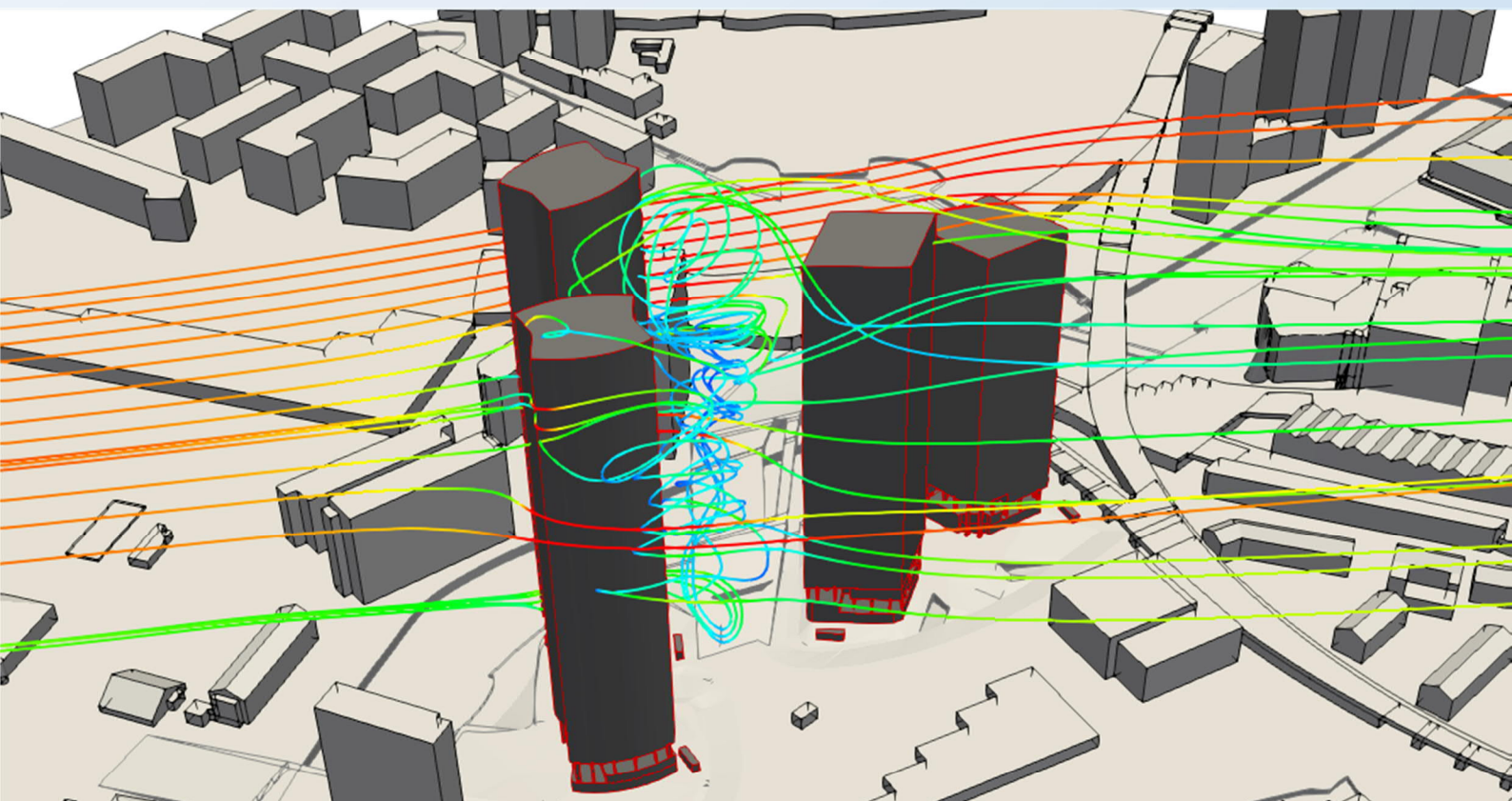




Renaker Build Ltd.

TRINITY ISLANDS

Wind Microclimate Study





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Wind Microclimate Study

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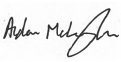
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EXECUTIVE SUMMARY

A wind microclimate study has been performed for the proposed Trinity Islands development in Manchester. A total of nine surrounds configurations (baseline included) were studied. All assessments included the proposed landscaping for the site, excluding the terraces at the bottom of the buildings.

The analyses 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, at ground level, wind conditions rate as safe for all users across all scenarios, provided that the proposed landscaping scheme is implemented. At the elevated levels, some terraces rate as unsafe for pedestrians across all scenarios.

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1 INTRODUCTION

- 1.1.1. WSP have been appointed by Renaker Build Ltd to perform a wind microclimate study around the proposed 'Trinity Islands' development in Manchester. The development consists of four towers (Building C1, Building C2, Building D1 & Building D2).
- 1.1.2. This study aims to compare the pedestrian-level wind environment around the proposed development against comfort and safety 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

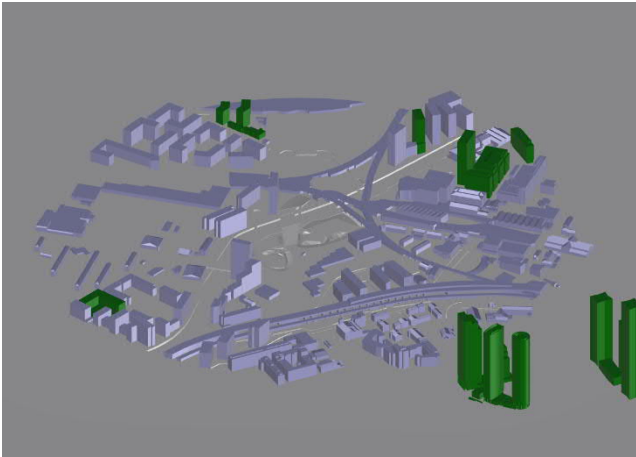
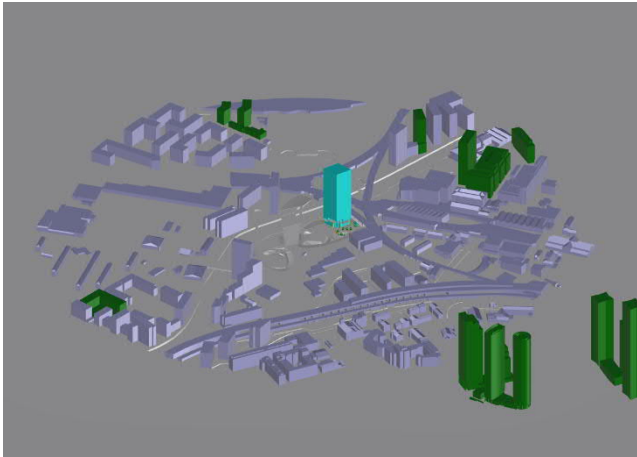
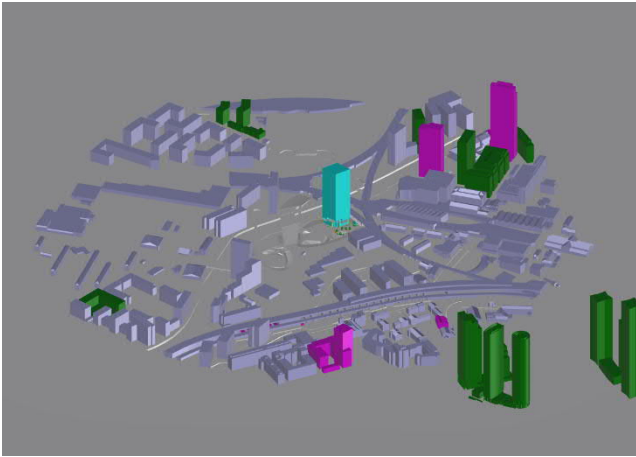
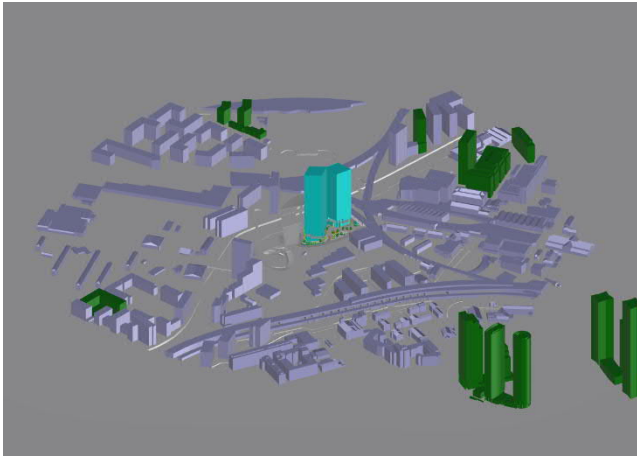
- 1.2.1. The wind microclimate around an urban environment is affected by terrain, buildings, and other obstructions. The introduction of a new building development can affect the local wind flow patterns, which can produce an uncomfortable and/or unsafe wind environment at pedestrian level.
- 1.2.2. 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 1991-1-4:2005¹, 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 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

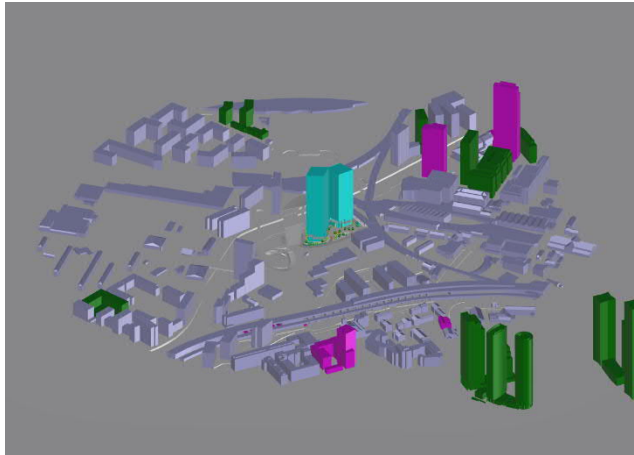
2.1 ASSESSMENT METHODOLOGY

- 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 all the scenarios depicted in Table 2-1.

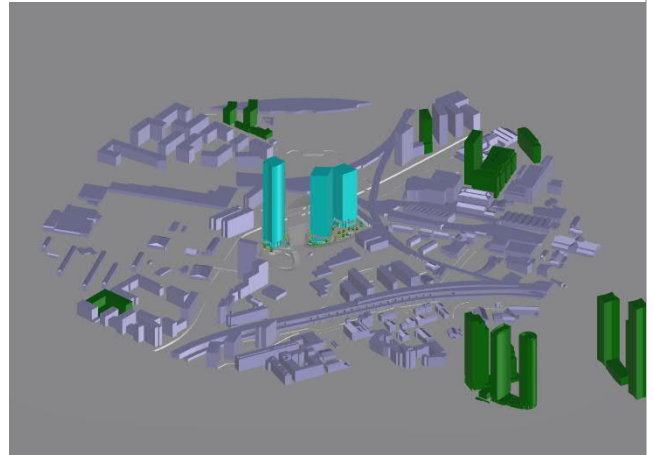
Table 2-1 - All scenarios simulated as part of the wind microclimate studies.

Scenario 1: Baseline 	Scenario 2: Phase 1 in existing surrounds 
Scenario 3: Phase 1 in cumulative surrounds 	Scenario 4: Phase 1+2 in existing surrounds 

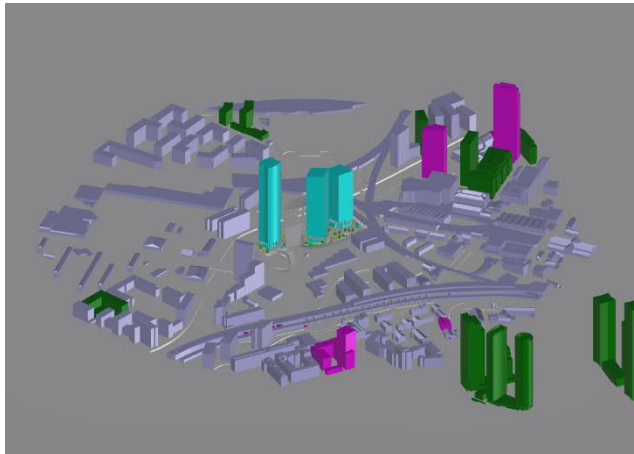
Scenario 5: Phase 1+2 in cumulative surrounds



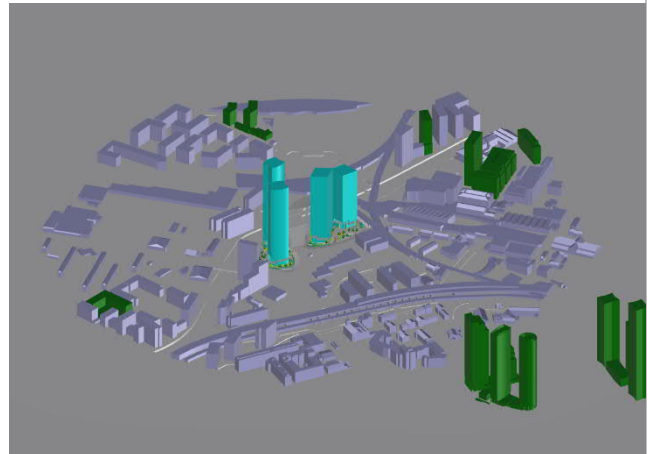
Scenario 6: Phase 1+2+3 in existing surrounds



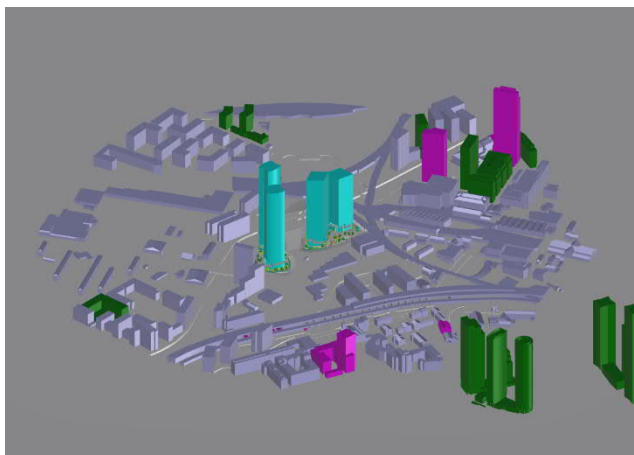
Scenario 7: Phase 1+2+3 in cumulative surrounds



Scenario 8: Phase 1+2+3+4 in existing surrounds



Scenario 9: Phase 1+2+3+4 in cumulative surrounds



2.2 SITE AND STUDY AREA

- 2.2.1. The project site is bisected by Trinity Way, and is bound by Water Street to the south-east, Regent Road to the south-west and the River Irwell to the north. The areas to the south and east consist of medium-to-high rise buildings, while other directions consist primarily of low- and medium-rise buildings.

A three-dimensional CAD model of the site and surrounding buildings has been constructed using the following drawing sets:

Table 2-2 - Drawing sets used to construct the model.

Date issued (dd/mm/yy)	Title	Filename	Usage
16/09/21	ZD-SHP-G000-MD-XX_Podium-0001	ZD-SHP-G000-MD-XX_Podium-0001.dwg	Construction of D towers in 3D model
03/09/21	Z1-SHP-G000-MD-XX-Site	Z1-SHP-G000-MD-XX-Site.dwg	Construction of C towers in 3D model
14/10/21	ZC-TPM-G710-PL-XX-3852 101	ZC-TPM-G710-PL-XX-3852 101.pdf	Positioning of Site C proposed landscaping
14/10/21	ZD-TPM-G710-PL-XX-3852 102	ZD-TPM-G710-PL-XX-3852 102.pdf	Positioning of Site D proposed landscaping

- 2.2.2. The model includes the site and all buildings within an approx. 500m radius of the site as shown in Figure 2-1. The surrounds included in the model were agreed with Deloitte. 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.
- 2.2.3. The detail of the CAD model increases from approximately 1m for the surrounding buildings to 0.2m around the site. The landscaping plan, which was informed by a series of wind mitigation workshops between WSP, Renaker, SimpsonHaugh and TPM Landscaping, was included in the computational model and is shown in Figure 2-2.

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2.3 ASSESSMENT CRITERIA

- 2.3.1. The criteria used in this study were developed by Lawson², and have been reproduced in Table 2-3. 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 2-3 - 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 safety 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 2-4.

Table 2-4 - Safety criteria used in this study.

Criteria	Description	Threshold mean wind speed for 2.2hrs/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 14km to the 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 2-2 shows a summary of the wind data at 10m height in open country 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 can be deduced that the prevailing strong winds from the south, which blow over relatively flat terrain, will be the dominant winds for the site.

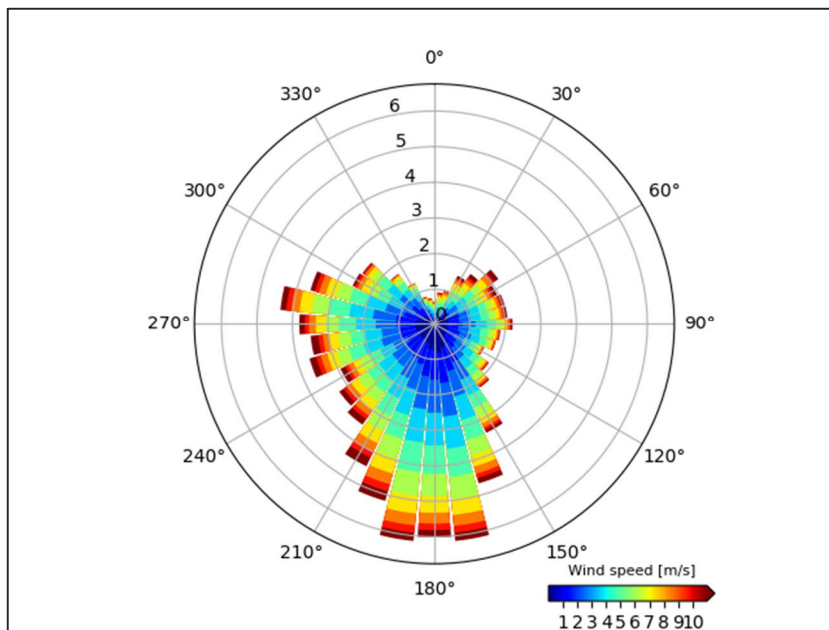


Figure 2-3 - Annual wind rose for Manchester (10m height in open country terrain), showing the frequency and magnitude of mean-hourly wind speeds.

2.4.3. Figure 2-3 shows similar wind roses split into three-month seasons. It shows that during spring, the north-easterly sector provides additional strong and frequent winds while during summer, westerly winds are frequent.

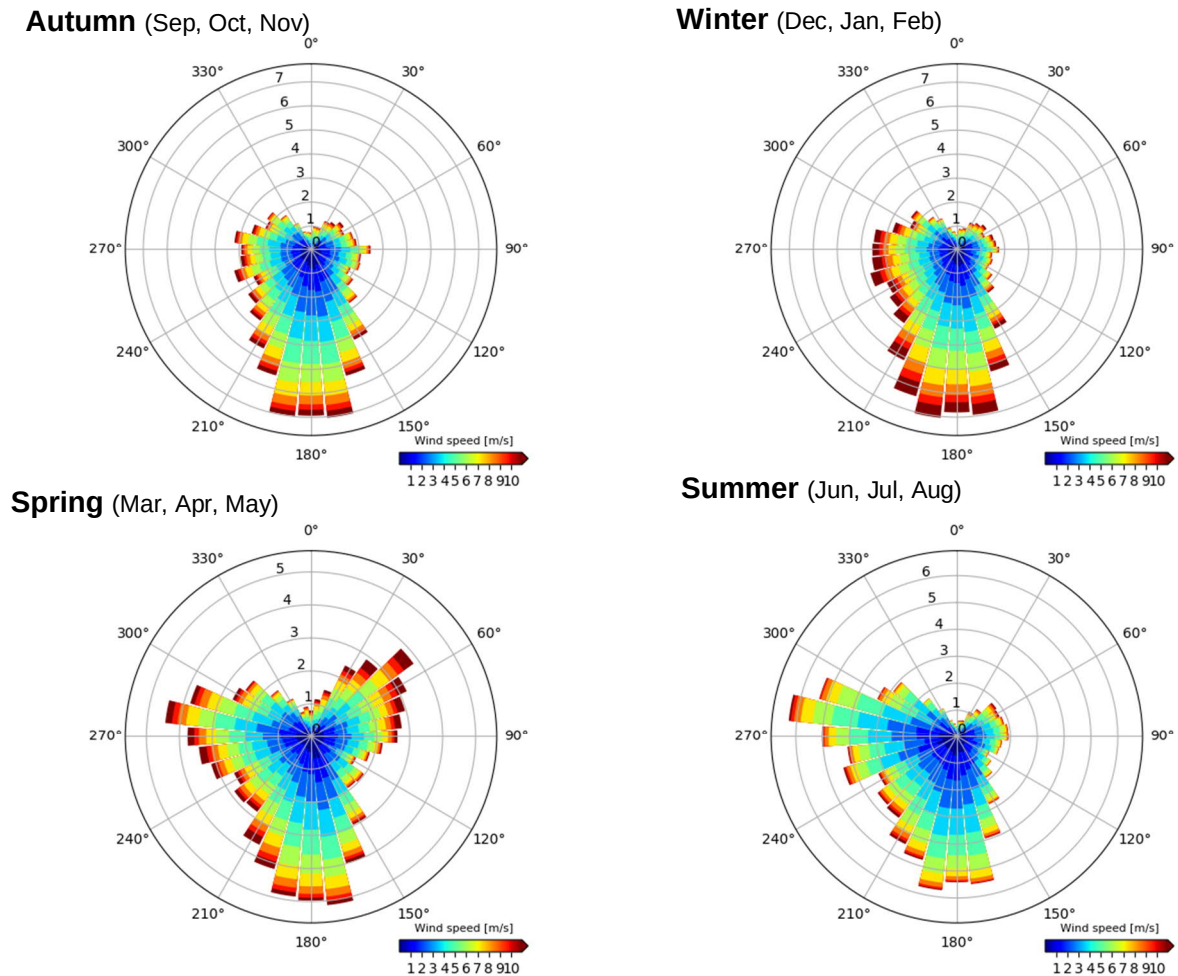


Figure 2-4 - Wind roses for each season.

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 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 170m 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) dataset⁴ which is shown in Figure 2-5. This resulted in the transposition factors shown in Table 2.5.

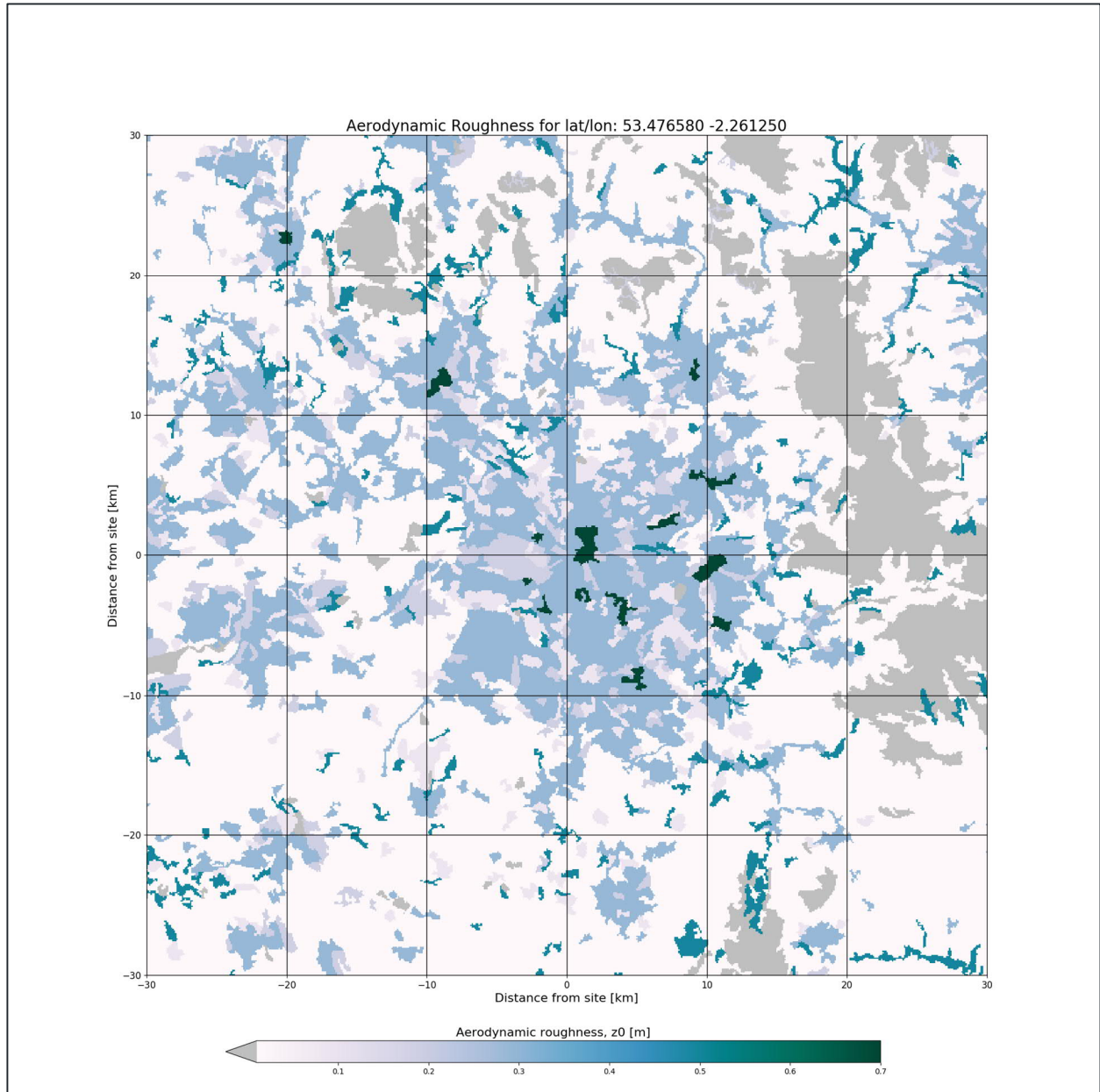


Figure 2-5 - Categorisation of the terrain surrounding the site.

Table 2-5 - Transposition factors from 10m open country to 170m reference height at the project site.

0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
1.409	1.368	1.352	1.373	1.386	1.368	1.390	1.385	1.417	1.421	1.388	1.398

- 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 2-6).

Table 2-6 - Wind directions simulated.

Simulated direction [°]	Bins included [°]	Combined frequency [%]
0	350,0,10	2.3
30	20,30,40	4.3
55	50,60	4.2
75	70,80	4.1
95	90,100	4.1
120	110,120,130	5.2
145	140,150	5.6
160	160	4.7
170	170	6.2
180	180	6.0
190	190	6.2
200	200	5.2
210	210	4.5
220	220	3.5
235	230,240	6.2
250	250	3.7
260	260	3.5
270	270	3.8
280	280	4.4
290	290	3.6
305	300,310	5.0
330	320,330,340	3.9

2.5 SIMULATION DETAILS AND ASSUMPTIONS

- 2.5.1. A CFD numerical simulation has been performed for each of the directions shown in Table 2-6. 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 3km in the horizontal directions and 700m 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 was ~57 million.
- 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)⁵ 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 $\bar{u'^2} = 0$ but $\overline{u'^2} \neq 0$, where u' is the fluctuating part of the instantaneous velocity, u . Using the fact that $k = \frac{1}{2}(\overline{u'^2} + \overline{v'^2} + \overline{w'^2})$, the velocity used of interest from the RANS equations is:

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

- 2.5.5. 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 and heavily forested areas had a rough wall function with 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:

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

and $\kappa = 0.41$ is the Von Karman constant, z is the height above the ground, $z_{ref} = 170m$, z_0 is the upstream roughness which varies by direction and $U_{ref} = 10m/s$.

- 2.5.6. 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.
- 2.5.7. Trees and other landscaping furniture 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.

3 RESULTS – SCENARIO 1: BASELINE

3.1 INTRODUCTION

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

SAFETY CRITERIA ANALYSIS

- 3.1.1. Figure 3-1 shows that for the existing site within the context of existing surrounds ground level wind conditions are rated as safe for all users.



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.

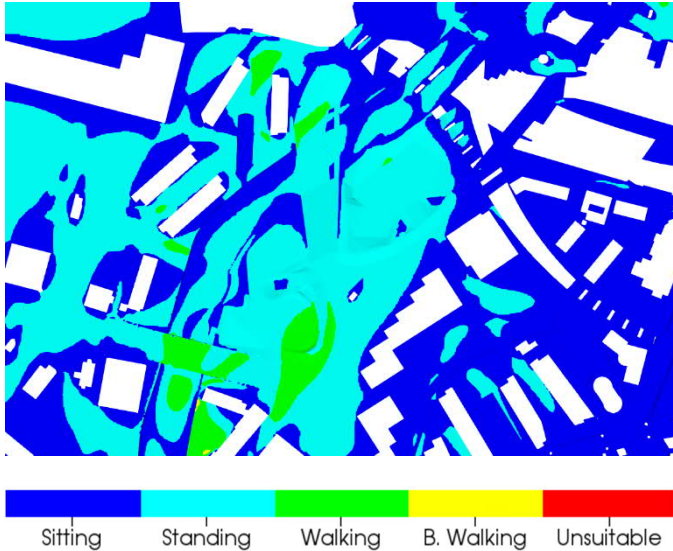


Figure 3-2 - Contours of comfort criteria for winter for Scenario 1.

- 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.

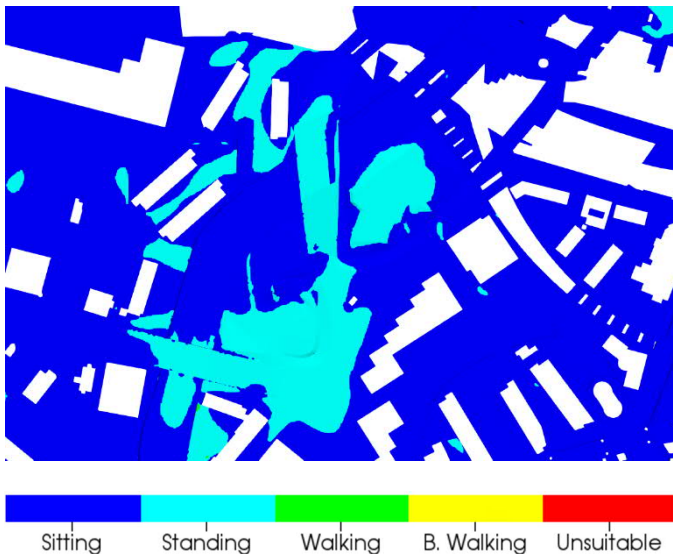


Figure 3-3 - Contours of comfort criteria for summer for Scenario 1.

- 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.

4 RESULTS – SCENARIO 2: PHASE 1 IN EXISTING SURROUNDS

4.1 INTRODUCTION

This section analyses the results of Phase 1 in existing surrounds and its associated landscaping.

SAFETY CRITERIA ANALYSIS

- 4.1.1. Figure 4-1 shows that the introduction of the proposed development and landscaping for Scenario 2 results in ground level wind conditions that are rated as safe for all users.



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

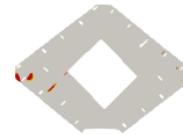


Figure 4-2 - Contours of safety criteria on elevated levels for Scenario 2.

- 4.1.2. Figure 4-2 indicates that elevated levels rate as safe for all users with the exception of some small areas towards the west of the terrace. It should be noted that no proposed landscaping has been modelled on the terraces.

COMFORT CRITERIA ANALYSIS

- 4.1.3. Figure 4-3 and Figure 4-4 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).

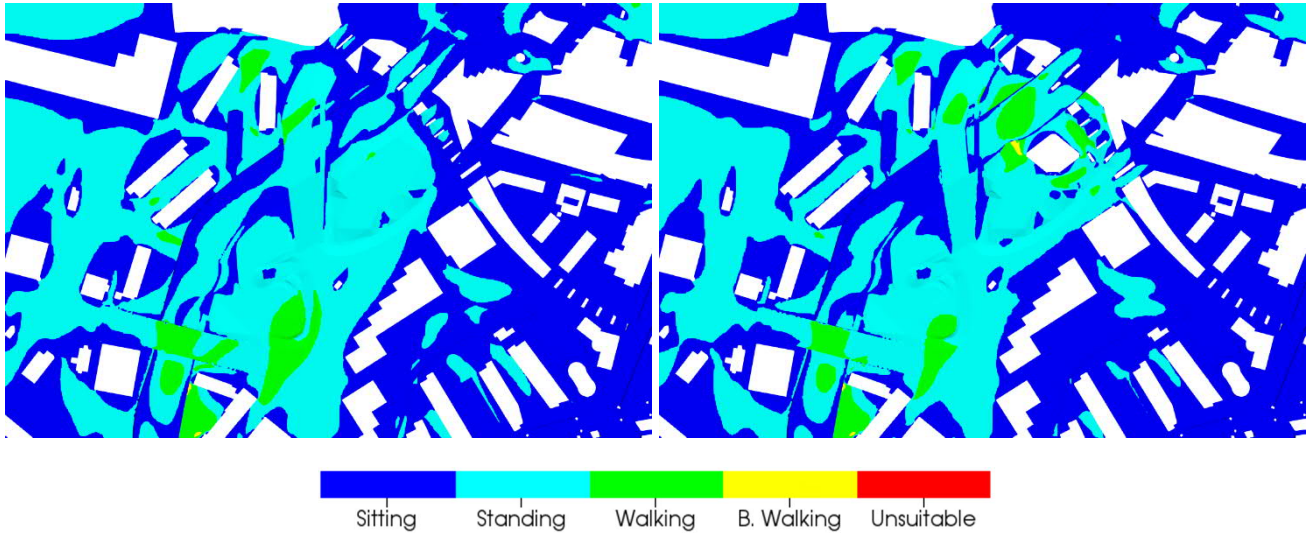


Figure 4-3 - Contours of comfort criteria for winter (left: Scenario 1, right: Scenario 2).

- 4.1.4. Figure 4-3 shows that, with the introduction of the proposed development (Scenario 2), wind conditions within the site rate as suitable for business walking, leisure walking, standing and sitting during winter.

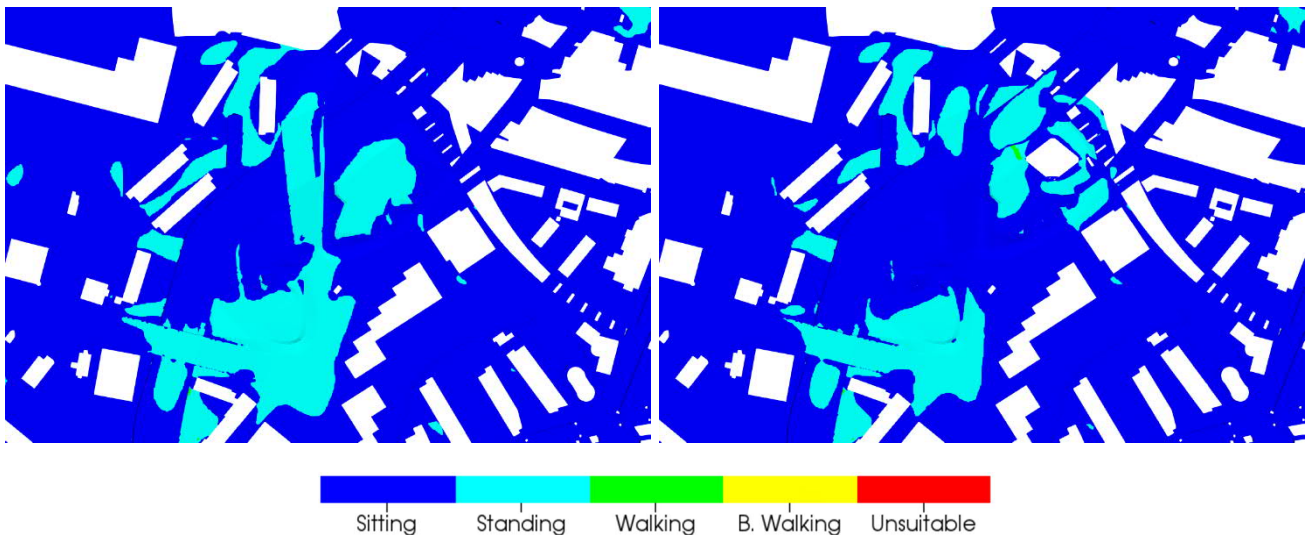


Figure 4-4 - Contours of comfort criteria for summer (left: Scenario 1, right: Scenario 2).

- 4.1.5. Figure 4-4 shows that, with the introduction of the proposed development (Scenario 2), wind conditions within the site rate as suitable for standing and sitting during summer.

- 4.1.6. Figure 4-5 shows contours of comfort criteria on a plane 1.5m above the elevated levels for the summer season for Scenario 2.



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

- 4.1.7. Figure 4-5 indicates that during summer, most north-facing 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.

5 RESULTS – SCENARIO 3: PHASE 1 IN CUMULATIVE SURROUNDS

5.1 INTRODUCTION

This section analyses the results of Phase 1 in cumulative surrounds.

SAFETY CRITERIA ANALYSIS

- 5.1.1. Figure 5-1 shows that the introduction of the proposed development and cumulative surrounds results in ground level wind conditions that are rated as safe for all users.



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



Figure 5-2 - Contours of safety criteria on elevated levels for Scenario 3.

- 5.1.2. Figure 5-2 indicates that elevated levels rate as safe for all users with the exception of some small areas towards the west of the terrace. It should be noted that no proposed landscaping has been modelled on the terraces.

COMFORT CRITERIA ANALYSIS

- 5.1.3. Figure 5-3 and Figure 5-4 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 existing surround scenario (Scenario 2).

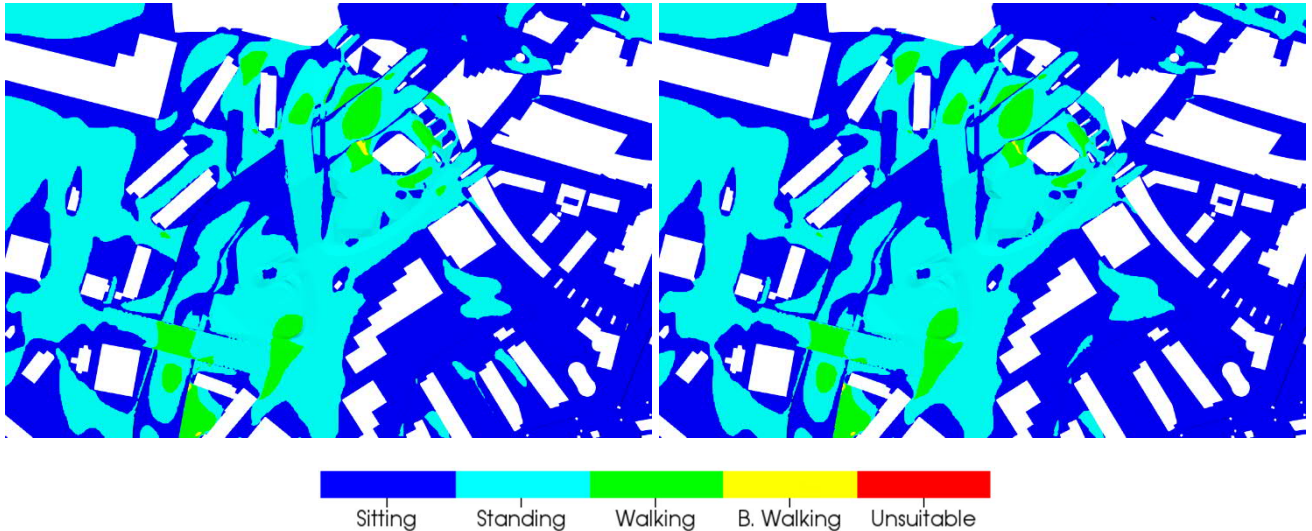


Figure 5-3 - Contours of comfort criteria for winter (left: Scenario 2, right: Scenario 3).

- 5.1.4. Figure 5-3 shows that, with the introduction of the proposed development and cumulative surrounds, wind conditions within the site rate as suitable for business walking, leisure walking, standing and sitting during winter.

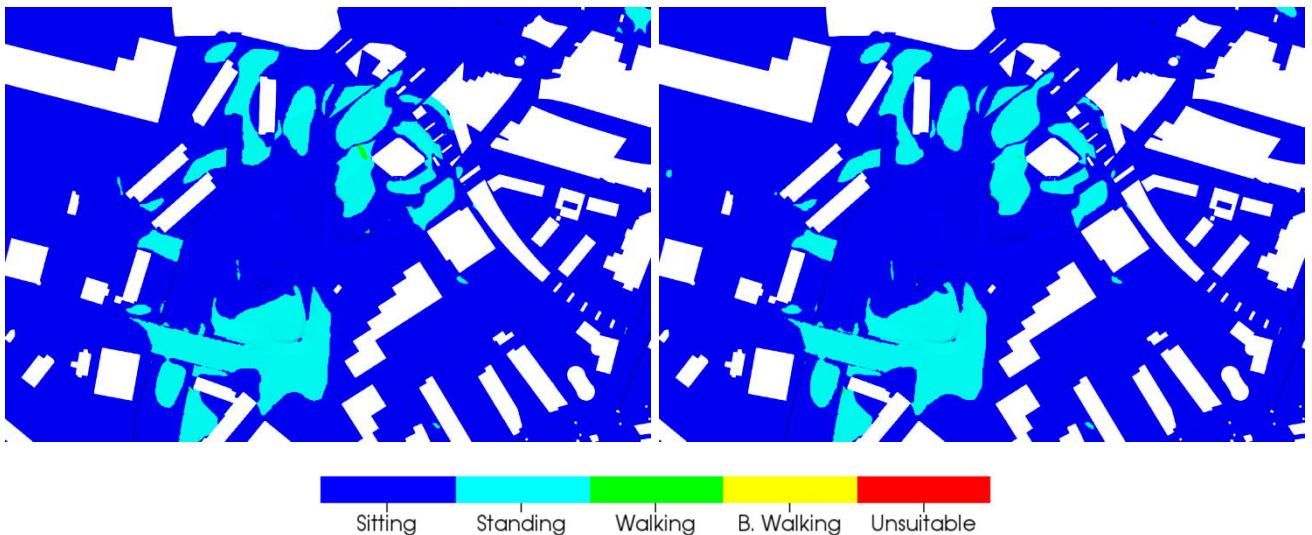


Figure 5-4 - Contours of comfort criteria for summer (left: Scenario 2, right: Scenario 3).

- 5.1.5. Figure 5-4 shows that, with the introduction of the proposed development and cumulative surrounds, wind conditions within the site rate as suitable for walking, standing and sitting during summer.
- 5.1.6. Figure 5-5 shows contours of comfort criteria on a plane 1.5m above the elevated levels for the summer season for Scenario 3.



Figure 5-5 - Contours of comfort criteria on elevated levels in summer.

- 5.1.7. Figure 5-5 indicates that during summer, most north-facing 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.

6 RESULTS – SCENARIO 4: PHASE 1 AND 2 IN EXISTING SURROUNDS

6.1 INTRODUCTION

This section analyses the results of Phase 1 and 2 in existing surrounds and its associated landscaping.

SAFETY CRITERIA ANALYSIS

- 6.1.1. Figure 6-1 shows that the introduction of the proposed development and landscaping for Scenario 4 results in ground level wind conditions that are rated as safe for all users.



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

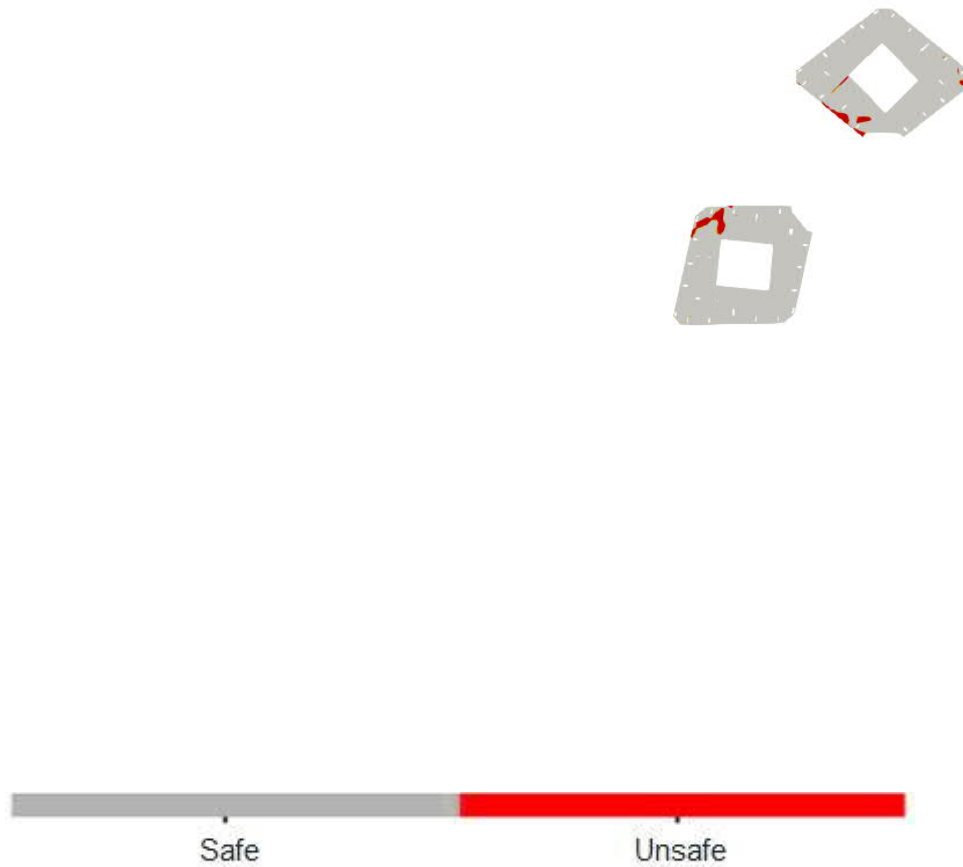


Figure 6-2 - Contours of safety criteria on elevated levels for Scenario 4.

- 6.1.2. Figure 6-2Figure 4-2 indicates that elevated levels rate as safe for all users with the exception of some small areas on the south-west and east of Building C1 and north-west of Building C2. It should be noted that no proposed landscaping has been modelled on the terraces.

COMFORT CRITERIA ANALYSIS

- 6.1.3. Figure 6-3 and Figure 6-4 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 Scenario 2.

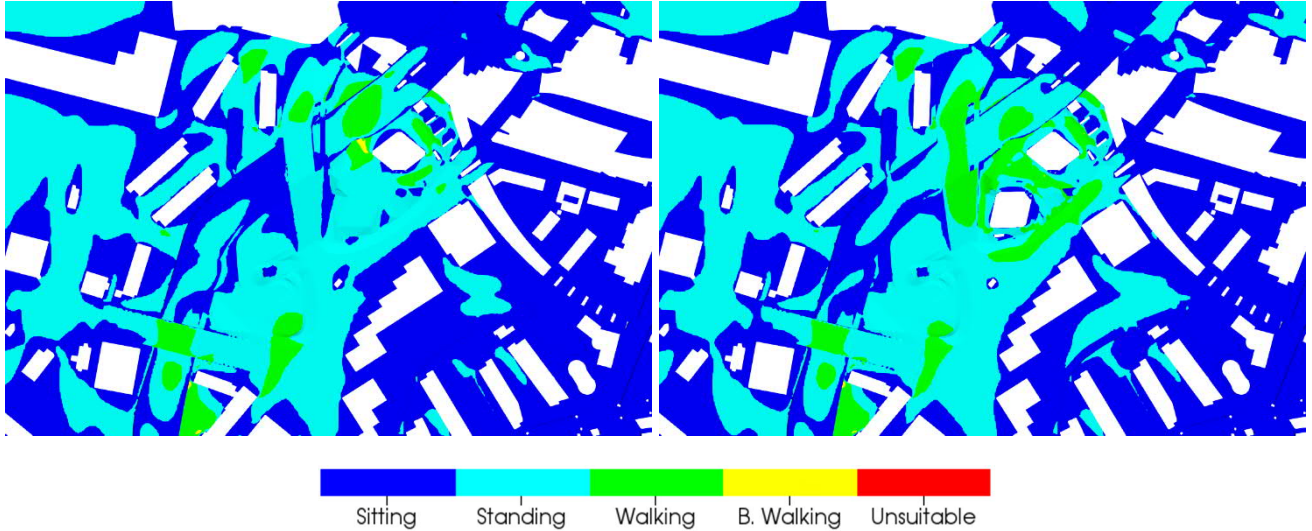


Figure 6-3 - Contours of comfort criteria for winter (left: Scenario 2, right: Scenario 4).

- 6.1.4. Figure 6-3 shows that, with the introduction of the proposed development (Scenario 4), wind conditions within the site rate as suitable for walking, standing and sitting during winter.

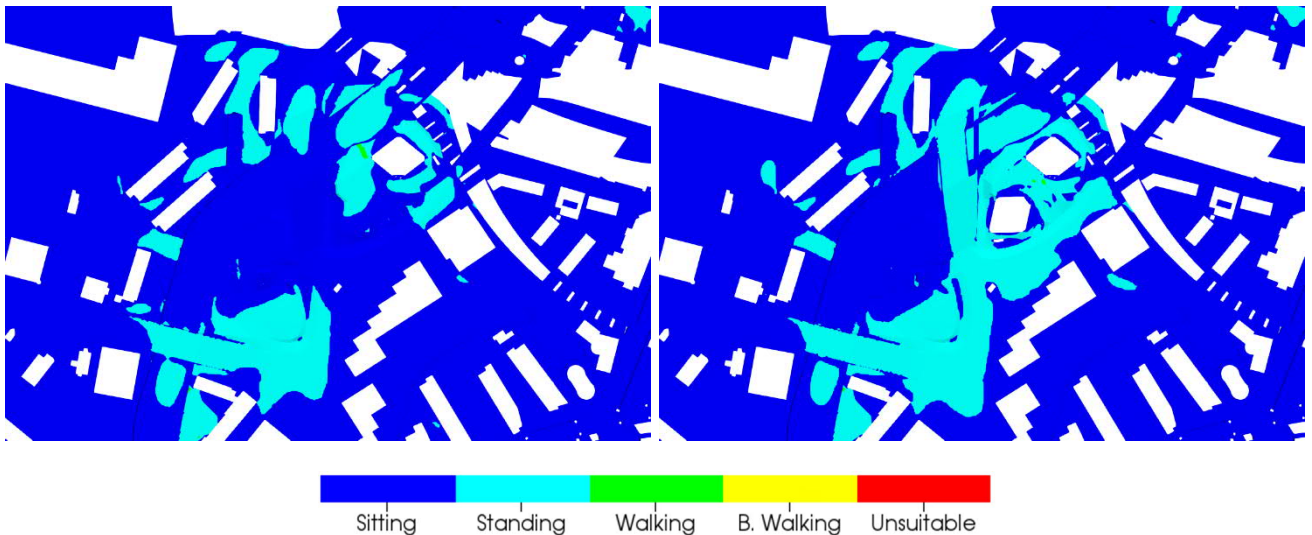


Figure 6-4 - Contours of comfort criteria for summer (left: Scenario 2, right: Scenario 4).

- 6.1.5. Figure 6-4 shows that, with the introduction of the proposed development (Scenario 4), wind conditions within the site rate as suitable for standing and sitting during summer.

- 6.1.6. Figure 6-5 shows contours of comfort criteria on a plane 1.5m above the elevated levels for the summer season for Scenario 4.

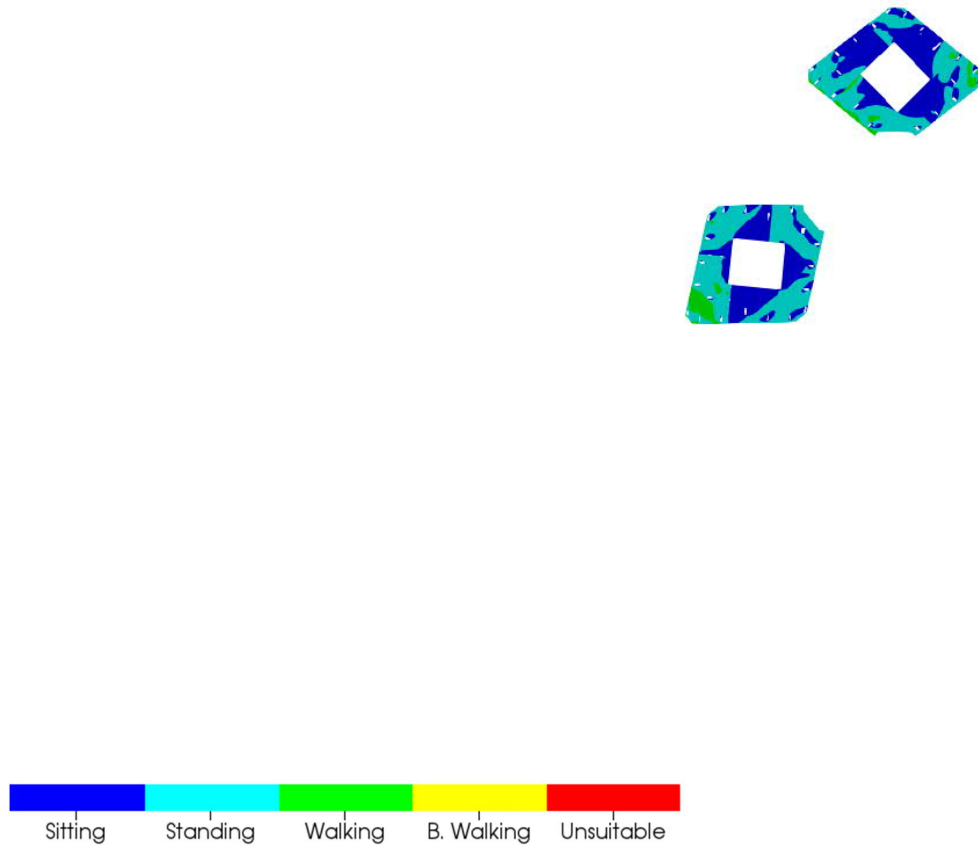


Figure 6-5 - Contours of comfort criteria on elevated levels in summer.

- 6.1.7. Figure 6-5 indicates that during summer, some areas rate as suitable for seating on both towers, however the majority of areas are suitable for standing, with localised patches only suitable for walking. It should be noted that no proposed landscaping has been modelled on the terraces.

7 RESULTS – SCENARIO 5: PHASE 1 AND 2 IN CUMULATIVE SURROUNDS

7.1 INTRODUCTION

This section analyses the results of Phase 1 and 2 in cumulative surrounds.

SAFETY CRITERIA ANALYSIS

- 7.1.1. Figure 7-1 shows that the introduction of the proposed development and cumulative surrounds results in ground level wind conditions that are rated as safe for all users.



Figure 7-1 - Contours of safety criteria (left: Scenario 4, right: Scenario 5).

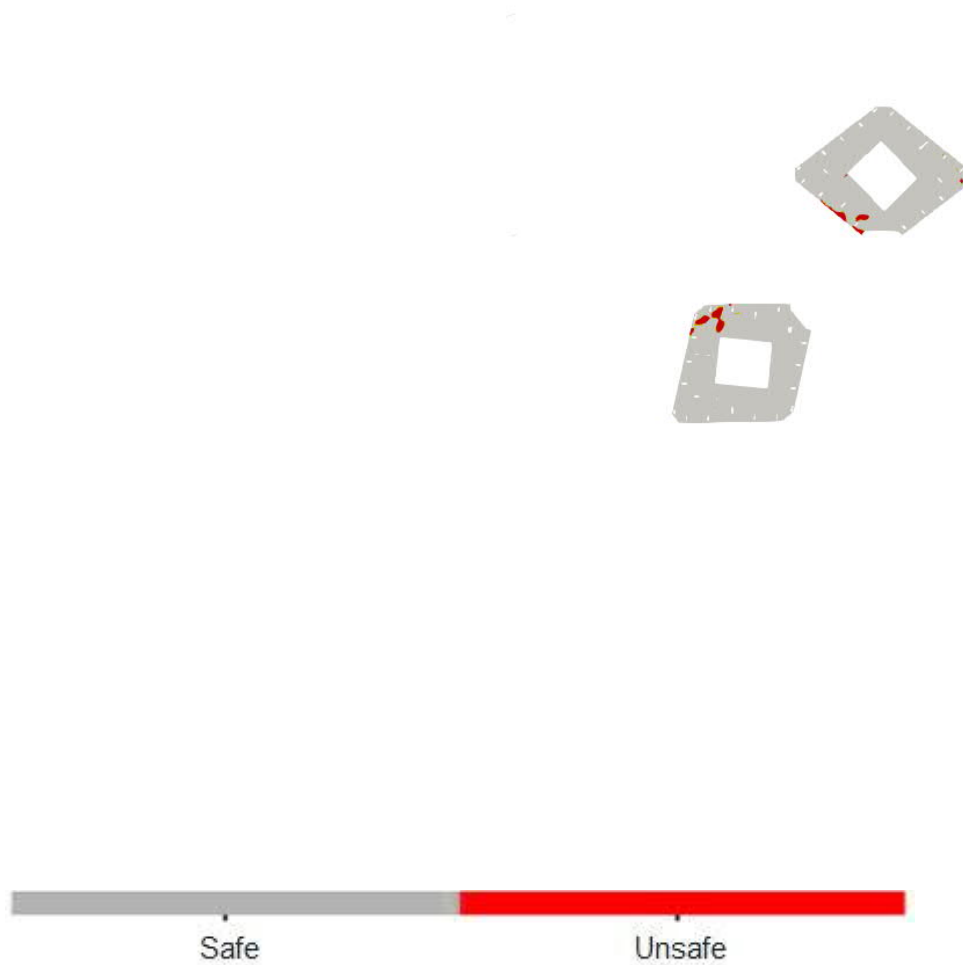


Figure 7-2 - Contours of safety criteria on elevated levels for Scenario 5.

Figure 7-2 indicates that elevated levels rate as safe for all users with the exception of some small areas on the south-west and east of Building C1 and north-west of Building C2. It should be noted that no proposed landscaping has been modelled on the terraces.

COMFORT CRITERIA ANALYSIS

- 7.1.2. Figure 7-3 and Figure 7-4 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 existing surrounds scenario (Scenario 4).

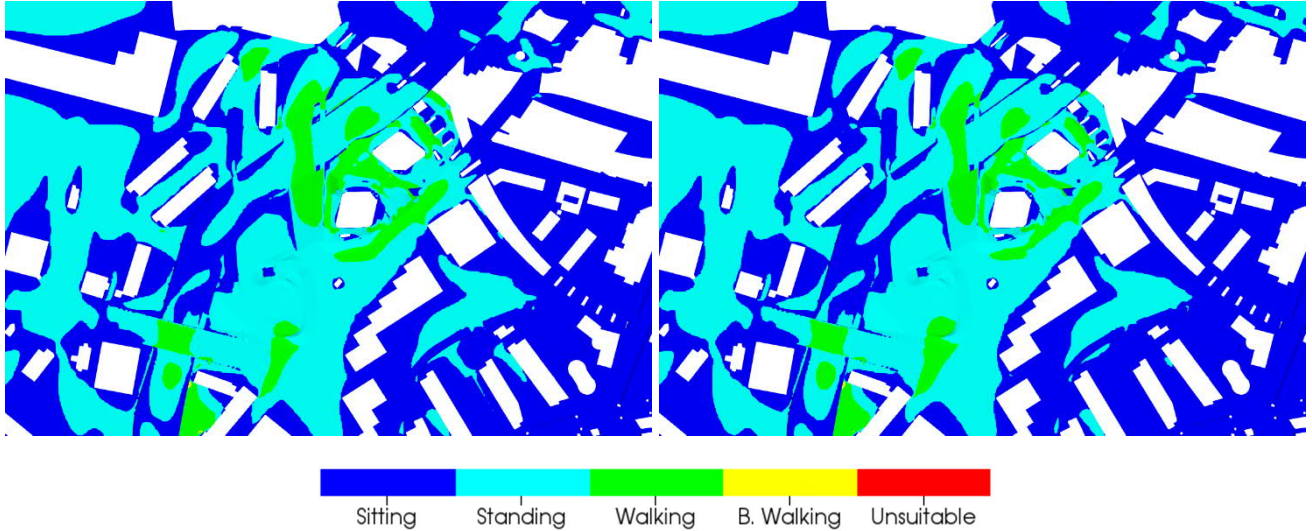


Figure 7-3 - Contours of comfort criteria for winter (left: Scenario 4, right: Scenario 5).

- 7.1.3. Figure 7-3 shows that, with the introduction of the proposed development and cumulative surrounds, wind conditions within the site rate as suitable for walking, standing and sitting during winter.

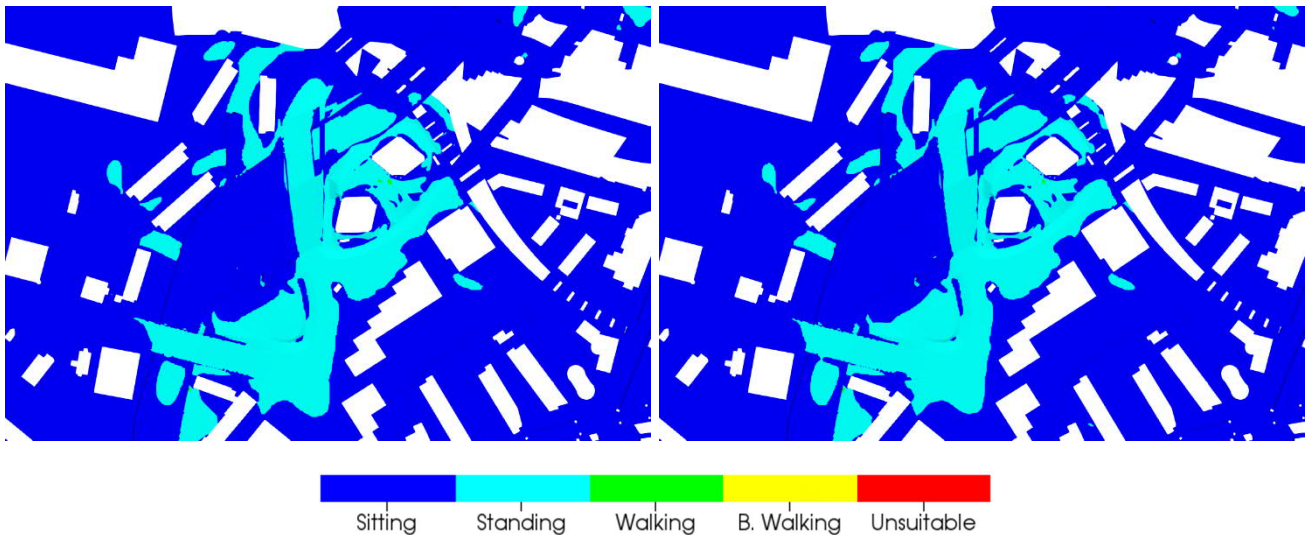


Figure 7-4 - Contours of comfort criteria for summer (left: Scenario 4, right: Scenario 5).

- 7.1.4. Figure 7-4 shows that, with the introduction of the proposed development and cumulative surrounds, wind conditions within the site rate as suitable for standing and sitting during summer.

- 7.1.5. Figure 7-5 shows contours of comfort criteria on a plane 1.5m above the elevated levels for the summer season for Scenario 5.

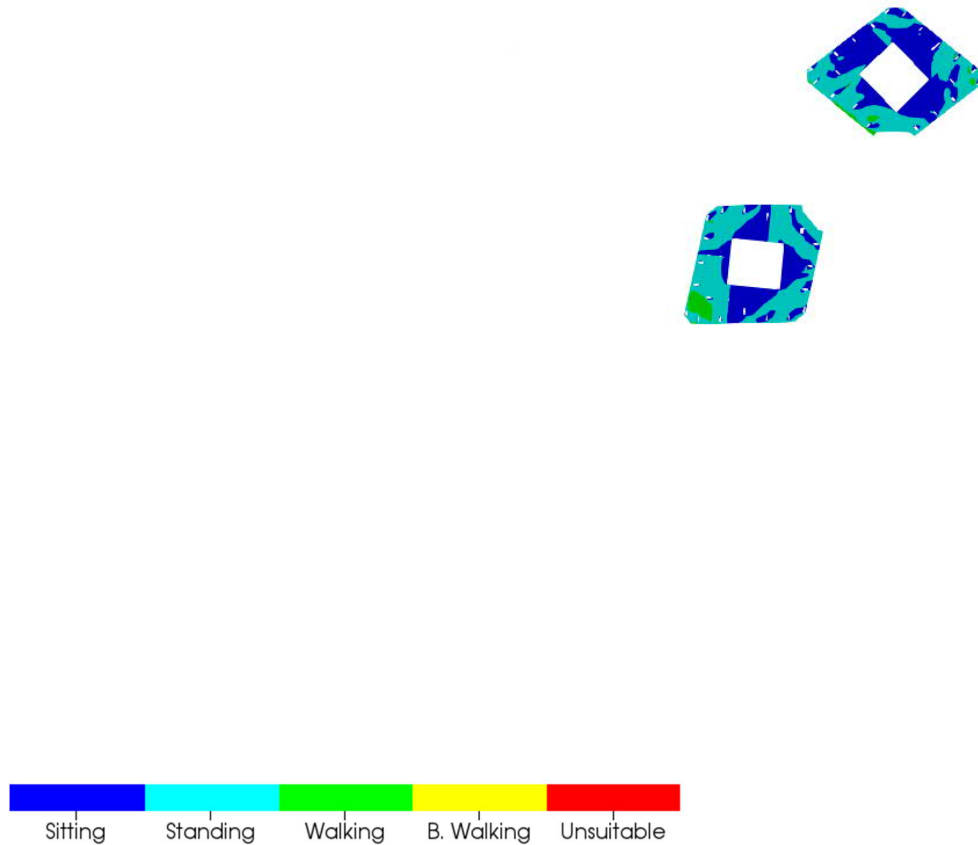


Figure 7-5 - Contours of comfort criteria on elevated levels in summer.

- 7.1.6. Figure 7-5 indicates that during summer, some areas rate as suitable for seating on both towers, however the majority of areas are suitable for standing, with localised patches only suitable for walking. It should be noted that no proposed landscaping has been modelled on the terraces.

8 RESULTS – SCENARIO 6: PHASE 1, 2 AND 3 IN EXISTING SURROUNDS

8.1 INTRODUCTION

This section analyses the results of Phase 1, 2 and 3 in existing surrounds and its associated landscaping.

SAFETY CRITERIA ANALYSIS

- 8.1.1. Figure 8-1 shows that the introduction of the proposed development and landscaping for Scenario 6 results in ground level wind conditions that are rated as safe for all users.



Figure 8-1 - Contours of safety criteria (left: Scenario 4, right: Scenario 6).

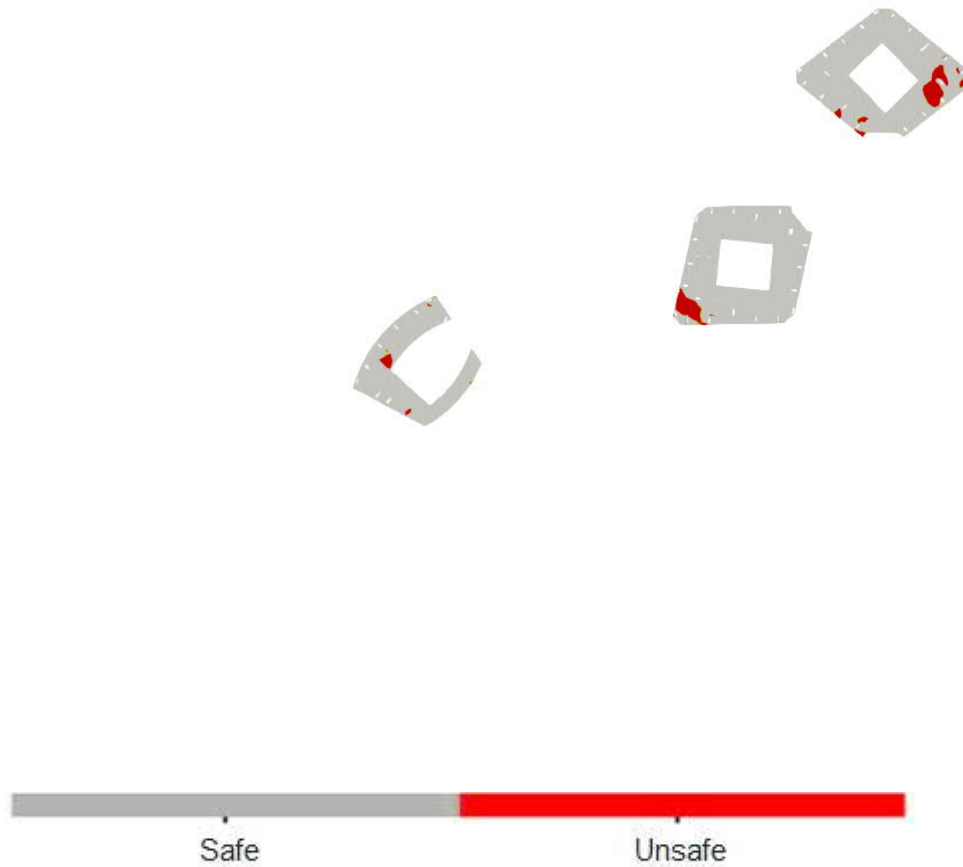


Figure 8-2 - Contours of safety criteria on elevated levels for Scenario 6.

- 8.1.2. Figure 8-2 indicates that elevated levels rate as safe for all users with the exception of some small areas on the south-west and east of Building C1, south-west of Building C2 and some small patches on Building D1. It should be noted that no proposed landscaping has been modelled on the terraces.

COMFORT CRITERIA ANALYSIS

- 8.1.3. Figure 8-3 and Figure 8-4 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 Scenario 4.

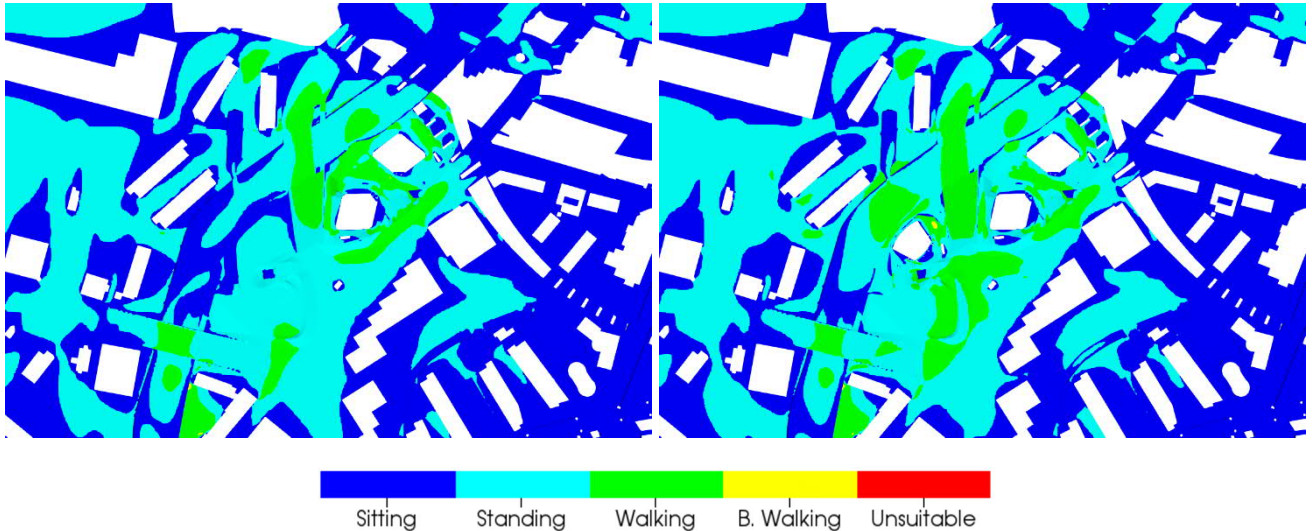


Figure 8-3 - Contours of comfort criteria for winter (left: Scenario 4, right: Scenario 6).

- 8.1.4. Figure 8-3 shows that, with the introduction of the proposed development (Scenario 6), wind conditions within the site rate as suitable for business walking, leisure walking, standing and sitting during winter.

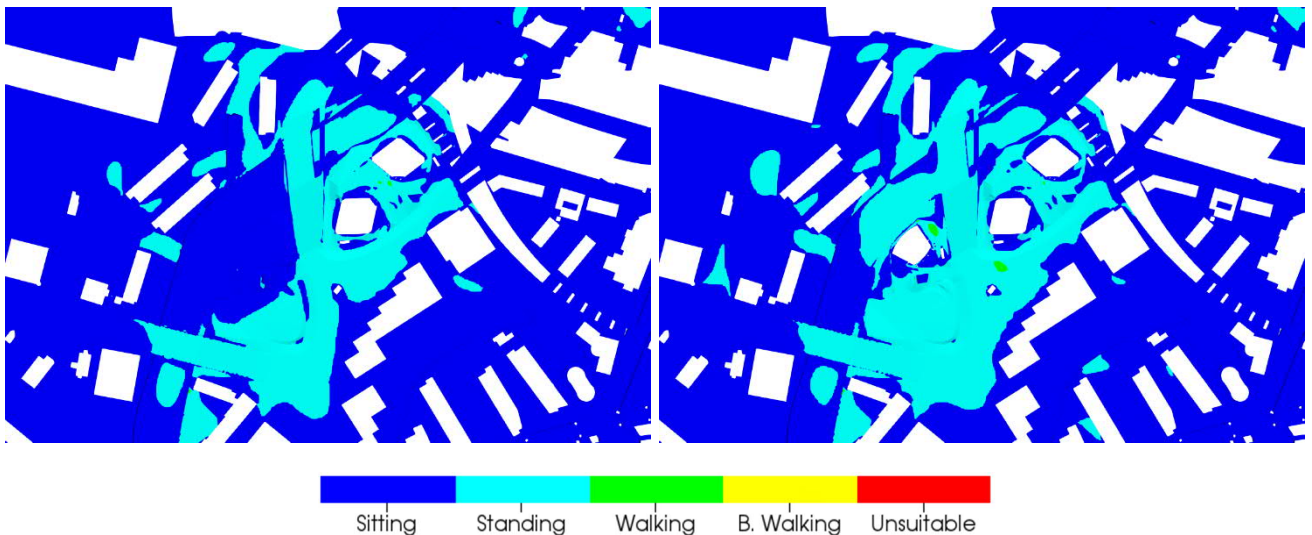


Figure 8-4 - Contours of comfort criteria for summer (left: Scenario 4, right: Scenario 6).

- 8.1.5. Figure 8-4 shows that, with the introduction of the proposed development (Scenario 6), wind conditions within the site rate as suitable for standing and sitting during summer, with a small area to the east of Building D1 being suitable for walking.

- 8.1.6. Figure 8-5 shows contours of comfort criteria on a plane 1.5m above the elevated levels for the summer season for Scenario 6.

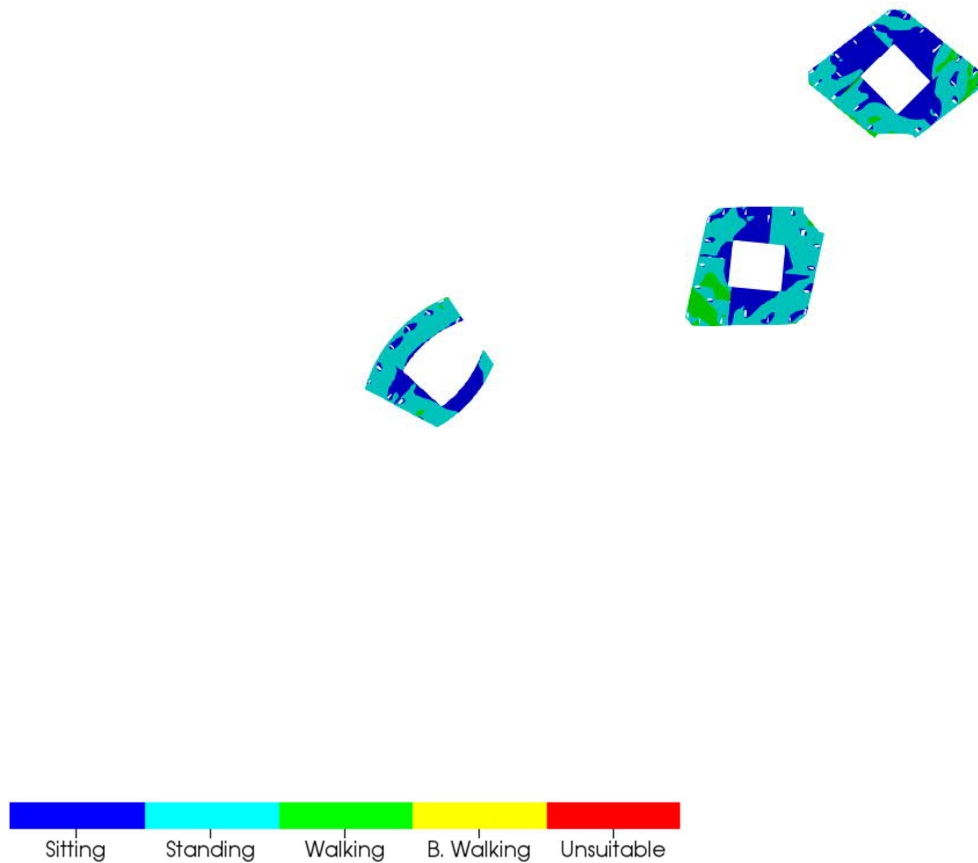


Figure 8-5 - Contours of comfort criteria on elevated levels in summer

- 8.1.7. Figure 8-5 indicates that during summer, some areas rate as suitable for seating on all the towers, however the majority of areas are suitable for standing, with localised patches only suitable for walking. It should be noted that no proposed landscaping has been modelled on the terraces.

9 RESULTS – SCENARIO 7: PHASE 1, 2 AND 3 IN CUMULATIVE SURROUNDS

9.1 INTRODUCTION

This section analyses the results of Phase 1, 2 and 3 in cumulative surrounds.

SAFETY CRITERIA ANALYSIS

- 9.1.1. Figure 9-1 shows that the introduction of the proposed development and cumulative surrounds results in ground level wind conditions that are rated as safe for all users.



Figure 9-1 - Contours of safety criteria (left: Scenario 6, right: Scenario 7).

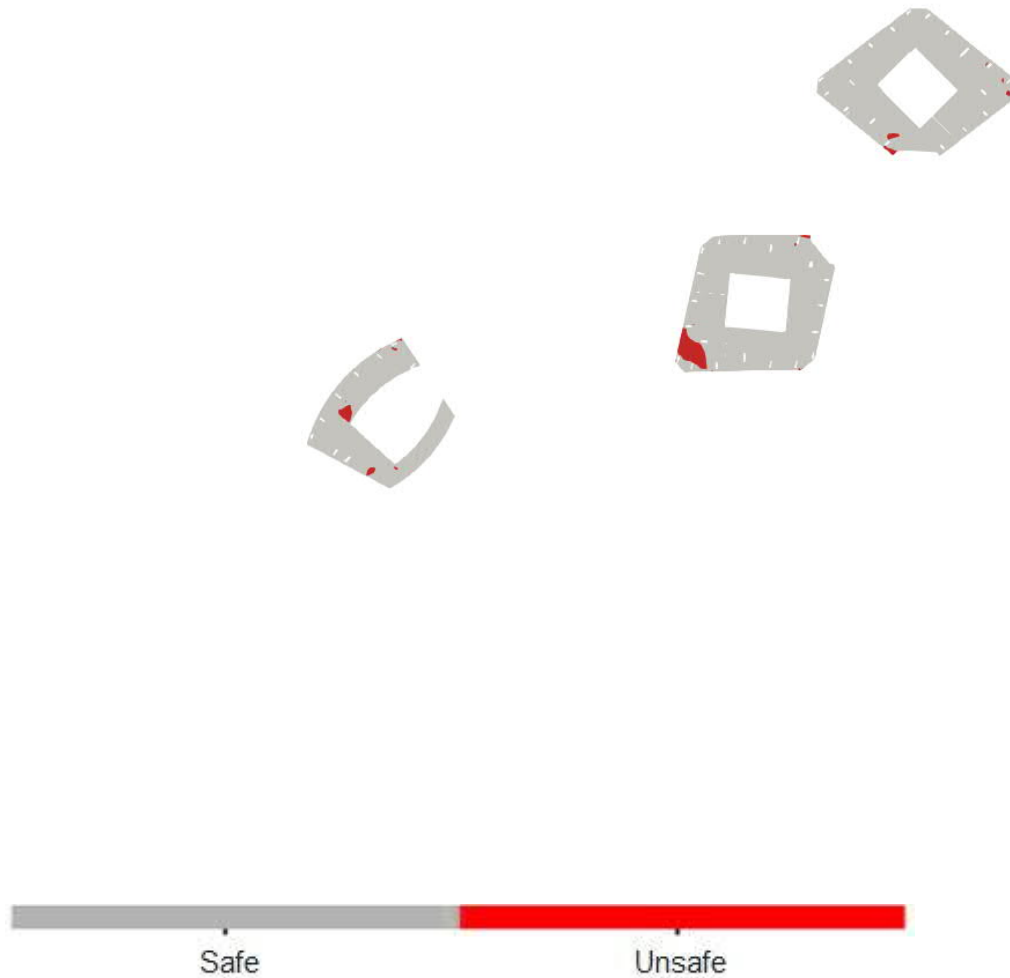


Figure 9-2 - Contours of safety criteria on elevated levels for Scenario 7.

- 9.1.2. Figure 9-2 indicates that elevated levels rate as safe for all users with the exception of some small areas on the south-west and east of Building C1, south-west of Building C2 and some small patches on Building D1. It should be noted that no proposed landscaping has been modelled on the terraces.

COMFORT CRITERIA ANALYSIS

- 9.1.3. Figure 9-3 and Figure 9-4 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 existing surrounds scenario (Scenario 6).

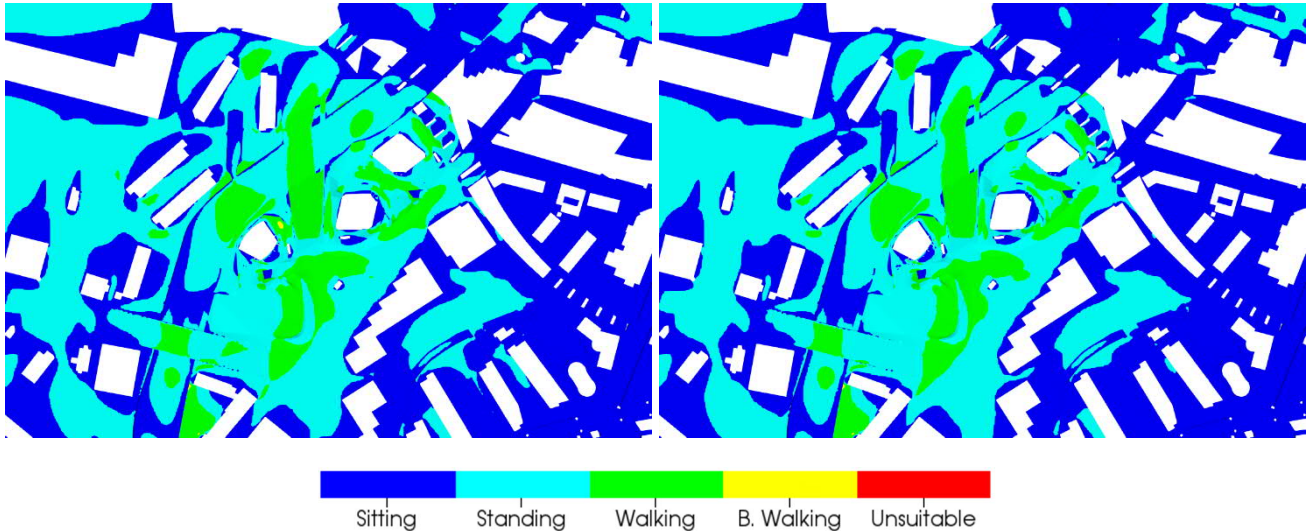


Figure 9-3 - Contours of comfort criteria for winter (left: Scenario 6, right: Scenario 7).

- 9.1.4. Figure 9-3 shows that, with the introduction of the proposed development and cumulative surrounds (Scenario 7), wind conditions within the site rate as suitable for walking, standing and sitting during winter.

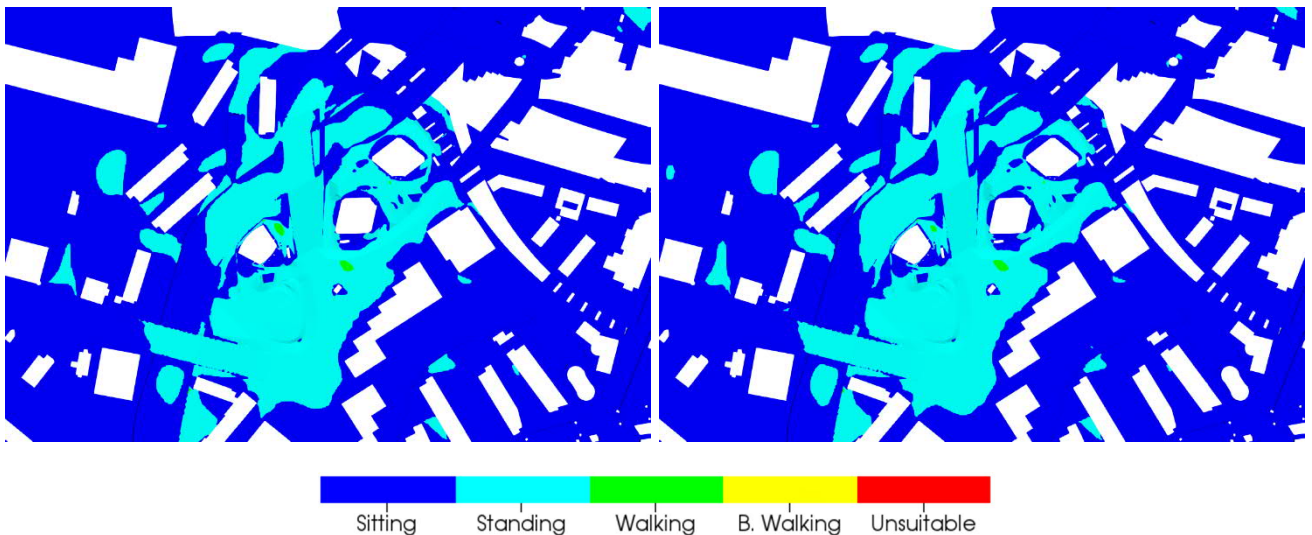


Figure 9-4 - Contours of comfort criteria for summer (left: Scenario 6, right: Scenario 7).

- 9.1.5. Figure 9-4 shows that, with the introduction of the proposed development and cumulative surrounds (Scenario 7), wind conditions within the site rate as suitable for standing and sitting during summer.

- 9.1.6. Figure 9-5 shows contours of comfort criteria on a plane 1.5m above the elevated levels for the summer season for Scenario 7.

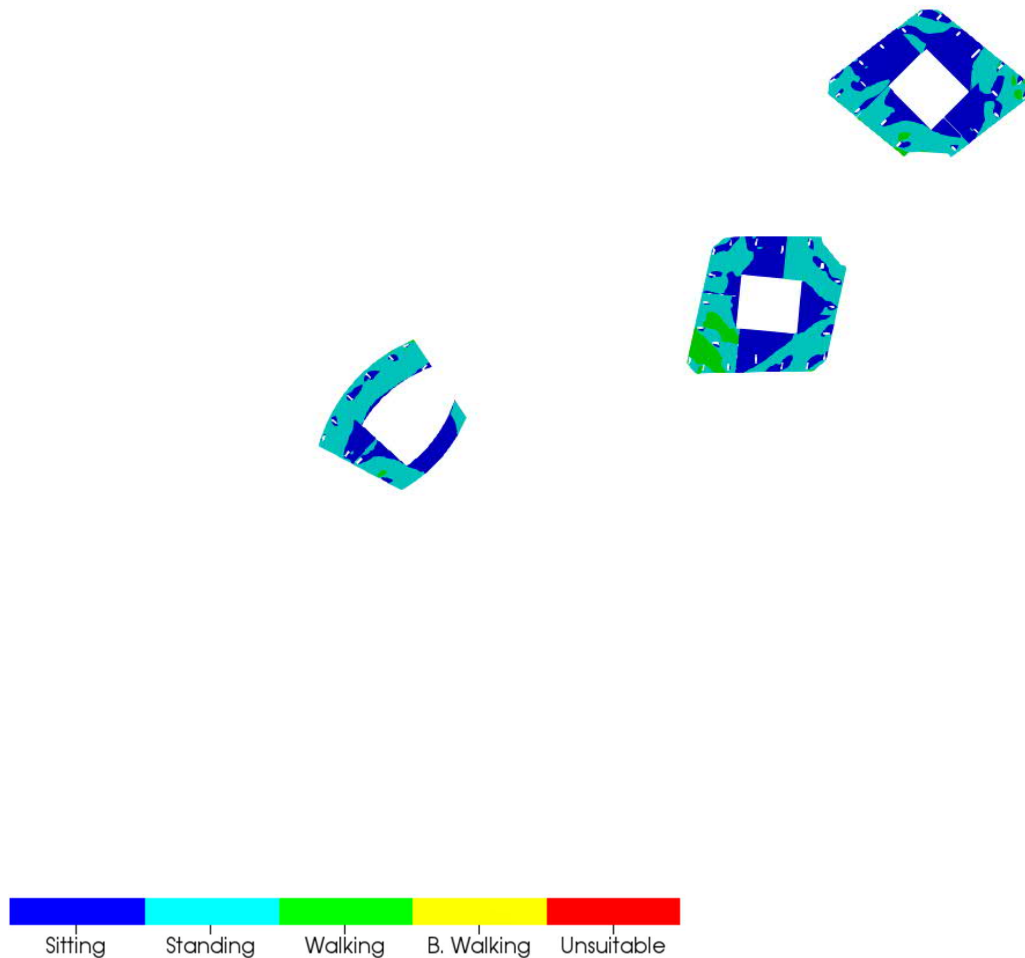


Figure 9-5 - Contours of comfort criteria on elevated levels in summer.

- 9.1.7. Figure 9-5 indicates that during summer, some areas rate as suitable for seating on all the towers, however the majority of areas are suitable for standing, with localised patches only suitable for walking. It should be noted that no proposed landscaping has been modelled on the terraces.

10 RESULTS – SCENARIO 8: PHASE 1, 2, 3 AND 4 IN EXISTING SURROUNDS

10.1 INTRODUCTION

This section analyses the results of Phase 1, 2, 3 and 4 in existing surrounds and its associated landscaping.

SAFETY CRITERIA ANALYSIS

- 10.1.1. Figure 10-1 shows that the introduction of the proposed development and landscaping for Scenario 8 results in ground level wind conditions that are rated as safe for all users.



Figure 10-1 - Contours of safety criteria (left: Scenario 6, right: Scenario 8).

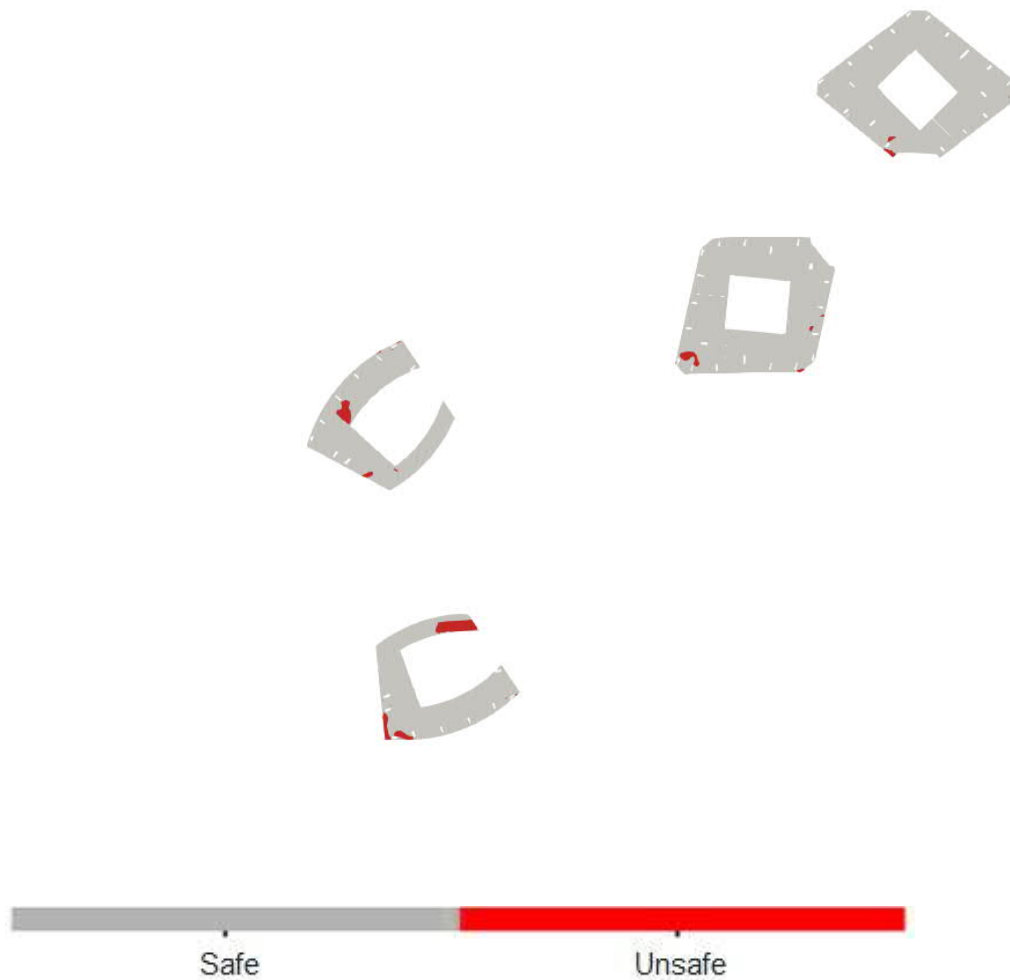


Figure 10-2 - Contours of safety criteria on elevated levels for Scenario 8.

10.1.2. Figure 10-2 indicates that elevated levels rate as safe for all users with the exception of some small patches on Building C1, south-west and east on Building C2, south and west on Building D1 and south-west and north on Building D2. It should be noted that no proposed landscaping has been modelled on the terraces.

COMFORT CRITERIA ANALYSIS

- 10.1.3. Figure 10-3 and Figure 10-4 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 Scenario 6.

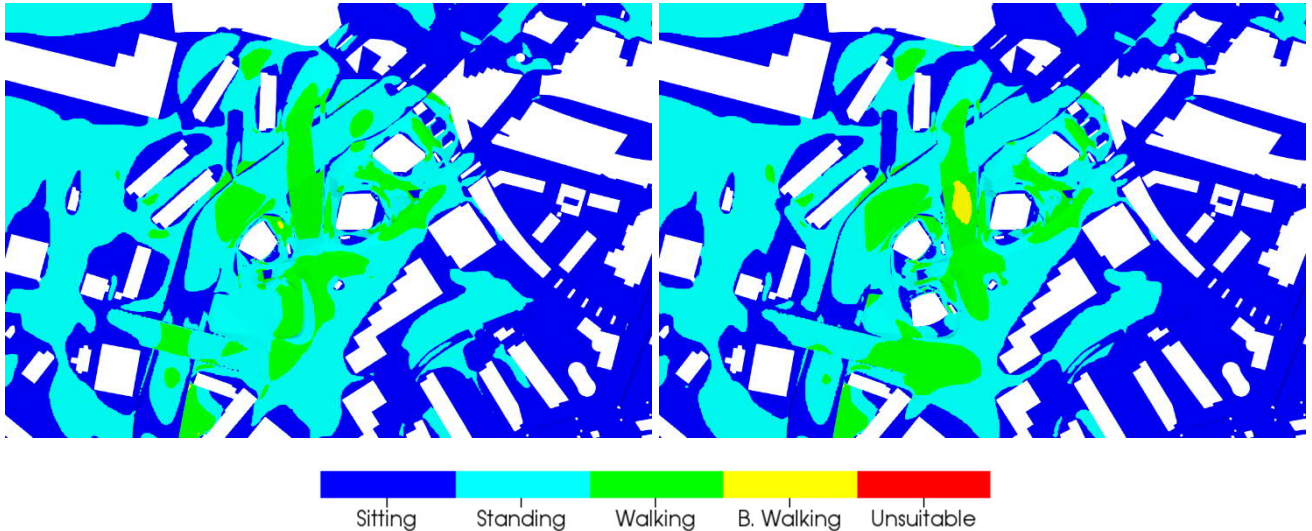


Figure 10-3 - Contours of comfort criteria for winter (left: Scenario 6, right: Scenario 8).

- 10.1.4. Figure 10-3 shows that, with the introduction of the proposed development (Scenario 8), wind conditions within the site rate as suitable for walking, standing and sitting during winter. An area of business walking is identified on the bridge between the sites.

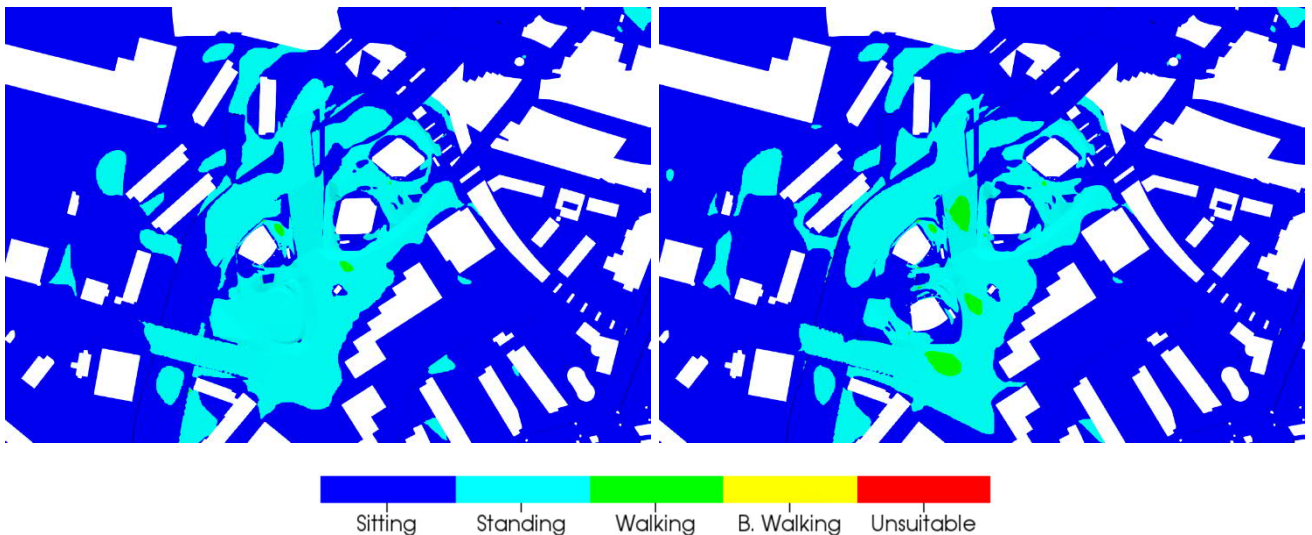


Figure 10-4 - Contours of comfort criteria for summer (left: Scenario 6, right: Scenario 8).

- 10.1.5. Figure 10-4 shows that, with the introduction of the proposed development (Scenario 8), wind conditions within the site rate as suitable for standing and sitting during summer. Off-site, some areas suitable for walking are identified.

10.1.6. Figure 10-5 shows contours of comfort criteria on a plane 1.5m above the elevated levels for the summer season for Scenario 8.

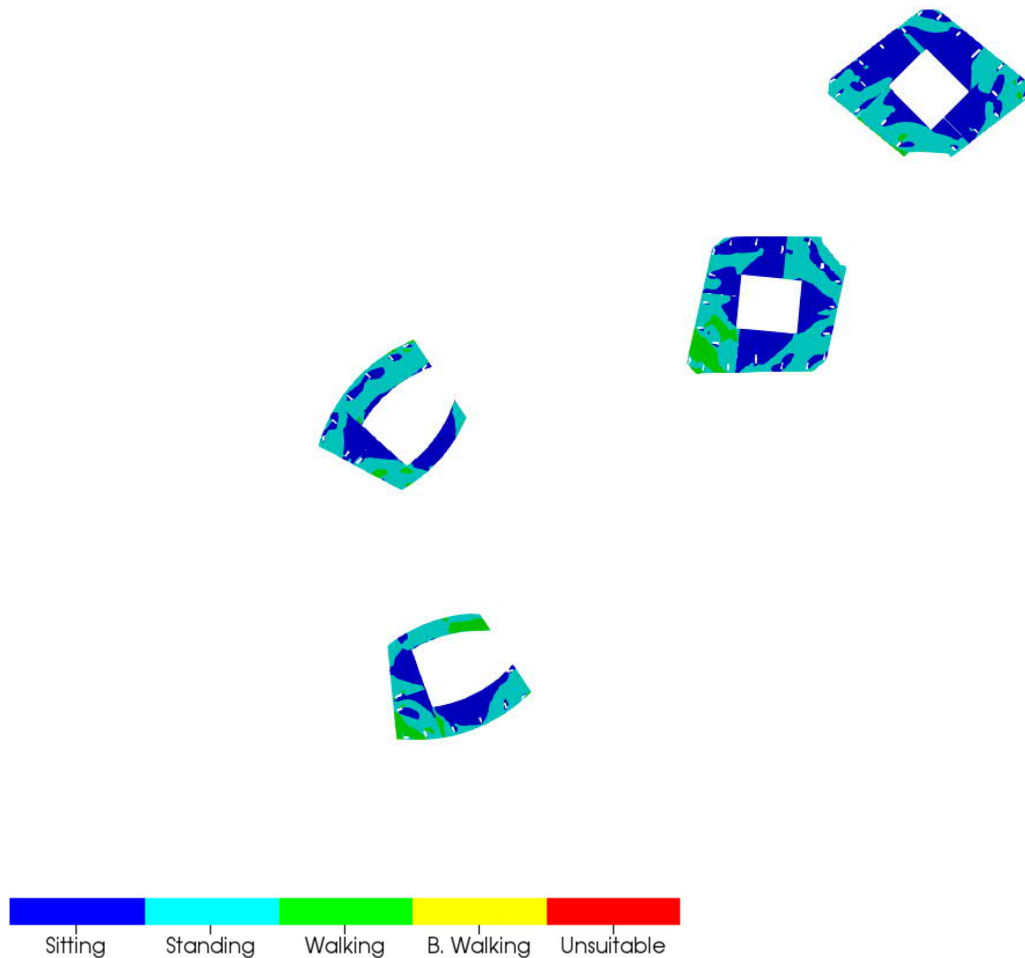


Figure 10-5 - Contours of comfort criteria on elevated levels in summer.

10.1.7. Figure 10-5 indicates that during summer, some areas rate as suitable for seating on all the towers, however the majority of areas are suitable for standing, with localised patches only suitable for walking. It should be noted that no proposed landscaping has been modelled on the terraces.

11 RESULTS – SCENARIO 9: PHASE 1, 2, 3 AND 4 IN CUMULATIVE SURROUNDS

11.1 INTRODUCTION

This section analyses the results of Phase 1, 2, 3 and 4 in cumulative surrounds.

SAFETY CRITERIA ANALYSIS

- 11.1.1. Figure 11-1 shows that the introduction of the proposed development and cumulative surrounds results in ground level wind conditions that are rated as safe for all users.



Figure 11-1 - Contours of safety criteria (left: Scenario 8, right: Scenario 9).

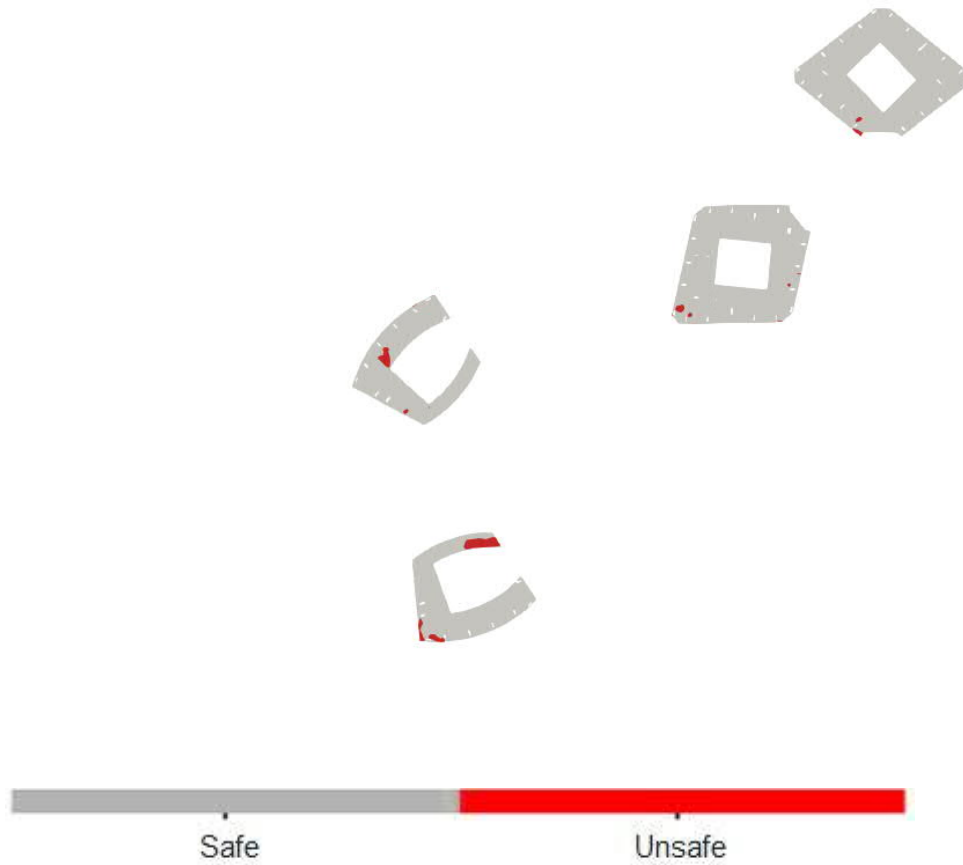


Figure 11-2 - Contours of safety criteria on elevated levels for Scenario 9.

- 11.1.2. Figure 11-2 indicates that elevated levels rate as safe for all users with the exception of some small patches on Building C1, south-west and east on Building C2, south and west on Building D1 and south-west and north on Building D2. It should be noted that no proposed landscaping has been modelled on the terraces.

COMFORT CRITERIA ANALYSIS

- 11.1.3. Figure 11-3 and Figure 11-4 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 existing surrounds scenario (Scenario 8).

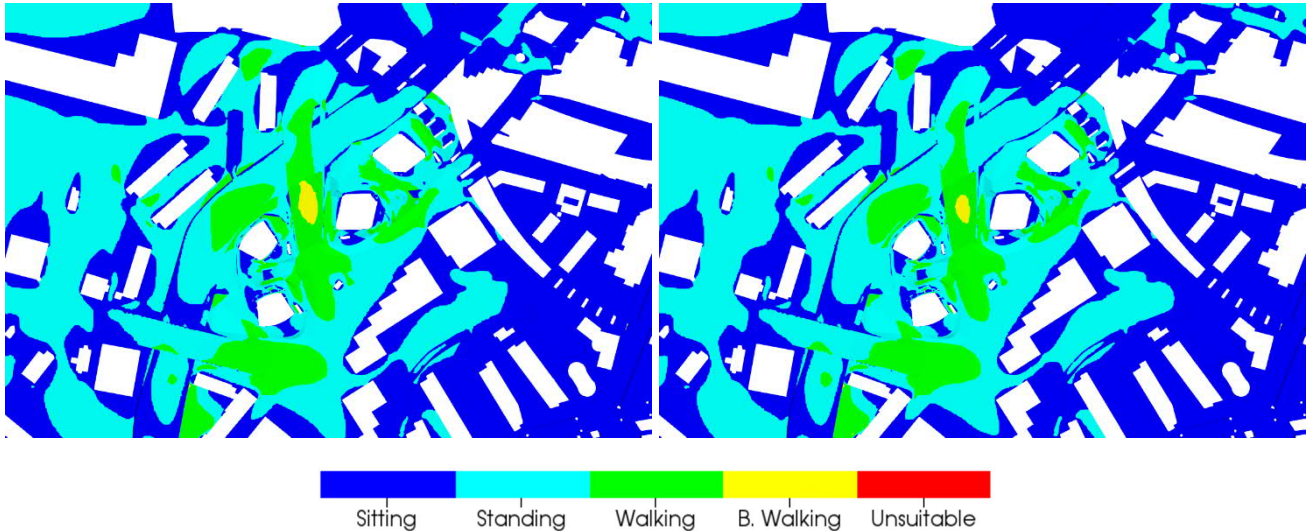


Figure 11-3 - Contours of comfort criteria for winter (left: Scenario 8, right: Scenario 9).

- 11.1.4. Figure 11-3 shows that, with the introduction of the proposed development and cumulative surrounds (Scenario 9), wind conditions within the site rate as suitable for walking, standing and sitting during winter. An area of business walking is identified on the bridge between the sites.

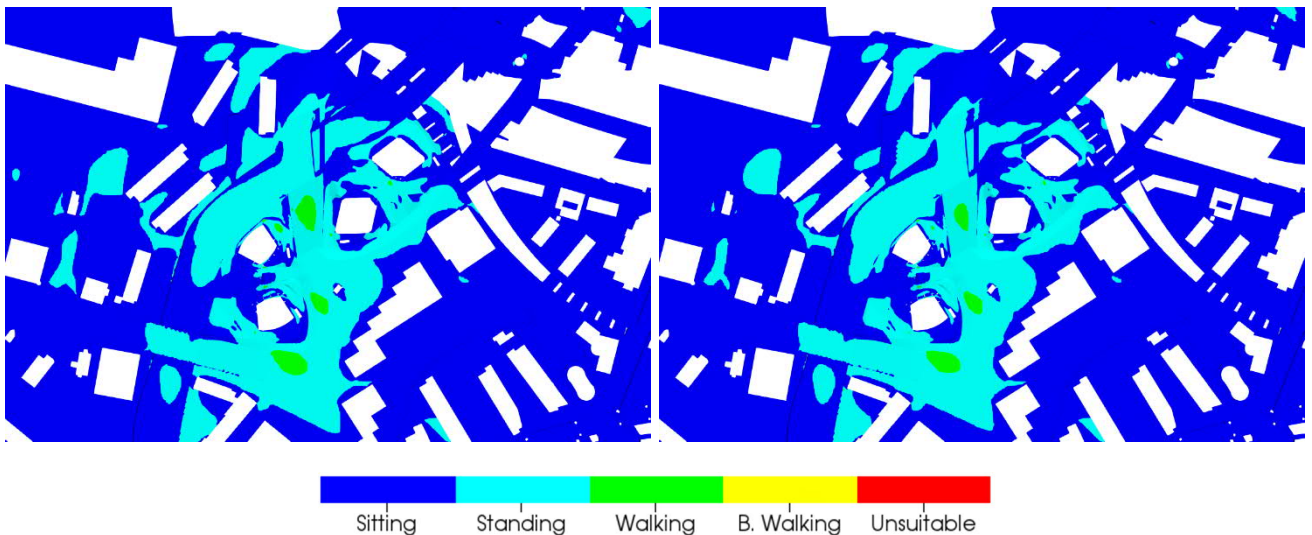


Figure 11-4 - Contours of comfort criteria for summer (left: Scenario 8, right: Scenario 9).

- 11.1.5. Figure 11-4 shows that, with the introduction of the proposed development and cumulative surrounds (Scenario 9), wind conditions within the site rate as suitable for standing and sitting during summer. Off-site, some areas suitable for walking are identified.

11.1.6. Figure 11-5 shows contours of comfort criteria on a plane 1.5m above the elevated levels for the summer season for Scenario 9.

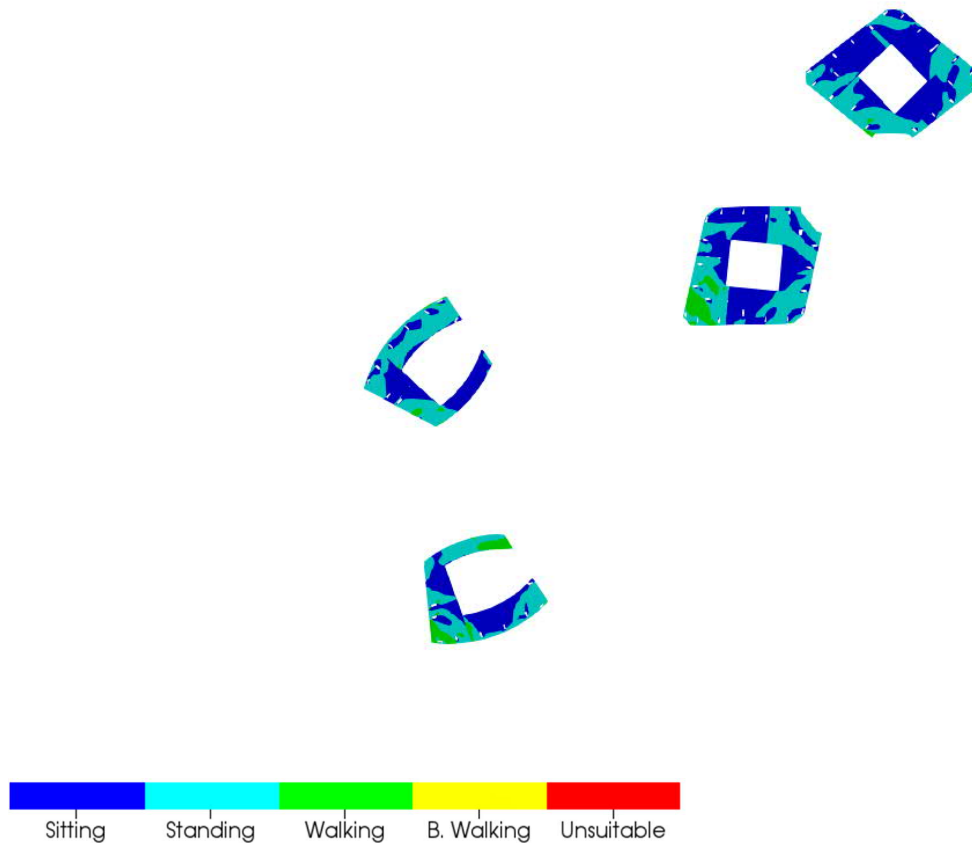


Figure 11-5 - Contours of comfort criteria on elevated levels in summer.

11.1.7. Figure 11-5 indicates that during summer, some areas rate as suitable for seating on all the towers, however the majority of areas are suitable for standing, with localised patches only suitable for walking. It should be noted that no proposed landscaping has been modelled on the terraces.

12 CONCLUSIONS

An analysis of the wind conditions around the proposed Trinity Islands development in Manchester 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. A total of nine surrounds configurations (baseline included) were studied. All assessments included the proposed landscaping for the site, excluding the terraces at the bottom of the buildings. The conclusions are as follows:

- With the implementation of the proposed landscaping scheme, all ground-level areas around the proposed development rate as safe for pedestrians in all scenarios.
- At elevated levels, some areas rate as unsafe for pedestrians in all scenarios. It should be noted that no landscaping has been modelled on any terraces.

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