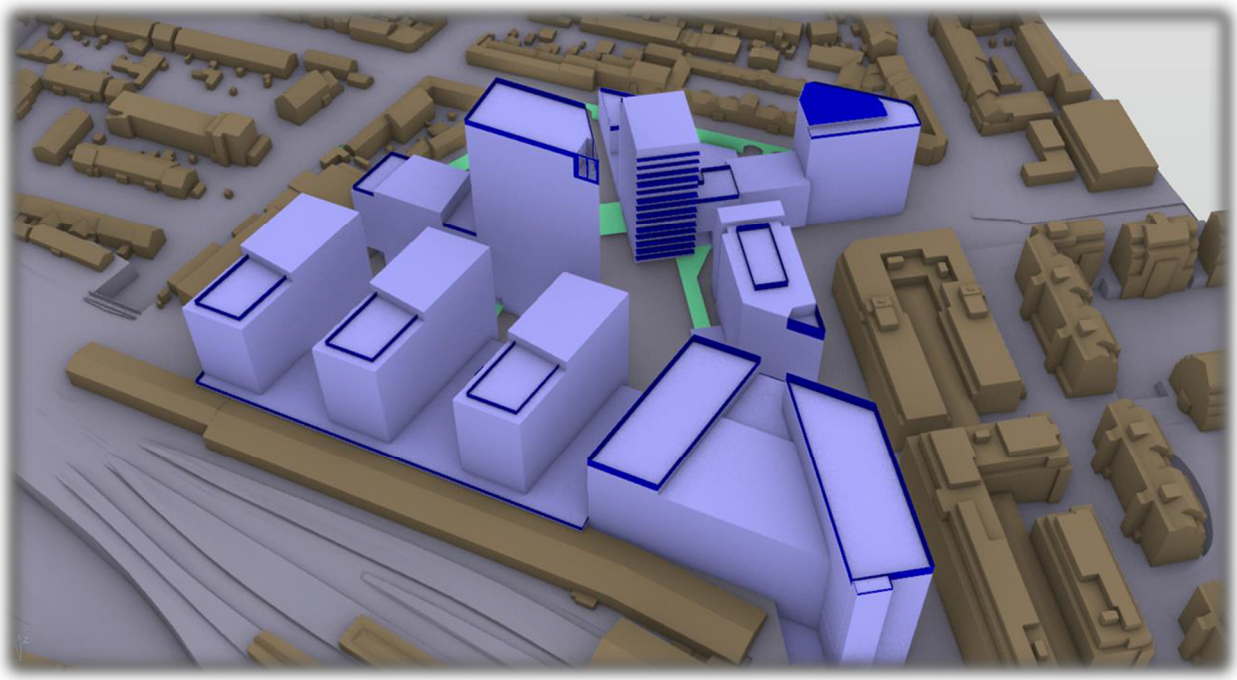
INTEGRATED ENVIRONMENTAL SOLUTIONS

14232

The Connolly Quarter

Report_P3



Project Ref.	Document Title	Rev	Prepared by:	Issue Date	Approved by:
1831	Pedestrian Comfort CFD Analysis	P1	JG	09-10-2019	SOB

Contents

Figures

1 Executive Summary

The Connolly Quarter is a mixed-use development in the heart of Dublin, neighboring the Connolly station. It consists of five distinct blocks.

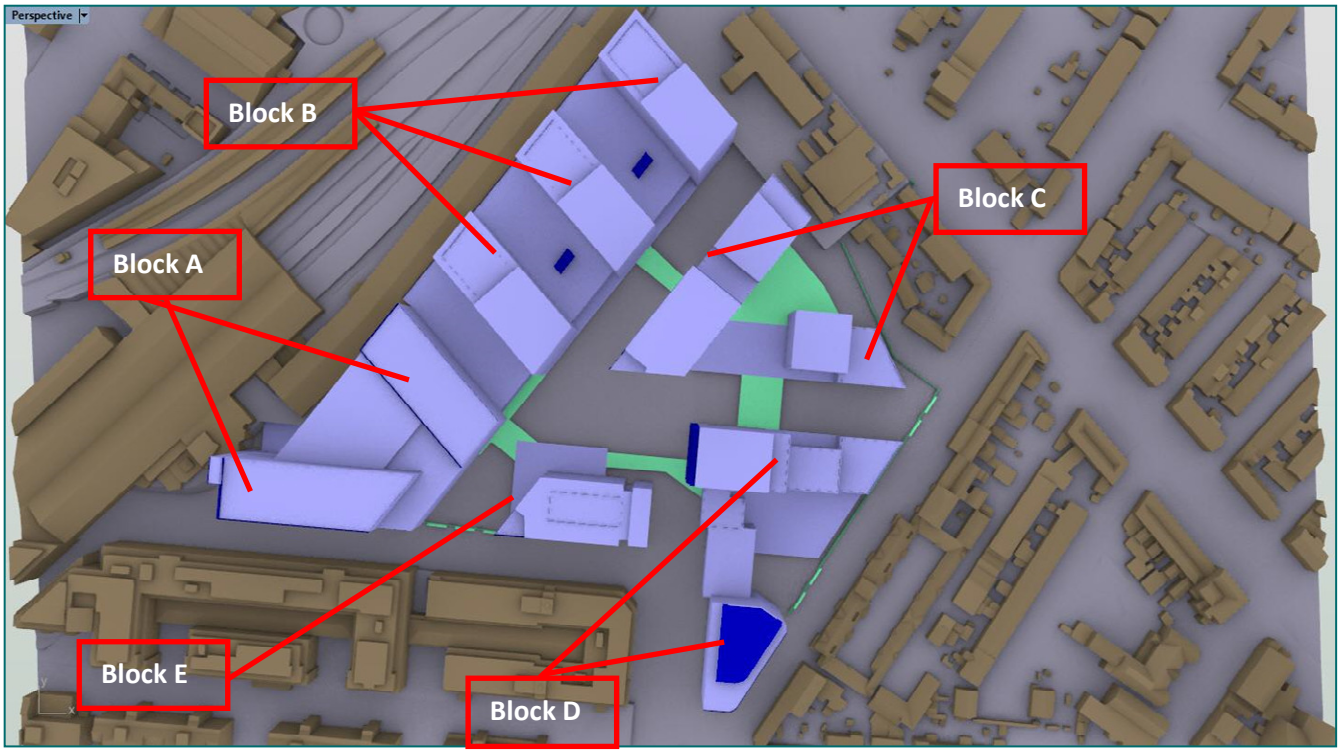


Figure 1: The Connolly Quarter Layout

Block A is primarily an office building along Sheriff Street Lower. Access to the building is from the street and from inside the development after passing through the arches.

Block B consists of three residential buildings connected by a low-level podium. There are public amenity spaces located on the podium. There are private amenity spaces provided on the roof. The building also has private balconies for the residents.

Block C is a cluster of four residential buildings. The building height varies from 5, 10, 11 and 22 storeys. There are public amenity spaces around this block. There are also roof level amenity spaces considered for the tower.

Block D is a mixed development and is fronted by a 10 storey hotel. Behind it are the residential buildings varying in height from 5-14 storeys. The hotel has a roof top seating area with a shading canopy. The residential towers have ground level public amenity spaces and roof top private amenity spaces.

Block E is an office block along Sheriff Street Lower.

Even though Block A, the Hotel in Block D and Block E do not form part of the SHD application it was necessary to include their potential impact on wind distribution for the whole site.

For the analysis, 8 steady state CFD simulations were performed for the main wind directions (N, NE, E, SE, S, SW, W and NW) and annual average wind speed for Dublin. The wind was assumed to have characteristics associated with wind flowing through a city centre. The results obtained from the simulations were extrapolated along the Dublin annual weather data to obtain the most probable local air speed for each hour of the year. Statistical analysis was performed on this dataset to check compliance against the Lawson's Pedestrian Comfort criterion.

The following table provides values for the Lawson's pedestrian comfort assessment criteria for various activities.

Category	Pedestrian Activity	Threshold mean hourly wind speed not to be exceeded for more than 5% of the time (m/s)
C1	Business Walking	10
C2	Leisurely Walking	8
C3	Standing	6
C4	Sitting	4

The following table provides values for Lawson's Pedestrian Safety Assessment criteria.

Category	Pedestrian Type	Threshold mean hourly wind speed not to be exceeded more than once per annum [2](m/s)
S1	Typical Pedestrian	20
S2	Sensitive Pedestrian	15

The CFD study carried out demonstrated that the proposed development as designed complies with the walking standing and sitting wind comfort criteria.

There are areas highlighted in the report where the wind speed threshold for sitting has been exceeded. In these limited areas mitigation measures have been suggested that can bring the wind speed below the sitting threshold. These mitigation measures generally include the use of balustrades and landscaping.

This CFD wind study has been used by the Design Team to inform architectural and landscaping design for the development.

The following findings arose from the analysis:

1.1 Block A

There are three main locations of interest for block A; the high level terrace, mid-level terrace and the ground level space, which provide access to the development and entrance of block A.

The terraces were considered as candidates for the sitting and standing comfort criteria. The ground level spaces were considered as candidates for walking comfort criteria.

As noted in Figure 2 below, the high-level terrace shows good compliance with the sitting criterion due to its 1.8m high balustrades. However, the mid-level terrace shows very limited compliance for the sitting comfort criterion. The reason for this limited compliance of mid-level terrace was the balustrades are of lower height (< 1.5m).

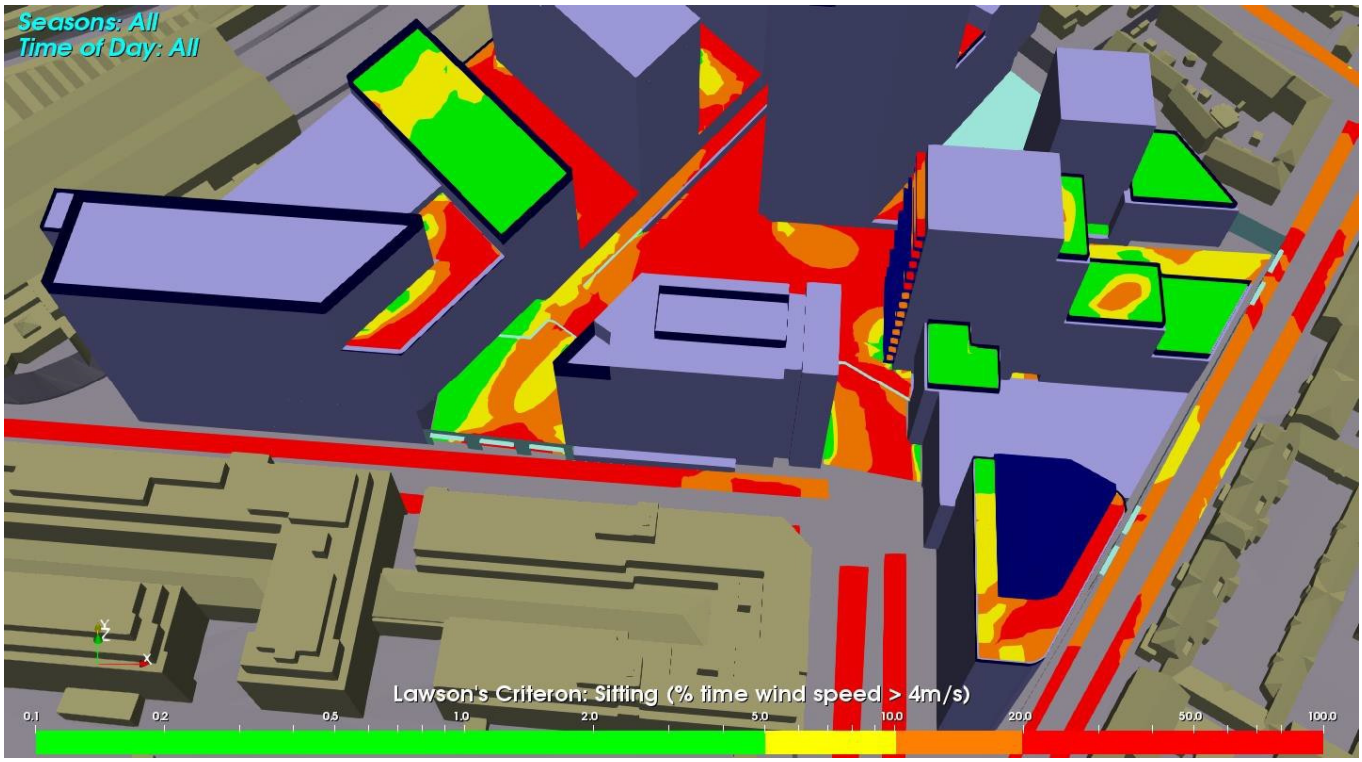


Figure 2: Block A: Sitting comfort

As noted in Figure 34 , the location shows good compliance for other comfort criterion. To show compliance with sitting criteria, it is recommended balustrades located here are raised to 1.8m.

The ground level space of this building is a location of interest from a walking and standing point of view as this provides access to the building and rest of the development. As observed in Figure 3, this location shows good compliance for leisure walking and by extension, business walking too.

Sheriff Street Lower runs west to east along one of the dominant wind directions for Dublin. This increases the likelihood of wind accelerating along the street more frequently during the year.

The other spot is underneath the bridge connecting the Block A to Block E. This space opens to the south-west which is the predominant wind direction for Dublin. As such, conditions are conducive to the wind-tunneling effect here but the location is compliant in other criterion.

Figure 3: Block A: Leisure Walking Criterion

Mitigation features for this could be wind barriers under the bridge and before the bridge to prevent acceleration. This will be dealt with under a separate Planning Application.

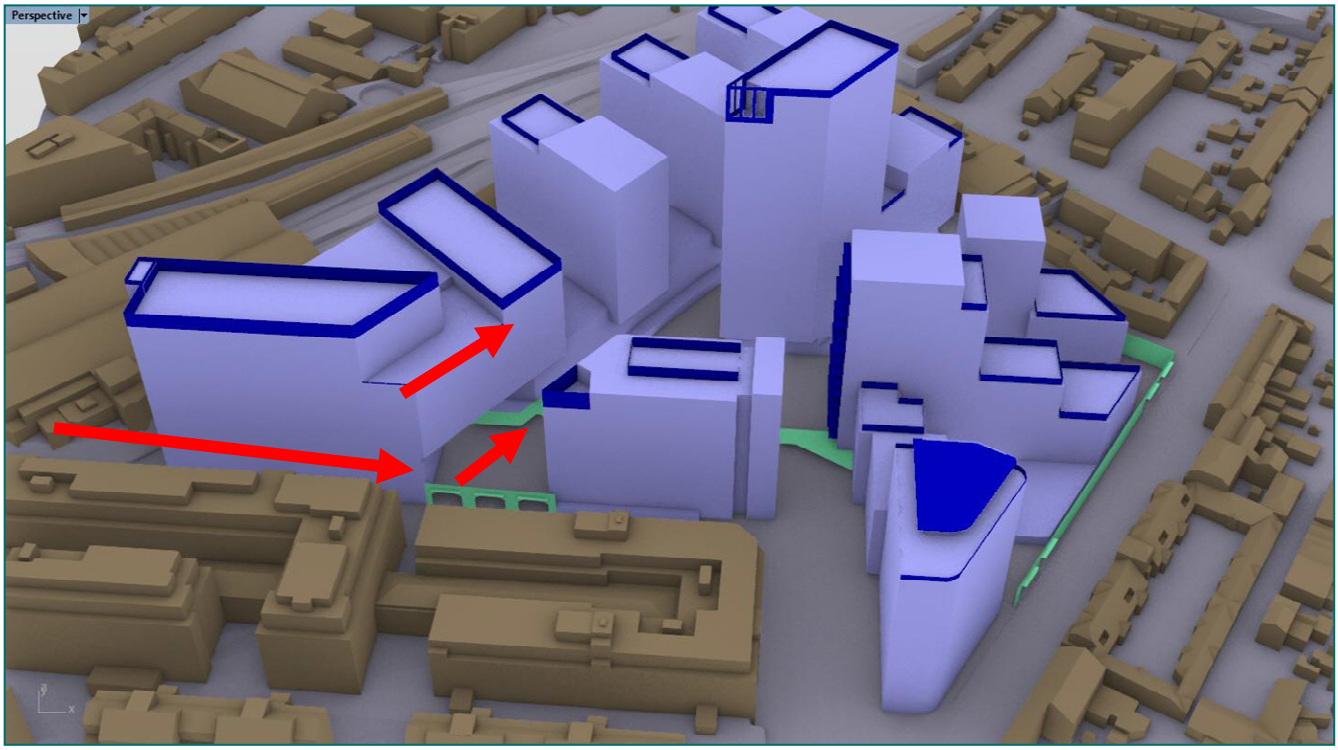


Figure 4: Block A: Wind acceleration potential

1.2 Block B

For Block B, the locations of interest are the low-level podium spaces as public amenity spaces and roof terraces as private amenity spaces. All these spaces show good compliance for standing and walking criteria as noted in Figure 37. However, they show potential for the sitting criterion to exceed more than 5% of the year.

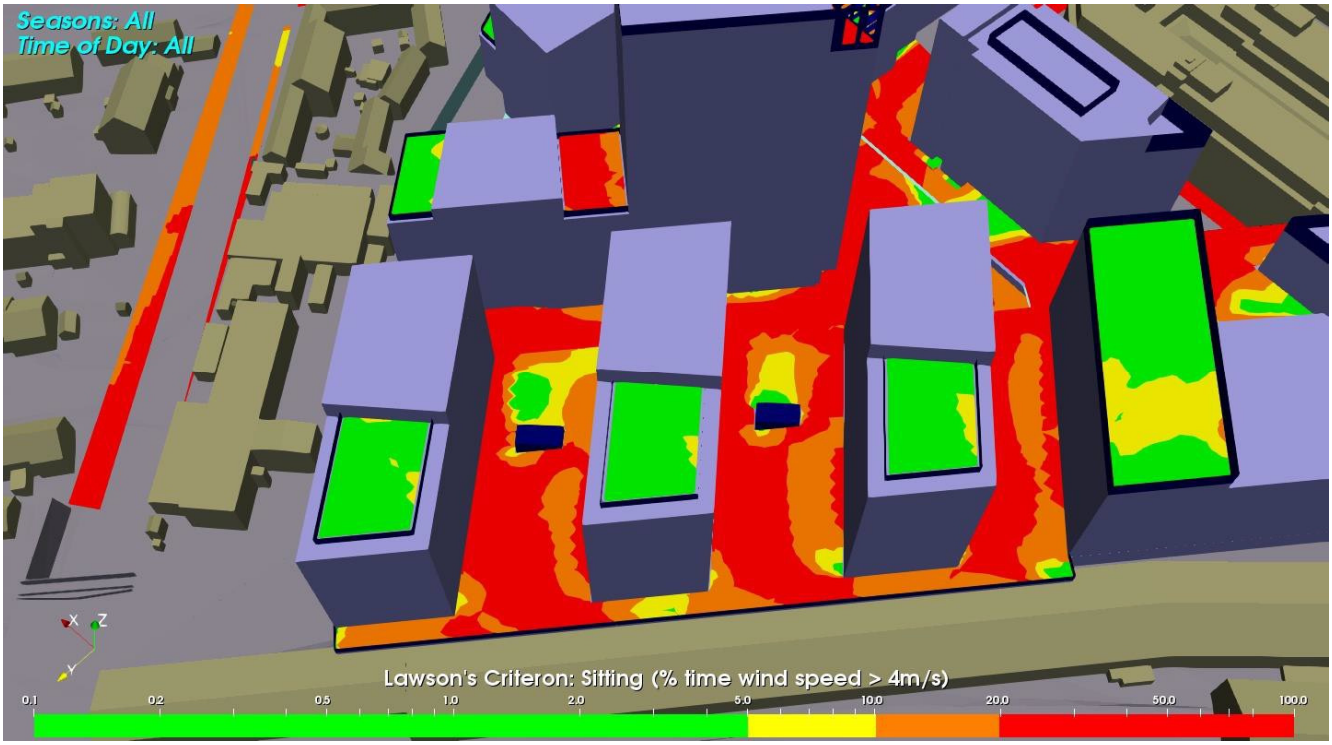


Figure 5: Block B: Sitting Criterion Results

The primary reason is the orientation of these podium spaces, which makes them susceptible to wind tunneling from both the westerly and southerly winds. These are dominant wind directions in Dublin. The spaces though are fully compliant in the standing in walking criteria.

The roof terrace spaces show compliance with all criterion, as the balustrades are higher than 1.8m.

Mitigation features recommended to satisfy the sitting criterion for podium will be large wide features that would disrupt the wind flow at podium level. These include landscaping measures and locating seating in conjunction with optimum locations in the daylighting report.

The roof terrace spaces show compliance with all criterion.

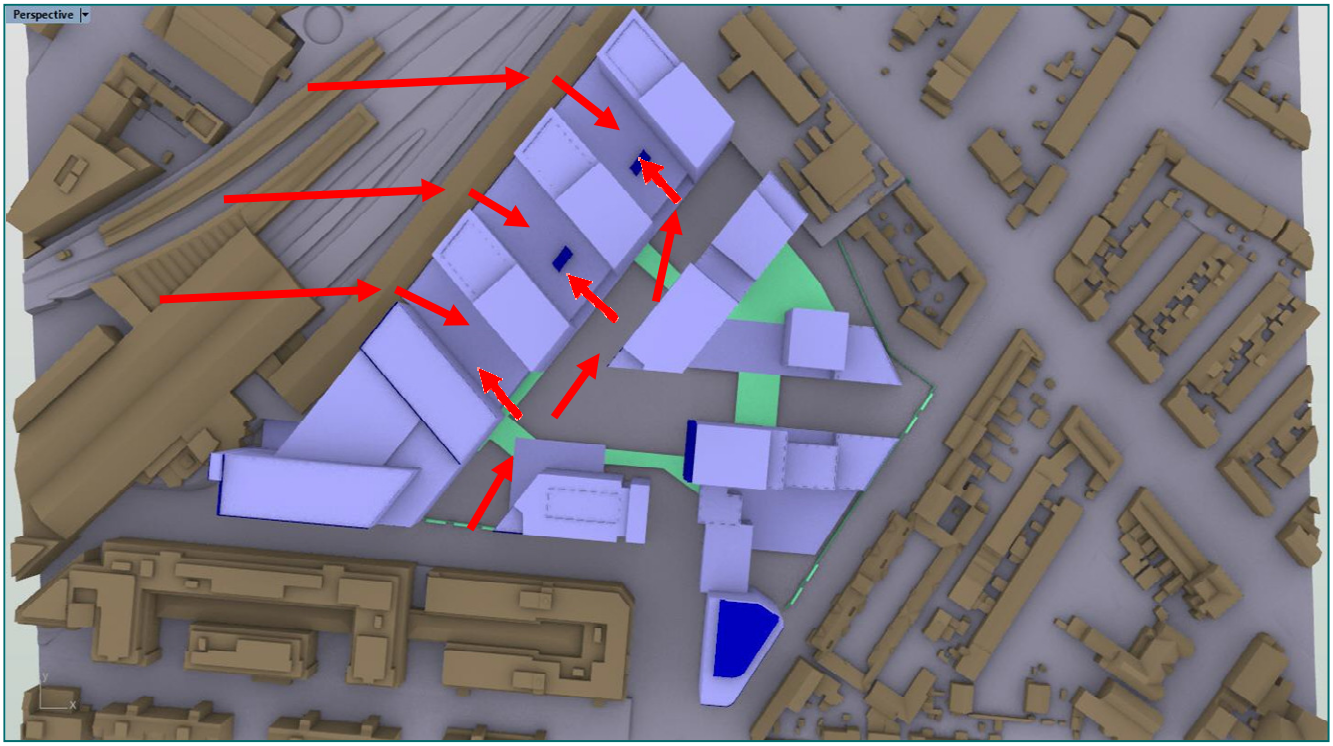


Figure 6: Block B: Wind Acceleration

1.3 Block C

There are many locations of interest around Block C. First, the high-level private terrace of the 22 storey block shows limited compliance with sitting criterion despite balustrades for shelter. The location showed compliance with the standing and walking criteria as seen in Figure 36.

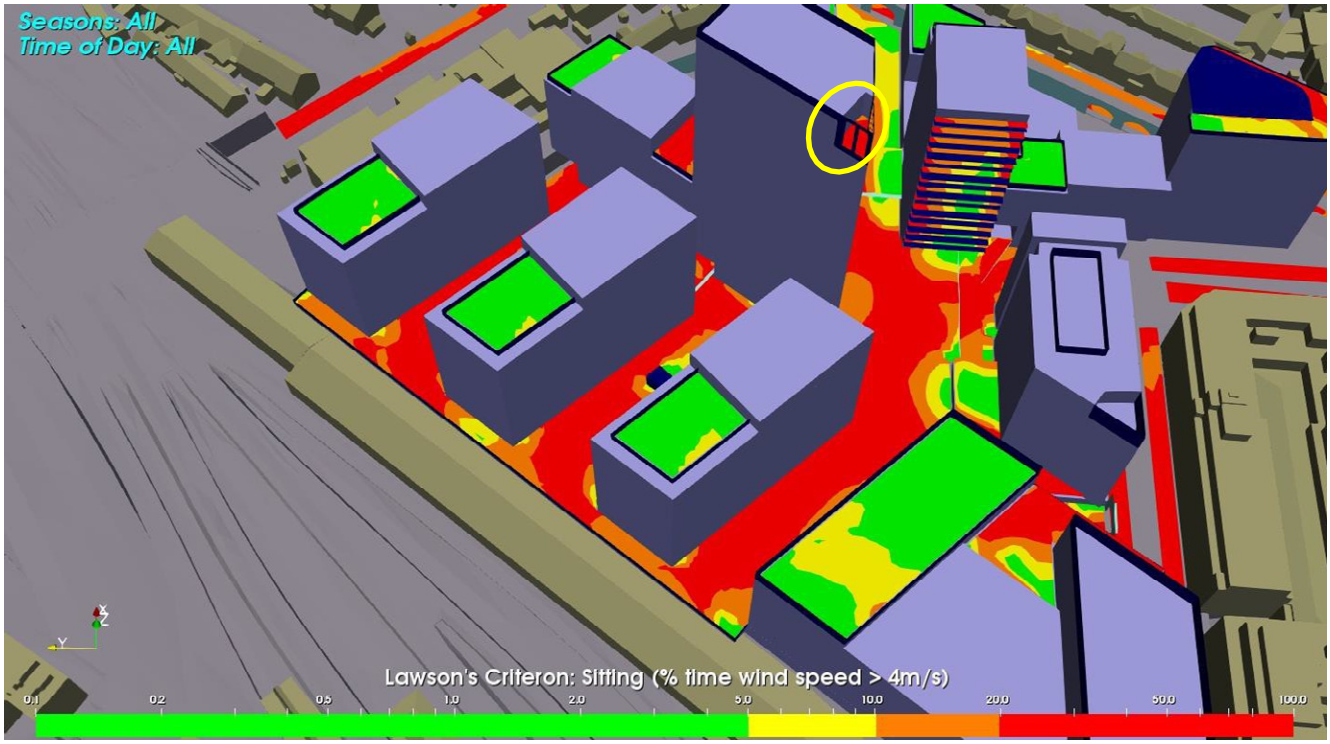


Figure 7: Block C: Sitting Criterion - 22 Storey building

The primary reason is recirculating wind as it blows over the space. There is no shelter directly above, so recirculating wind flows downwards as is passes over the roof. Also due to the height of the location, the wind is unhindered and high speed. Mitigation measure includes horizontal elements to deflect and slow down the recirculating wind, and locating seating away from this area.

The low-level roof terrace adjoining the tower shows non-compliance with the sitting criterion. The standing and walking criteria show good compliance.

Similar to the podium spaces for Block B the westerly wind accelerating between the block B towers is likely to reach this roof terrace. Possible mitigation is higher balustrades to the western side to deflect the wind over the terrace.

The other locations around Block C show good compliance with all Lawson's comfort criterion.

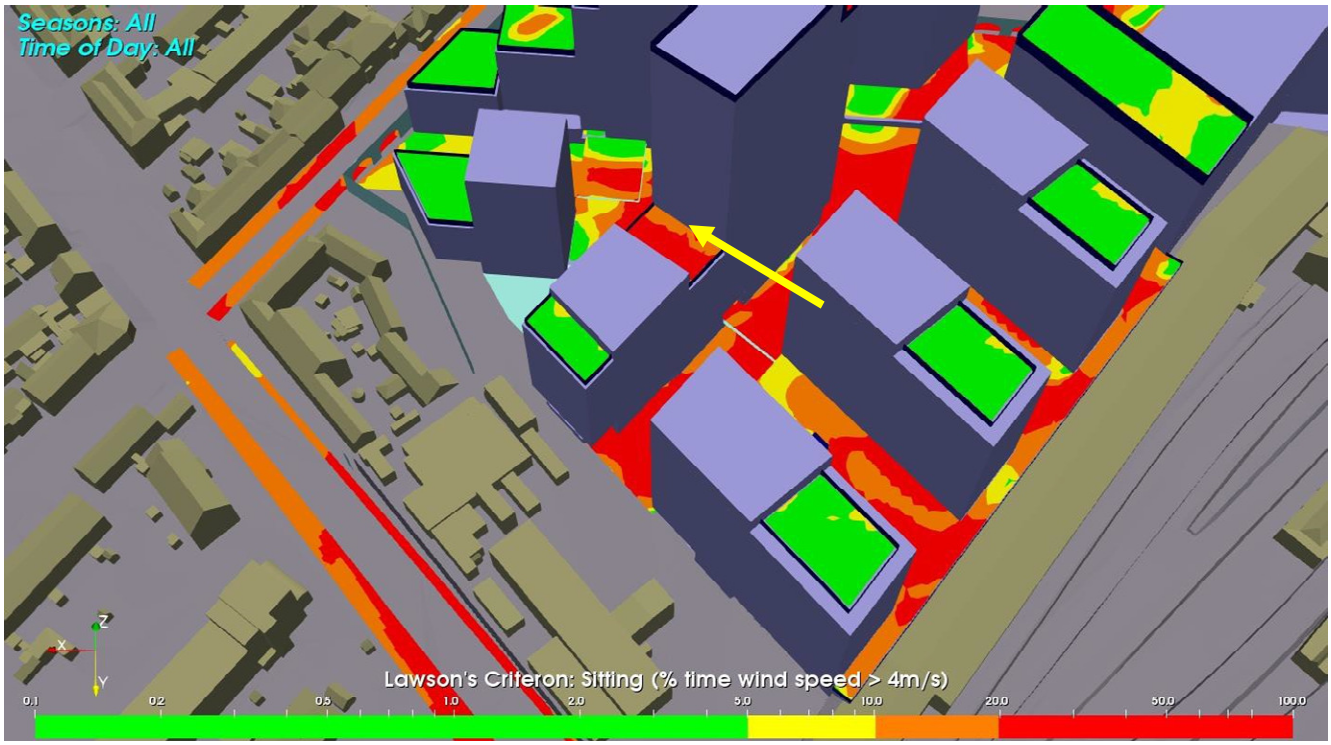


Figure 8: Block C: Low level roof terrace

1.4 Block D

For block D, the roof top hotel shows limited compliance with the sitting criterion on the southeastern side of the roof.

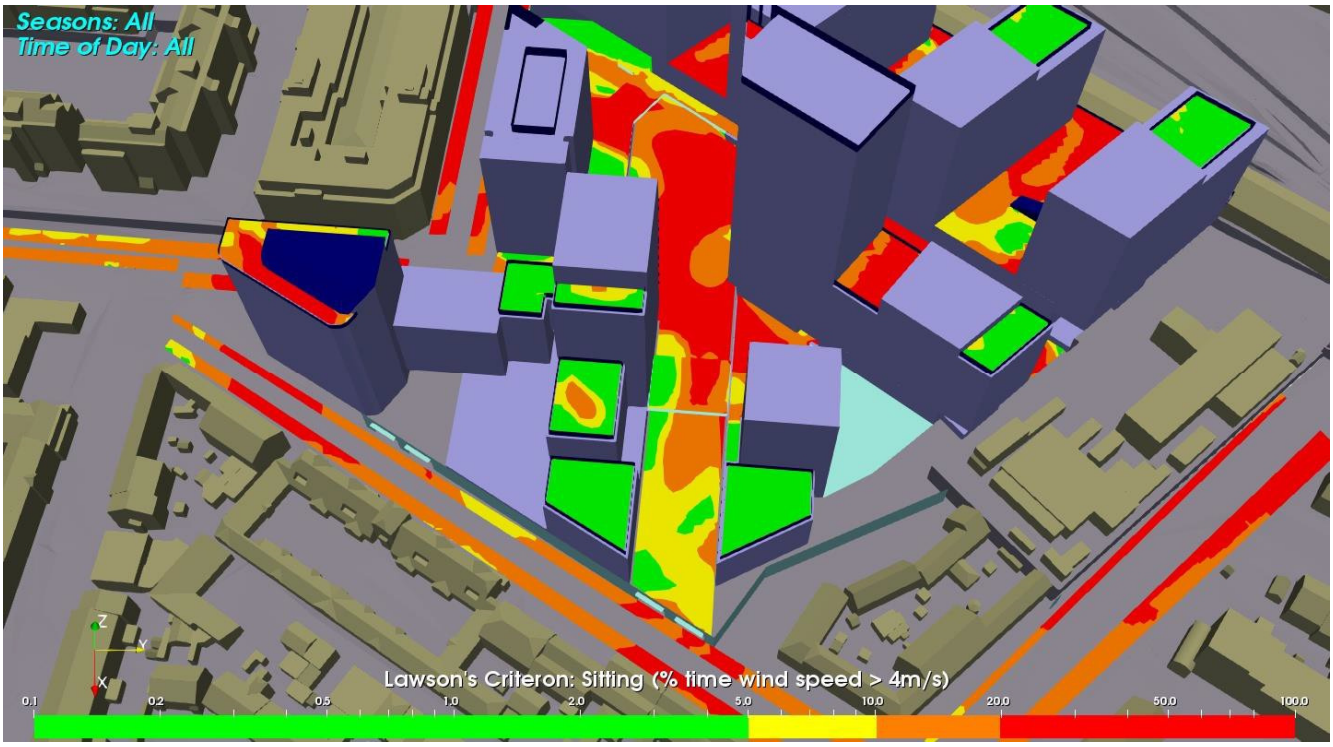


Figure 9: Block D: Sitting Criterion

The other location is outside the covered passageway above the 7 storey aspect of Block D.

For the roof top space, the orientation of the space along the SW direction meant there was potential for wind acceleration under the shade and balustrades due to wind tunnelling. A possible mitigation measure is higher balustrades to ensure wind deflects away rather than underneath the shades.

For the location outside the passage, wind deflection measures inside the passage will prevent acceleration of wind inside the passage.

The other Block D spaces show good compliance with all criterion.

1.5 Block E

All the area around Block E shows good compliance with all walking criterion including sitting as seen in Figure 10 below.

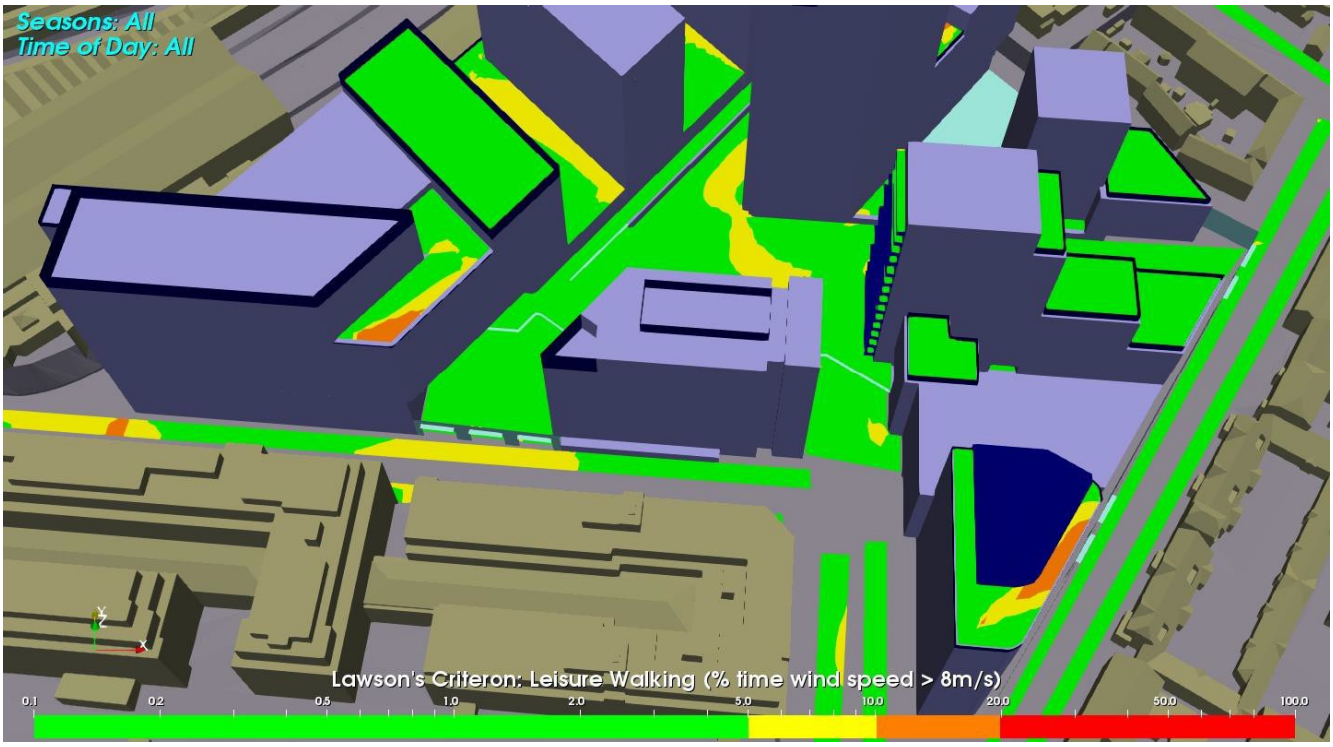


Figure 10: Block E: Walking criterion

Other locations:

All streets and the Hi-Line route show good compliance with the walking and standing and sitting criterion at all locations around the development.

2 Introduction

IES Consulting have been commissioned to investigate the potential impact of wind movement on pedestrian comfort around the proposed development near Connolly Station in Dublin.

The analysis is to be performed to study the effect from building layout on pedestrian comfort for people using public amenity spaces around the site.

The following simulation report describes the modelling methodology used in the study, including assumptions made and calculations used to determine the boundary conditions and the results obtained from the simulations.

3 Weather Data

The analysis is based on the 'Dublin_TMY5.epw' weather file. The variation of wind speed recorded in the weather file is shown in figure 11 below. Figure 12 shows the wind direction variation and Figure 13 shows the wind rose.

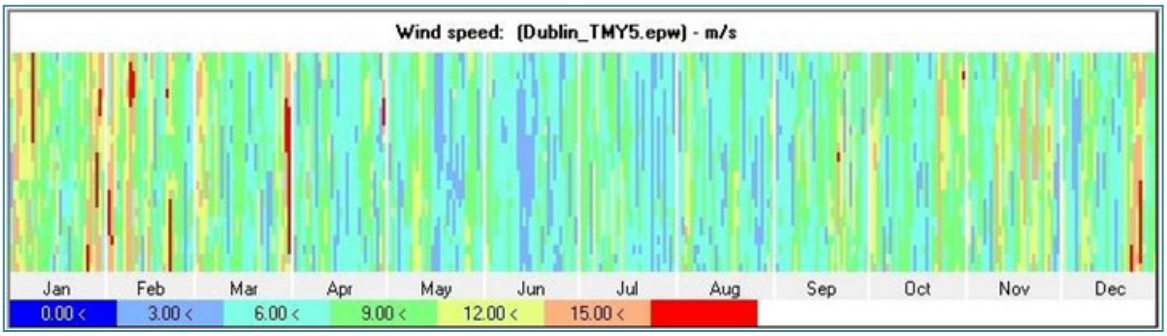


Figure 11: Wind speed variation as per Dublin_TMY5.epw

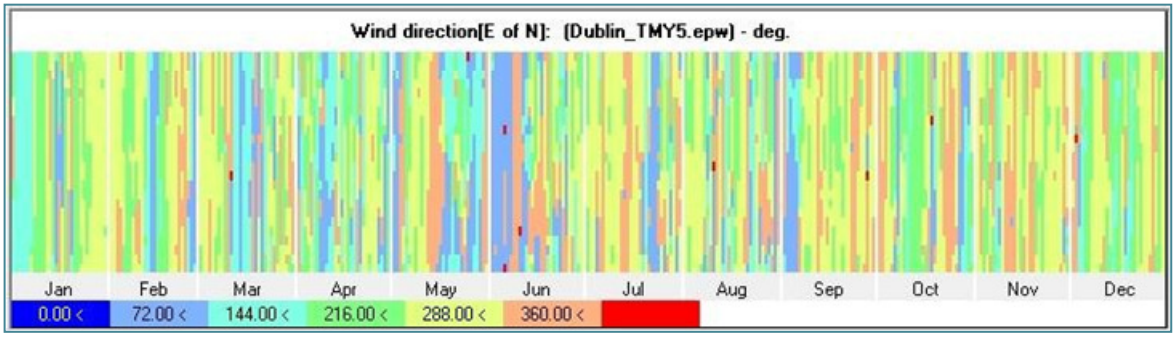


Figure 12: Wind direction variation as per Dublin_TMY5.epw

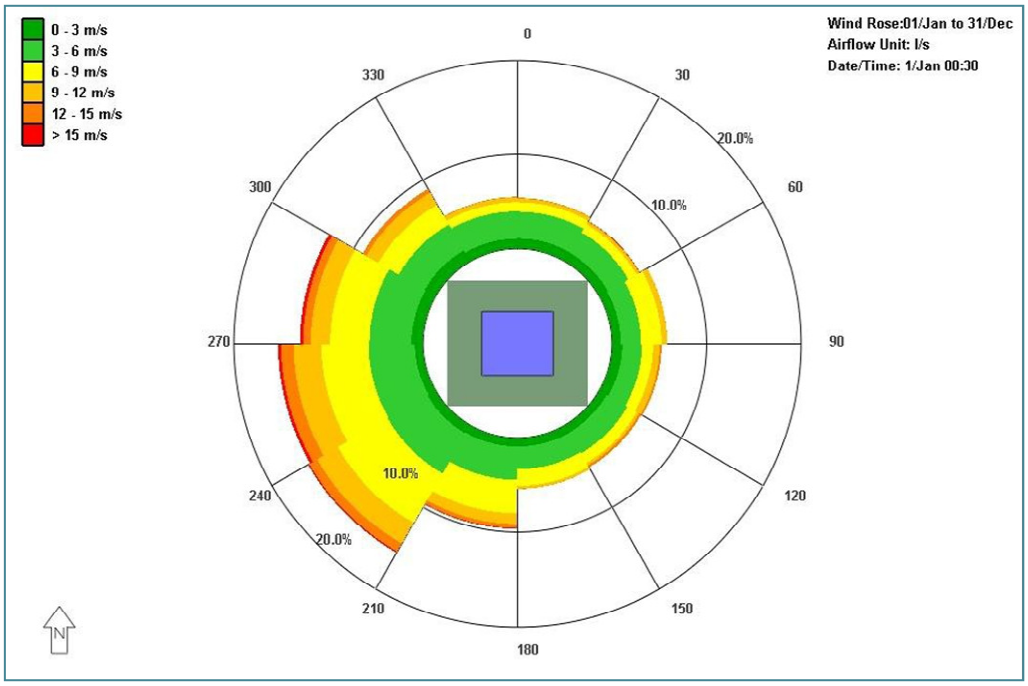


Figure 13: Wind rose as per Dublin_TMY5.epw

Based on this, the mean wind speed recorded was **6.4m/s** with a westerly prevailing direction.

4 Wind Boundary Layer

In an atmospheric boundary layer, wind speed increases with height due to the influence of surface roughness (i.e. the presence of buildings, trees, roads etc. on the ground), see Figure 14.

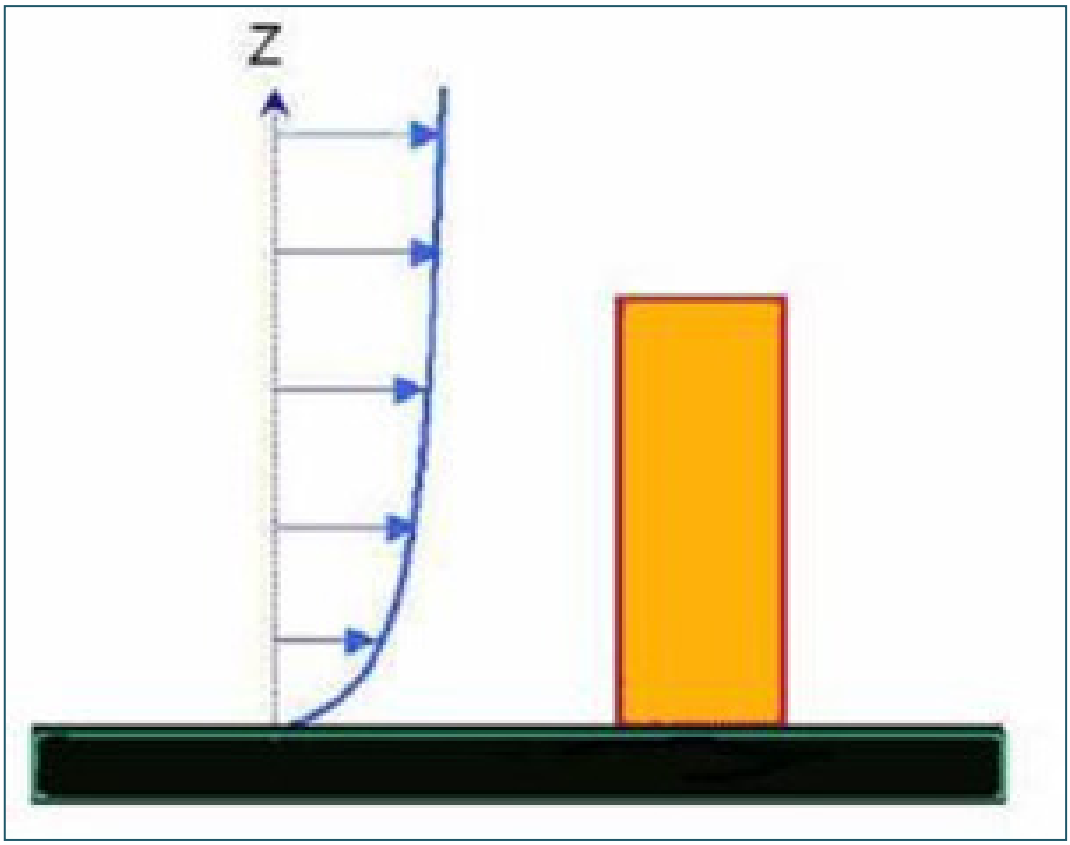


Figure 14: Typical velocity profile of an atmospheric boundary layer

In the current CFD modelling, the velocity profile was generated according to the parameterised ASHRAE methodology described below. This allows for different wind profiles across various terrain types: Open country; urban; and city centre.

The wind speed U_H at height **H** above the ground is given by:

$$U_H = U_{met}\left(\frac{\delta_{met}}{H_{met}}\right)^{a_{met}}\left(\frac{H}{\delta}\right)^{a} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Eq.\ 1)$$

Where,

a = Exponent in power law wind speed profile for local building terrain
δ = fully developed strong wind atmospheric boundary layer thickness (m)
a_{met} = Exponent for the meteorological station
δ_{met} = Atmospheric boundary thickness at the meteorological station (m)
H_{met} = Height at which meteorological wind speed was measured (m)
U_{met} = Hourly meteorological wind speed, measured at height H_{met} (m/s)

The parameters for different types of terrain are given as in table 1.

Table 1: Atmospheric boundary layer parameters

Terrain Category	Description	a	δ
1	Large city centres 50% of buildings above 21m over a distance of at least 2000m upwind.	0.33	460
2	Urban, suburban, wooded areas.	0.22	370
3	Open, with scattered objects generally less than 10m high.	0.14	270
4	Flat, unobstructed areas exposed to wind flowing over a large water body (no more than 500m inland).	0.10	210

For the current project, we used the atmospheric boundary layer corresponding to the terrain category 1 i.e. large city centres type of site. The met data was taken on category 3 terrain at a height of 10m. Figure 15 below shows the shape of the wind boundary profile.

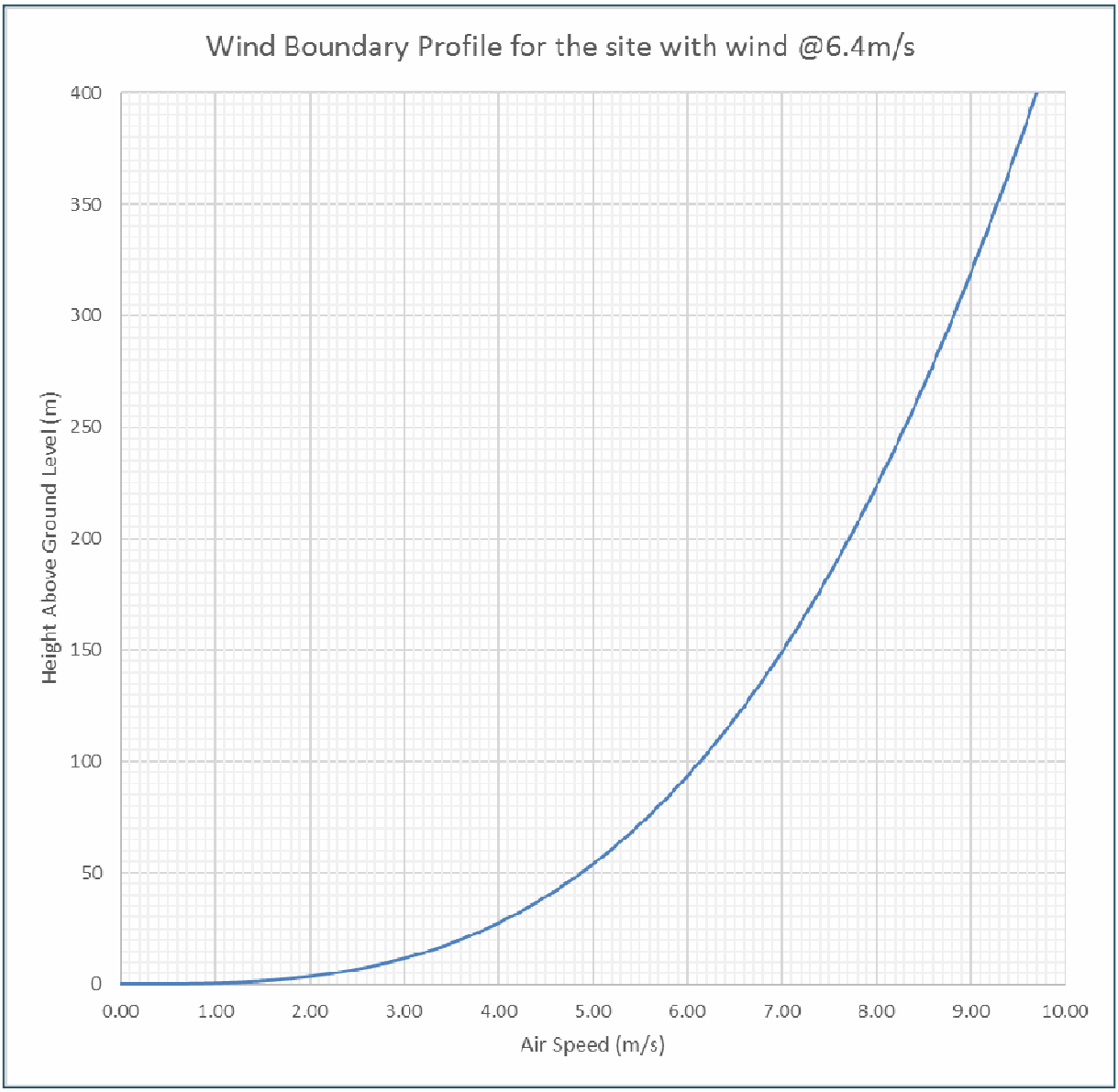


Figure 15: Wind boundary profile for the CFD simulations using annual average wind speed

5 Analysis Methodology

The methodology for the analysis was as follows:

1) The annual mean wind speed was determined from the weather file described earlier in section 2.
2) 8 steady state CFD simulations were performed corresponding to the 8 directions – SW, W, NW, N, NE, E, SE and S respectively.
3) The local air speed at various designated locations around the site was recorded for each of the simulations.
4) This value was compared to the meteorological wind speed used and the magnification factor at that location for the corresponding wind direction was determined.
5) The magnification factor was used to determine the air speed at the designated locations for the various recorded values of the wind speed and direction in the weather file, thus generating the local air speeds at designated locations for a year.
6) These recorded values were compared to the Lawson Pedestrian Comfort/Safety Criteria.

5.1 Lawson Pedestrian Comfort/Safety Criteria

The Lawson Criteria[1] was used as a reference to assess the wind effects. It is the most widely used reference for assessment of pedestrian comfort. It considers the air speed at the location as well as the frequency of the occurrence of this air speed. It consists of two assessment criteria:

1. The first criteria assesses whether the air movement will be comfortable for the pedestrian for different types of activities.
2. The second criteria assess the feeling of safety or distress by the pedestrian at higher air speeds.

Following table gives the values for the Lawson's pedestrian comfort assessment criteria for various activities.

Category	Pedestrian Activity	Threshold mean hourly wind speed not to be exceeded for more than 5% of the time (m/s)
C1	Business Walking	10
C2	Leisurely Walking	8
C3	Standing	6
C4	Sitting	4

Following table gives the values for Lawson's Pedestrian Safety Assessment criteria.

Category	Pedestrian Type	Threshold mean hourly wind speed not to be exceeded more than once per annum [2](m/s)
S1	Typical Pedestrian	20
S2	Sensitive Pedestrian	15

[1]T. V. Lawson (2001) *Building Aerodynamics*, Imperial College Press, London.
[2]Once per annum means the safety threshold is not be exceeded 0.01% of the year.

6 CFD Model

The CFD model was created based on the CAD drawings provided.

6.1 Model Geometry

Figures 16 to 26 show the geometry as modelled.

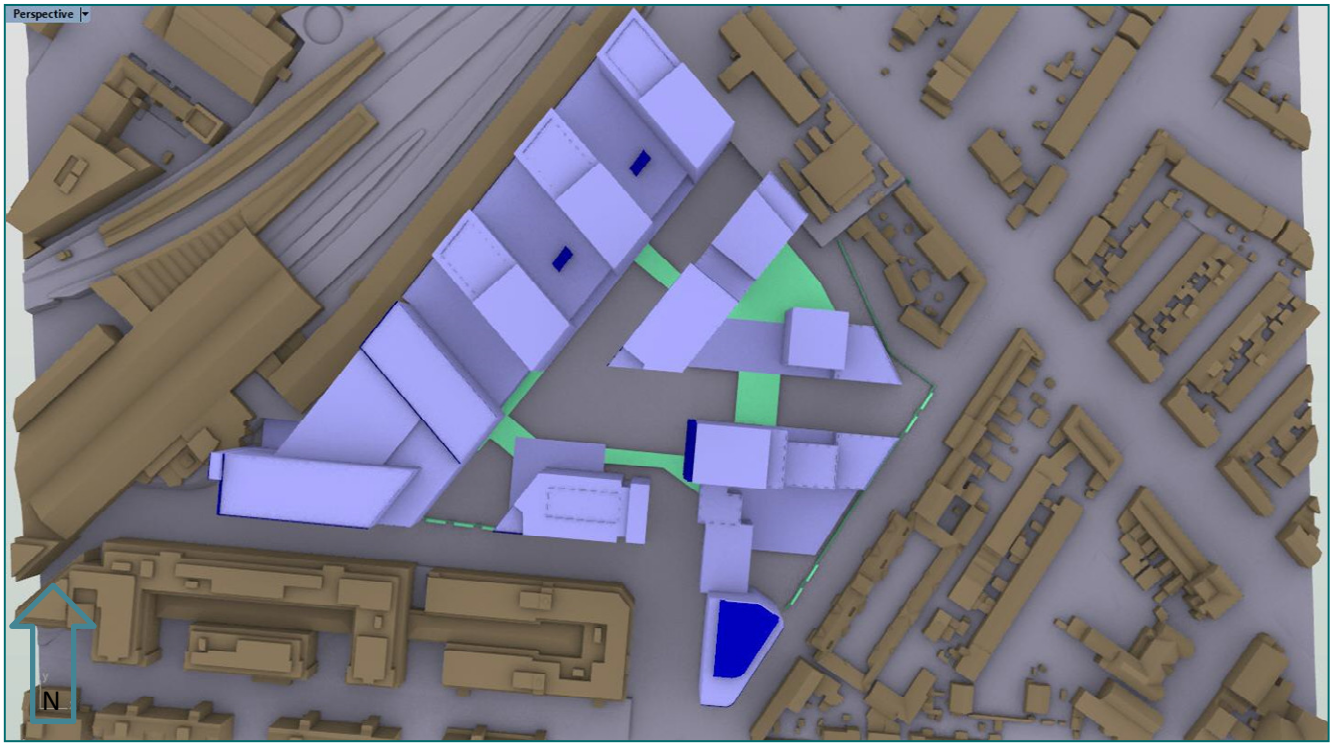


Figure 16: Plan view of the site

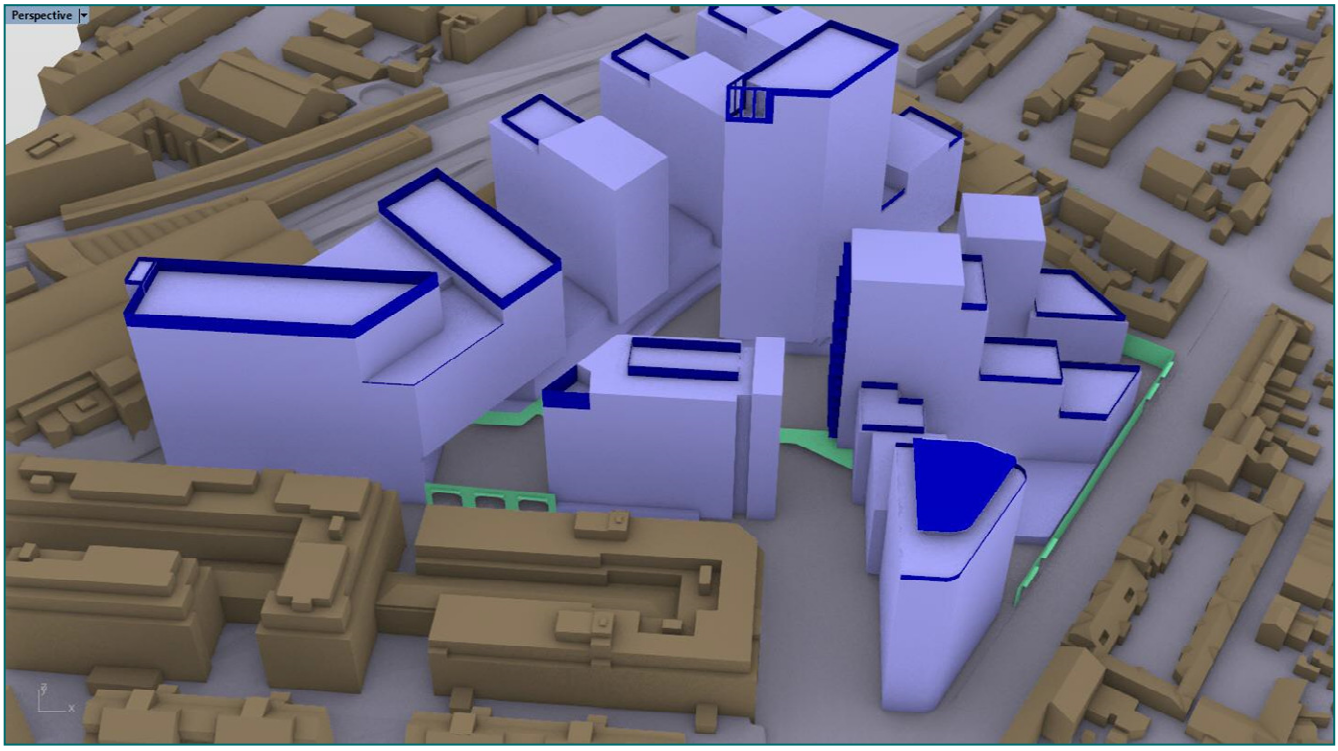


Figure 17: View of the site from the south

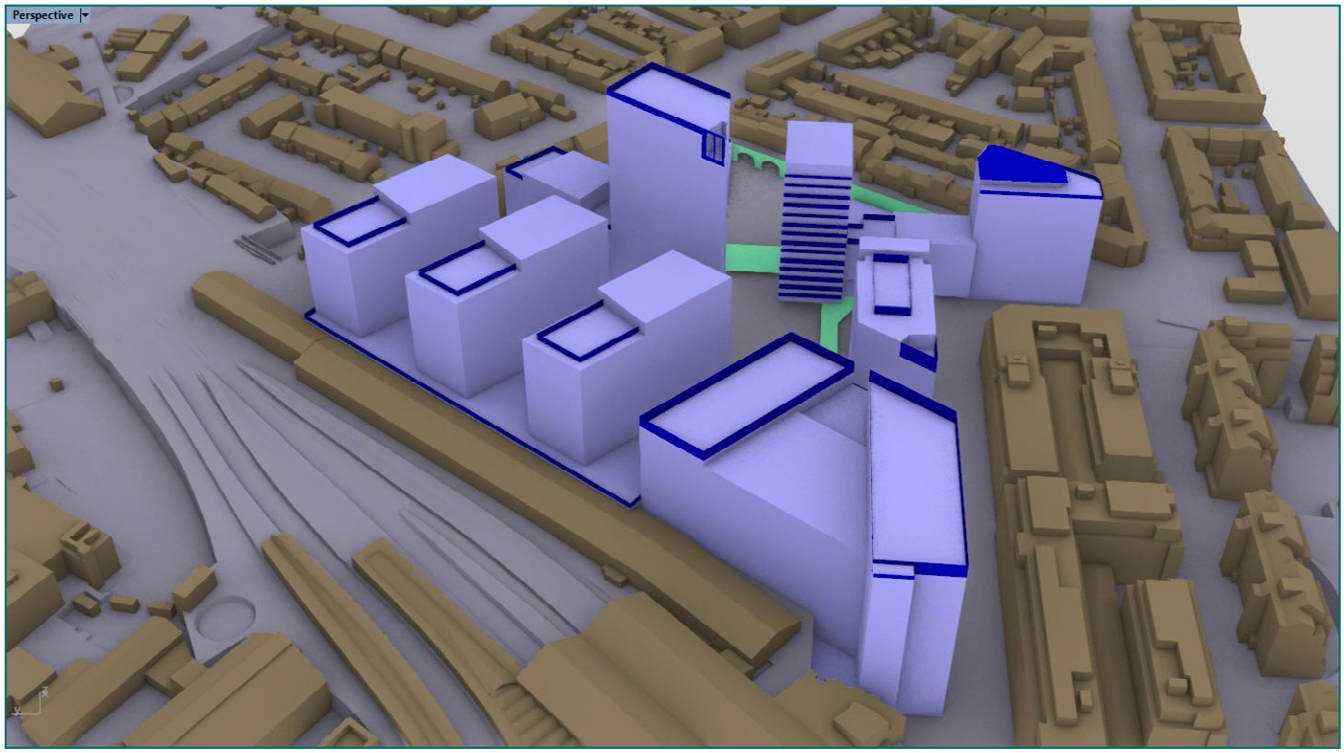


Figure 18: View of the site from the west

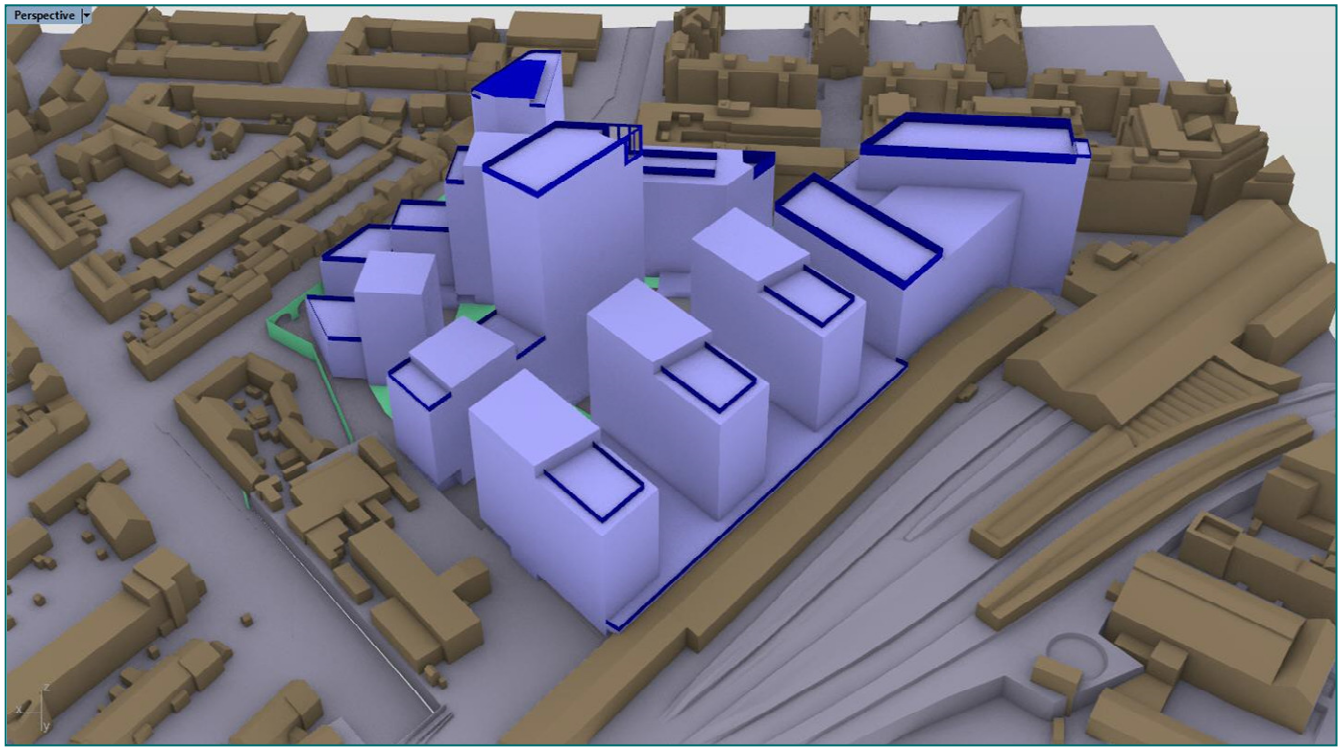


Figure 19: View of the site from the north

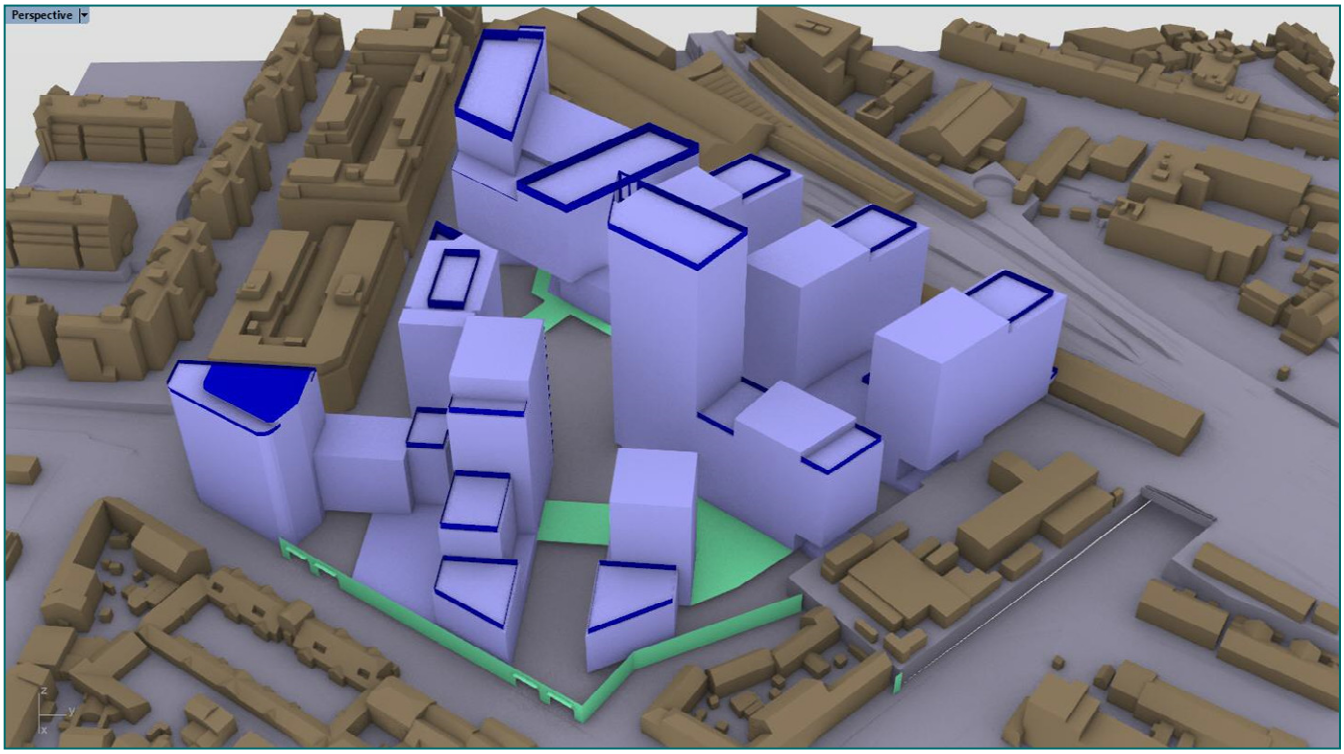


Figure 20: View of the site from the east

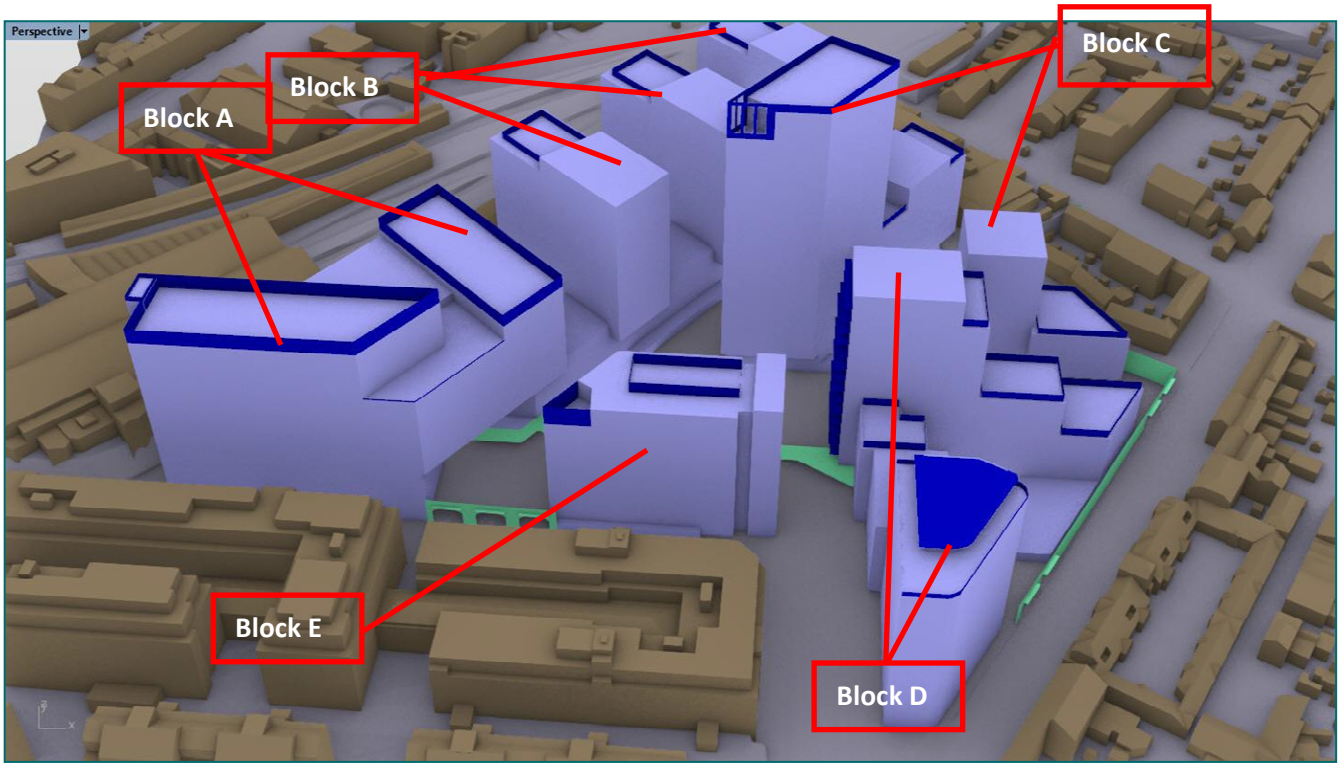


Figure 21: Closer view of buildings from the south

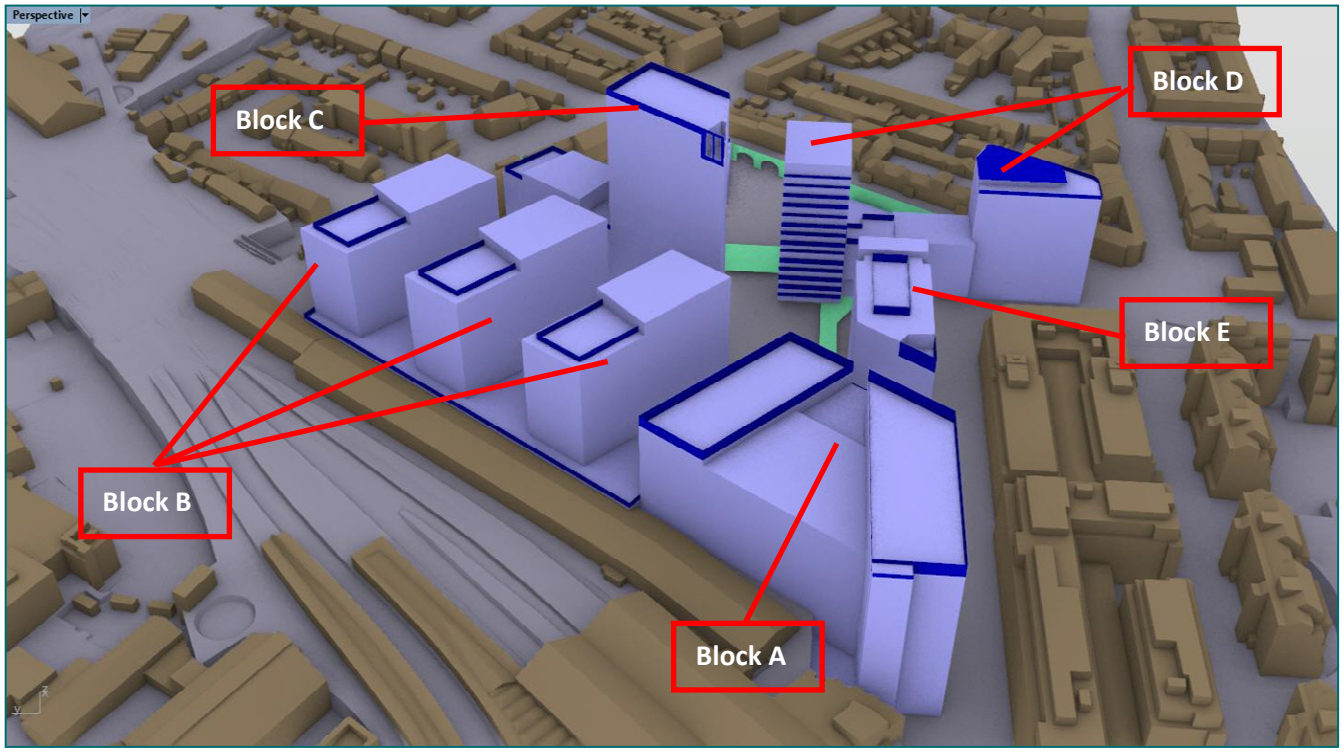


Figure 22: Closer view of buildings from the west

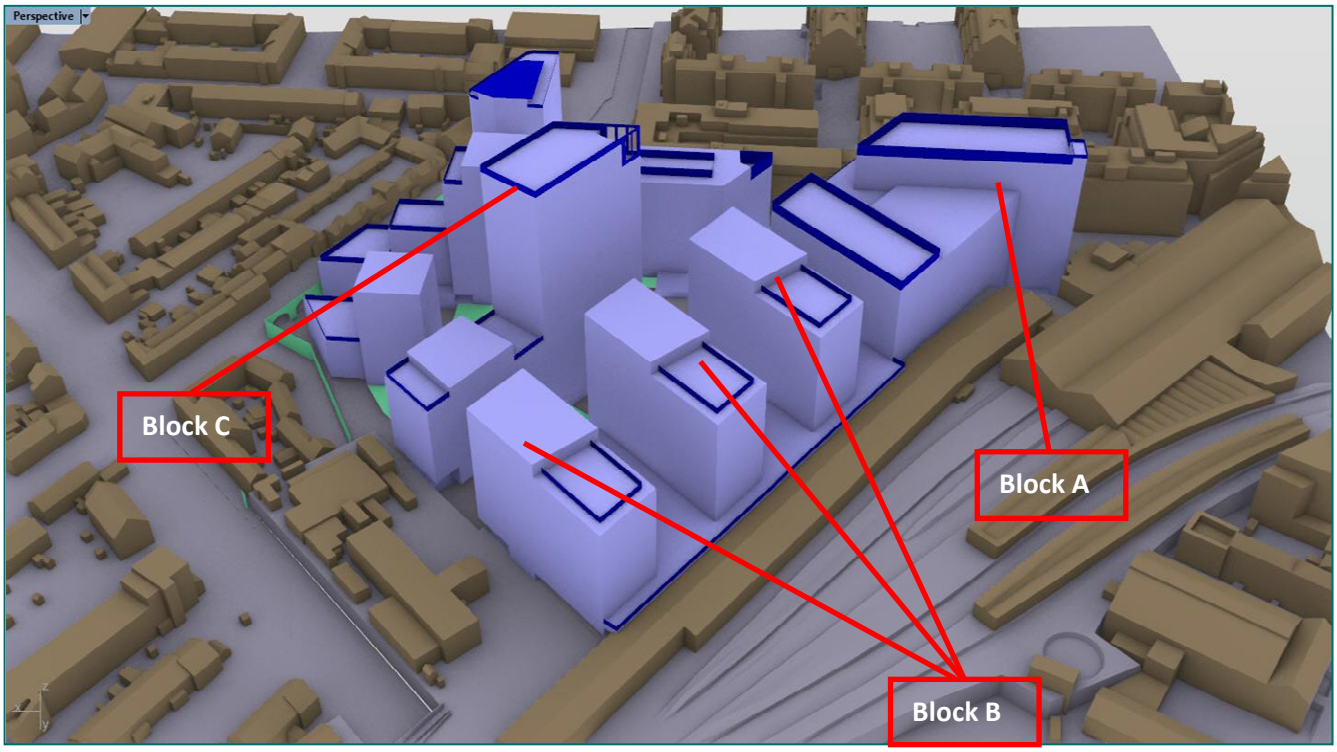


Figure 23: Closer view of buildings from the north

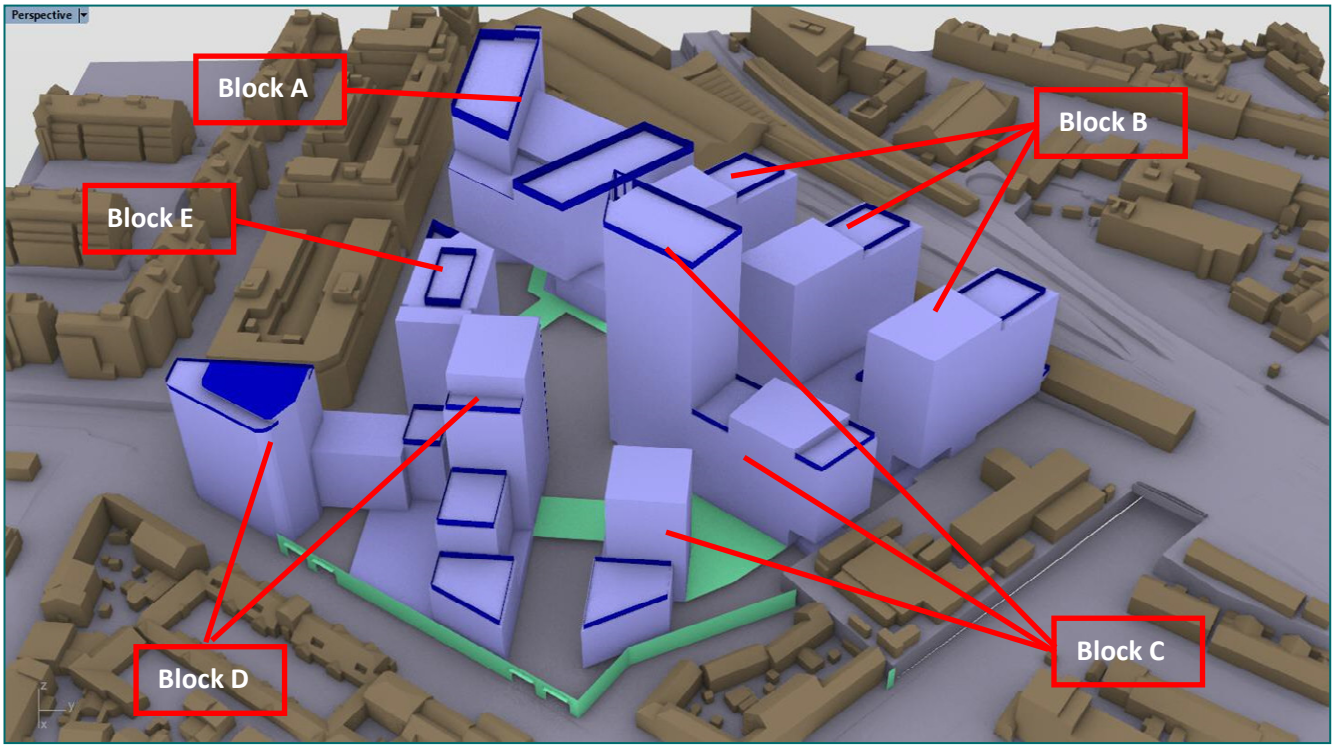


Figure 24: Closer view of buildings from the east

Figure 25: View of the streets around the site

Figure 26: View of the streets around the site

6.2 Reportage Locations

Figures 27 to 32 below show the different locations where pedestrian comfort parameters will be reported coloured in blue.

Figure 27: Reportage Locations: Focus on sitting and standing

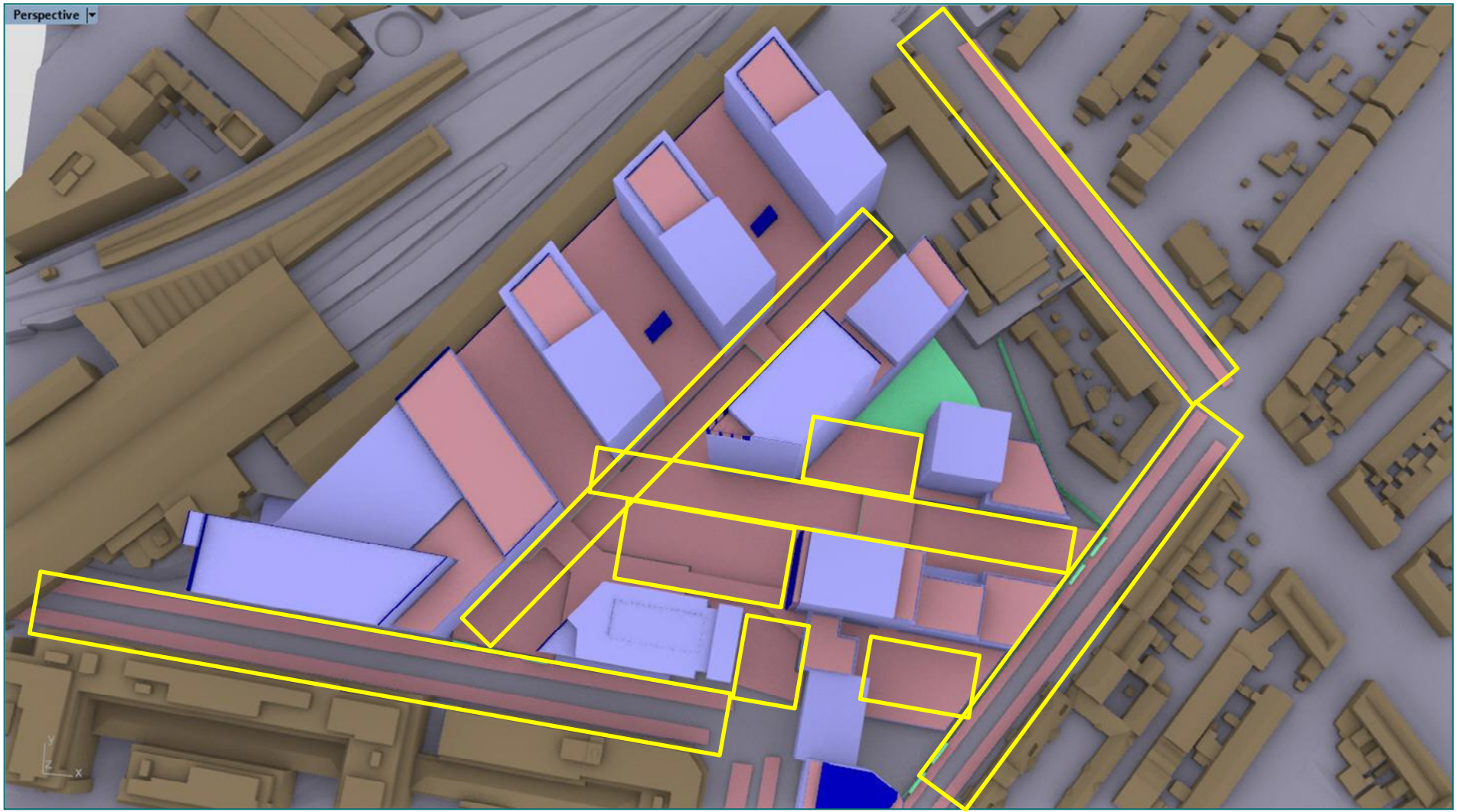


Figure 28: Reportage Locations: Focus on walking

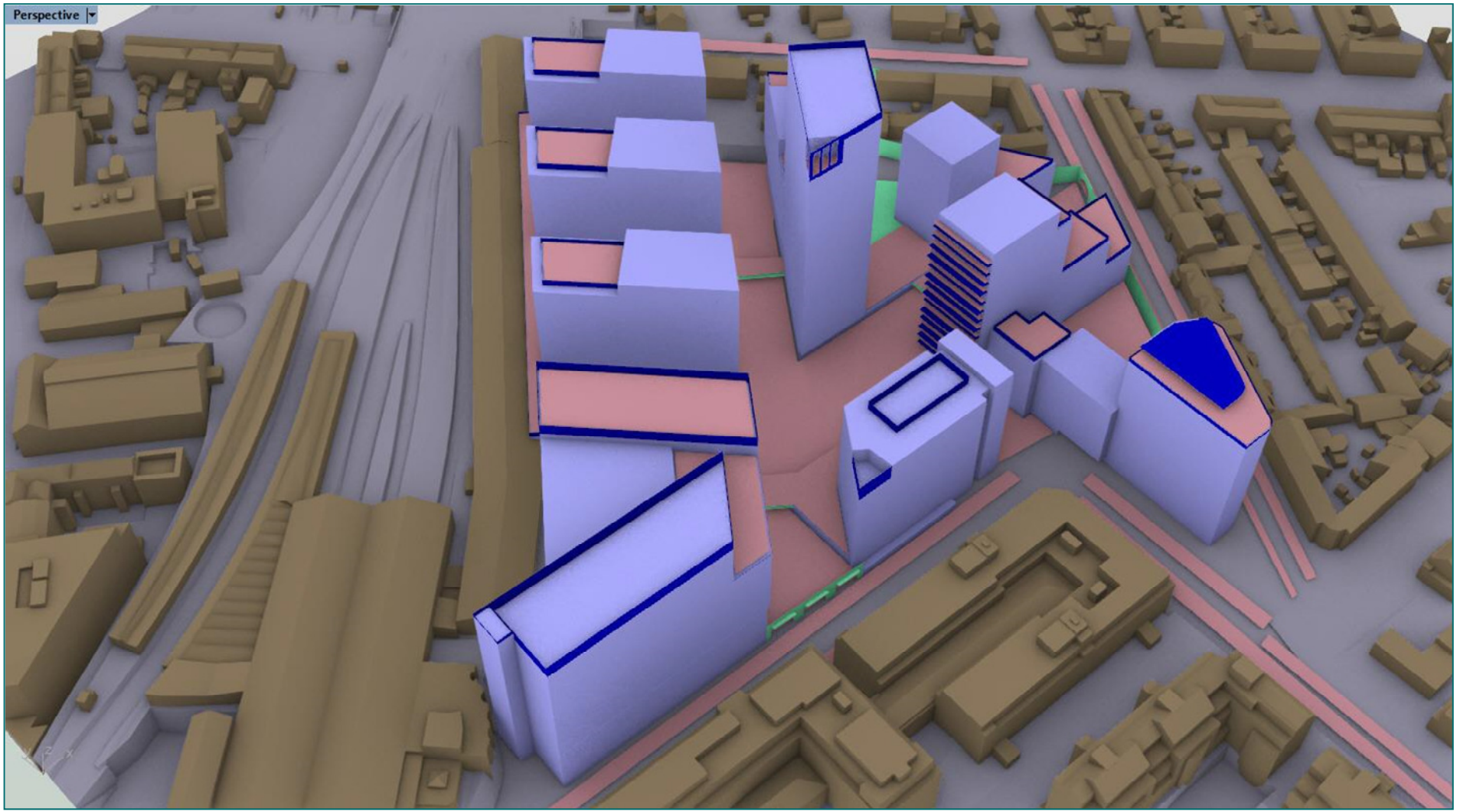


Figure 29: Reportage Locations: Seen from south-west

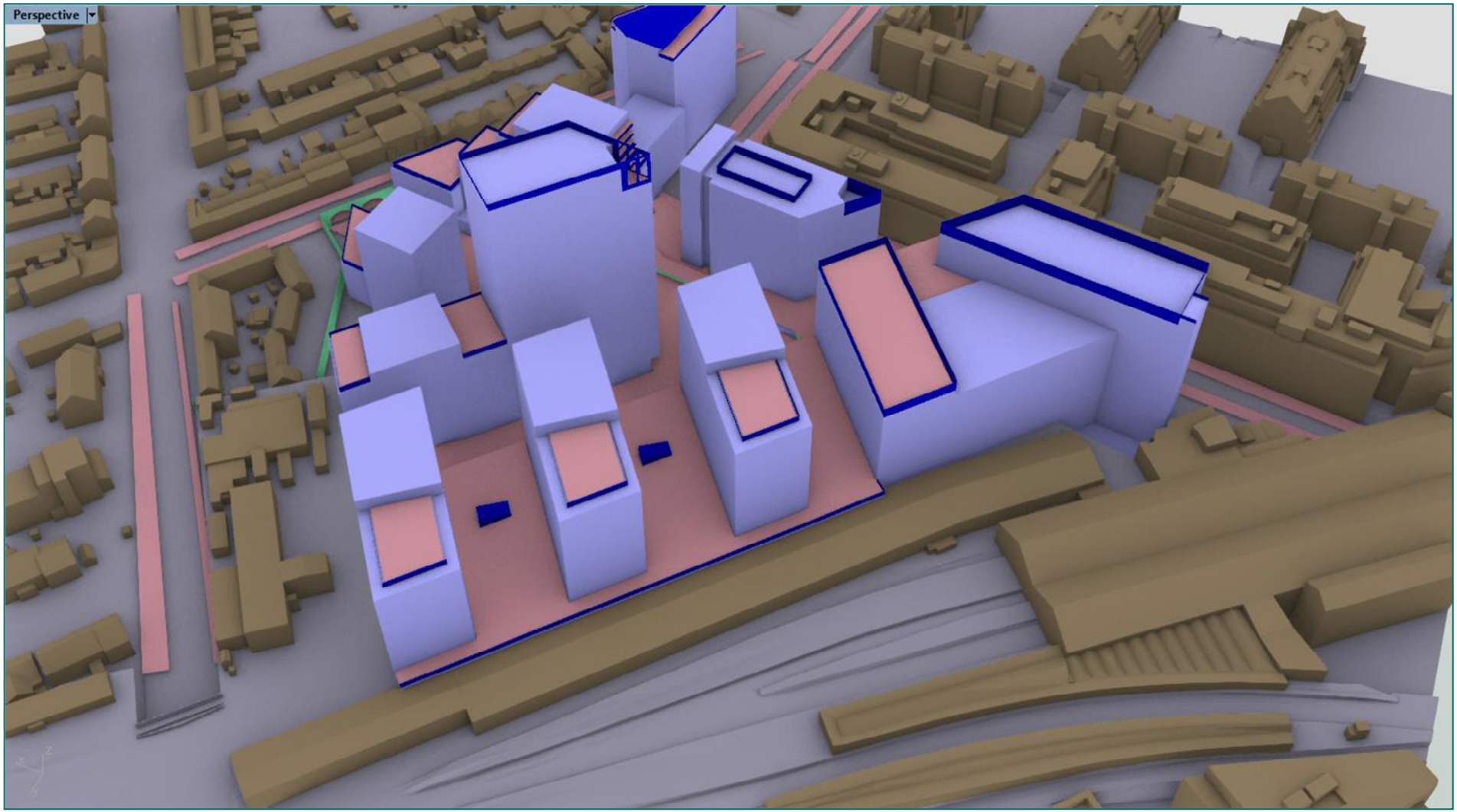


Figure 30: Reporting Locations: Seen from north-west

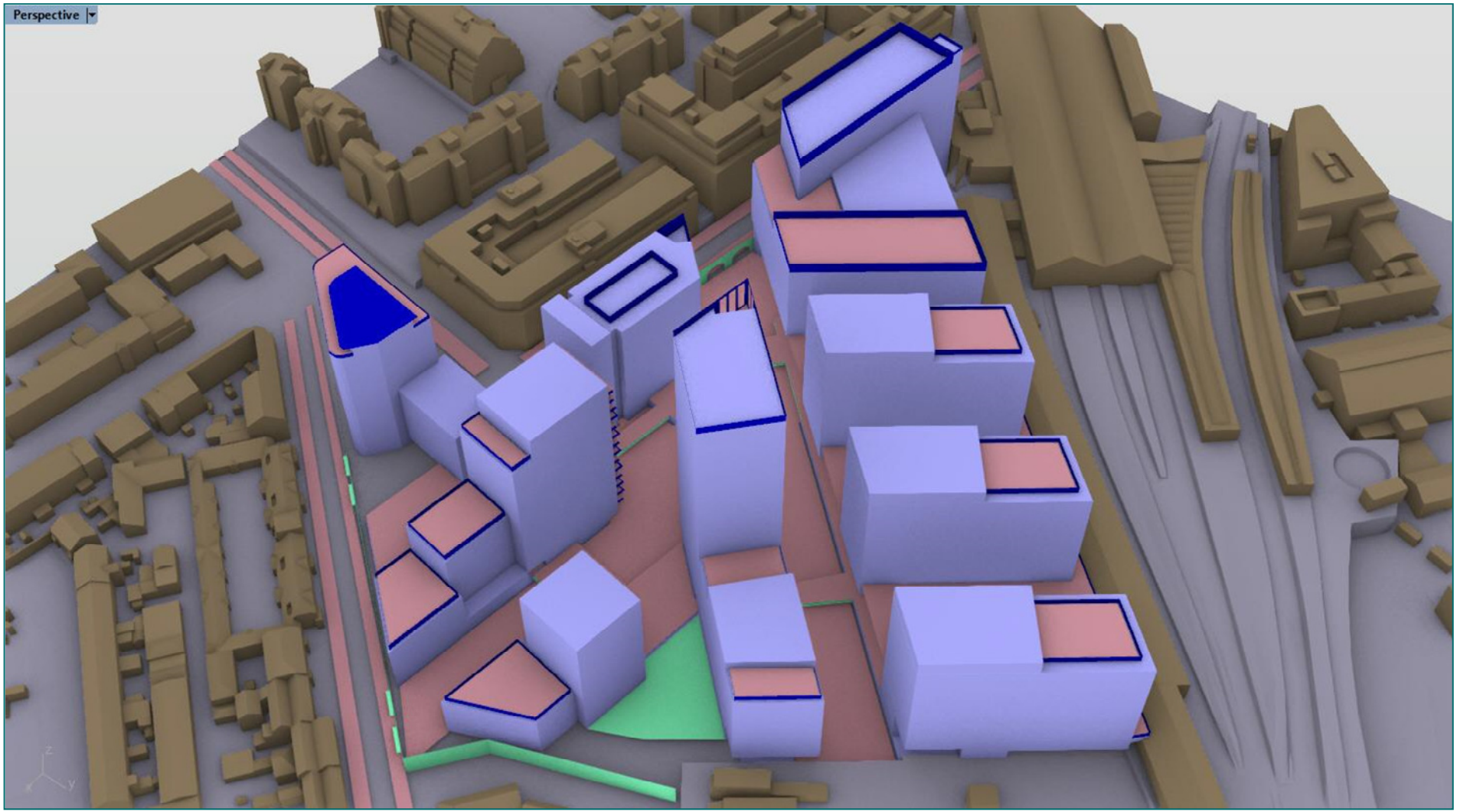


Figure 31: Reporting Locations: Seen from north-east

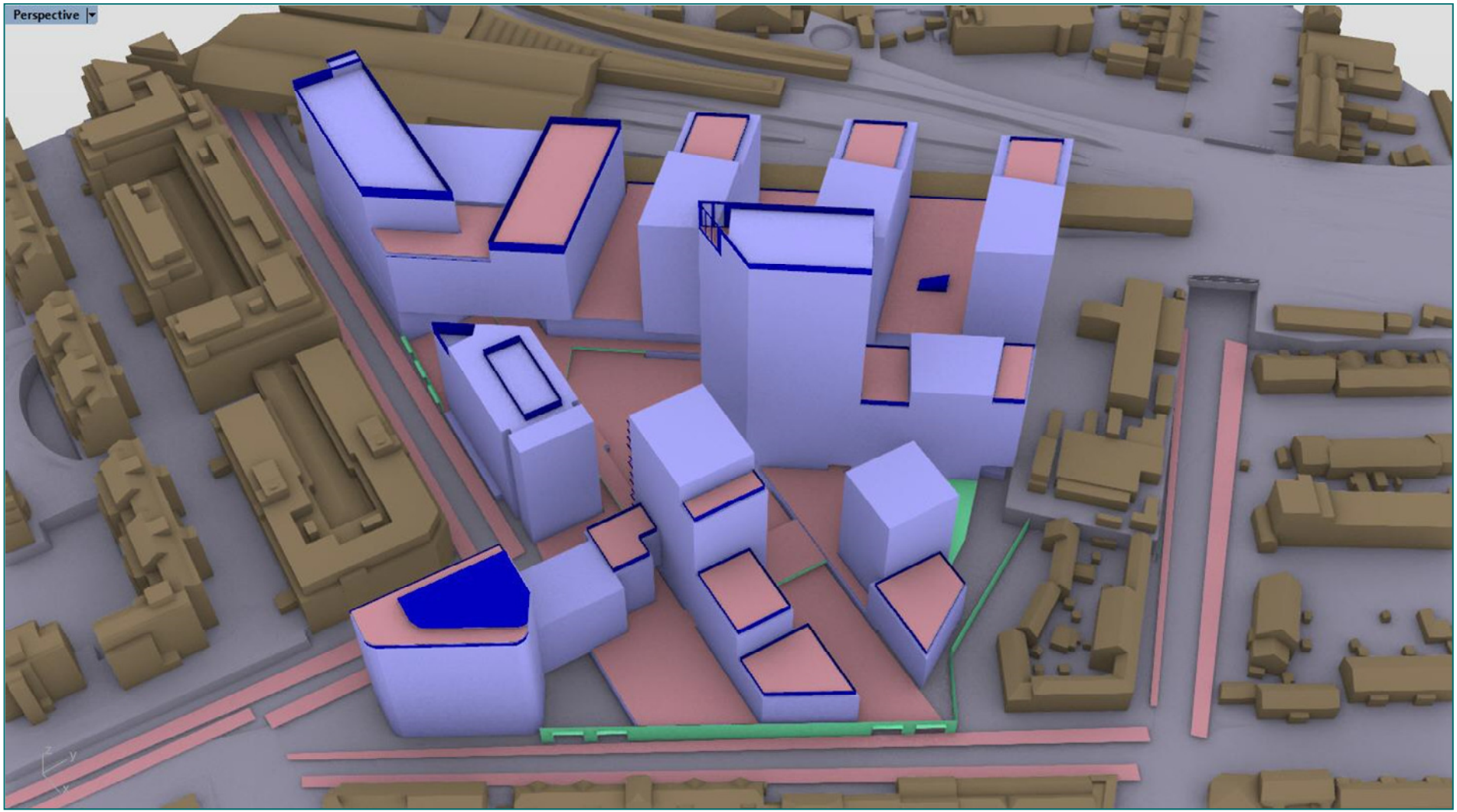


Figure 32: Reporting Locations: Seen from south-east

7 Results

7.1 Comfort Criteria

Figures 33 to 41 show the percentage of the year the hourly wind speed exceeds the threshold value for the comfort criteria such as Sitting, Standing, Leisurely Walking and Business Walking. The threshold values are 4 m/s, 6 m/s, 8 m/s and 10 m/s respectively.

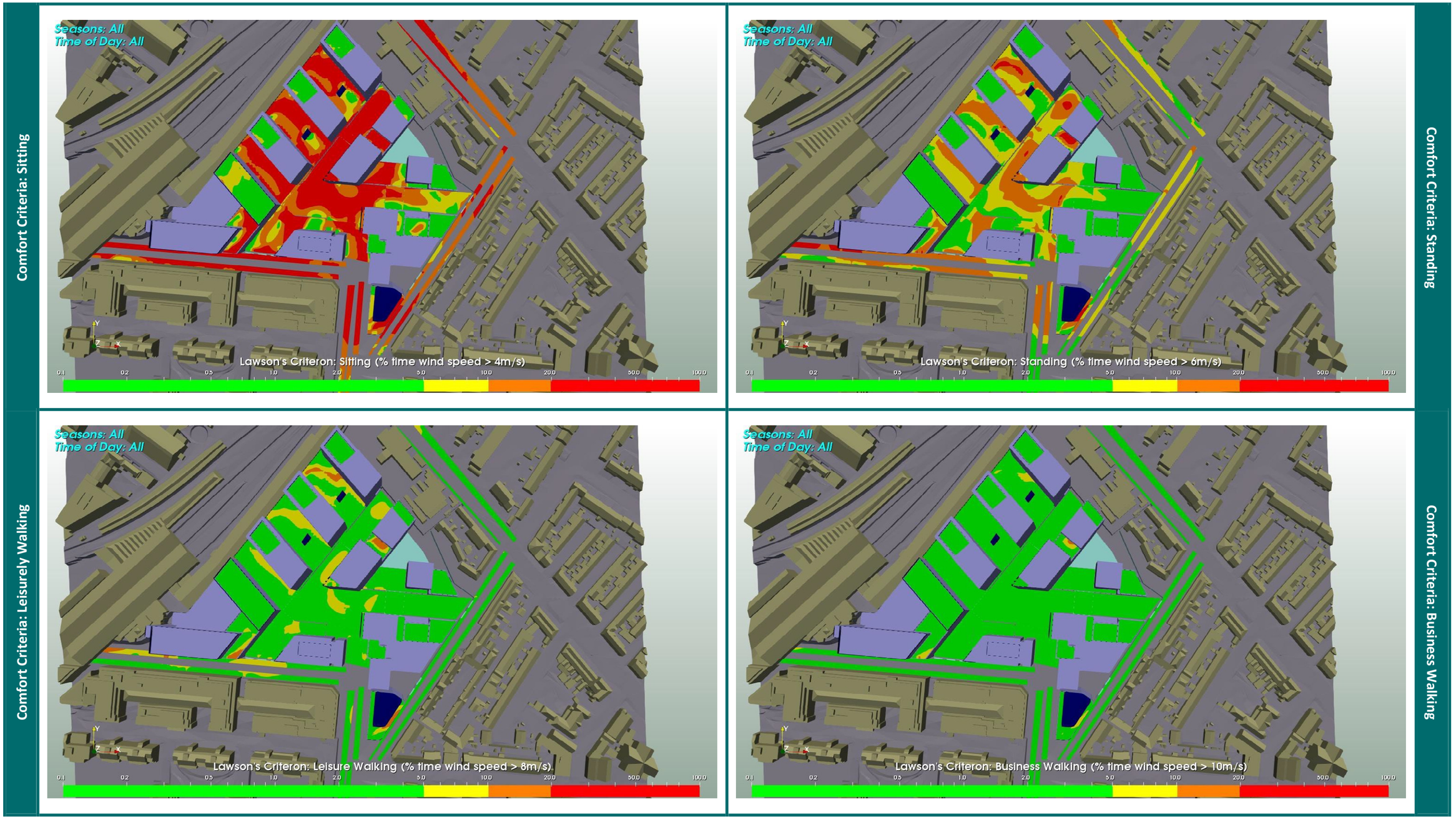


Figure 33: Comfort Criteria: Plan view

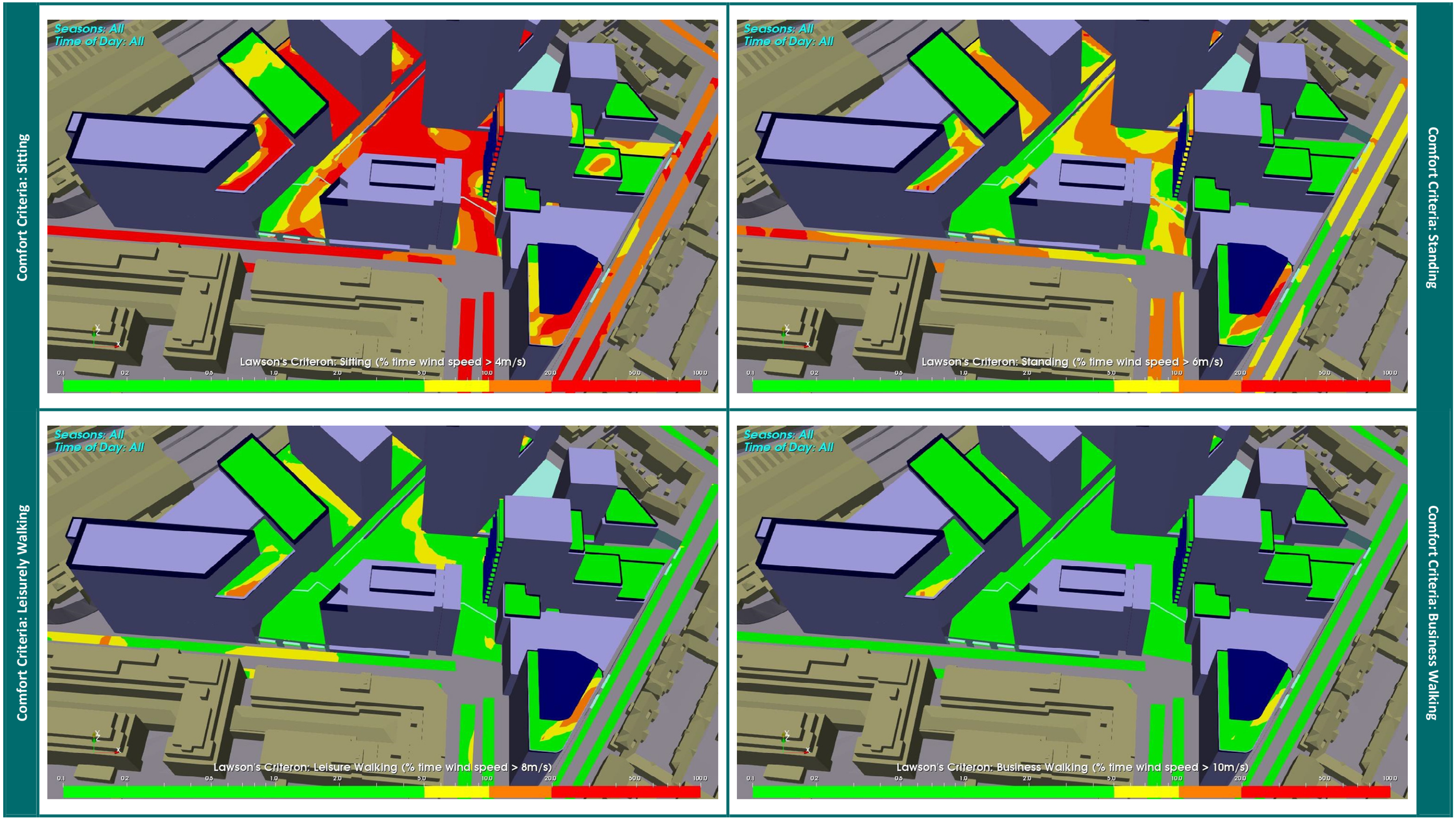
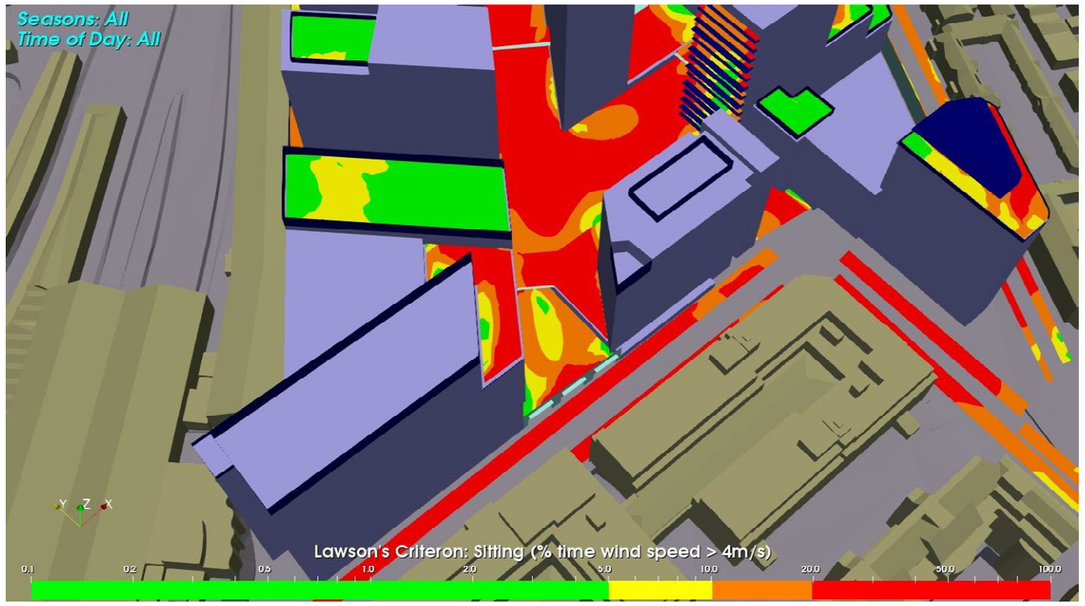
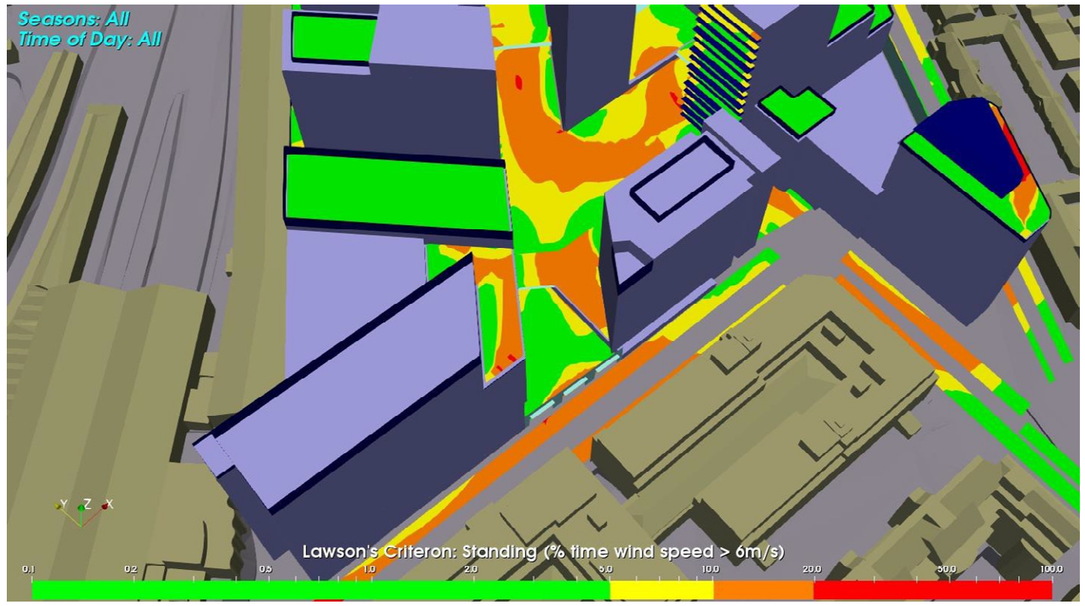


Figure 34: Comfort Criteria: View from south

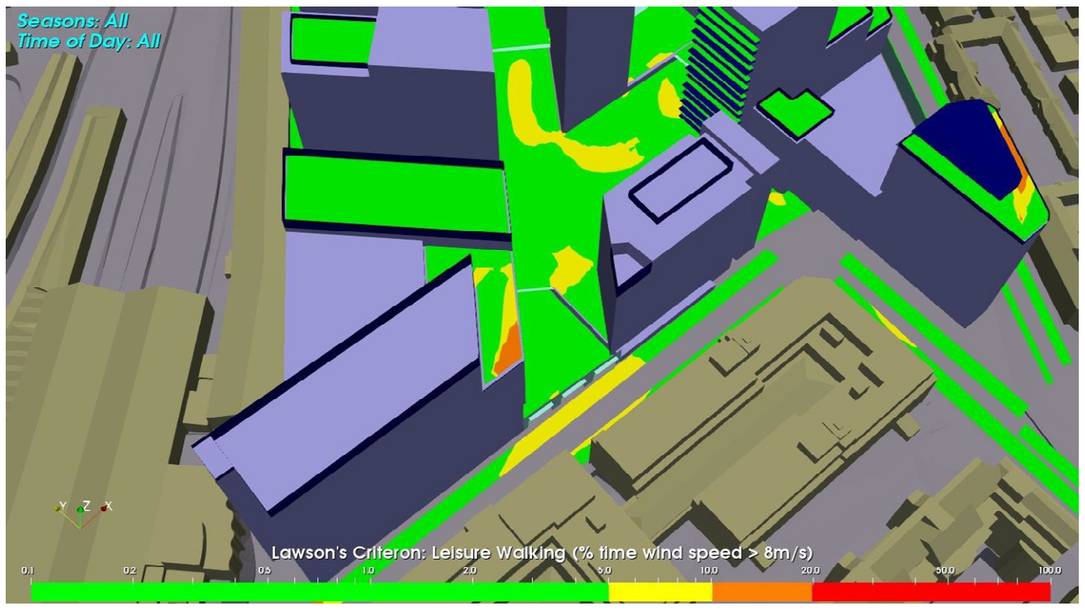
Comfort Criteria: Sitting



Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking



Comfort Criteria: Business Walking

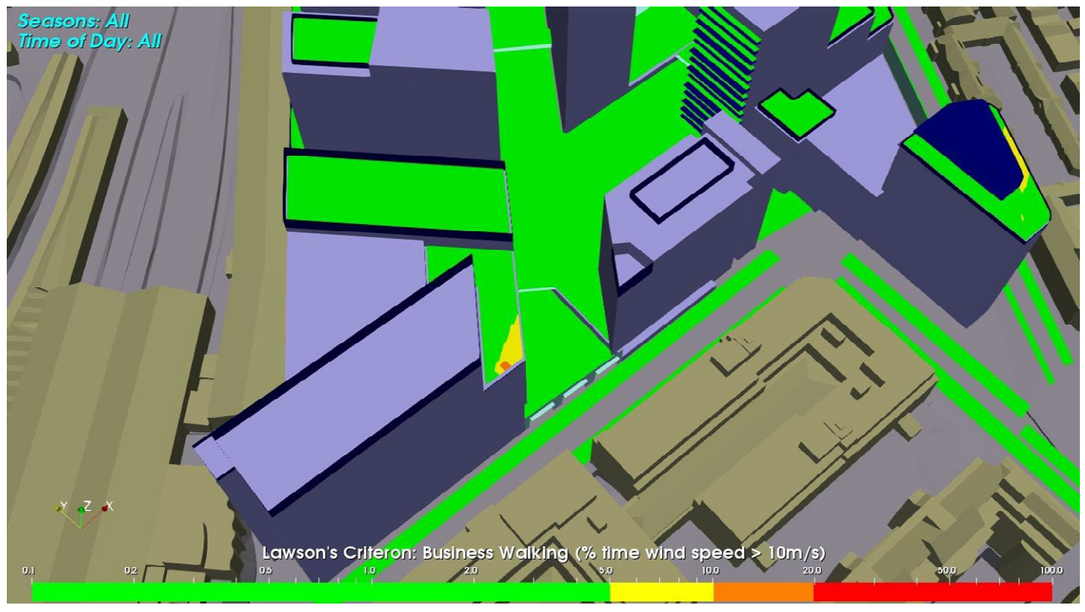
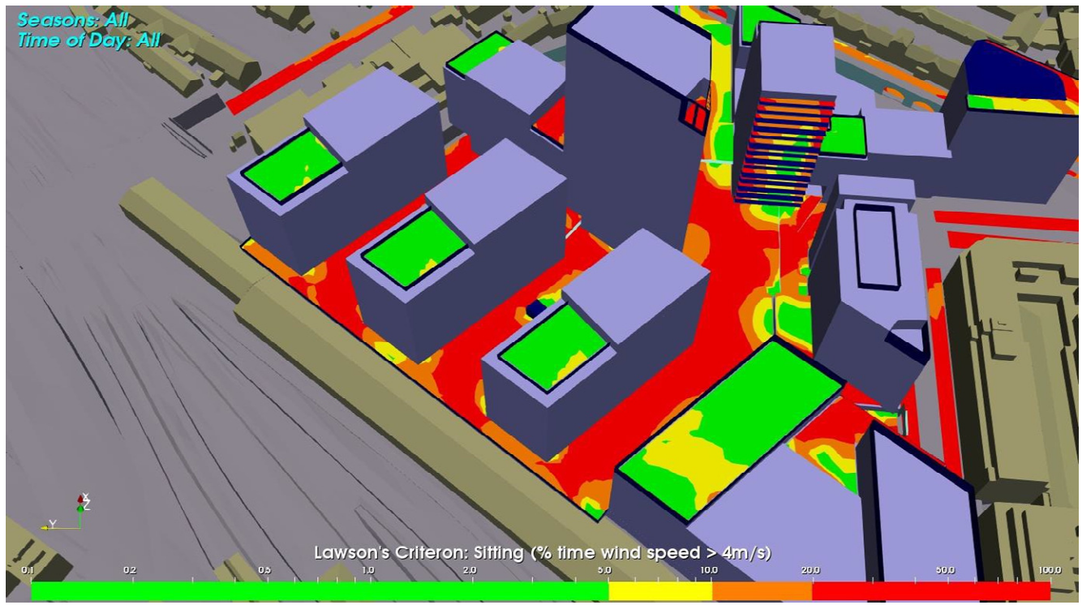
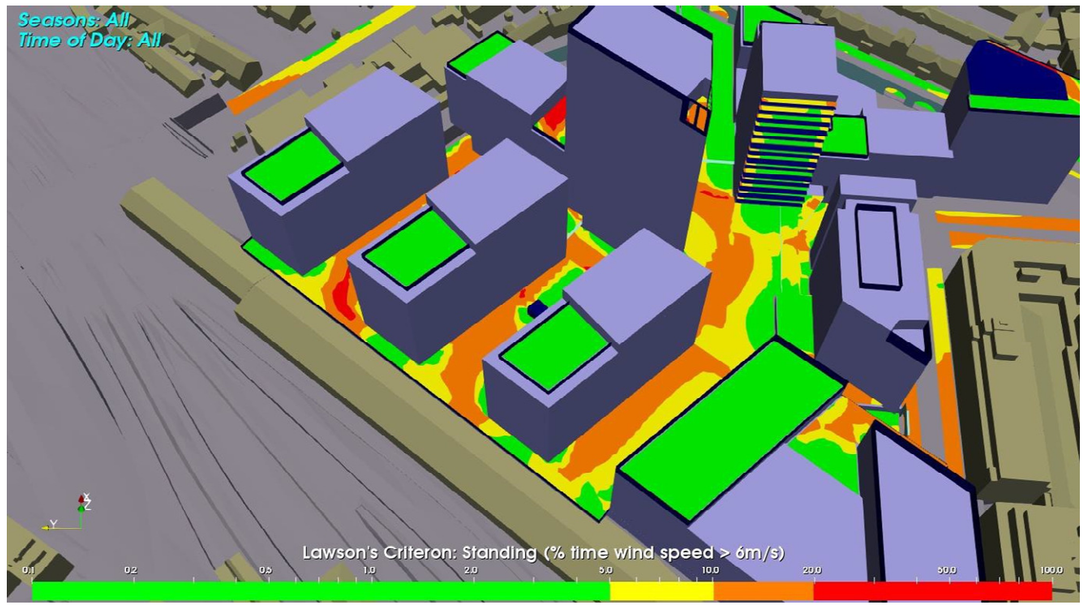


Figure 35: Comfort Criteria: View from south-west

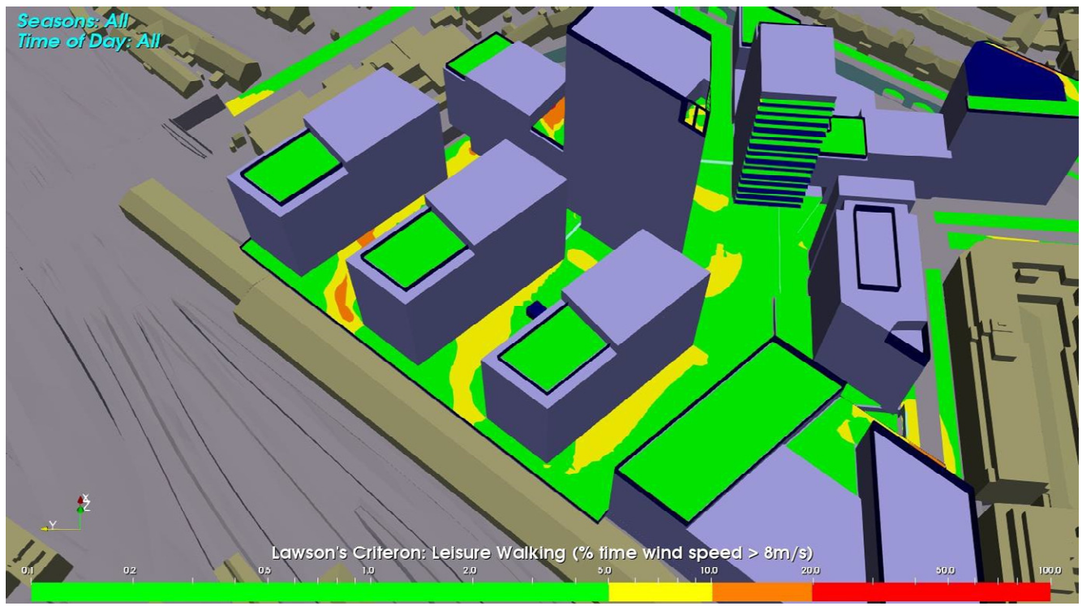
Comfort Criteria: Sitting



Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking



Comfort Criteria: Business Walking

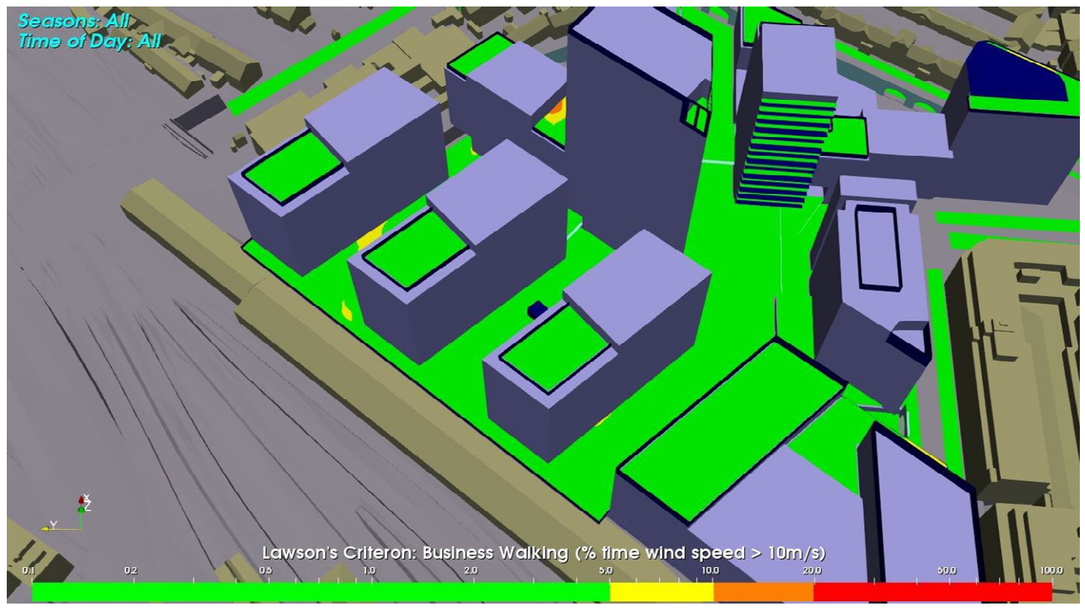
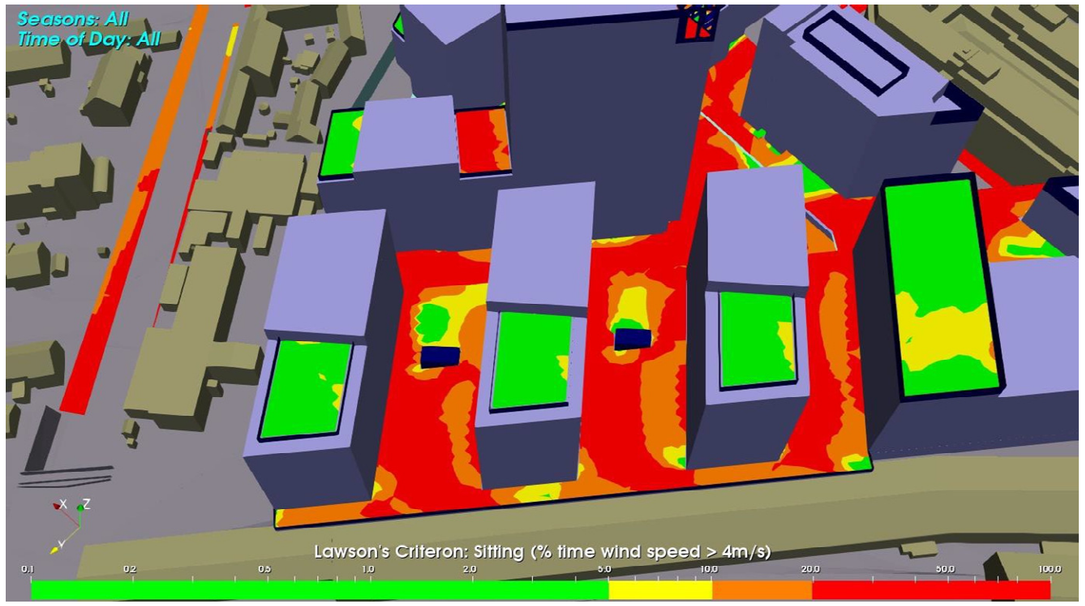
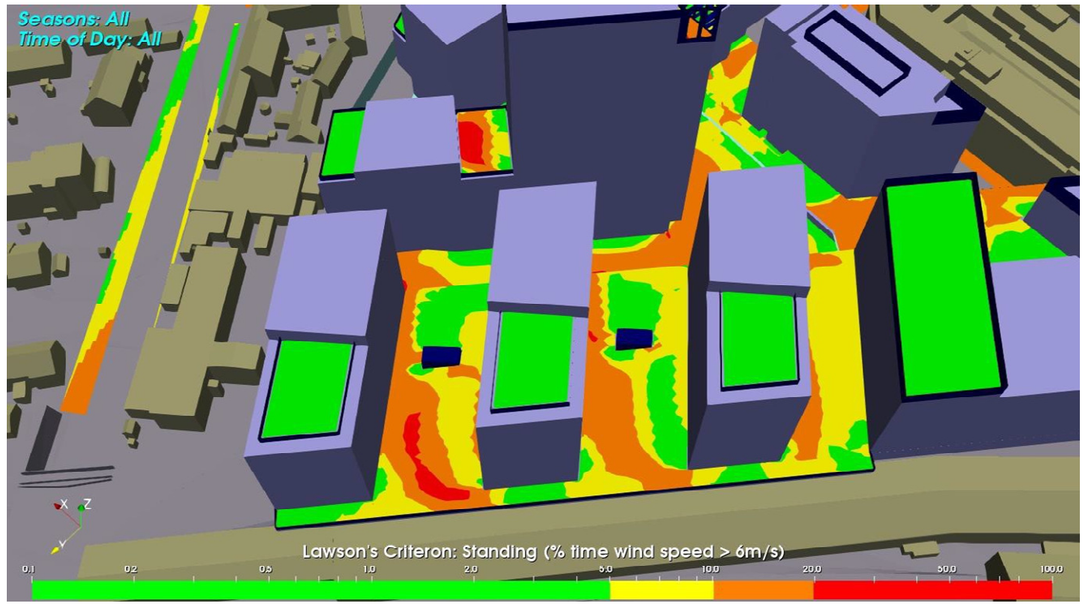


Figure 36: Comfort Criteria: View from west

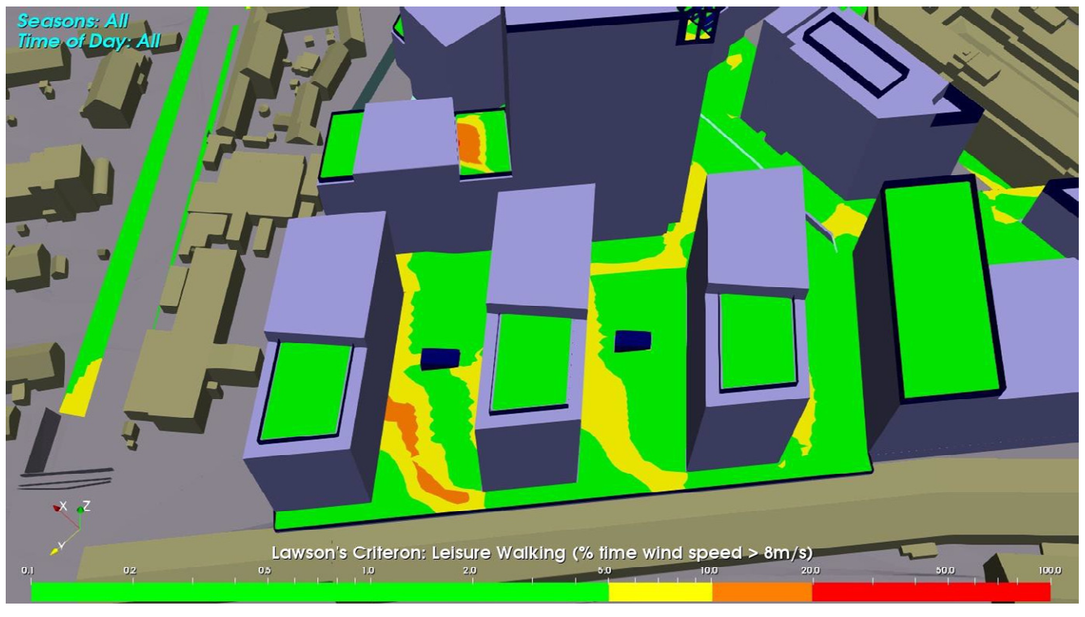
Comfort Criteria: Sitting



Comfort Criteria: Standing



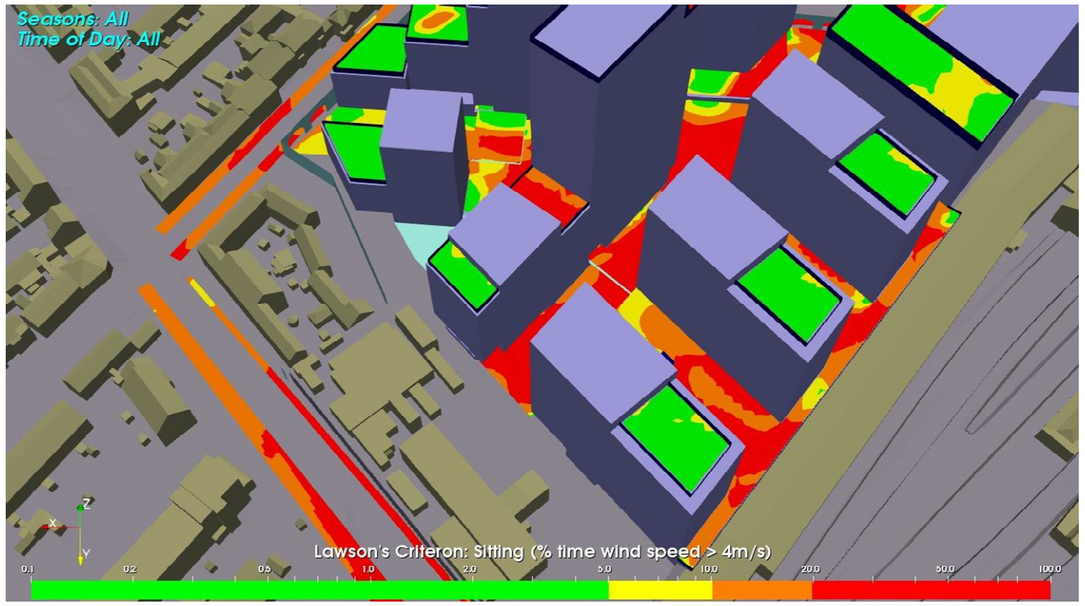
Comfort Criteria: Leisurely Walking



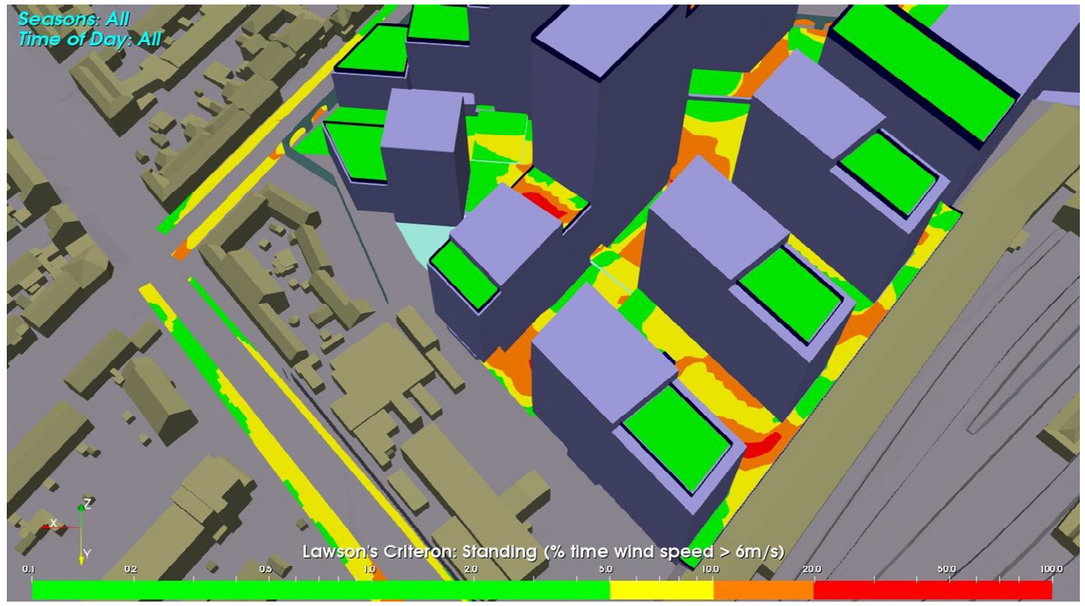
Comfort Criteria: Business Walking

Figure 37: Comfort Criteria: View from north-west

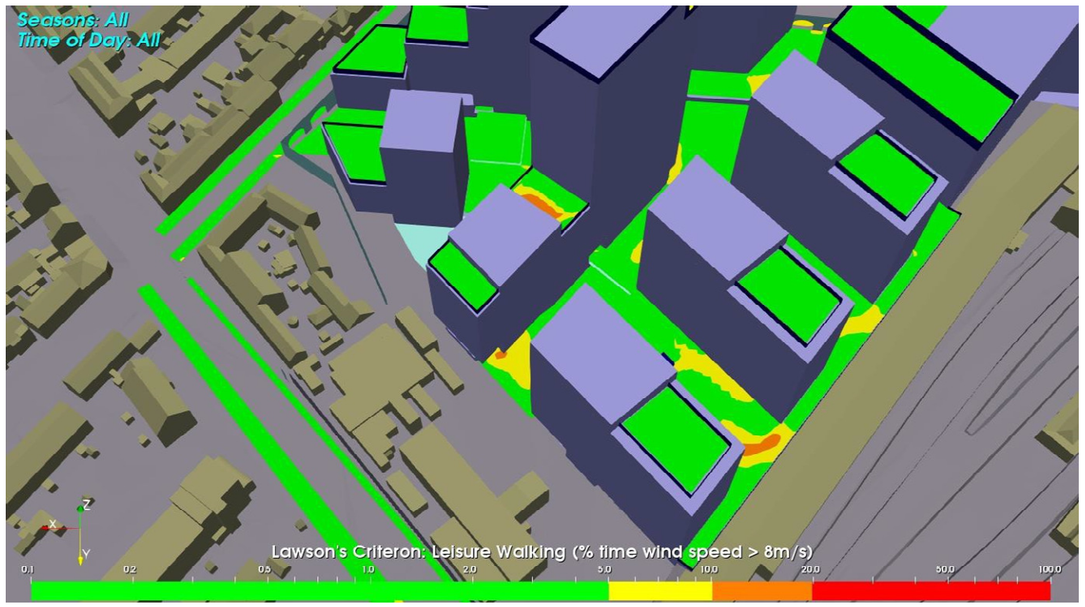
Comfort Criteria: Sitting



Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking



Comfort Criteria: Business Walking

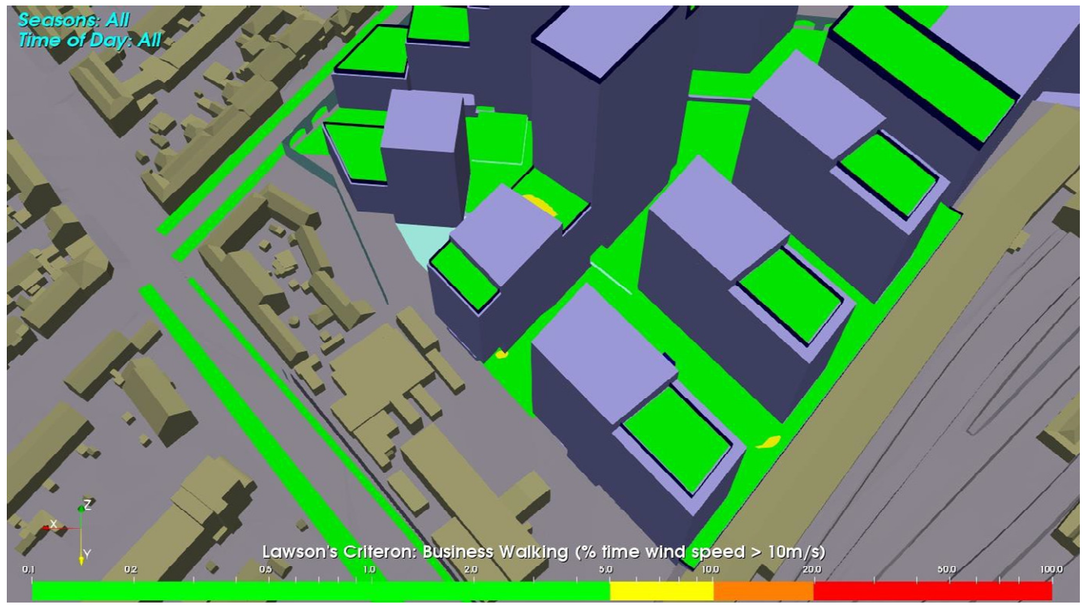
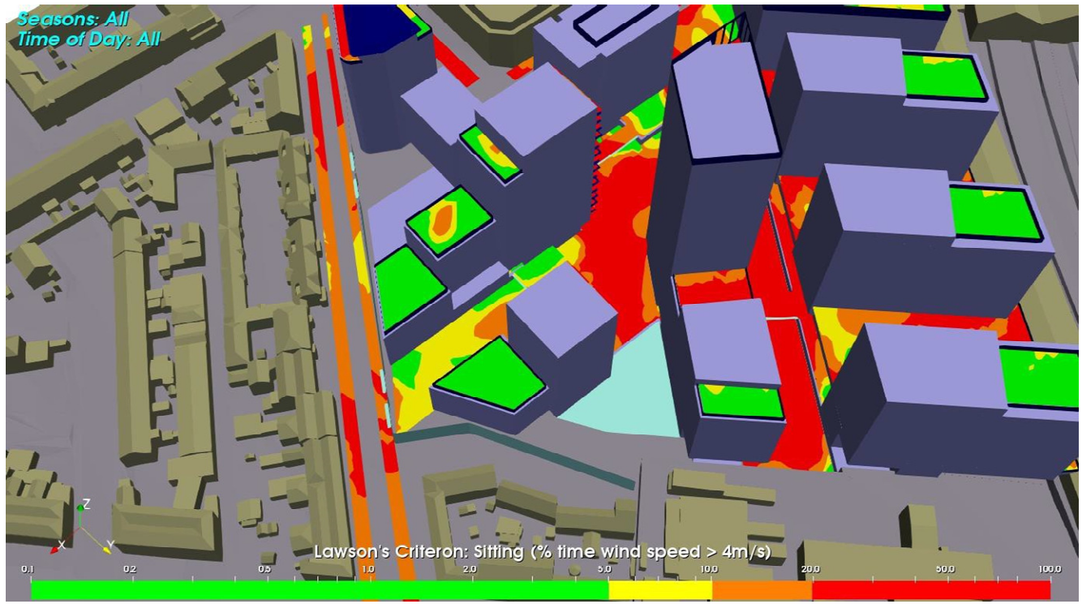
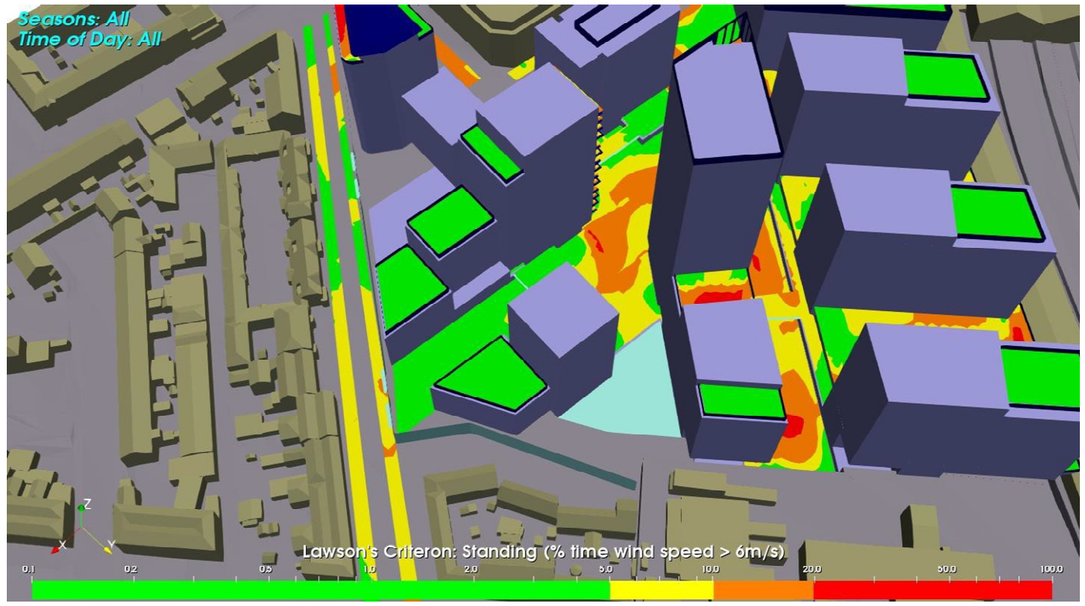


Figure 38: Comfort Criteria: View from north

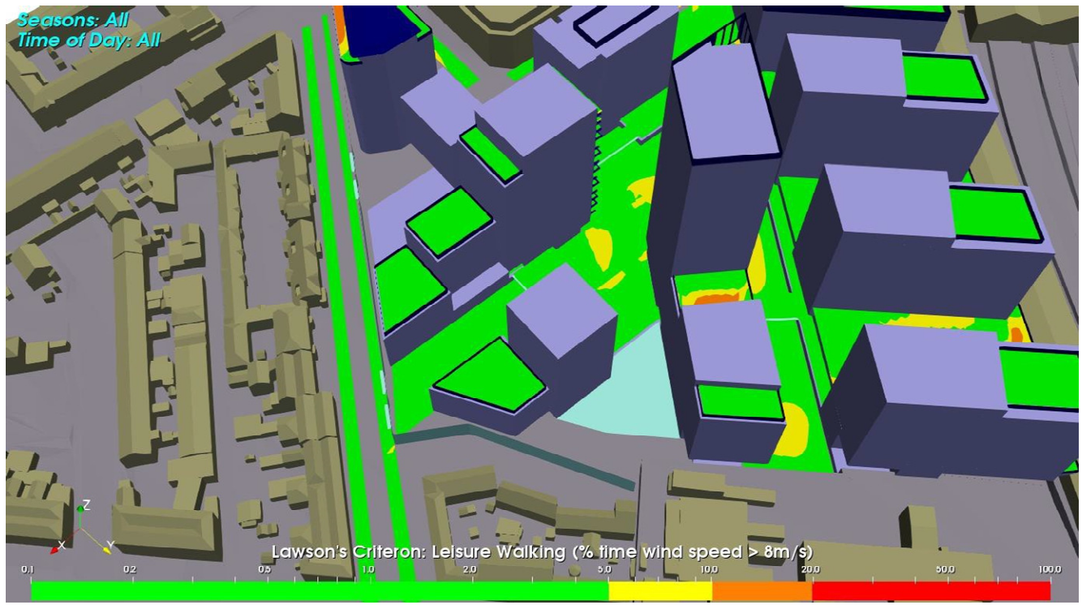
Comfort Criteria: Sitting



Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking



Comfort Criteria: Business Walking

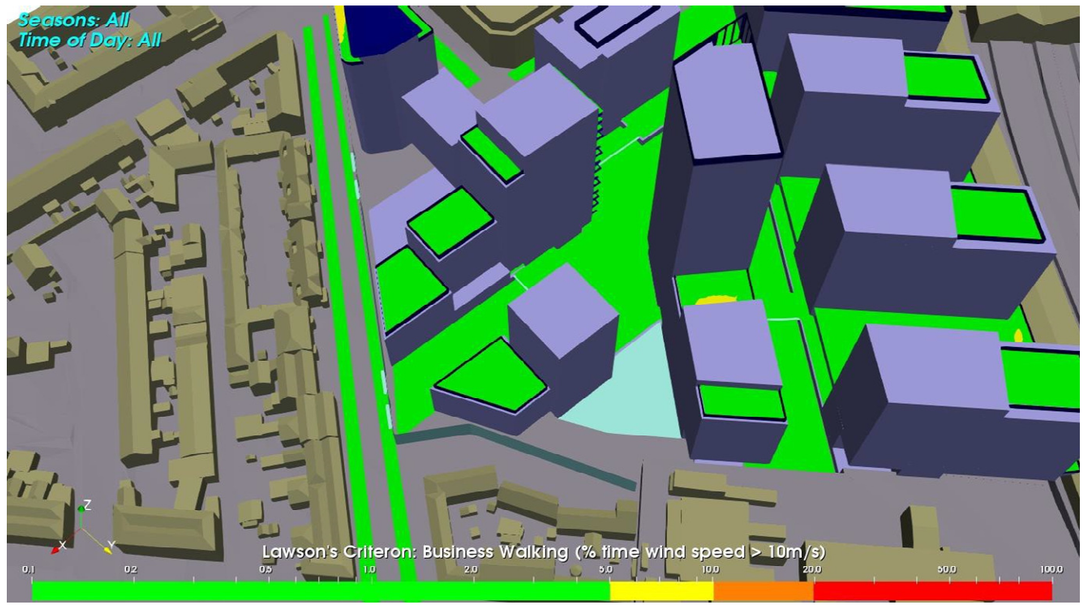
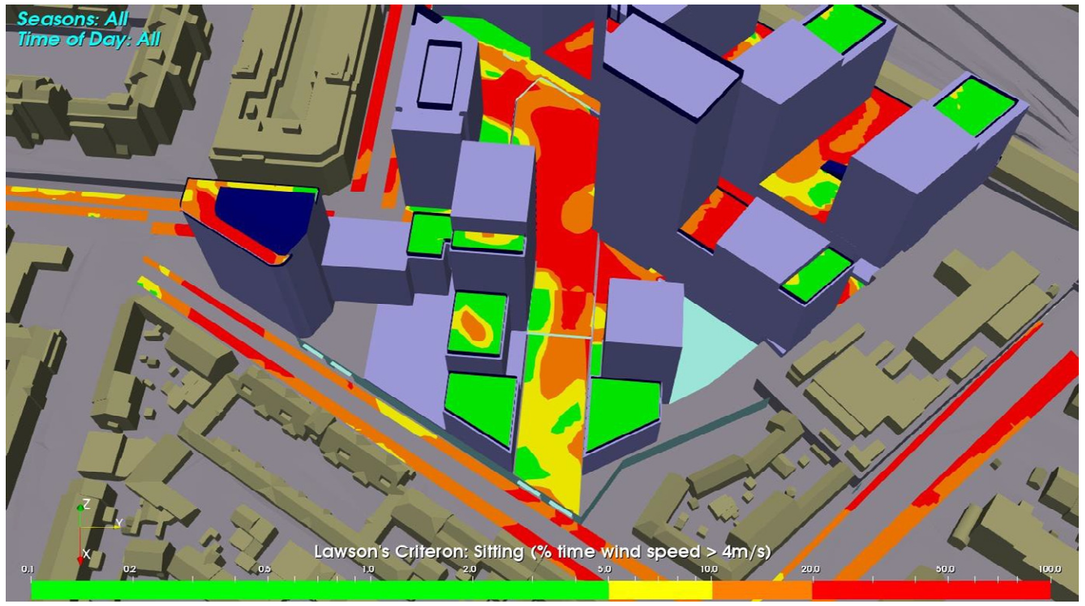
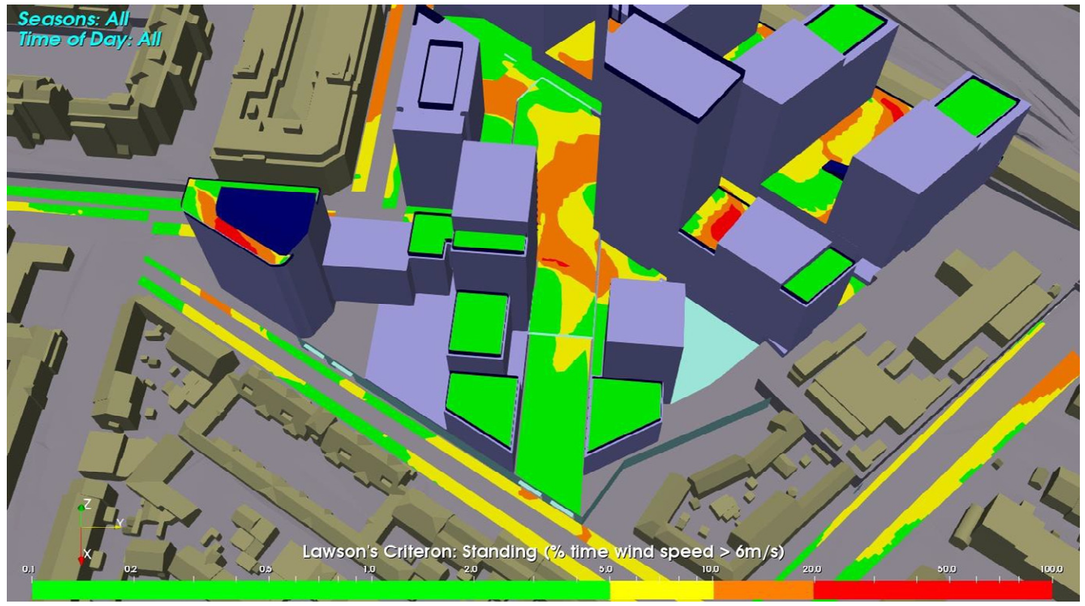


Figure 39: Comfort Criteria: View from north-east

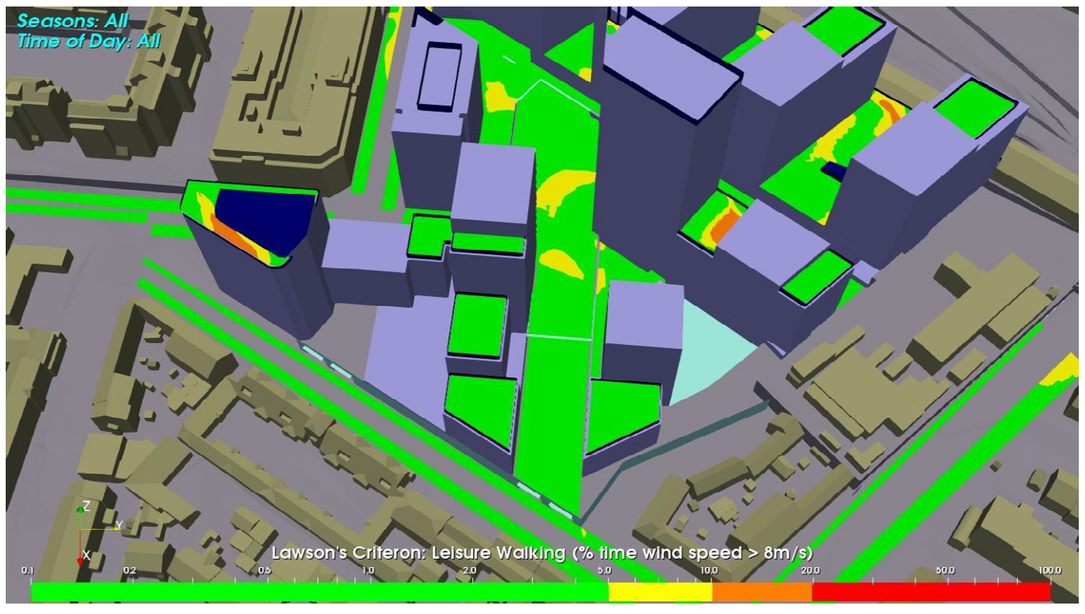
Comfort Criteria: Sitting



Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking



Comfort Criteria: Business Walking

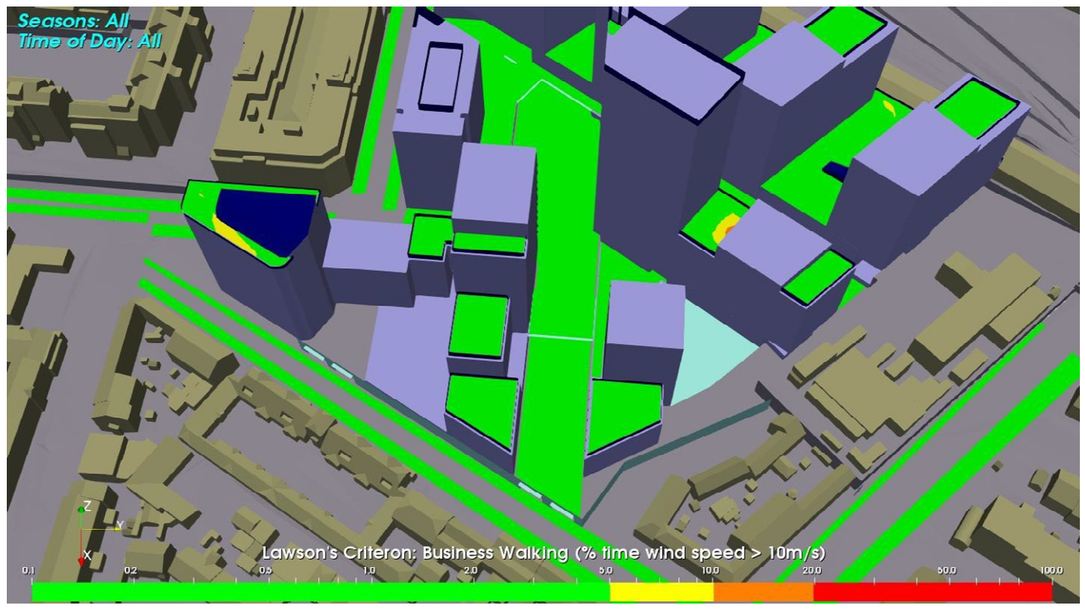
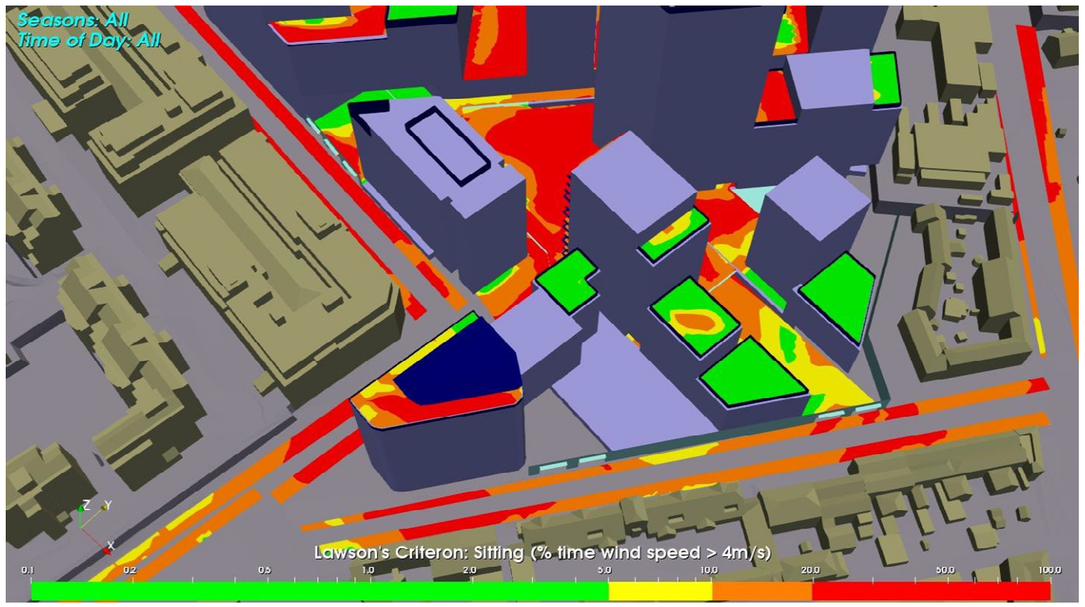
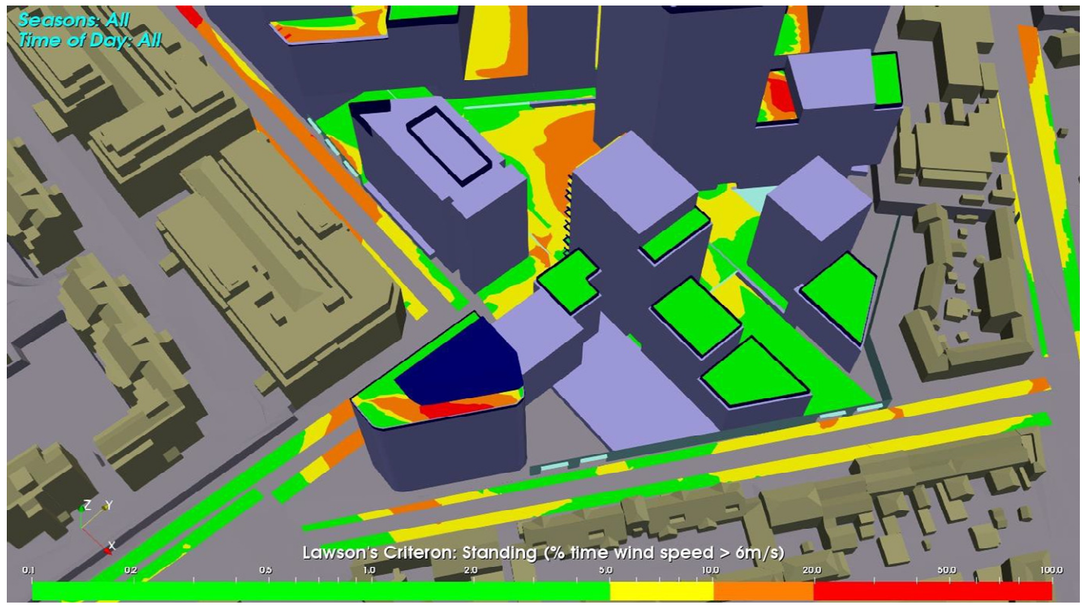


Figure 40: Comfort Criteria: View from east

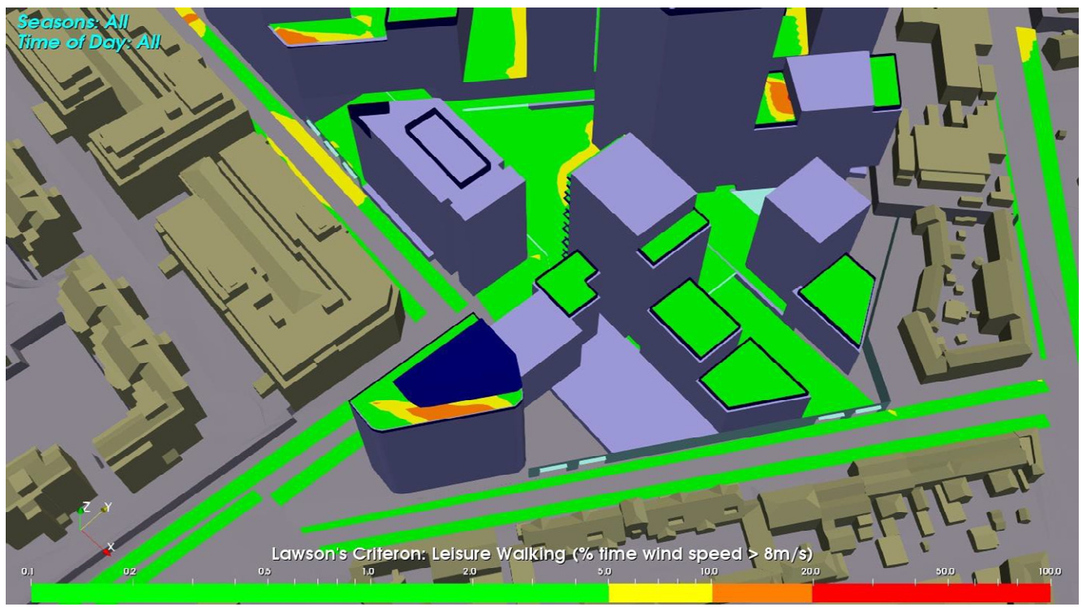
Comfort Criteria: Sitting



Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking



Comfort Criteria: Business Walking

Figure 41: Comfort Criteria: View from south-east

7.2 Safety Criteria

Figures 42 to 50 show the percentage of the year the hourly wind speed exceeds the threshold value for the safety criteria. The threshold values are 20 m/s for the normal pedestrian and 15 m/s for the sensitive pedestrian.

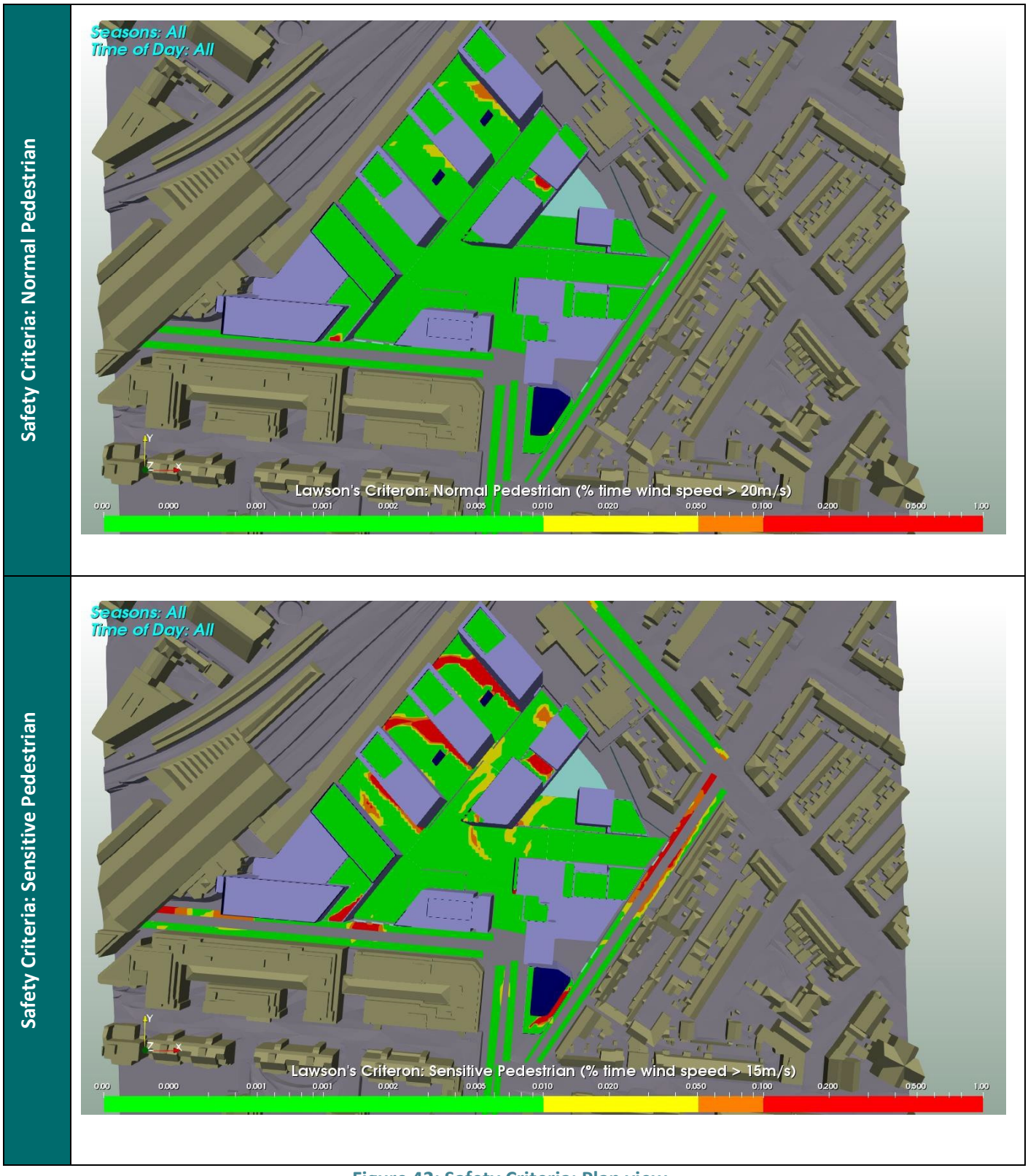
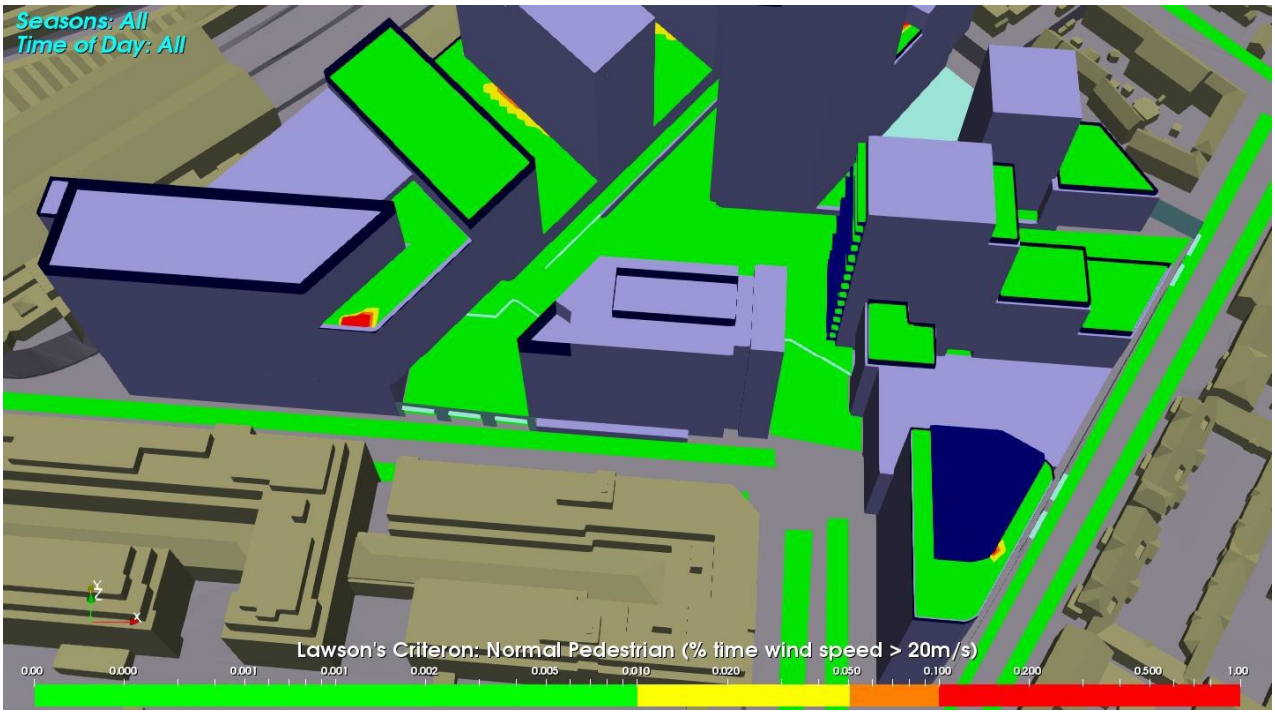


Figure 42: Safety Criteria: Plan view

Safety Criteria: Normal Pedestrian



Safety Criteria: Sensitive Pedestrian

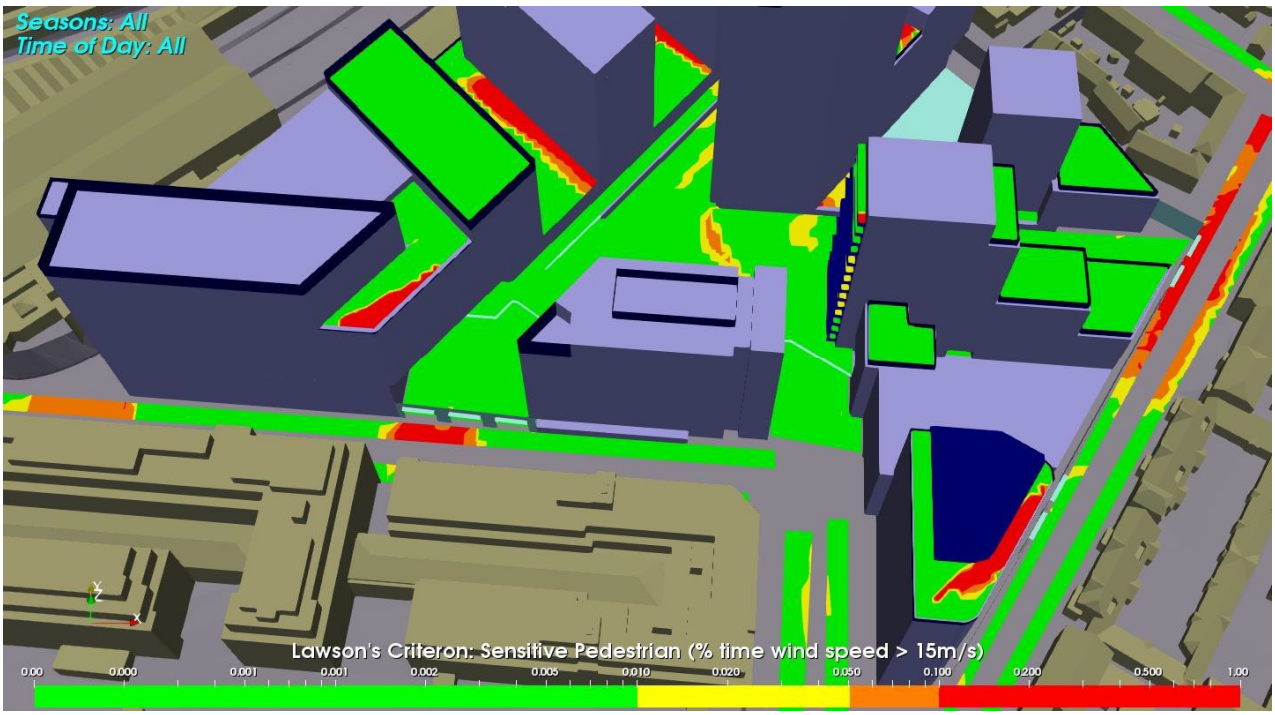
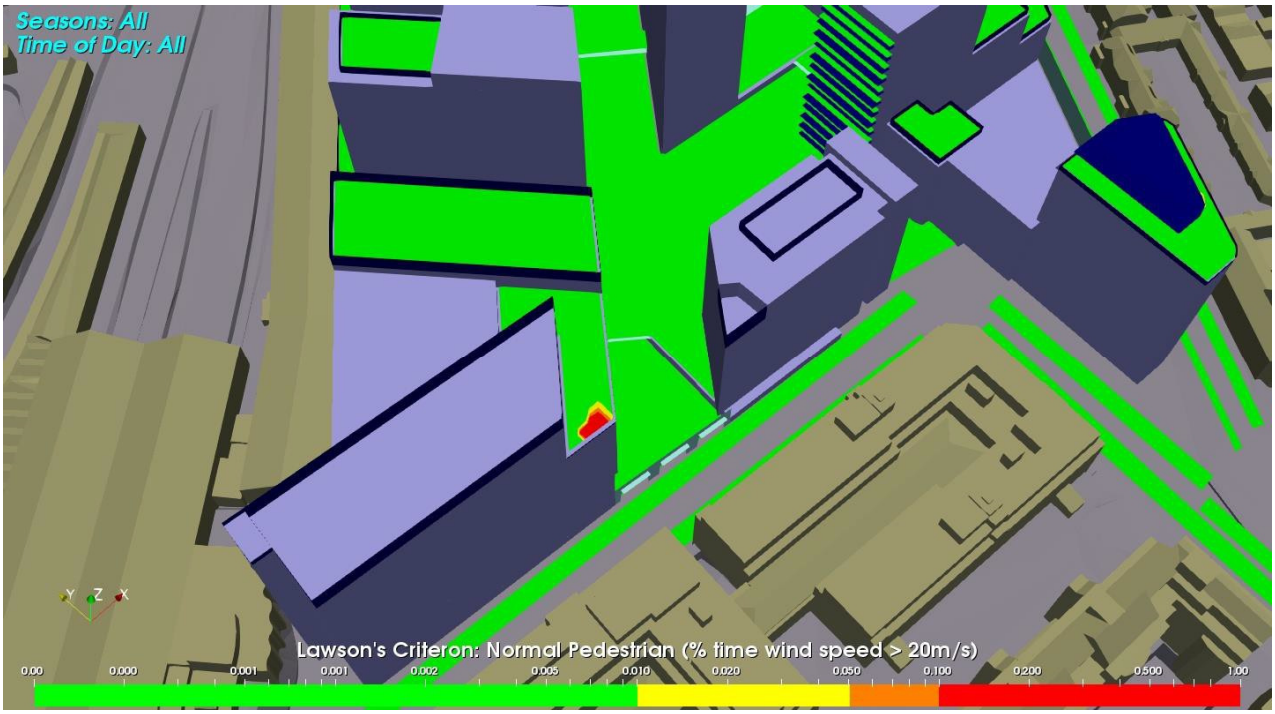


Figure 43: Safety Criteria View from south

Safety Criteria: Normal Pedestrian



Safety Criteria: Sensitive Pedestrian

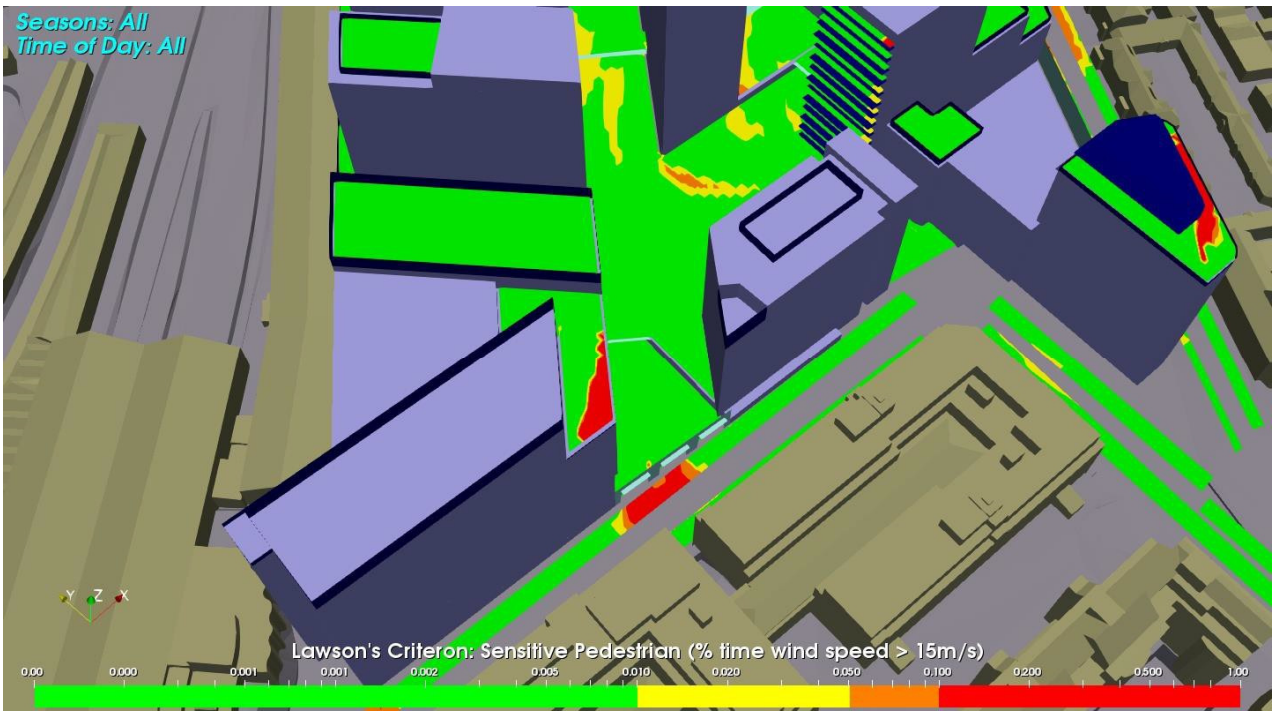
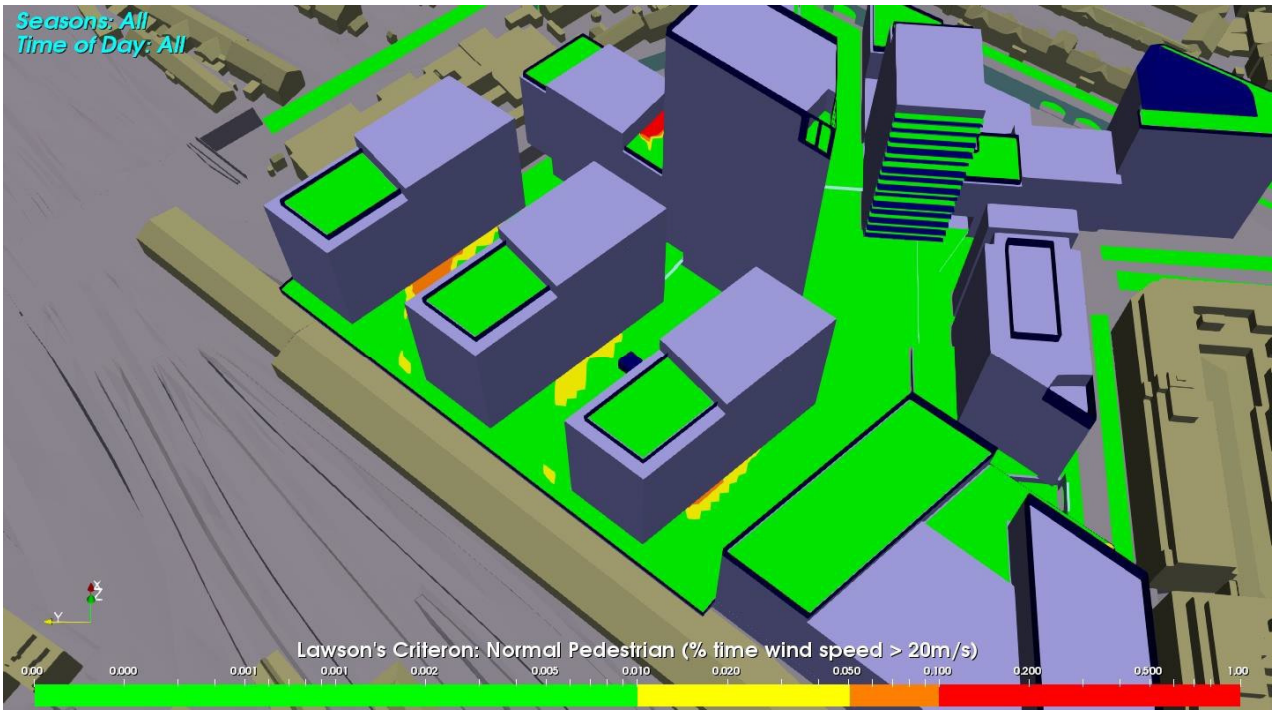


Figure 44: Safety Criteria View from south-west

Safety Criteria: Normal Pedestrian



Safety Criteria: Sensitive Pedestrian

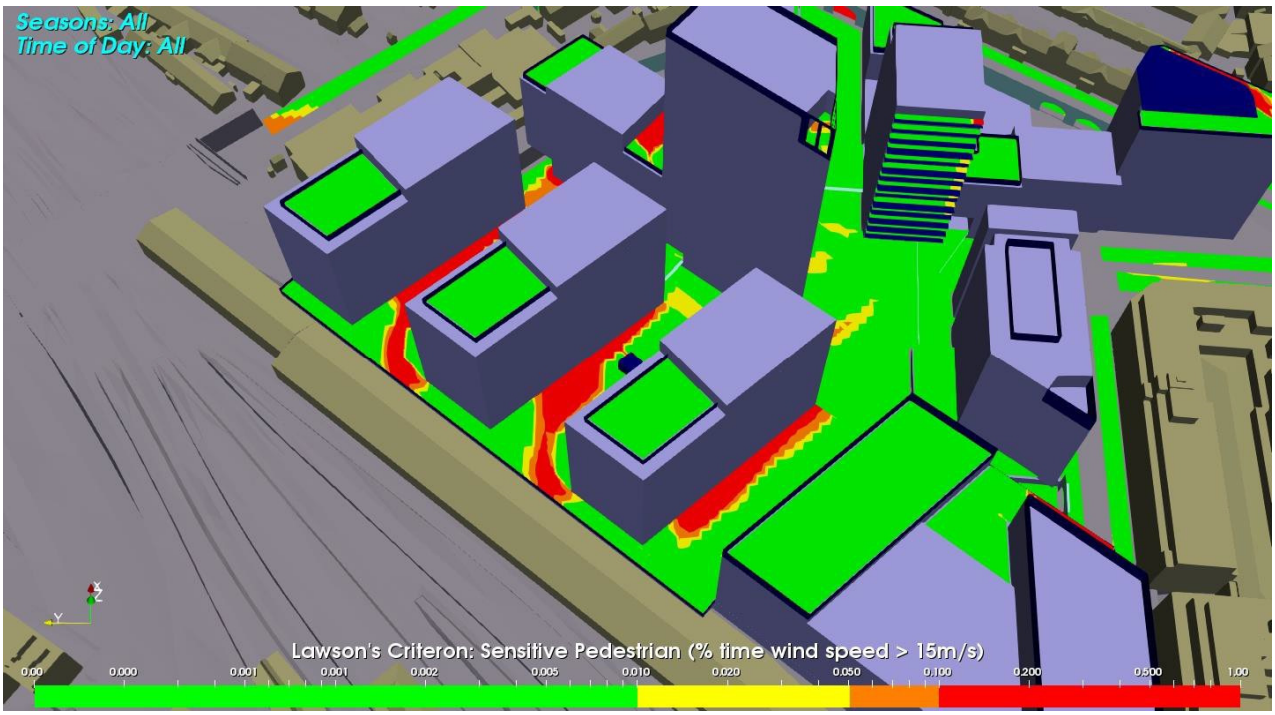
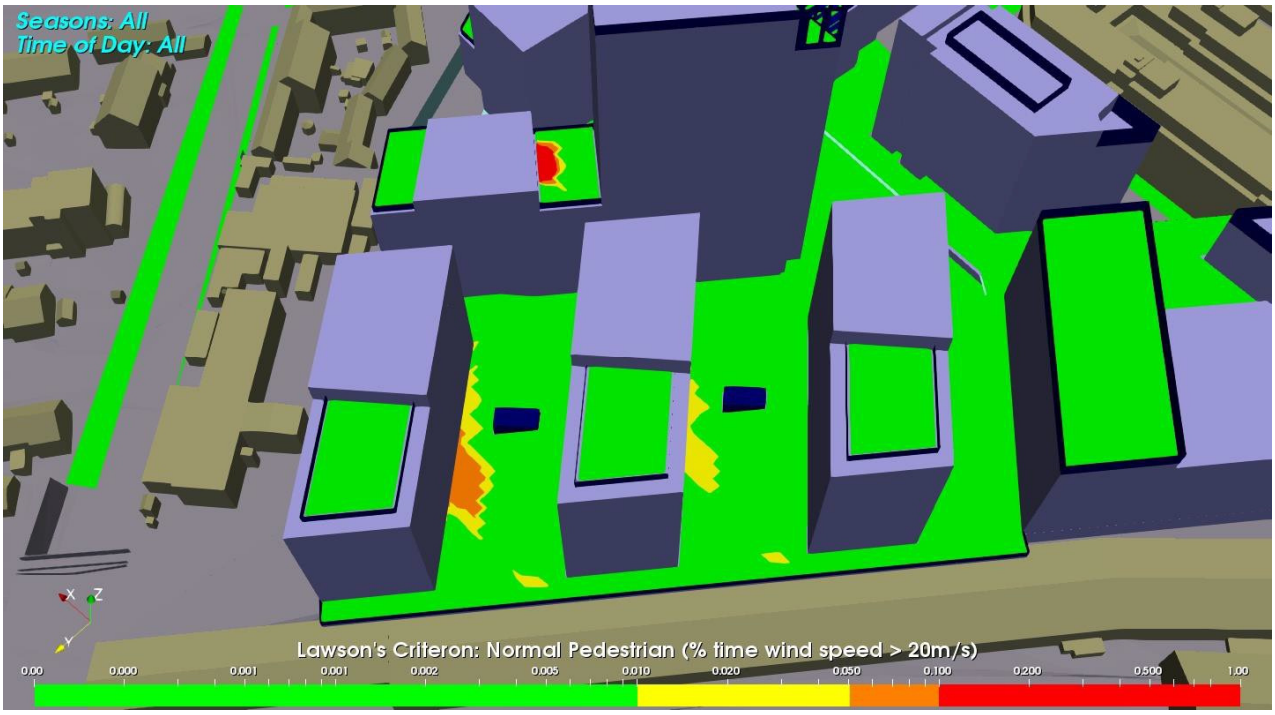


Figure 45: Safety Criteria View from west

Safety Criteria: Normal Pedestrian



Safety Criteria: Sensitive Pedestrian

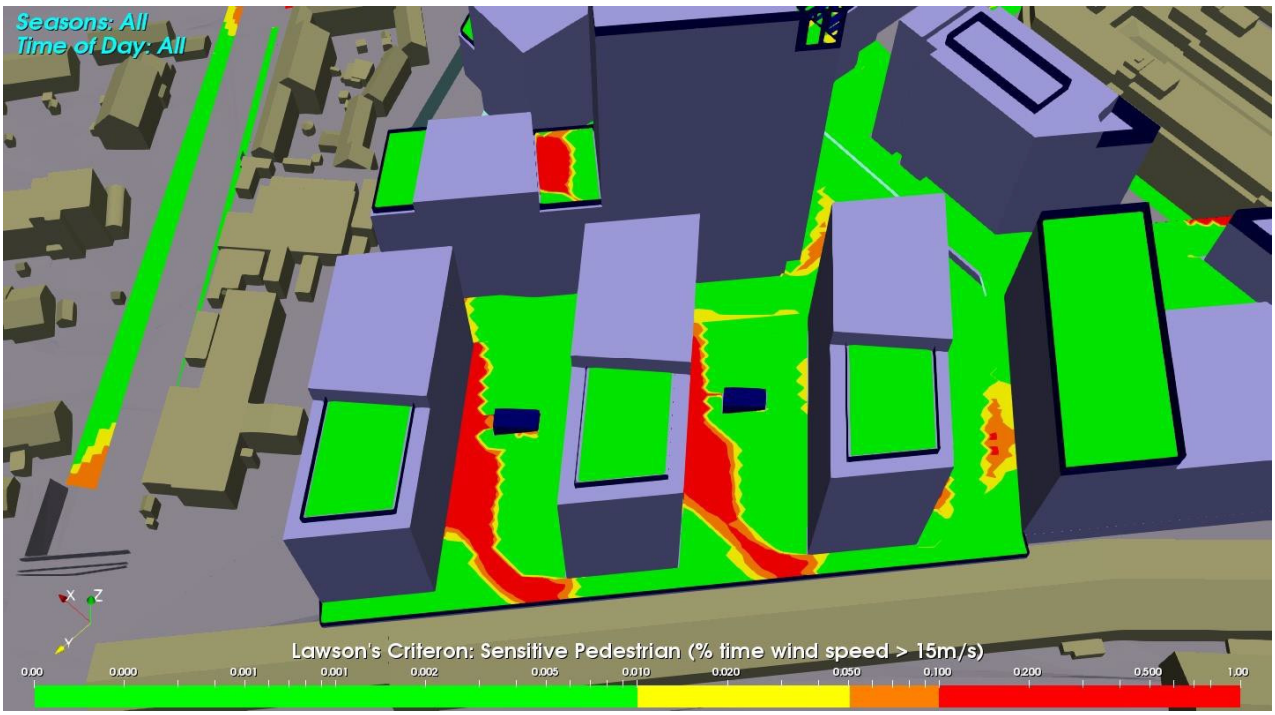
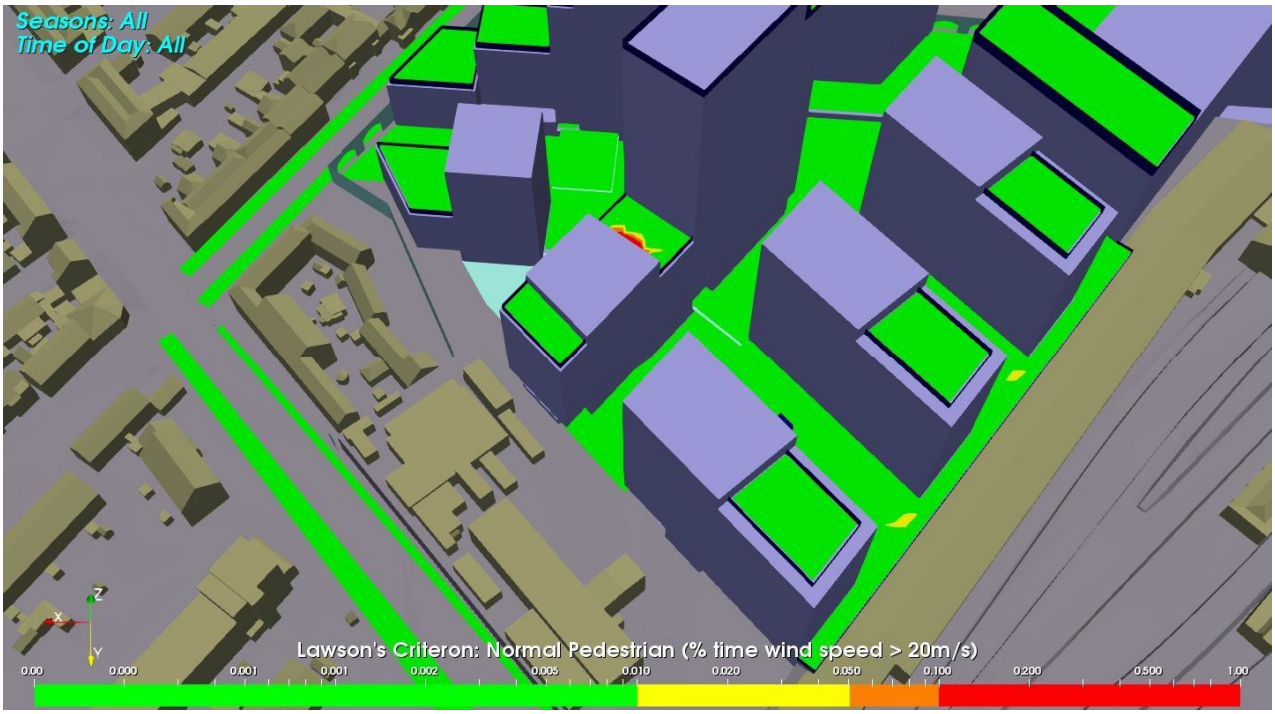


Figure 46: Safety Criteria View from north-west

Safety Criteria: Normal Pedestrian



Safety Criteria: Sensitive Pedestrian

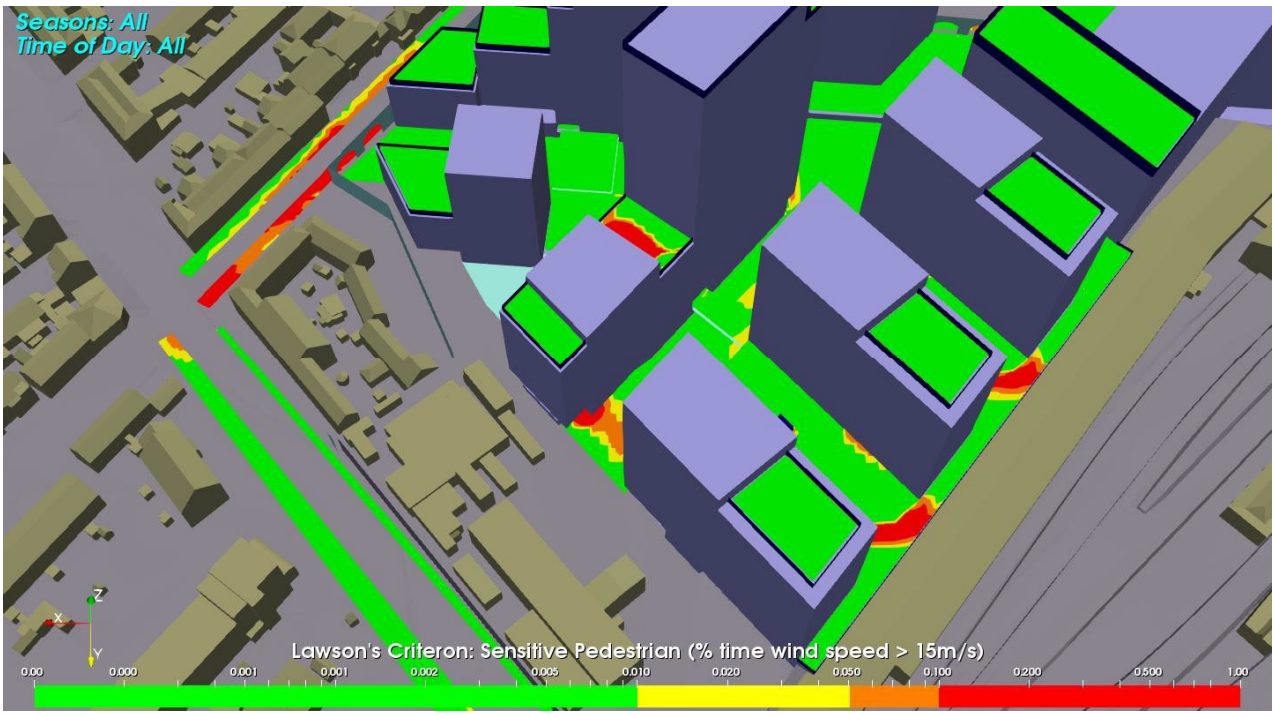
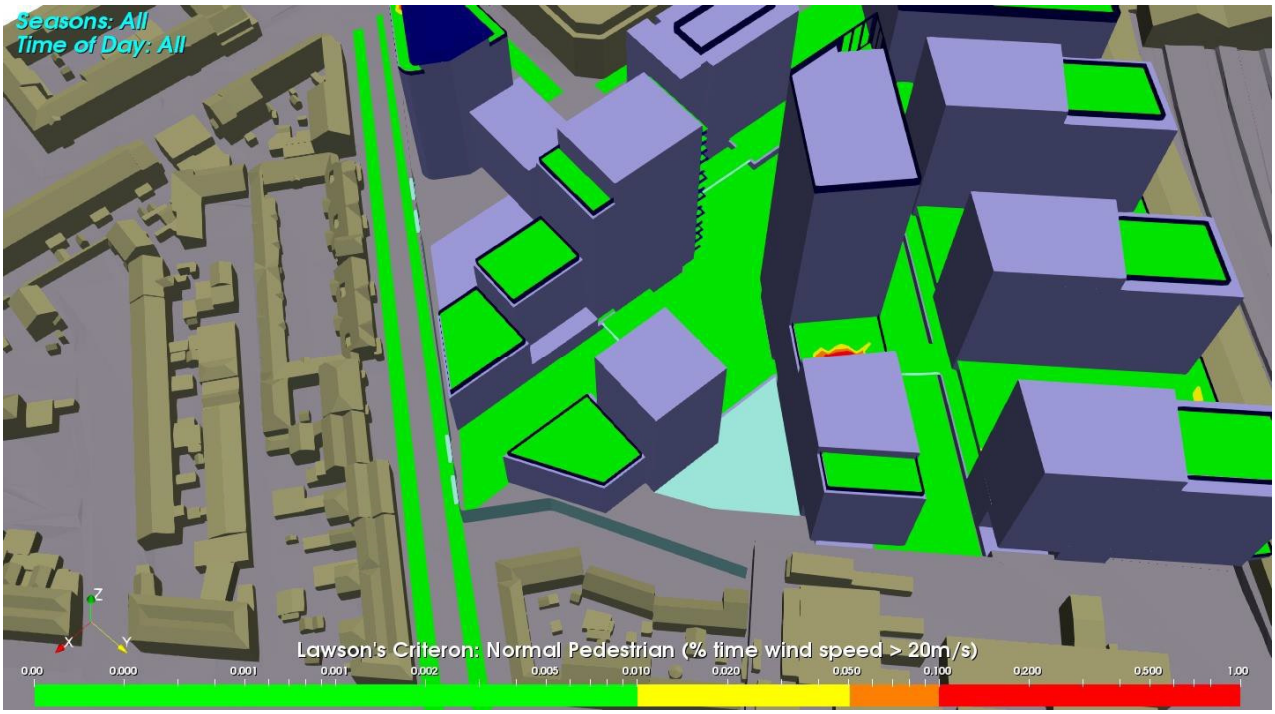


Figure 47: Safety Criteria: View from north

Safety Criteria: Normal Pedestrian



Safety Criteria: Sensitive Pedestrian

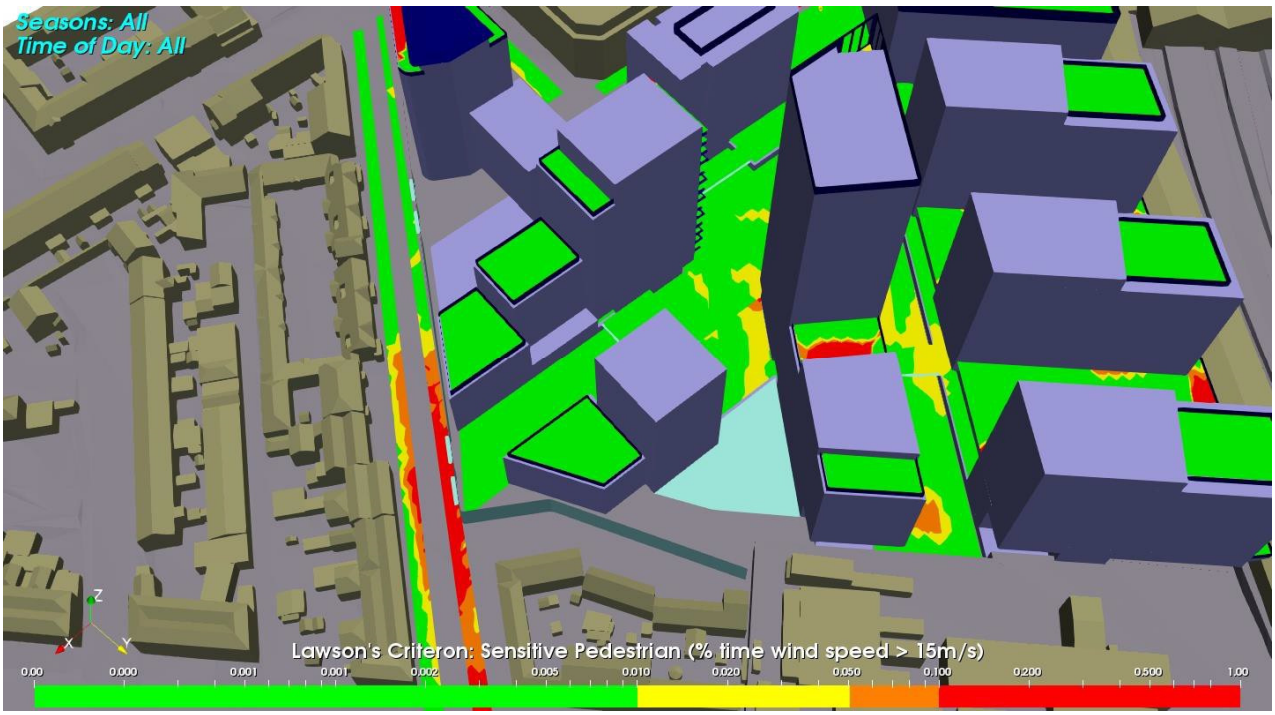
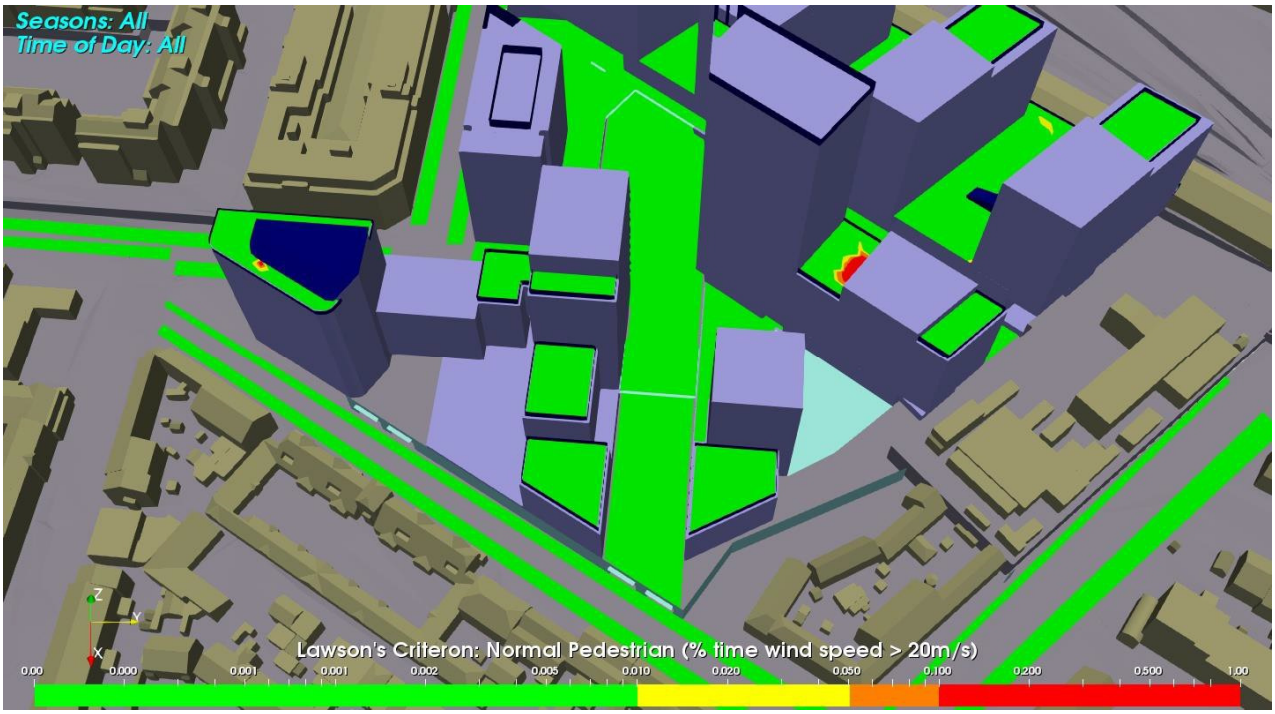


Figure 48: Safety Criteria: View from north-east

Pedestrian Comfort CFD Analysis

Safety Criteria: Normal Pedestrian



Safety Criteria: Sensitive Pedestrian

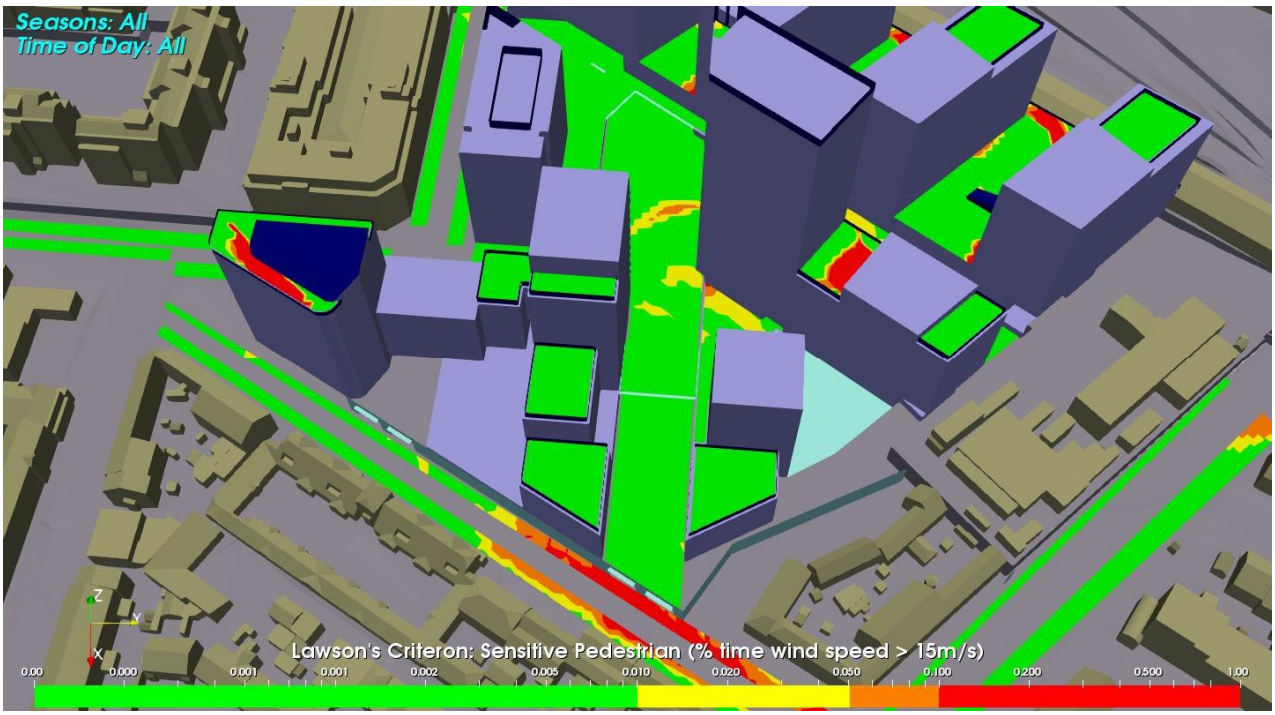
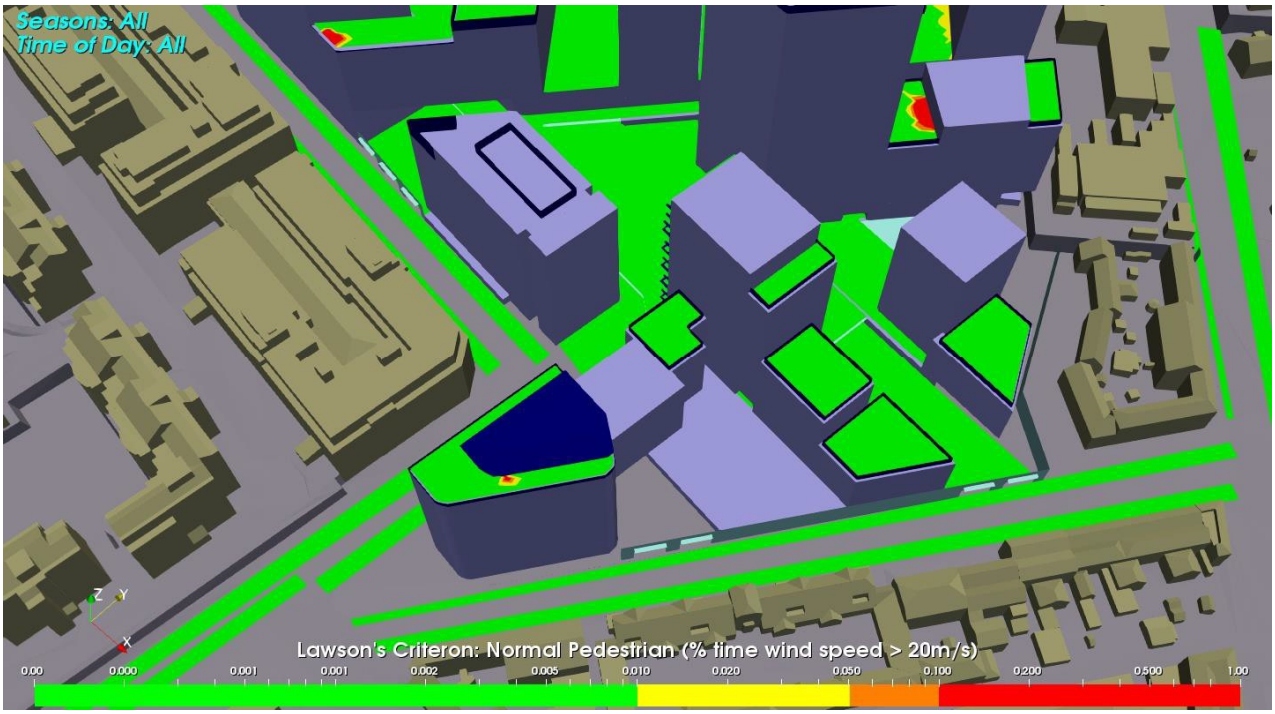


Figure 49: Safety Criteria: View from east

Safety Criteria: Normal Pedestrian



Safety Criteria: Sensitive Pedestrian

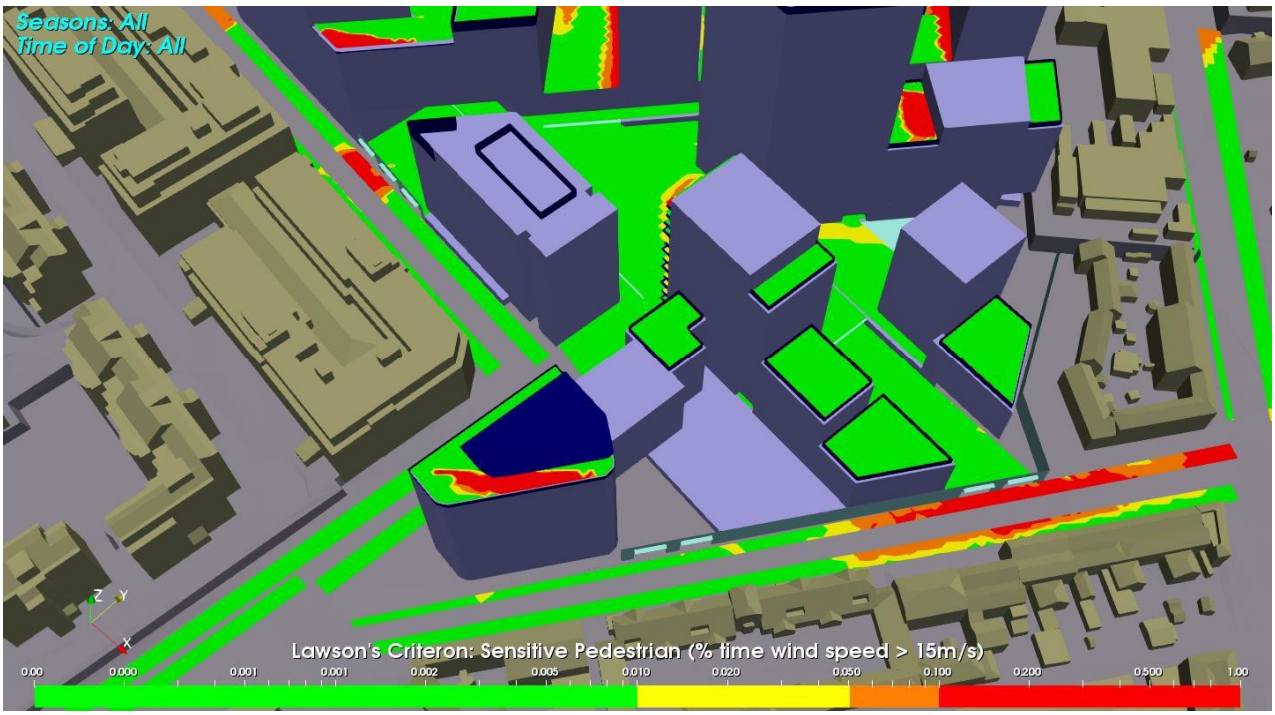


Figure 50: Safety Criteria: View from south-east

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