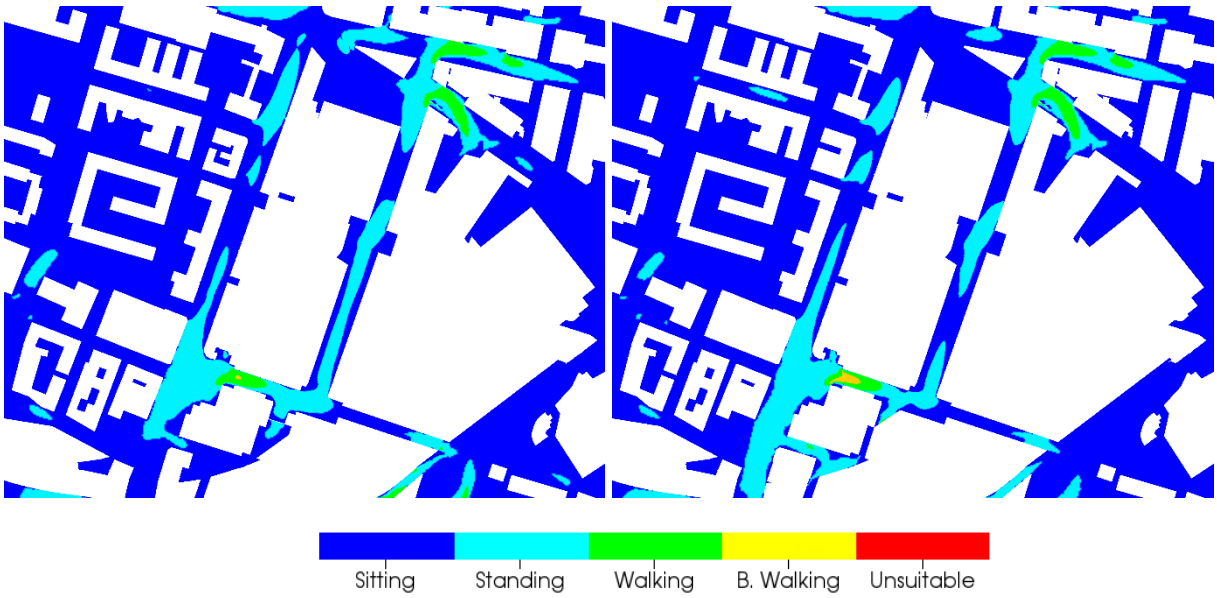


Figure 4-2 - Contours of comfort criteria in winter (left: Scenario 1, right: Scenario 2).

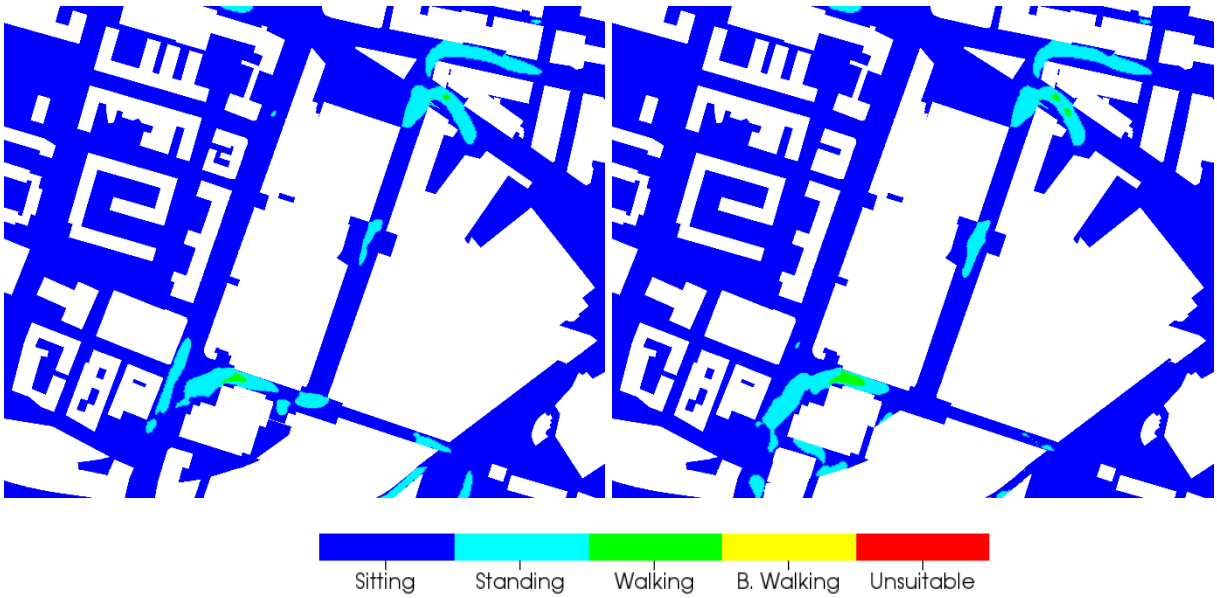


Figure 4-3 - Contours of comfort criteria in summer (left: Scenario 1, right: Scenario 2).

5 RESULTS – SCENARIO 3: PROPOSED DEVELOPMENT IN EXISTING SURROUNDS

This section analyses the results of the proposed development within the context of existing surrounds.

SAFETY CRITERIA ANALYSIS

5.1.1. Figure 5-1 shows contours of comfort criteria on a plane 1.5m above the ground for Scenario 3, directly compared against the baseline conditions (Scenario 1). It shows that with the introduction of the proposed development ground level wind conditions remain safe for all users, except for an area on Great Bridgewater Street to the north of Beetham Tower, which exists in the baseline. The small areas of exceedance on Windmill Street to the north-east improves with the introduction of the proposed development.

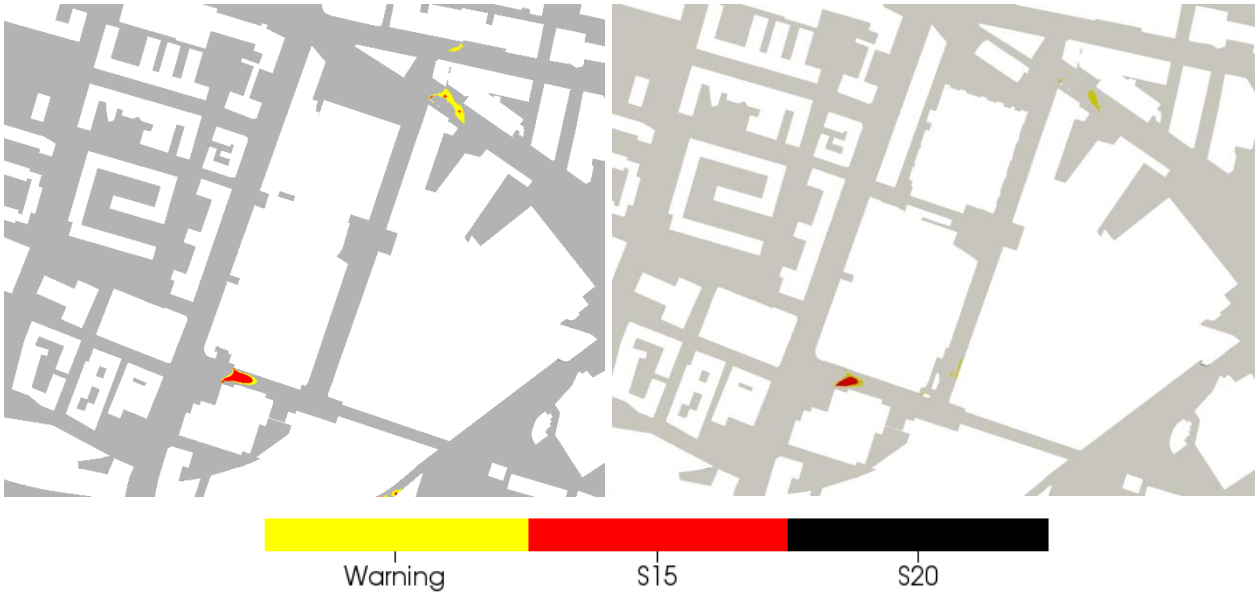


Figure 5-1 - Contours of safety criteria (left: Scenario 1, right: Scenario 3).

5.1.2. At elevated levels within the proposed development, wind conditions rate as safe for all users. Private balconies have been modelled with balustrades corresponding to Section 2.6. It should be noted that no proposed landscaping has been modelled on the terraces.

COMFORT CRITERIA ANALYSIS

5.1.3. Figure 5-2 and Figure 5-3 show contours of comfort criteria on a plane 1.5m above the ground for the worst-case season (winter) and summer seasons respectively, directly compared against the baseline conditions (Scenario 1).

5.1.4. Figure 5-2 shows that, with the introduction of the proposed development, wind conditions within the site rate as suitable for leisure walking, standing and sitting during winter.

5.1.5. Figure 5-3 shows that, with the introduction of the proposed development, wind conditions within the site rate as suitable for standing and sitting during summer.

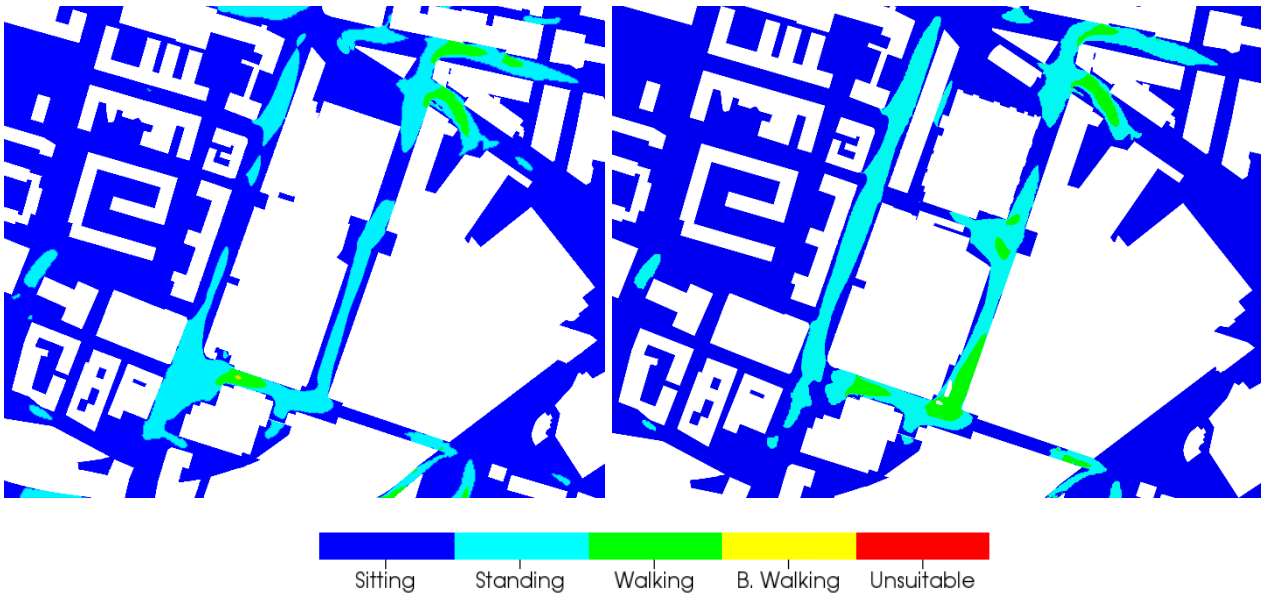


Figure 5-2 - Contours of comfort criteria in winter (left: Scenario 1, right: Scenario 3).

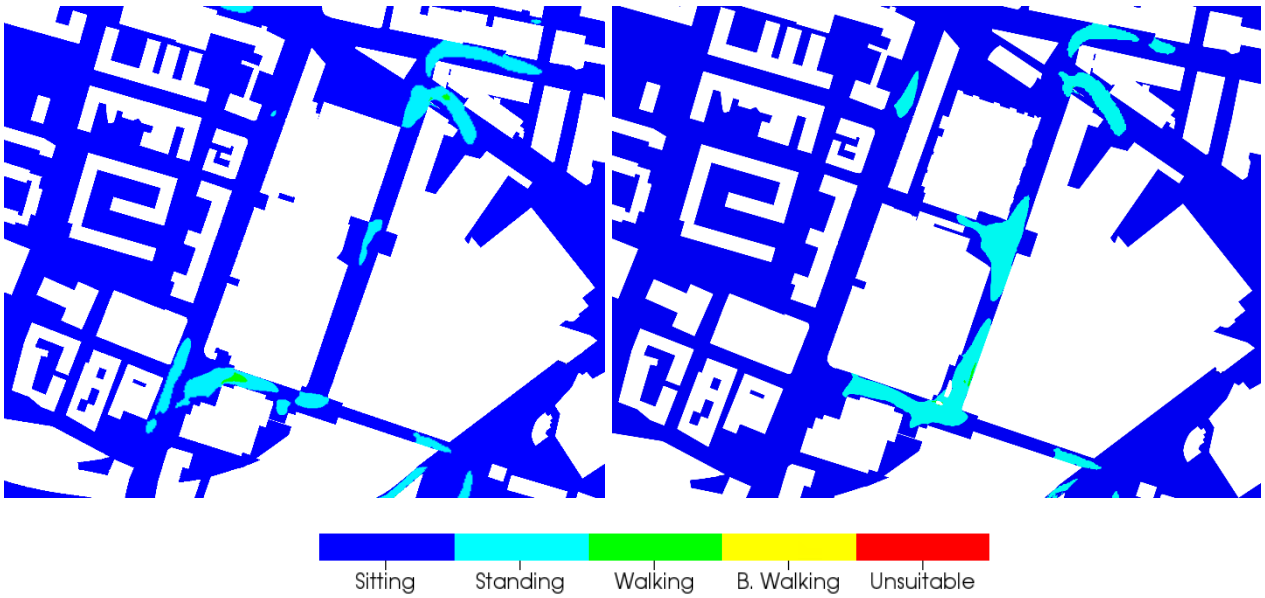


Figure 5-3 - Contours of comfort criteria in summer (left: Scenario 1, right: Scenario 3).

5.1.6. Figure 5-4 shows contours of comfort criteria on a plane 1.5m above the elevated levels in the summer season for Scenario 3.

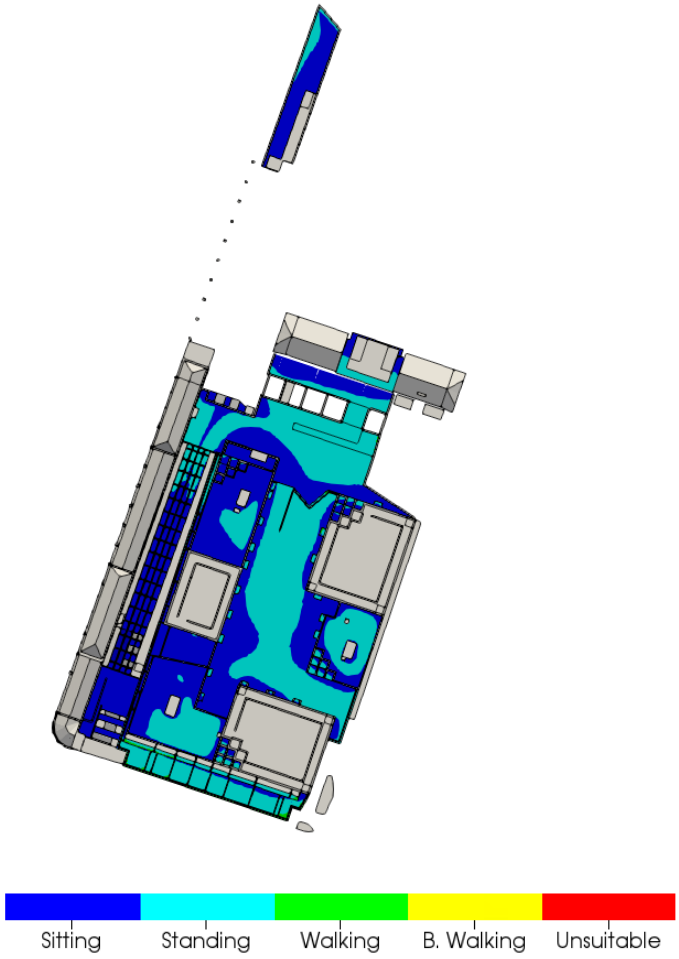


Figure 5-4 - Contours of comfort criteria on elevated levels in summer for Scenario 3.

5.1.7. Figure 5-4 indicates that during summer, most areas rate as suitable for sitting. Generally, other areas rate as suitable for standing. It should be noted that no proposed landscaping has been modelled on the terraces. Private balconies have been modelled with balustrades corresponding to Section 2.6 and mostly rate as suitable for sitting and standing during summer.

6 RESULTS – SCENARIO 4: PROPOSED DEVELOPMENT IN CUMULATIVE SURROUNDS

This section analyses the results of the proposed development in the context of cumulative surrounds.

SAFETY CRITERIA ANALYSIS

6.1.1. Figure 6-1 shows contours of comfort criteria on a plane 1.5m above the ground for Scenario 4, directly compared against the future baseline conditions (Scenario 2). It shows that with the introduction of the proposed development within the context of cumulative surrounds, ground level wind conditions remain safe for all users, except for an area on Great Bridgewater Street to the north of Beetham Tower, which exists in the future baseline. The small areas of exceedance on Windmill Street to the north-east improves with the introduction of the proposed development.

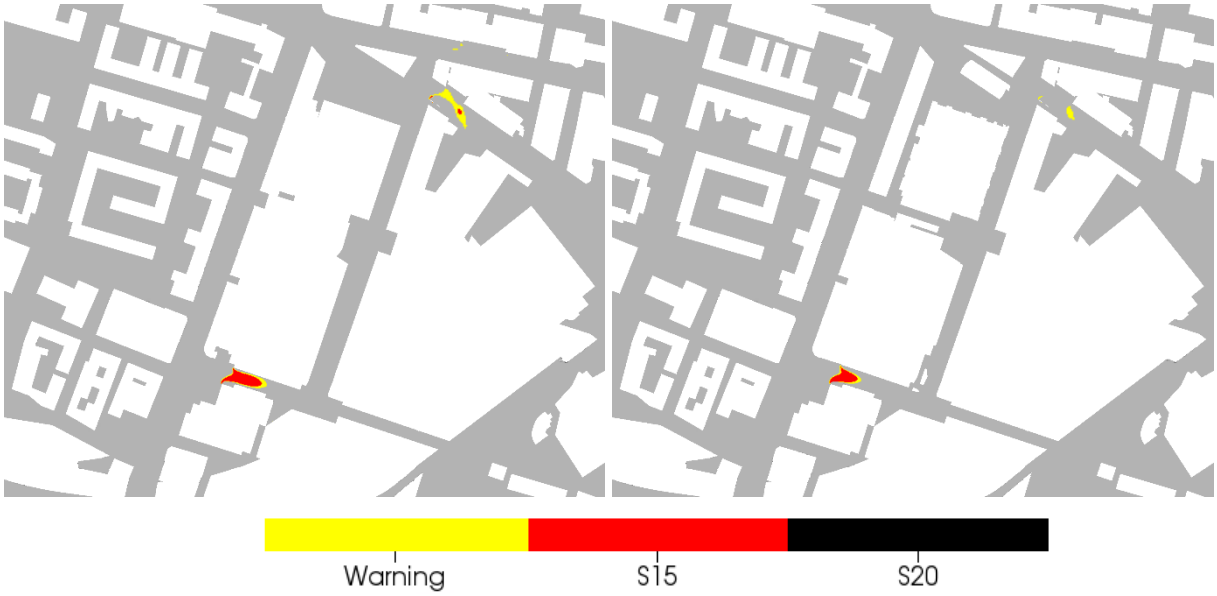


Figure 6-1 - Contours of safety criteria (left: Scenario 2, right: Scenario 4).

6.1.2. At elevated levels within the proposed development, wind conditions rate as safe for all users. Private balconies have been modelled with balustrades corresponding to Section 2.6. It should be noted that no proposed landscaping has been modelled on the terraces.

COMFORT CRITERIA ANALYSIS

6.1.4. Figure 6-2 and Figure 6-3 show contours of comfort criteria on a plane 1.5m above the ground for the worst-case season (winter) and summer seasons respectively, directly compared against the future baseline conditions (Scenario 2).

6.1.5. Figure 6-2 shows that, with the introduction of the proposed development within the context of cumulative surrounds, wind conditions within the site rate as suitable for business walking, leisure walking, standing and sitting during winter.

6.1.6. Figure 6-3 shows that, with the introduction of the proposed development within the context of cumulative surrounds, wind conditions within the site rate as suitable for standing and sitting during summer.

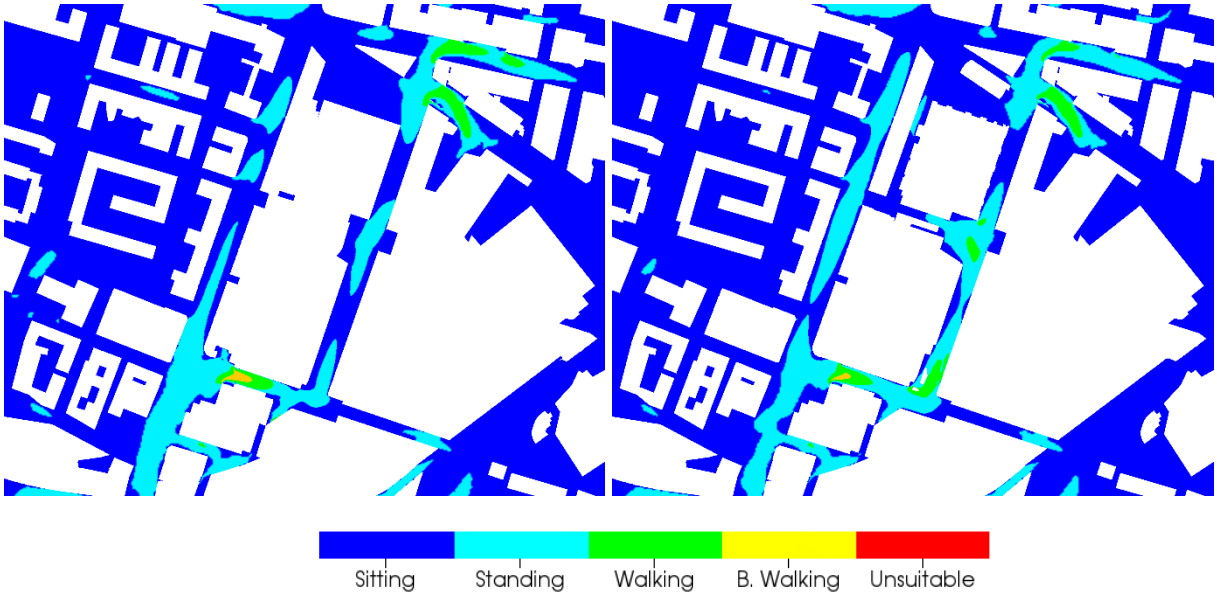


Figure 6-2 - Contours of comfort criteria in winter (left: Scenario 2, right: Scenario 4).

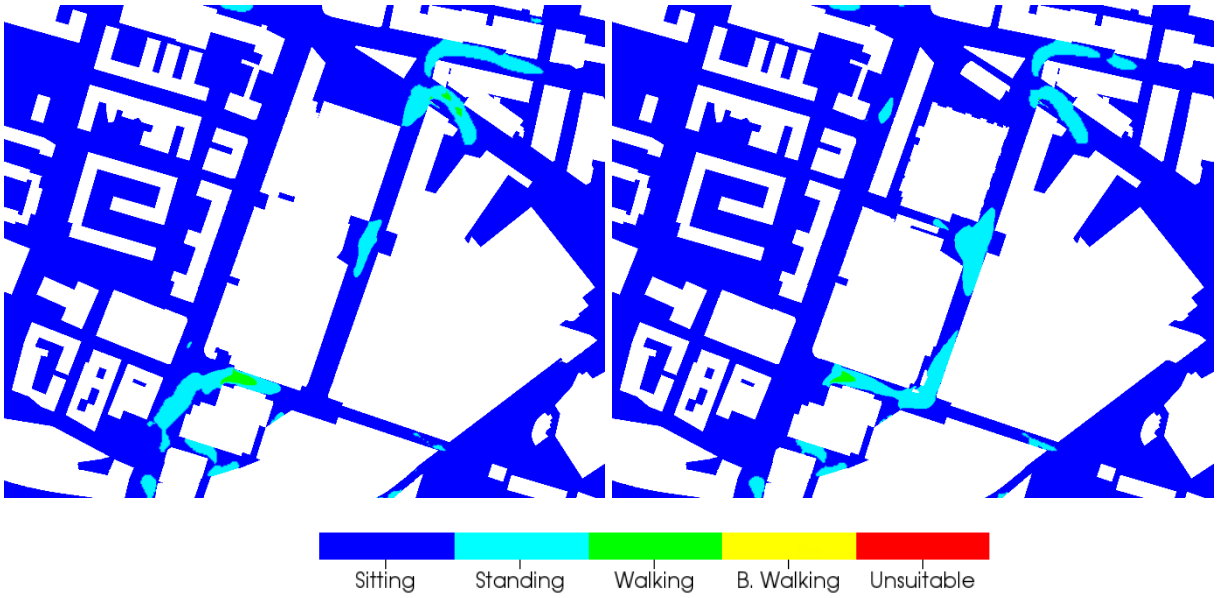


Figure 6-3 - Contours of comfort criteria in summer (left: Scenario 2, right: Scenario 4).

6.1.7. Figure 6-4 shows contours of comfort criteria on a plane 1.5m above the elevated levels in the summer season for Scenario 4.

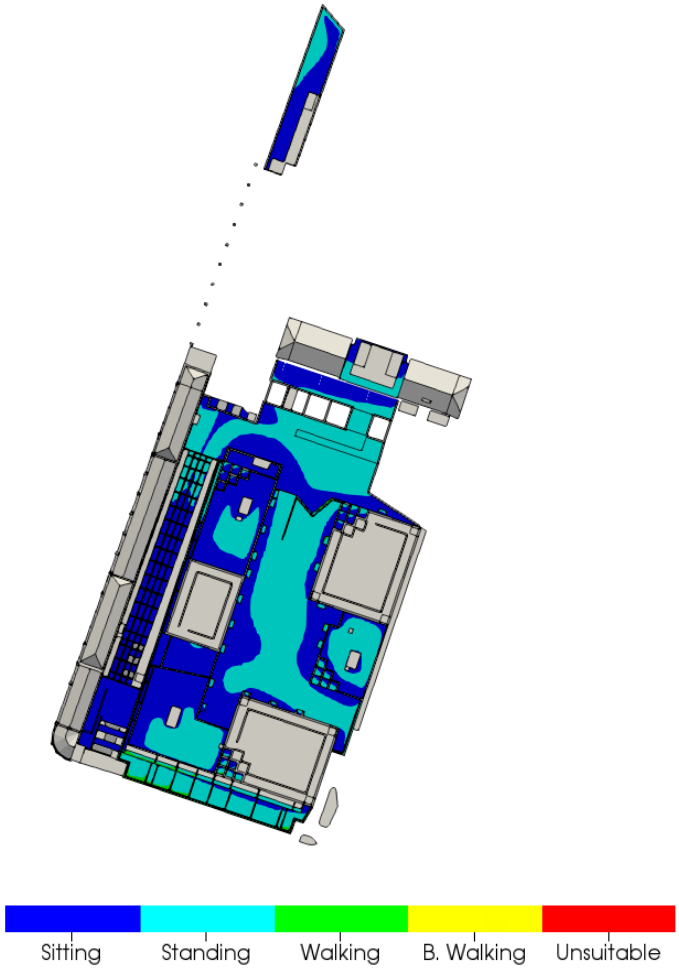


Figure 6-4 - Contours of comfort criteria on elevated levels in summer for Scenario 4.

6.1.8. Figure 6-4 indicates that during summer, most areas rate as suitable for sitting. Generally, other areas rate as suitable for standing. It should be noted that no proposed landscaping has been modelled on the terraces. Private balconies have been modelled with balustrades corresponding to Section 2.6 and mostly rate as suitable for sitting and standing during summer.

7 CONCLUSION

An analysis of the wind conditions around the proposed Great Northern Warehouse has been performed. The study consisted of CFD simulations over a range of wind directions which were combined with long-term wind statistics to provide a statistical representation of the expected wind conditions. The main findings were:

- In the baseline scenario, wind conditions in and around the site rate as safe for all users, except for an area on Great Bridgewater Street to the north of Beetham Tower and some small areas on Windmill Street to the north-east of the site.
- In the future baseline scenario, the introduction of consented surrounds results in ground level wind conditions that are similar to the baseline. The areas of exceedance on Great Bridgewater Street and Windmill Street remain.
- In the proposed scenario, the introduction of the proposed development ground level wind conditions remain safe for all users, except for an area on Great Bridgewater Street to the north of Beetham Tower, which exists in the baseline. The small areas of exceedance on Windmill Street to the north-east improves with the introduction of the proposed development.
- In the cumulative scenario, with the introduction of the proposed development within the context of cumulative surrounds, ground level wind conditions remain safe for all users, except for an area on Great Bridgewater Street to the north of Beetham Tower, which exists in the future baseline. The small areas of exceedance on Windmill Street to the north-east improves with the introduction of the proposed development.
- Elevated levels and private balconies across the proposed development rate as safe for all users and are mostly suitable for sitting and standing during summer across all scenarios. Private balconies have been modelled with balustrades corresponding to Section 2.6.

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