

Appendix 15.1

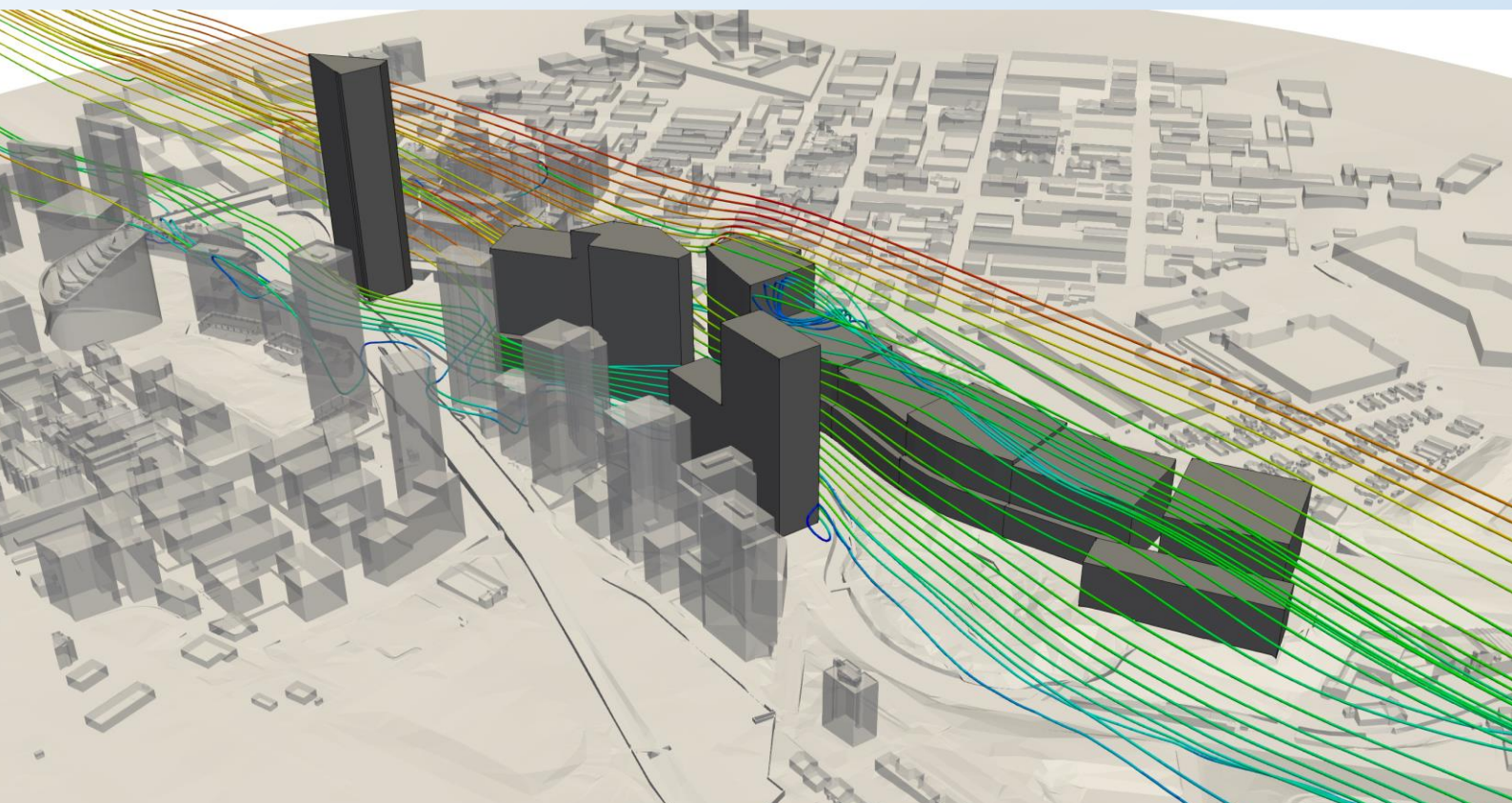
Wind Microclimate Study (Application 4)



Far East Consortium Ltd. (FEC)

RED BANK: OUTLINE APPLICATION

Wind Microclimate Study





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EXECUTIVE SUMMARY

A wind microclimate study has been performed for the proposed Red Bank Outline Masterplan 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 for the Outline Masterplan in the context of either existing or cumulative schemes and in the absence of the landscaping strategy, safety exceedances are recorded around RB10, as well as in between RB06 and RB01 and at the corner of RB17. In terms of pedestrian comfort all areas at ground level remain suitable for their intended usage. With the addition of the detailed NT02-04 plots, in the absence of the landscaping strategy, safety exceedances are still recorded around RB10, as well as in between RB06 and RB01; however, the safety exceedance at the corner of RB17 is no longer present. In terms of pedestrian comfort all areas at ground level remain suitable for their intended usage.

Results for the Outline Masterplan Scenario in the context of either existing or cumulative schemes and with the presence of the landscaping strategy and mitigation options show that there are no safety exceedances recorded. Compared to the scenarios without the landscaping, wind conditions are calmer and in terms of pedestrian comfort all areas at ground level remain suitable for their intended usage. With the addition of the detailed NT02-04 plots, results remain unchanged.

Overall, with the addition of the landscaping strategy and mitigation options, the wind conditions at all locations around the proposed development are suitable, in terms of both pedestrian comfort and safety, for their intended usage.

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1 INTRODUCTION

- 1.1.1. WSP have been appointed by Far East Consortium (FEC) to perform a wind microclimate study around the proposed Red Bank Outline Masterplan in Manchester.
- 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 1991-1-4:2005¹, 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 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

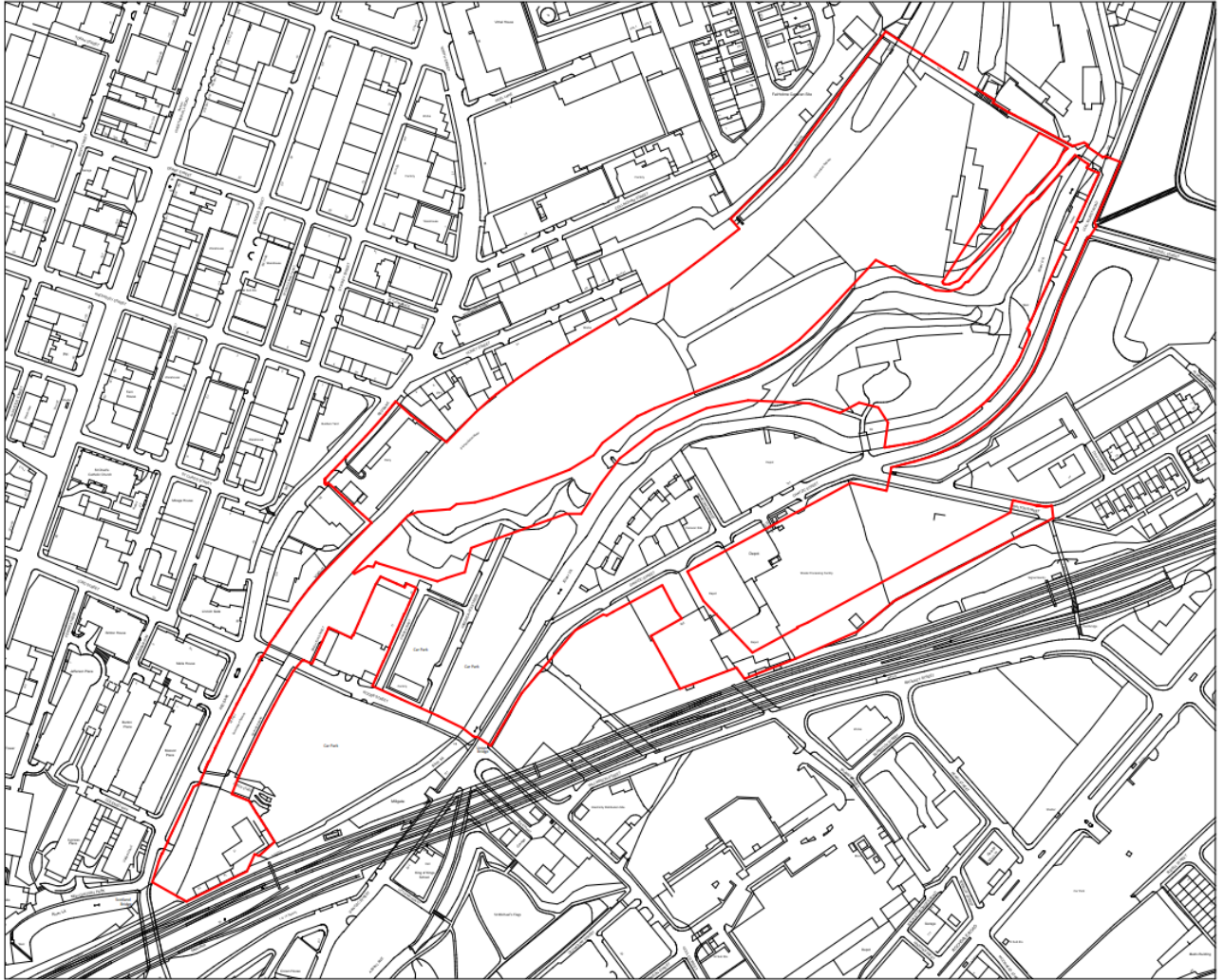
2.1 ASSESSMENT METHODOLOGY

- 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 five scenarios:
1. **Baseline**: the existing site conditions, including HIF works (access and infrastructure) and any schemes under construction
 2. **Outline Masterplan**: As '1' above, but with the inclusion of the maximum parameters for all plots in the Outline Application area and with the site of the NT02-04 scheme in the existing baseline condition.
 3. **Masterplan Cumulative**: As '2' above, but with the inclusion of consented / cumulative schemes.
 4. **Detailed Plots**: As '2' above, but with the inclusion of the detailed Plots: NT02, NT03 and NT04.
 5. **Detailed Cumulative**: As '4' above, but with the inclusion of the consented / cumulative schemes.
- 2.1.3. Scenarios '2' to '5' above are also studied with and without the presence of exiting / proposed landscaping strategies, as well as with the implementation of wind mitigation measures specifically developed to address localised areas of unwanted / excessive wind conditions where required.
- 2.1.4. Overall, a total of 9 different configurations are therefore explored using CFD.

2.2 SITE AND STUDY AREA

- 2.2.1. Figure 2-1 shows the location of the Site, highlighting the Outline planning application boundary in red, as well as the NT02-04 proposed detailed application boundary in green. The area in the vicinity consists mostly of a combination of low-level residential homes, industrial units and open spaces, and, towards the east, a range of mid to high-rise developments; furthermore, immediately south of the Site runs the railway lines through to Manchester Victoria Station.

Figure 2-1 – Outline Planning Application Boundary (Red)



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

Table 2-1 – Drawing sets used to construct the model.

Date issued (dd/mm/yy)	Title	Filename	Usage
20/12/22	EIA Combined Future Baseline	RDB-MLM-ZZ-XX-M3-AR-009001_EIA Combined Future Baseline.dwg	Construction of the topography, Maximum Parameter Outline Plots, and surrounding buildings
16/01/23	NT02 and NT03 Detailed Plots	RDB-HBA-2X-XX-M3-AR-XXXXXX_DetailedMassing.dwg	Construction and placement of the NT02 and NT03 detailed plots
13/01/23	NT04 Detailed Plot	230113-RDB-MLA-3D Model Cad_P05.04.dwg	Construction and placement of the NT04 detailed plot
16/01/23	NT02-04 Proposed Topography	RDB-OPN-XX-XX-M3-LA-200000_detached230111.dwg	Construction and detailed plots topography and placement of detailed plots
24/01/23	Illustrative Landscape Masterplan	RDB-SPG-00-XX-DR-LA-819601_Illustrative Landscape Masterplan.pdf	Implementation of proposed illustrative landscaping
24/01/23	Stage 2.1 Report	RDB-MLM-XX-XX-RP-AR-000005_STAGE 2.1 REPORT.pdf	Identification of climatic loop
27/01/23	Maximum Parameter Floor Plan Modifications	SK-230127-001-QA Massing-Maximum height parameter Floor Plan-change tracker.pdf	Modifications to RB06/07 and RB16/17 Massing resulting from flood risk assessment
07/02/23	List of Cumulative Schemes	Red Bank – List of Cumulative Schemes	Identification of buildings under construction and consented schemes

- 2.2.3. The model includes the site and all buildings within an approx. 750m radius of the site as shown in Figure 2-2. 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 length' 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 2-3. The effect of any soft landscaping near the building of interest has, conservatively, not been included.

Figure 2-2 - The 3D CAD model of the baseline case, showing the explicitly-modelled surrounding buildings and terrain. The terrain is coloured by its relative elevation.

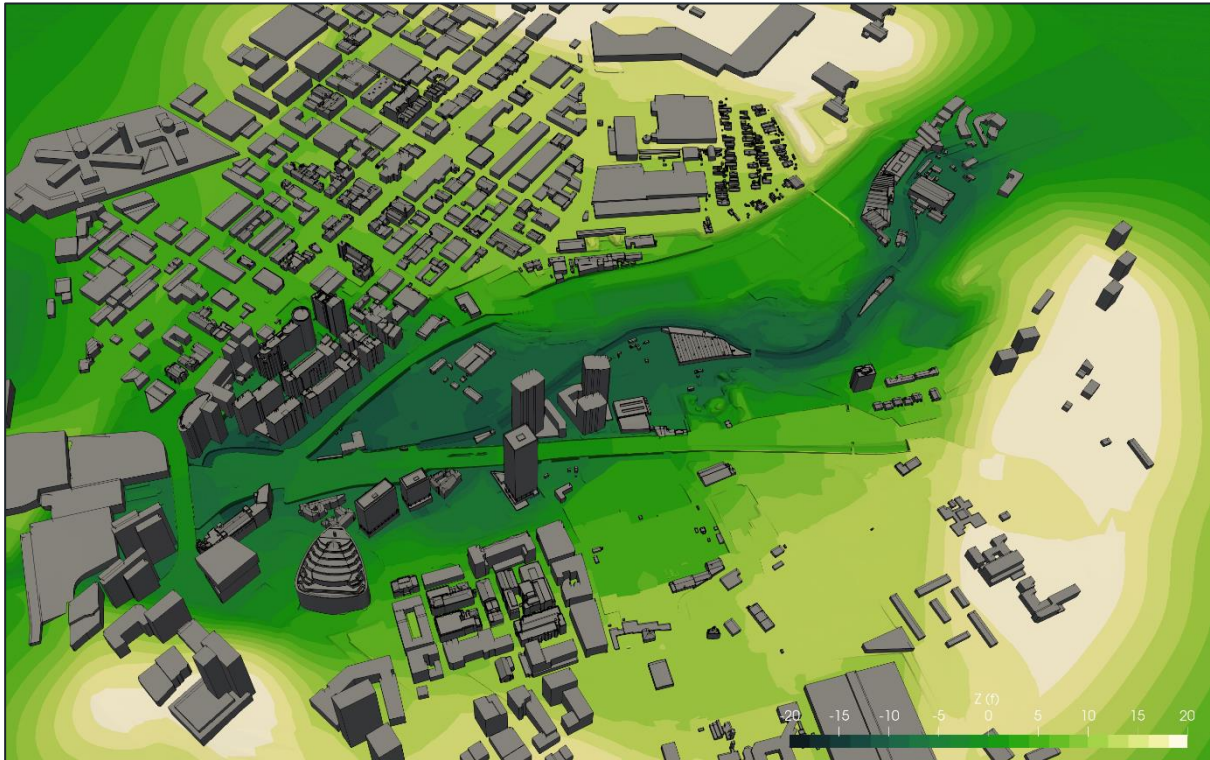


Figure 2-3 - Screenshot of the CAD model for the Outline Masterplan showing the level of detail in the model.



Figure 2-4 - Screenshot of the CAD model for the Outline Masterplan, including the detailed NT02-04 developments, showing the level of detail in the model.



Figure 2-5 - Screenshot of the CAD model for the Outline Masterplan, detailed NT02-04 developments and cumulative schemes, showing the level of detail in the model.



2.3 CUMULATIVE SCHEMES

- 2.3.1. At the time of writing, several cumulative schemes, that have been granted planning permission, within 750m of the Outline Masterplan have been identified. These are:
- The Gasworks: Erection of 9 buildings ranging from 8 to 34 storeys in height. (Ref: 128248/FO/2020)
 - 25 Rochdale Road: Erection of a 11-storey hotel. (Ref: 127537/FO/2020)
 - 2 and 3 Angel Square: Erection of an 11-storey and 12-storey building. (Ref: 124973/FO/2019)
 - 87 Rochdale Road: Erection of a part 11, part 13 storey building. (Ref: 131708/FO/2021)
 - 40 Swan Street: Erection of a ground plus 9-storey building. (Ref: 128997/FO/2020)
 - Great Ducie Street: Erection of two buildings part 27, 20, 17 storeys and part 11 and 10 storeys. (Ref: 132416/FO/2021)
 - 1 Lord Street: Erection of a 16-story building (Ref: 113914/FO/2016)
- 2.3.2. As part of the cumulative scenarios, the Outline Masterplan is therefore analysed within the context of these future/consented surrounds. Figure 2-5 shows an example of this for Scenario 5: the Outline Masterplan, in context of the detailed NT02-04 plots, all existing buildings and the future consented schemes within an approx. 750m radius of the Site.

2.4 LANDSCAPING AND MITIGATION STRATEGY

- 2.4.1. Figure 2-6 highlights the illustrative landscape masterplan use to implement the proposed landscaping for Scenarios '6' to '9'.
- 2.4.2. A series of wind mitigation workshops for the Outline Masterplan highlighted that some additional wind mitigation measures are required, in addition to the illustrative landscaping strategy, in some areas to ensure wind conditions are comfortable and safe for pedestrian use. The final mitigation option, including the illustrative landscaping tree strategy, these mitigation options are shown in Figure 2-8. These measures include:
- A small number of additional trees, ranging from 4m to 6m diameter placed at the corners of RB10 to counteract the effects of westerly winds down-drafting along the side of RB10 and accelerating through the gap
 - Two 50% porous screens at the corners of RB10, with a width and height of 2m x 4m
 - A single 50% porous screen placed at the corner of RB17, with a width and height of 2m x 4m.

Figure 2-6 - Illustrative Landscape Masterplan used for the Landscaping Strategy (RDB-SPG-00-XX-DR-LA-819601)

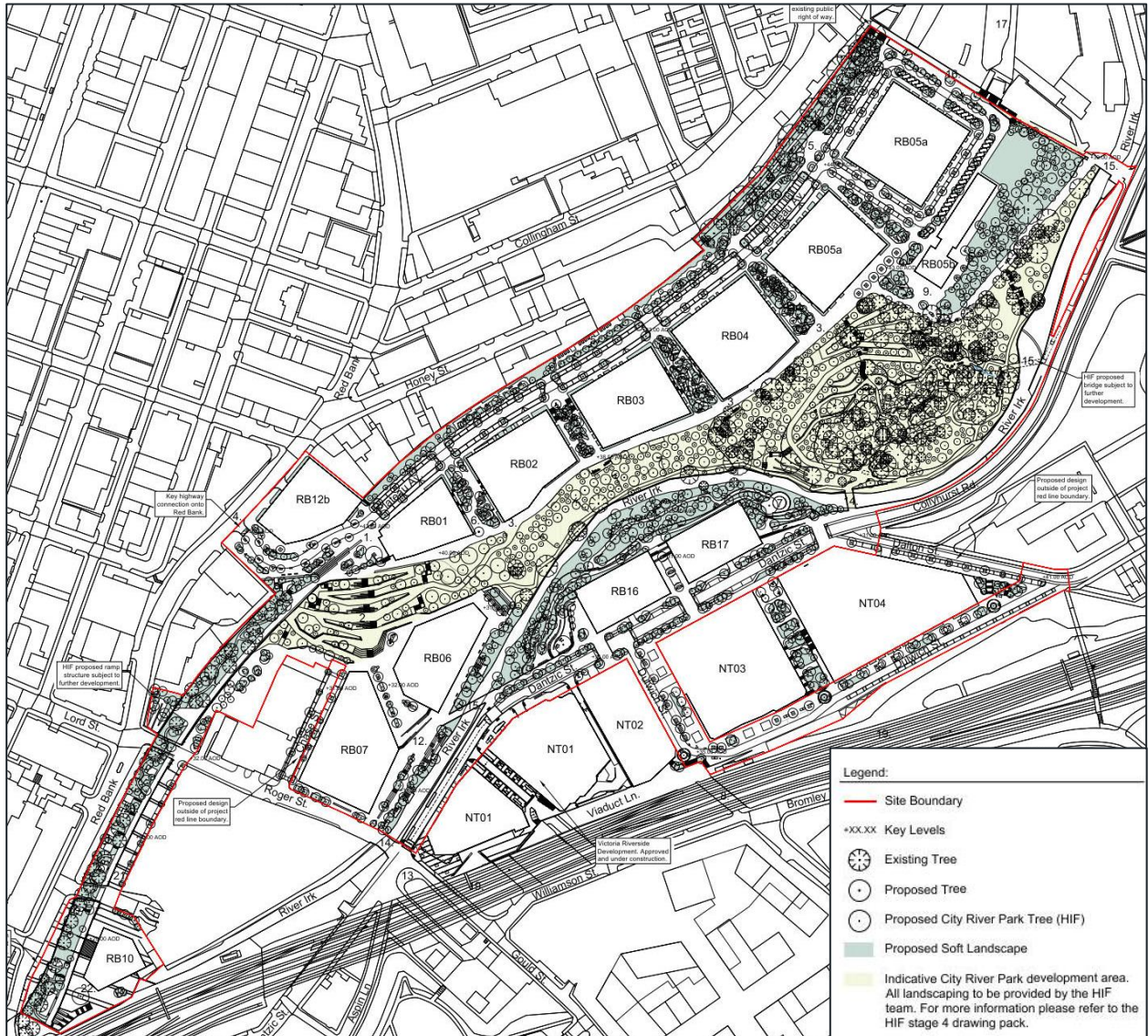
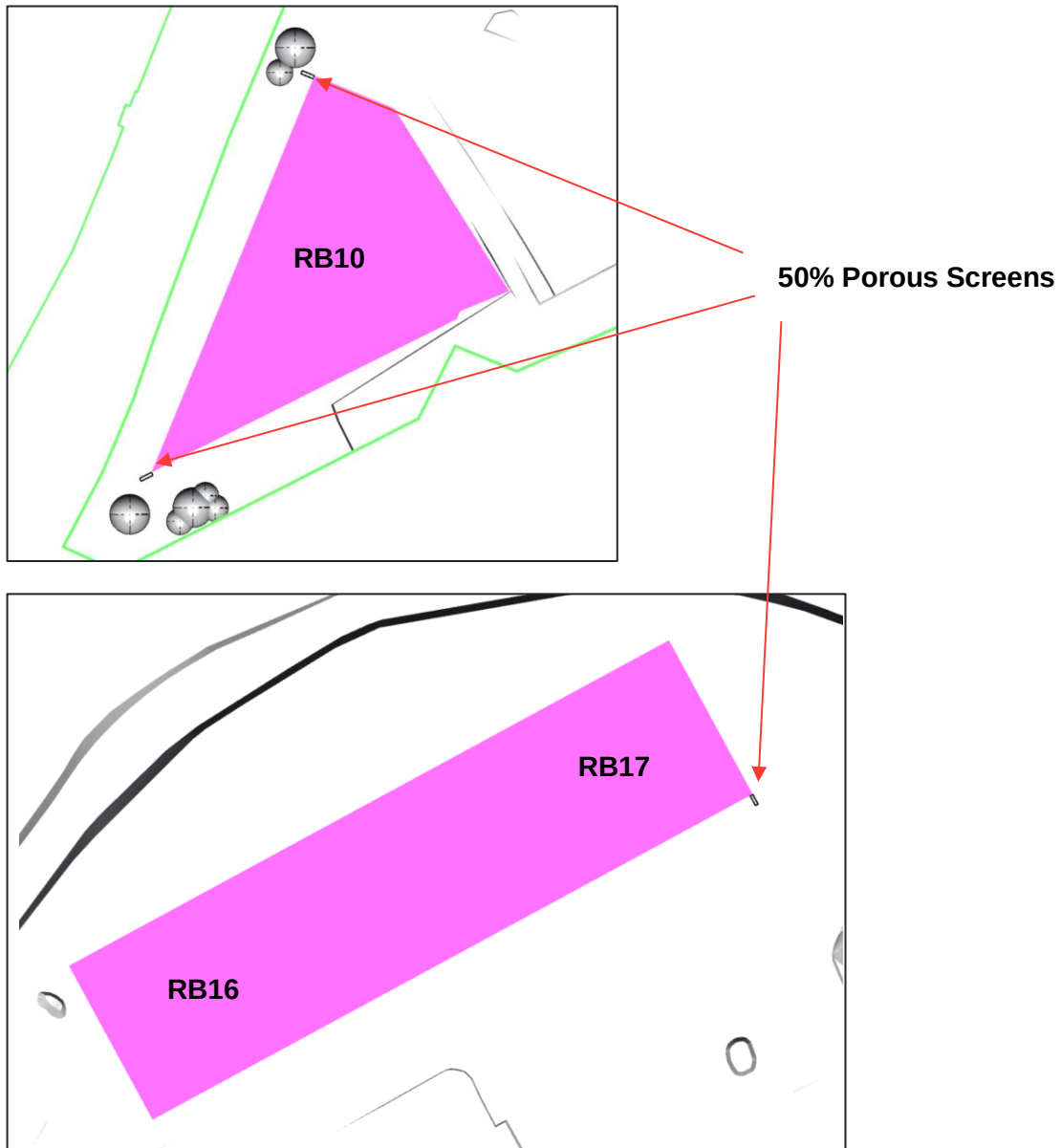


Figure 2-7 – Mitigation Strategy for RB10 and RB17 to highlight the additional trees around RB10 and the porous screens



2.5 ASSESSMENT CRITERIA

- 2.5.1. 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.
- 2.5.2. 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

- 2.5.3. 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.

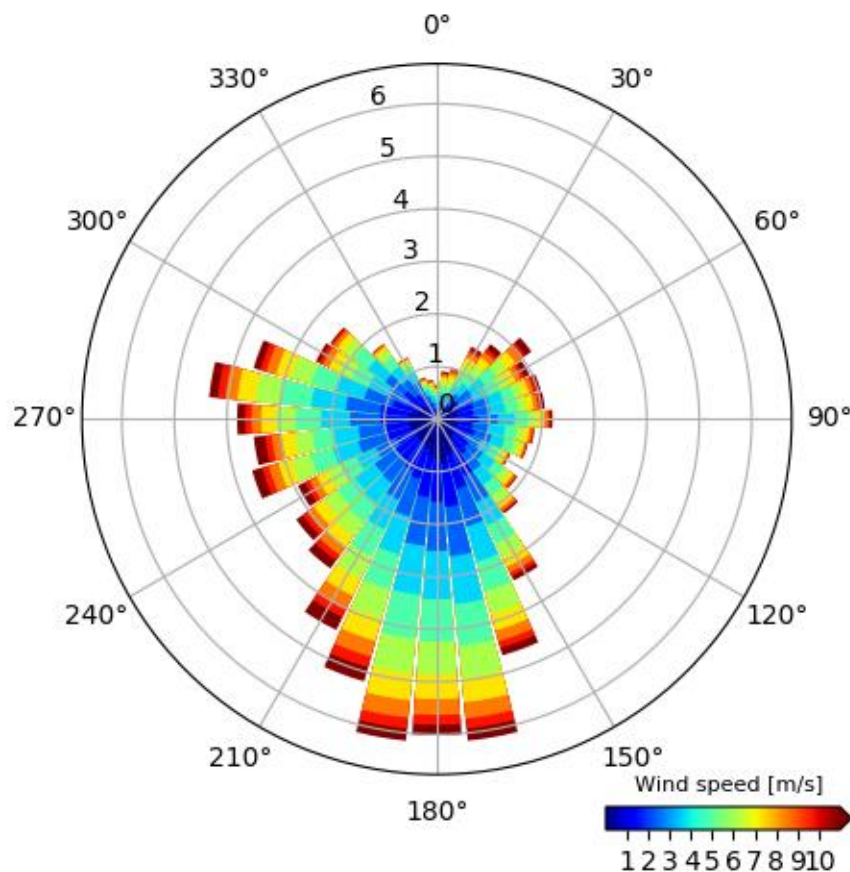
Table 2-3 – Distress criteria used in this study.

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

2.6 WIND CLIMATE ANALYSIS

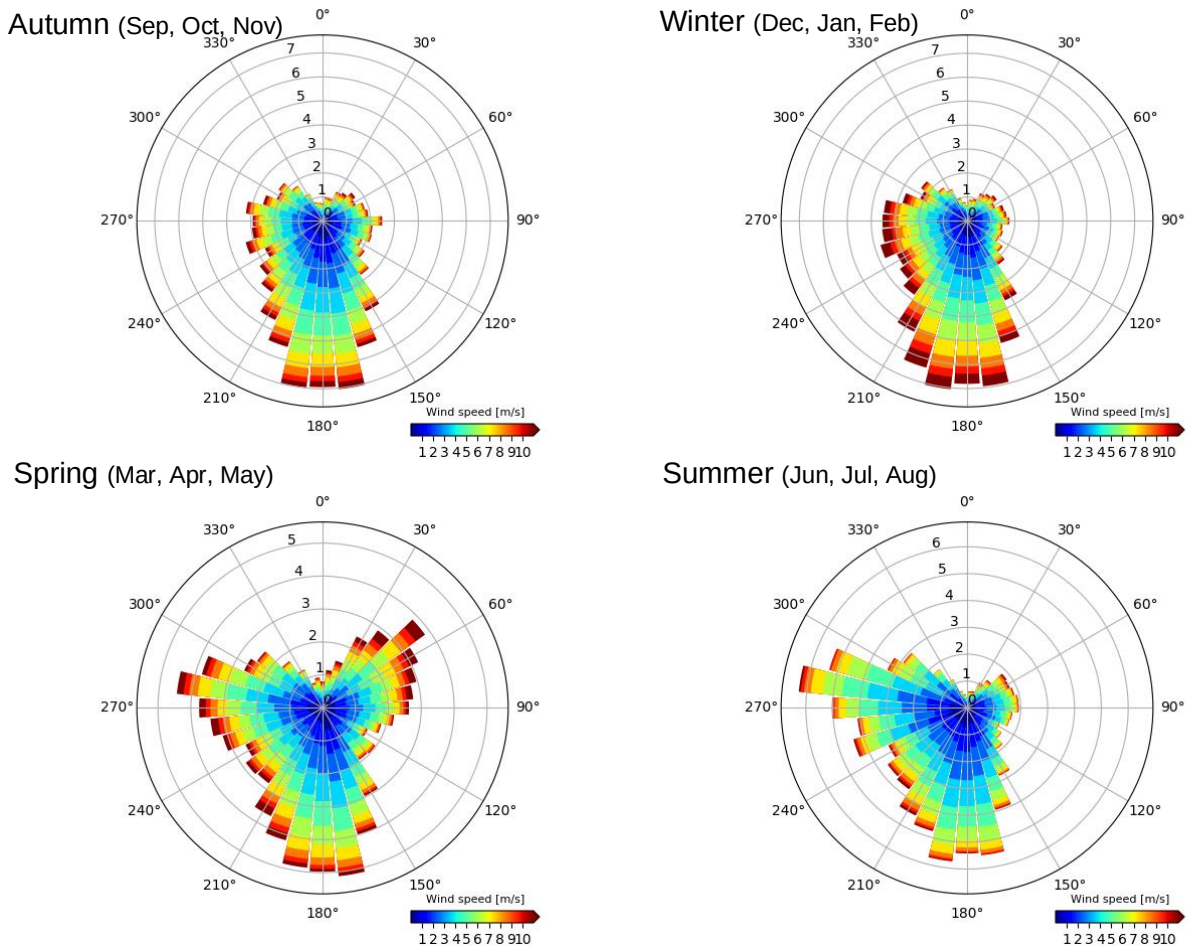
- 2.6.1. Wind data was collected from the nearby meteorological station at Manchester Airport, which is approximately 15km south of the site. The data consisted of mean hourly wind speeds and directions over the last 20 years. The data was discretised into 36 bins, representing 10° sectors. The nomenclature 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.
- 2.6.2. Figure 2-8 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 prevailing winds are from the south, with these winds representing the largest proportion of higher wind speeds. Additionally, there is a secondary peak of high wind speeds from the west.

Figure 2-8 - Annual wind rose at the site, showing the frequency and magnitude of mean-hourly wind speeds.



2.6.3. Figure 2-9 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 2-9 - Wind roses for each season.



2.6.4. 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.

2.6.5. 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 180m 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 2-10. This resulted in the transposition factors shown in Table 2-4.

Figure 2-10 - Categorisation of the terrain surrounding the site.

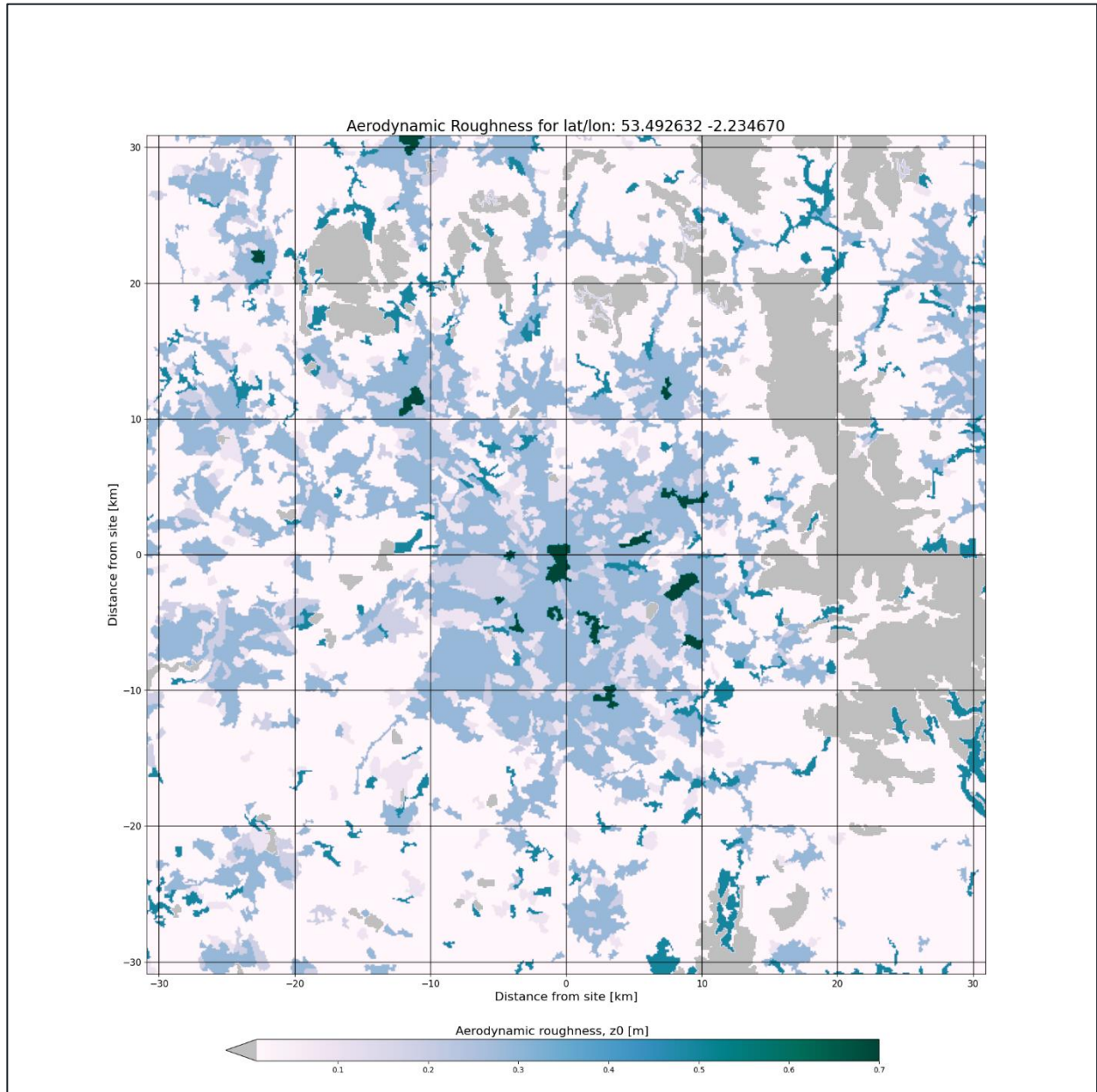


Table 2-4 – Transposition factors from 10m open country to 180m reference height at the project site

0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
1.410	1.401	1.389	1.385	1.385	1.370	1.370	1.364	1.381	1.383	1.390	1.389

- 2.6.6. 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.

2.6.7. 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	2.31
30	20, 30, 40	4.30
55	50, 60	4.17
75	70, 80	4.12
95	90, 100	4.07
120	110, 120, 130	5.24
145	140, 150	5.61
160	160	4.67
170	170	6.15
180	180	6.02
190	190	6.15
200	200	5.18
210	210	4.45
220	220	3.49
235	230, 240	6.23
250	250	3.65
260	260	3.51
270	270	3.81
280	280	4.36
290	290	3.62
305	300, 310	5.04
330	320, 330, 340	3.87

2.7 SIMULATION DETAILS AND ASSUMPTIONS

- 2.7.1. 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 2.6 and compared against criteria discussed in section 2.5.
- 2.7.2. 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 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 ~67 million.
- 2.7.3. 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).
- 2.7.4. 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

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

- 2.7.5. 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 3.5. 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.

- 2.7.6. A non-slip condition was applied to the ground and buildings. Buildings and ground within the 750m radius had a rough wall function with an assigned roughness of $z_0 = 0.02m$; the far-field (>750m

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, $z_{ref} = 180m$, z_0 is the upstream roughness which varies by direction and $U_{ref} = 10m/s$.

- 2.7.7. Trees and other landscaping measures were treated as porous regions in the CFD model. For these porous regions, 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:

$$\Delta P = CU^2$$

where ΔP is the pressure drop across the volume of the porous element, U is the air velocity and C is the inertial term, which can be related to a drag coefficient. For the different tree species investigated computationally, drag coefficients were obtained from the experimental measurements of *Bitog et al (2011)*⁶.

- 2.7.8. 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.

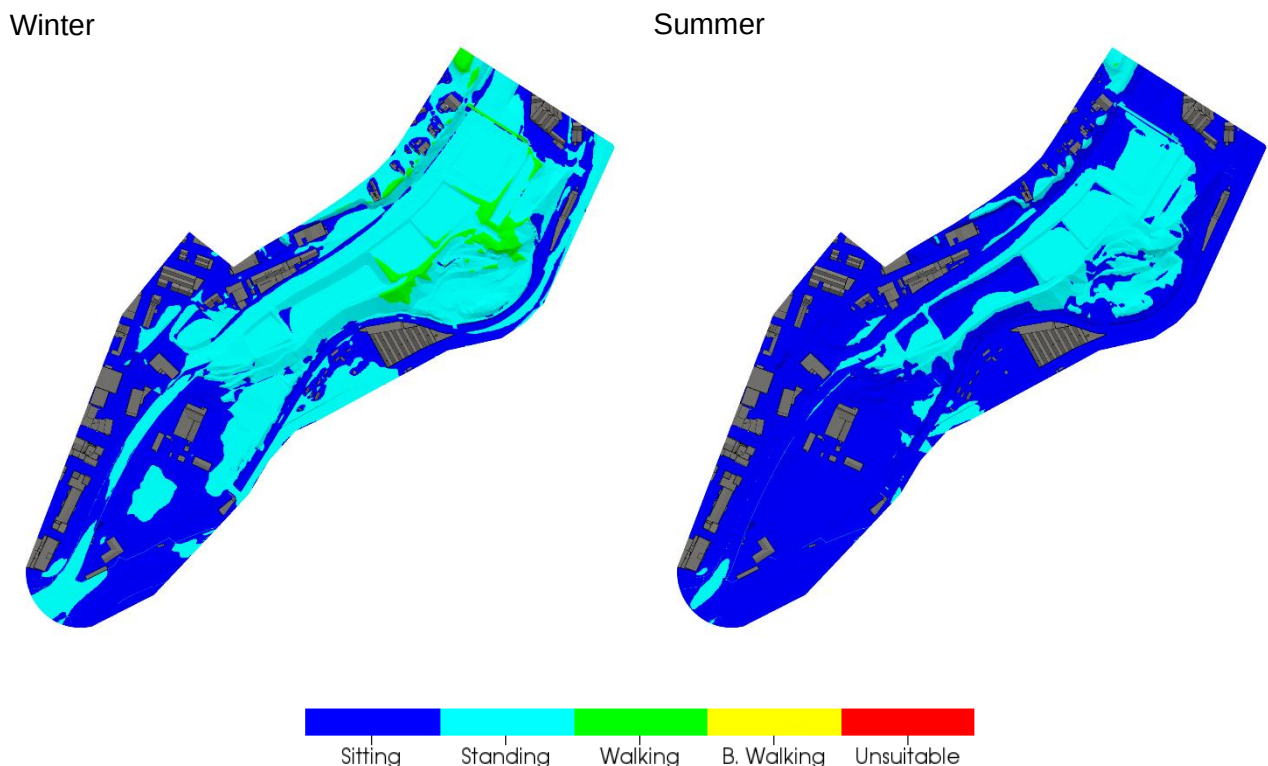
3 RESULTS WITHOUT LANDSCAPING

This section presents the results for the first 5 scenarios of the study. Conditions are assessed, first, without the illustrative landscaping strategy and mitigation options presented in 2.4 and comparisons are made between the 5 Scenarios: Baseline, Outline Masterplan, Masterplan Cumulative, Detailed Plots, Detailed Cumulative. Seasonal results for each case, as well as directional contour plots are presented in full in Appendix A.

3.1 BASELINE

- 3.1.1. Figure 3-1 shows contours of comfort criteria on a plane 1.5m above the ground for the winter and summer months respectively for the baseline scenario.
- 3.1.2. In winter, results show that conditions around the Outline Masterplan are mostly calm, being suitable predominantly for standing, however there are some localised regions of walking conditions toward the east of the Site.
- 3.1.3. Results are calmer in the summer months, with all of the Site and surrounding area being suitable for sitting or standing.

Figure 3-1 - Comfort criteria for winter (left) and summer (right) months for the Baseline scenario.



- 3.1.4. Figure 3-2 shows contours of pedestrian safety criteria on a plane 1.5m above the ground, indicating that there are no exceedances around the Site and conditions are safe for all users.

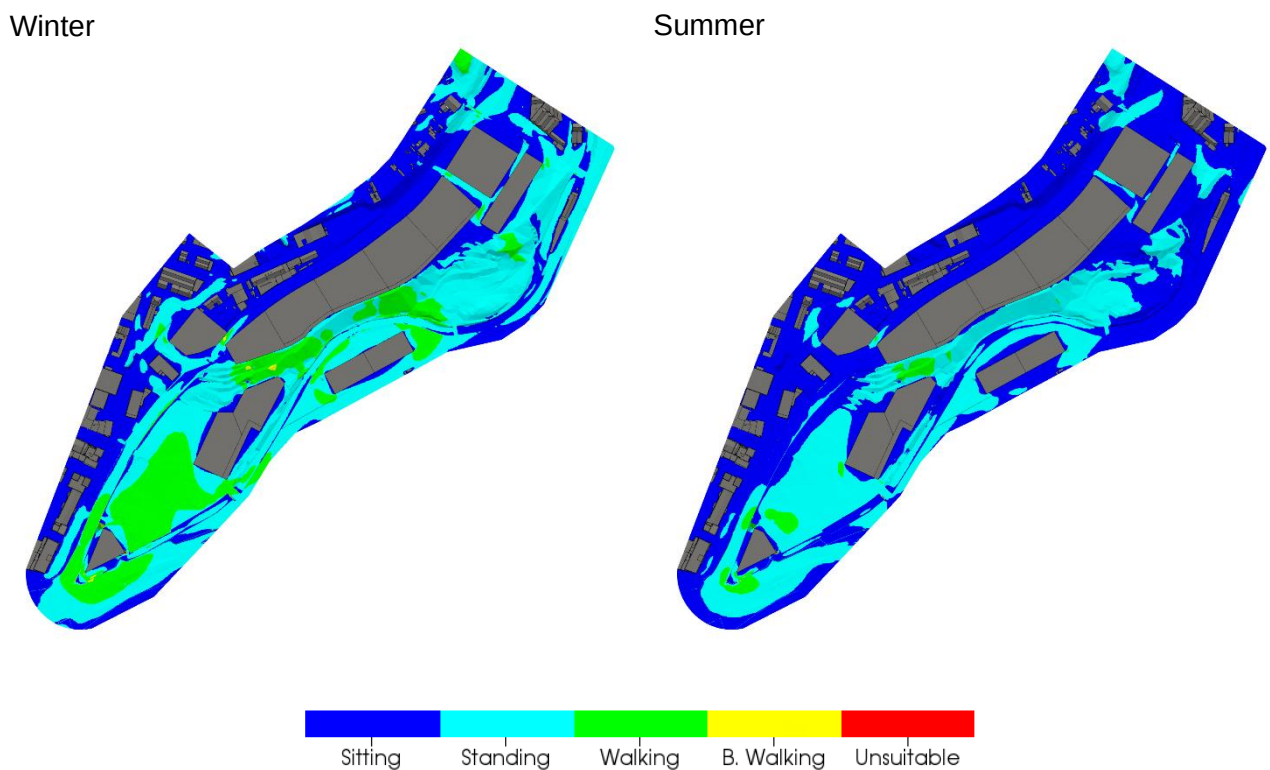
Figure 3-2 – Pedestrian safety criteria for the Baseline scenario



3.2 OUTLINE MASTERPLAN

- 3.2.1. Figure 3-3 shows contours of comfort criteria on a plane 1.5m above the ground for the winter and summer months respectively for the Outline Masterplan in the context of existing surrounds.
- 3.2.2. In winter, results show that conditions around the Site are windier than in the baseline scenario, being generally only suitable for walking or standing.
- 3.2.3. Results are calmer in the summer months, with most of the Site and surrounding area being suitable for standing. Some localised regions of walking conditions are identified close to RB10 and in between RB06 and RB01

Figure 3-3 - Comfort criteria for winter (left) and summer (right) months for the Outline Masterplan scenario.



- 3.2.4. Figure 3-4 shows contours of pedestrian safety criteria on a plane 1.5m above the ground, indicating that there are localised safety exceedances, most notably around RB10, as well as in between RB06 and RB01, in between RB01 and RB12b, to the north of RB05a and at the corner of RB17.

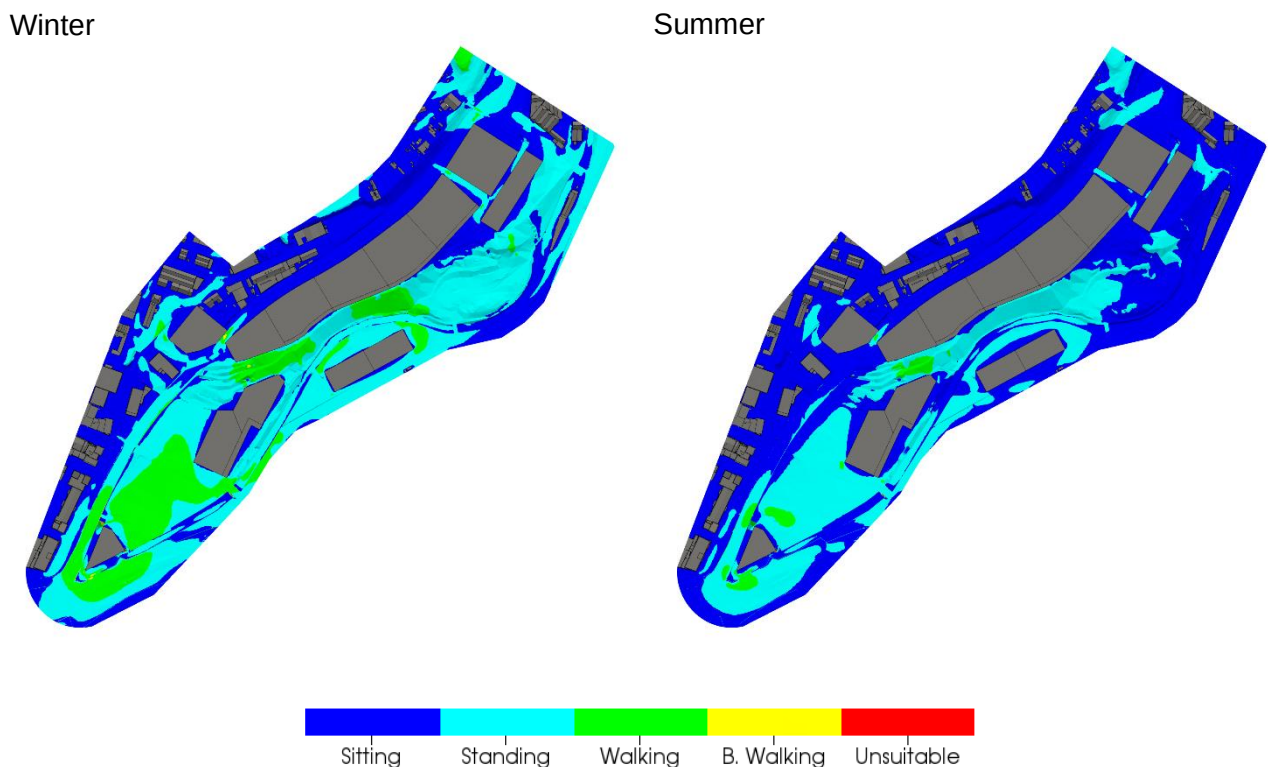
Figure 3-4 – Pedestrian safety criteria for the Outline Masterplan scenario



3.3 MASTERPLAN CUMULATIVE

- 3.3.1. Figure 3-5 shows contours of comfort criteria on a plane 1.5m above the ground for the winter and summer months respectively for the Outline Masterplan in the context of both existing surrounds and cumulative schemes.
- 3.3.2. Across both winter and summer months conditions in and around the Site are similar to the previous scenario for the Outline Masterplan in the context of existing surrounds.

Figure 3-5 - Comfort criteria for winter (left) and summer (right) months for the Masterplan Cumulative scenario.



- 3.3.3. Figure 3-6 shows contours of pedestrian safety criteria on a plane 1.5m above the ground, indicating that the previous localised safety exceedances are still observed, most notably around RB10, as well as in between RB06 and RB01, in between RB01 and RB12b, to the north of RB05a.
- 3.3.4. In the presence of cumulative schemes, the safety exceedance at the corner of RB17 is still present however the number of hours exceeding the safety criteria is reduced.

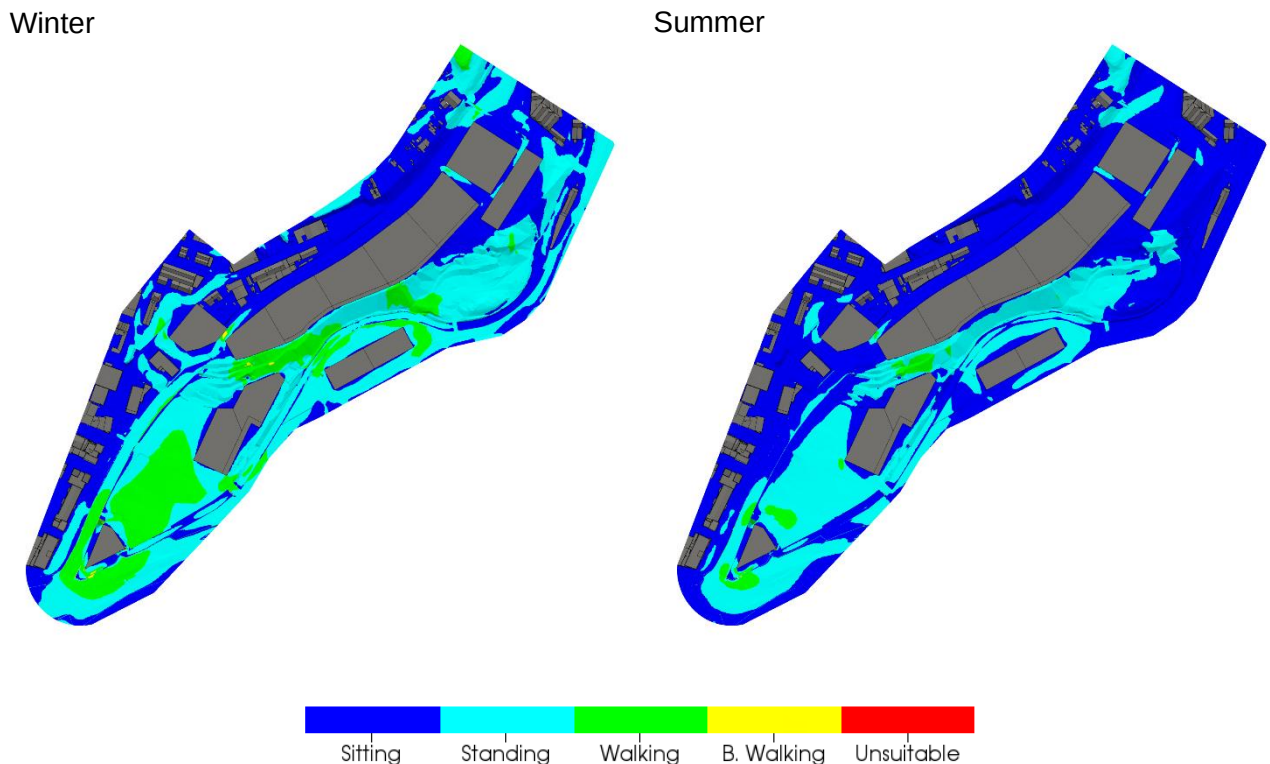
Figure 3-6 – Pedestrian safety criteria for the Masterplan Cumulative scenario



3.4 DETAILED PLOTS

- 3.4.1. Figure 3-7 shows contours of comfort criteria on a plane 1.5m above the ground for the winter and summer months respectively for the Outline Masterplan with the inclusion of the detailed NT02-04 plots in the context of existing surrounds.
- 3.4.2. Across both winter and summer months conditions in and around the Site are largely unchanged from the previous two scenarios involving the Outline Masterplan in the context of existing surrounds both with and without cumulative schemes.

Figure 3-7 - Comfort criteria for winter (left) and summer (right) months for the Detailed Plots scenario.



- 3.4.3. Figure 3-8 shows contours of pedestrian safety criteria on a plane 1.5m above the ground, indicating that the previous localised safety exceedances are still observed, most notably around RB10, as well as in between RB06 and RB01, in between RB01 and RB12b, to the north of RB05a.
- 3.4.4. In the presence of detailed NT02-04 plots, the safety exceedance at the corner of RB17 is no longer present.

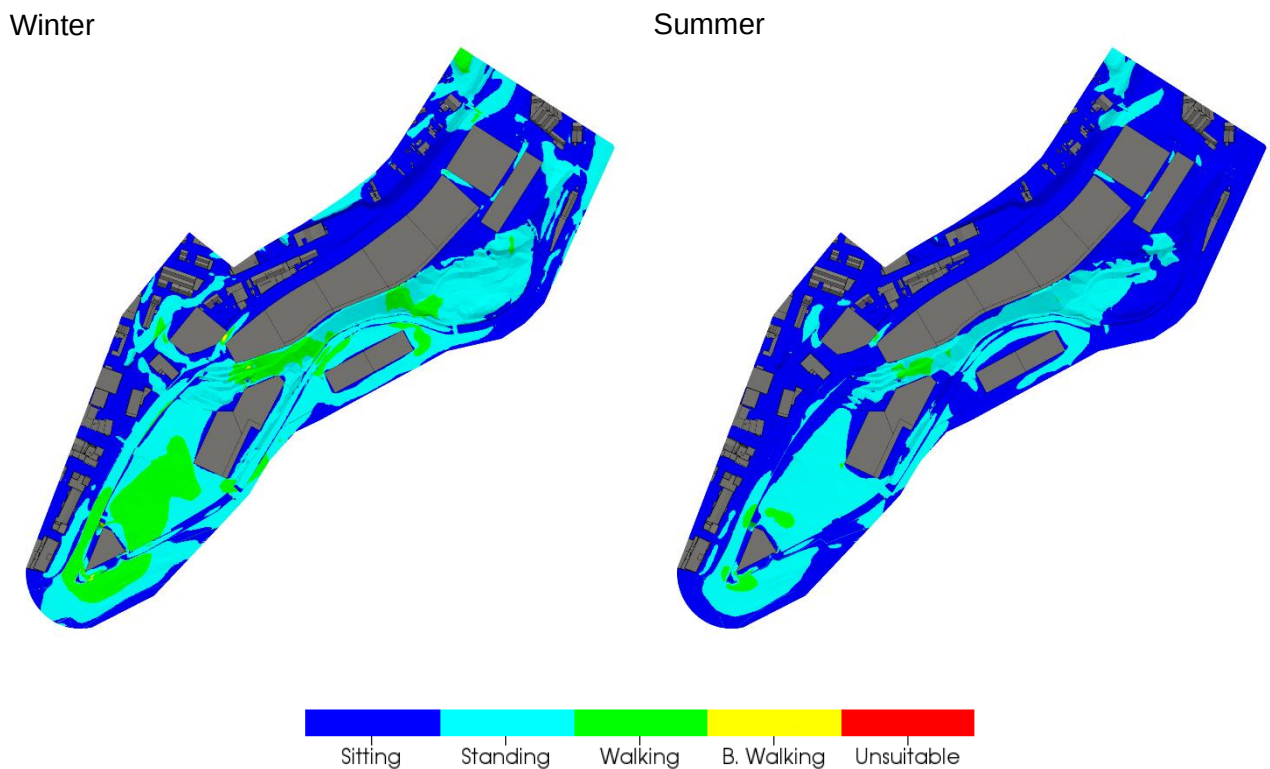
Figure 3-8 – Pedestrian safety criteria for the Detailed Plots scenario



3.5 DETAILED CUMULATIVE

- 3.5.1. Figure 3-9 shows contours of comfort criteria on a plane 1.5m above the ground for the winter and summer months respectively for the Outline Masterplan with the inclusion of the detailed NT02-04 plots in the context of both existing surrounds and cumulative schemes.
- 3.5.2. Across both winter and summer months conditions in and around the Site are largely unchanged from the previous scenarios involving the Outline Masterplan in the context of existing surrounds both with and without cumulative schemes; and the Outline Masterplan with the inclusion of detailed NT02-04 plots in context of the existing surrounds.

Figure 3-9 - Comfort criteria for winter (left) and summer (right) months for the Detailed Cumulative scenario.



- 3.5.3. Figure 3-10 shows contours of pedestrian safety criteria on a plane 1.5m above the ground, indicating that the previous localised safety exceedances are still observed, most notably around RB10, as well as in between RB06 and RB01, in between RB01 and RB12b, to the north of RB05a.
- 3.5.4. In the presence of detailed NT02-04 plots, in line with the previous scenario, the safety exceedance at the corner of RB17 is no longer present.

Figure 3-10 – Pedestrian safety criteria for the Detailed Cumulative scenario



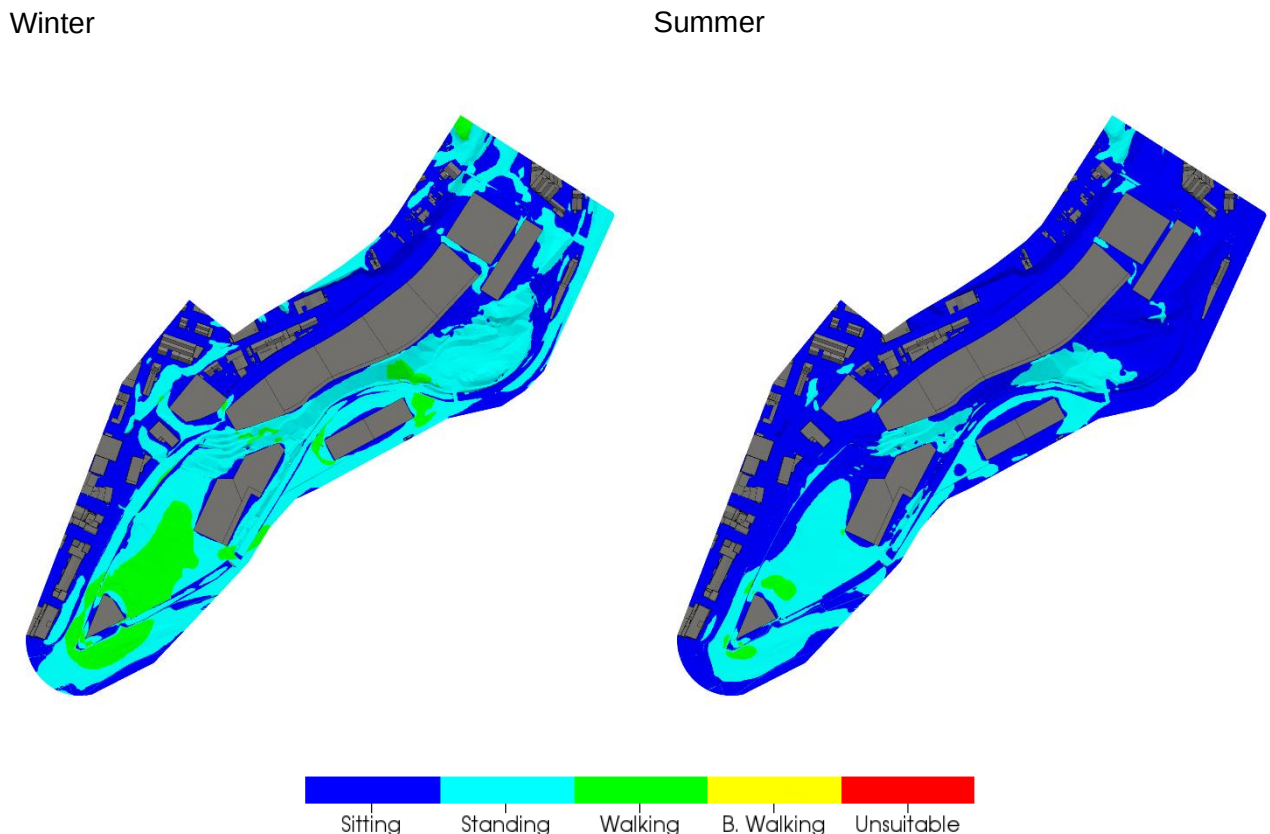
4 RESULTS WITH LANDSCAPING AND MITIGATION STRATEGY

This section presents the results for the remaining scenarios of the study. Conditions are assessed with the illustrative landscaping strategy and mitigation options presented in 2.4 and comparisons are made between the 4 Scenarios: Outline Masterplan, Masterplan Cumulative, Detailed Plots, Detailed Cumulative. Seasonal results for each case, as well as directional contour plots are presented in full in Appendix A.

4.1 OUTLINE MASTERPLAN

- 4.1.1. Figure 4-1 shows contours of comfort criteria on a plane 1.5m above the ground for the winter and summer months respectively for the Outline Masterplan in the context of existing surrounds with the addition of the illustrative landscaping strategy and mitigation options.
- 4.1.2. In winter, results show that conditions around the Site are calmer than in the equivalent Outline Masterplan scenario in the absence of any landscaping strategy Figure 3-3. Conditions are generally only suitable for standing or walking; however, the extent of walking conditions especially in between RB06 and RB01 are significantly reduced as well as surrounding RB16 and RB17 when compared to the Outline Masterplan in the absence of any landscaping strategy.
- 4.1.3. Results are calmer in the summer months, with most of the Site and surrounding area being suitable for standing and sitting. Some localised regions of walking conditions are identified close to RB10.

Figure 4-1 - Comfort criteria for winter (left) and summer (right) months for the Outline Masterplan scenario with the inclusion of the landscaping and mitigation strategy



- 4.1.4. Figure 4-2 shows contours of pedestrian safety criteria on a plane 1.5m above the ground, indicating that there are no safety exceedances around the Site and surrounding area.

Figure 4-2 – Pedestrian safety criteria for the Outline Masterplan scenario with the inclusion of the landscaping and mitigation strategy



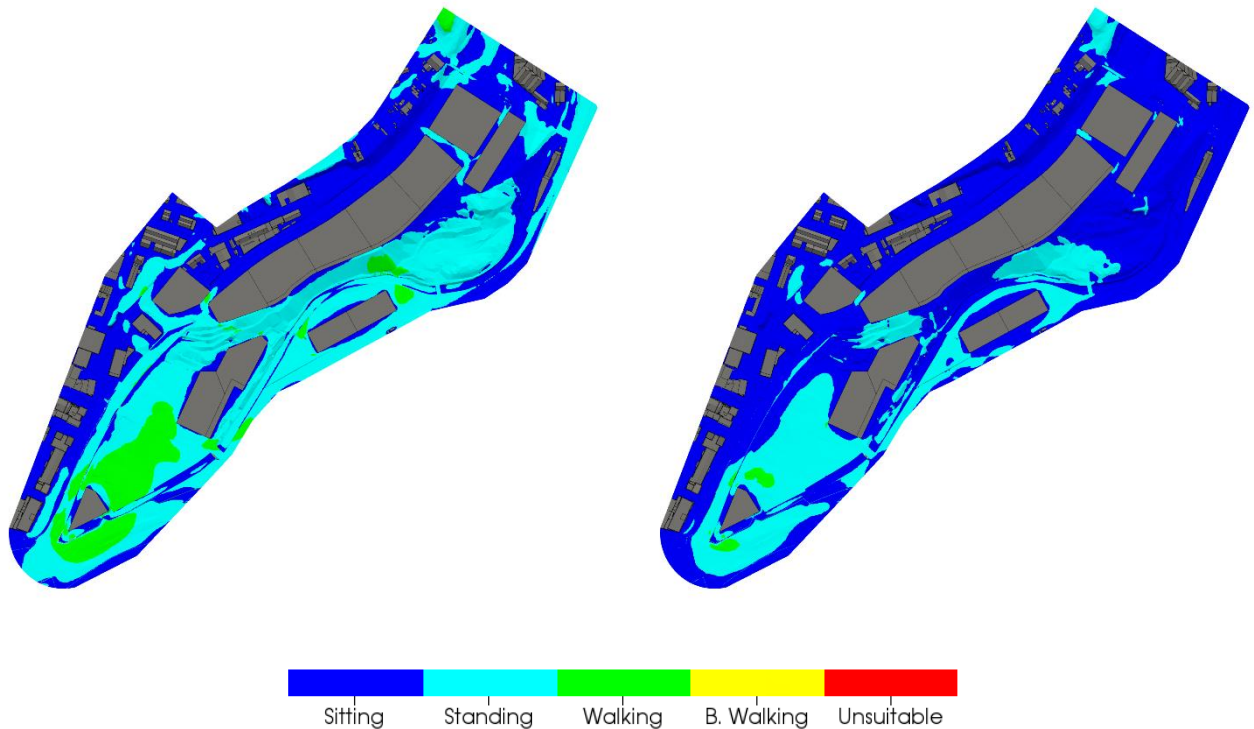
4.2 MASTERPLAN CUMULATIVE

- 4.2.1. Figure 4-3 shows contours of comfort criteria on a plane 1.5m above the ground for the winter and summer months respectively for the Outline Masterplan in the context of existing surrounds and cumulative schemes with the addition of the illustrative landscaping strategy and mitigation options.
- 4.2.2. Across both winter and summer months conditions in and around the Site remain largely unchanged when compared to the previous scenario for the Outline Masterplan in the context of existing surrounds with the inclusion of the illustrative landscaping strategy and mitigation options.

Figure 4-3 - Comfort criteria for winter (left) and summer (right) months for the Masterplan Cumulative scenario with the inclusion of the landscaping and mitigation strategy

Winter

Summer



- 4.2.3. Figure 4-4 shows contours of pedestrian safety criteria on a plane 1.5m above the ground, indicating that there are no safety exceedances around the Site and surrounding area.

Figure 4-4 – Pedestrian safety criteria for the Masterplan Cumulative scenario with the inclusion of the landscaping and mitigation strategy



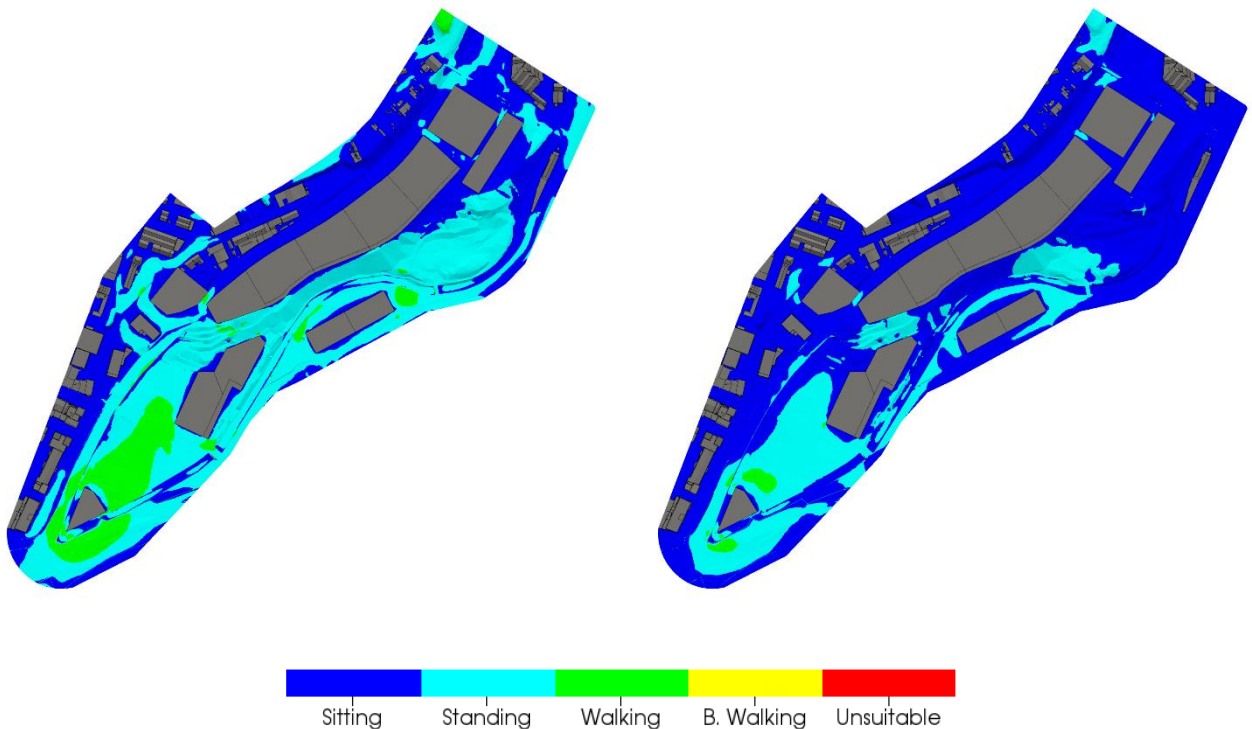
4.3 DETAILED PLOTS

- 4.3.1. Figure 4-5 shows contours of comfort criteria on a plane 1.5m above the ground for the winter and summer months respectively for the Outline Masterplan with the inclusion of the detailed NT02-04 plots in the context of existing surrounds, as well as the addition of the illustrative landscaping strategy and mitigation options.
- 4.3.2. Across both winter and summer months conditions in and around the Site remain largely unchanged when compared to the previous scenarios for the Outline Masterplan with the inclusion of the illustrative landscaping strategy and mitigation options.

Figure 4-5 - Comfort criteria for winter (left) and summer (right) months for the Detailed Plots scenario with the inclusion of the landscaping and mitigation strategy

Winter

Summer



- 4.3.3. Figure 4-6 shows contours of pedestrian safety criteria on a plane 1.5m above the ground, indicating that there are no safety exceedances around the Site and surrounding area.

Figure 4-6 – Pedestrian safety criteria for the Detailed Plots scenario with the inclusion of the landscaping and mitigation strategy



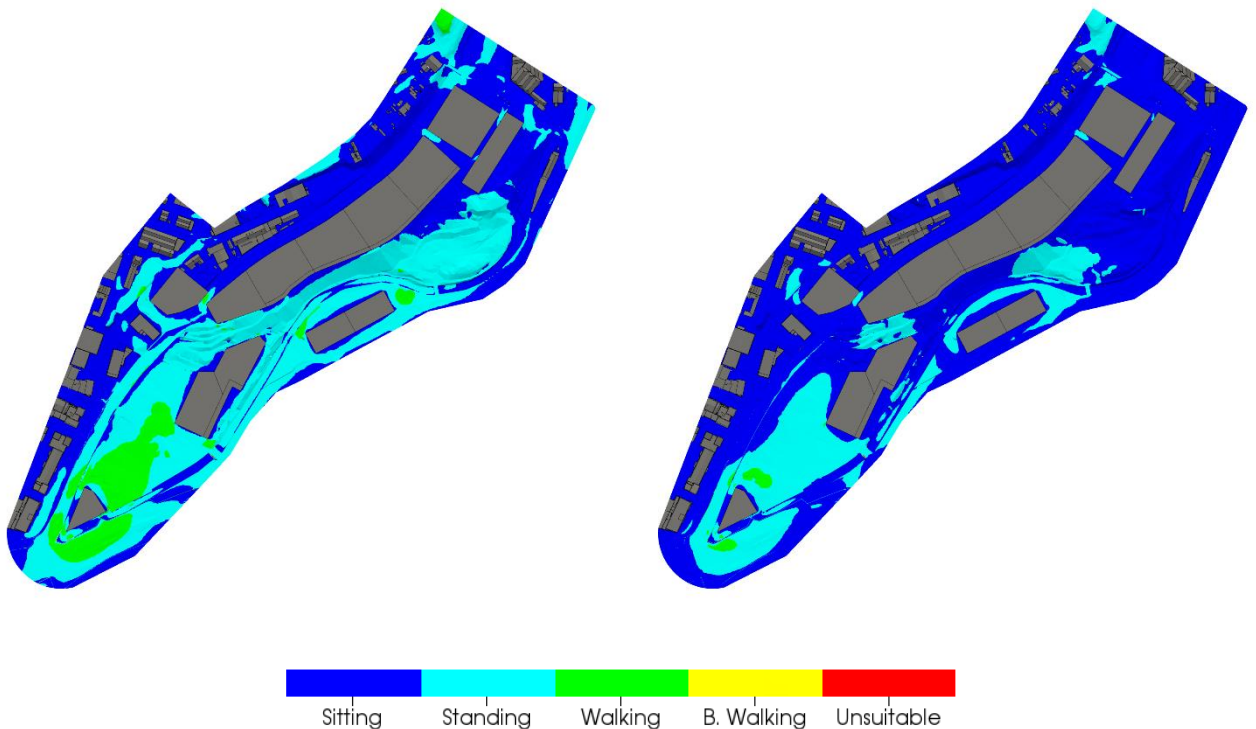
4.4 DETAILED CUMULATIVE

- 4.4.1. Figure 4-7 shows contours of comfort criteria on a plane 1.5m above the ground for the winter and summer months respectively for the Outline Masterplan with the inclusion of the detailed NT02-04 plots in the context of both existing surrounds and cumulative schemes, as well as the addition of the illustrative landscaping strategy and mitigation options.
- 4.4.2. Across both winter and summer months conditions in and around the Site remain largely unchanged when compared to the previous scenarios for the Outline Masterplan with the inclusion of the illustrative landscaping strategy and mitigation options.

Figure 4-7 - Comfort criteria for winter (left) and summer (right) months for the Detailed Cumulative scenario with the inclusion of the landscaping and mitigation strategy

Winter

Summer



- 4.4.3. Figure 4-8 shows contours of pedestrian safety criteria on a plane 1.5m above the ground, indicating that there are no safety exceedances around the Site and surrounding area.

Figure 4-8 – Pedestrian safety criteria for the Detailed Cumulative scenario with the inclusion of the landscaping and mitigation strategy



5 CONCLUSION

An analysis of the wind conditions around the proposed Red Bank Outline Masterplan has been performed. The study consisted of CFD simulations over all wind directions which were combined with long-term wind statistics to provide a statistical representation of the expected wind conditions.

In the absence of any landscaping strategy and mitigation options, the main findings were:

1. In the Baseline scenario there are no safety exceedances recorded; in summer results show that conditions around the site are calm, being suitable for either sitting or standing; in winter results are slightly windier, with most of the site being suitable for standing and some localised regions of walking.
2. For the Outline Masterplan Scenario in the context of the existing surrounds, localised safety exceedances are recorded around RB10, as well as in between RB06 and RB01, in between RB01 and RB12b, to the north of RB05a and at the corner of RB17. In summer the vast majority of the site is suitable for standing with some localised regions of walking close to RB10 and in between RB06 and RB01; conditions are windier in winter, with sections of the site only suitable for walking.
3. For the Outline Masterplan Scenario in the context of the cumulative schemes, safety exceedances are still observed in-line with the previous scenario, however, the presence of the cumulative schemes helps to reduce the number of hours exceeding the safety criteria around RB17. In both summer and winter, comfort conditions in and around the site are similar to that observed for the previous scenario.
4. For the Outline Masterplan with the inclusion of the detailed NT02-04 plots, in both scenarios involving either existing or cumulative surrounds wind conditions largely remain largely unchanged from the two above scenarios.

With the presence of the illustrative landscaping strategy and mitigation options, the main findings were:

5. For the Outline Masterplan Scenario in the context of the existing surrounds there are no safety exceedances recorded. Compared to the equivalent scenario without the landscaping and mitigation strategy, results are calmer in the summer months being suitable for either sitting or standing. Similarly, in winter results are calmer with most of the site being suitable for standing, however there are still localised regions of walking conditions, most notably around RB10.
6. For the Outline Masterplan Scenario in the context of the cumulative schemes, there are no safety exceedances. In both summer and winter, comfort conditions in and around the site are similar to that observed for the previous scenario.
7. For the Outline Masterplan with the inclusion of the detailed NT02-04 plots, in both scenarios involving either existing or cumulative surrounds wind conditions largely remain largely unchanged from the two above scenarios.

Overall, with the addition of the landscaping strategy and mitigation options, the wind conditions at all locations around the proposed development are suitable, in terms of both pedestrian comfort and safety, for their intended usage.

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