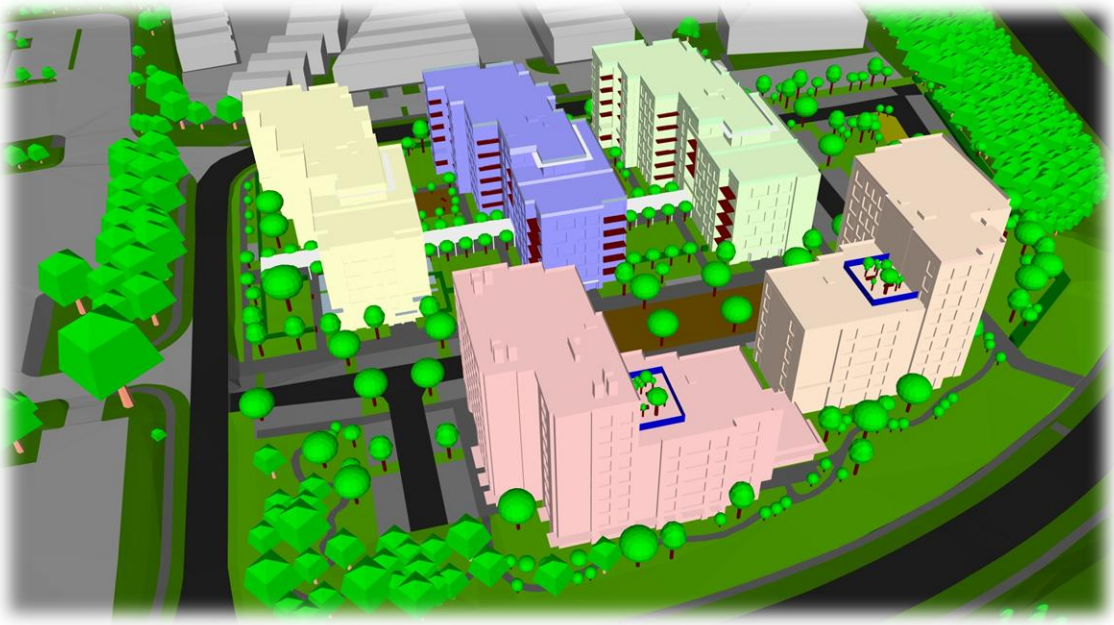
21045 – Greenfield Swords LRD

Wind Microclimate Study



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Simulation Report	Pushkar Patil CFD Team Leader		Dónal O'Connor Associate Director, Consultancy
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1 Contents

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1 Introduction

IES Consulting has been commissioned to investigate the potential impact of wind around the proposed Greenfields LRD development located in Swords, Co. Dublin. The development consists of five blocks, each 6 to 9 levels high, for a total of 289 units.

The analysis assesses the impact of the building layout on pedestrian comfort and safety for people using public and other amenity spaces around the site. The analysis examines air movement around the buildings in eight wind directions (SW, W, NW, N, NE, E, SE, and S), with the wind velocity set to the mean value from the local weather file.

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

2 Executive Summary

In summary, the results of the wind microclimate study for the Greenfield Swords LRD development are as follows:

1. The balconies on all blocks show excellent results and fully meet the requirements of the Sitting and Standing Comfort criteria.

2. All Public Open spaces show excellent results and fully meet the requirements of the Sitting and Standing Comfort Criteria.

3. The Terrace amenities show excellent results and fully meet the requirements of the Sitting and Standing Comfort Criteria.

4. Overall results of the Walking comfort show excellent compliance with Lawson's Leisure Walking and Business Walking Comfort criteria.

5. The Lawson's Normal and Sensitive Pedestrian Safety Criteria are achieved throughout the site.

The site meets Lawson's Standing and Sitting criteria when used together in all amenity spaces. It also meets Lawson's Walking criteria requirements on all walkways across the site.

3 Key Findings

For the analysis, eight steady-state Computational Fluid Dynamics (CFD) simulations were performed for the main wind directions (N, NE, E, SE, S, SW, W, and NW) and the annual average wind speed obtained from the Dublin Airport weather dataset. The simulation results were extrapolated from 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 Lawson's Pedestrian Comfort criterion.

The following table summarises 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

Table 1: Lawson's Pedestrian Comfort Assessment Criteria for Various Activities

The following table summarises Lawson's Pedestrian Safety Assessment criteria.

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

Table 2: Lawson's Pedestrian Safety Assessment Criteria

The results are presented as false-colour contour images illustrating the percentage of the year during which the local air speed is likely to exceed a given value at each point in the area of interest. The air speed threshold value is noted in the title of the colour legend in the top-left corner of each image. Note the comfort criterion results scale ranges from 0.1% to 100% (as a percentage of the year). This is with reference to Table 1 above. The scale for the safety-criteria results images ranges from 0.001% to 1% (as a percentage of the year). This is with reference to Table 2 above. These criteria are explained in detail in Section 6.1.

The median wind speed recorded was more than 5.7 m/s for Dublin's climatic conditions. That means that for 50% of the year, the wind speed in Dublin is above 5.7 m/s. The Lawson's Sitting Criterion requires the local air speed to be no more than 4m/s for 95% of the year. Thus, the Lawson's Sitting Criterion presents the task of improving 10 times over the climatic conditions at the location of interest within Dublin. This can be achieved through appropriate landscaping and wind-mitigation measures.

3.1 Collective Results

Figure 1 illustrates the collective results for wind comfort at the 5% threshold, as noted above. These results were summed to calculate the total number of hours during which a given pedestrian activity class exceeds the 5% yearly threshold, based on the wind-speed hierarchy. The sitting comfort indicates that the wind speed was lower than 4m/s, while the rest of the classes were above this threshold. It is worth noting that when a space is classified under a certain activity class, it will also meet the requirements of all activity classes above it in the hierarchy scale. For example, if a space is comfortable for sitting, it will also be comfortable for standing and walking.

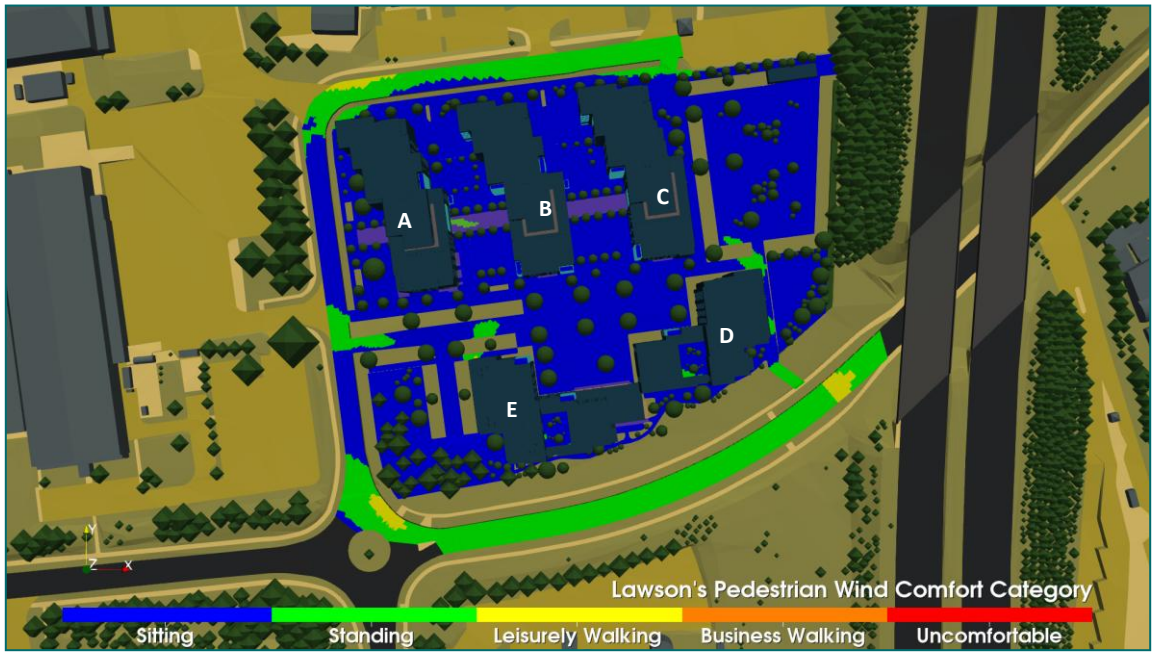


Figure 1: Collective Results: 5% Threshold

The following areas show excellent compliance with Lawson's Sitting and Standing Comfort Criteria:

- Public open space near Block A
- Communal open space
- Public open space near Block D and E
- Public open space on the east side of Blocks C and D
- Terrace amenities

The entire site showed excellent compliance with Walking activities. No location exhibited completely uncomfortable conditions anywhere on the site at the 5% threshold.

It is worth noting that a pedestrian activity class is merely a statistical assessment of the local wind climate. When a region is classified as a certain class, this does not mean that people are prevented from engaging in that activity for an extended period. Rather, it only means that for more than 5% of the time (per year), the wind speed for this activity could result in an uncomfortable environment. However, during the remaining times of the year, this activity can be considered comfortable.

3.2 Sitting and Standing Comfort Results

The Lawson's Sitting Comfort Criterion states that the local air speed at designated locations should not exceed 4 m/s for more than 5% of the duration analysed. The Lawson's Standing Comfort Criterion states that the local air speed at designated locations should not exceed 6 m/s for more than 5% of the duration analysed.

3.2.1 Balconies

3.2.1.1 Block A

Figure 2 to Figure 5 illustrate Lawson's Sitting and Standing Comfort Criteria results for the balconies of Block A. All balconies are equipped with railings and do not consist of a solid wind screen. The results demonstrate excellent compliance and fully meet the requirements of Lawson's Sitting and Standing Comfort Criterion for the full year. The local air speed does not exceed 4m/s and 6m/s for more than 5% of the year as per the criterion's requirement.

No further mitigation measures are recommended.

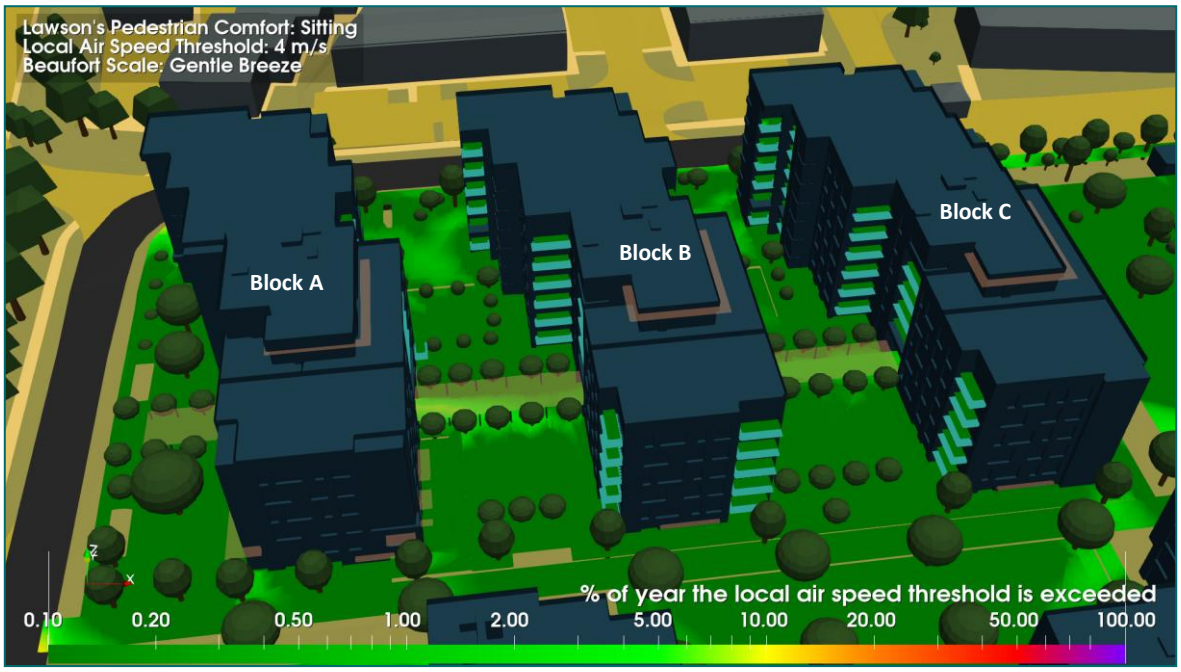


Figure 2: Sitting Comfort Criterion - Balconies - Block A (View from the South)

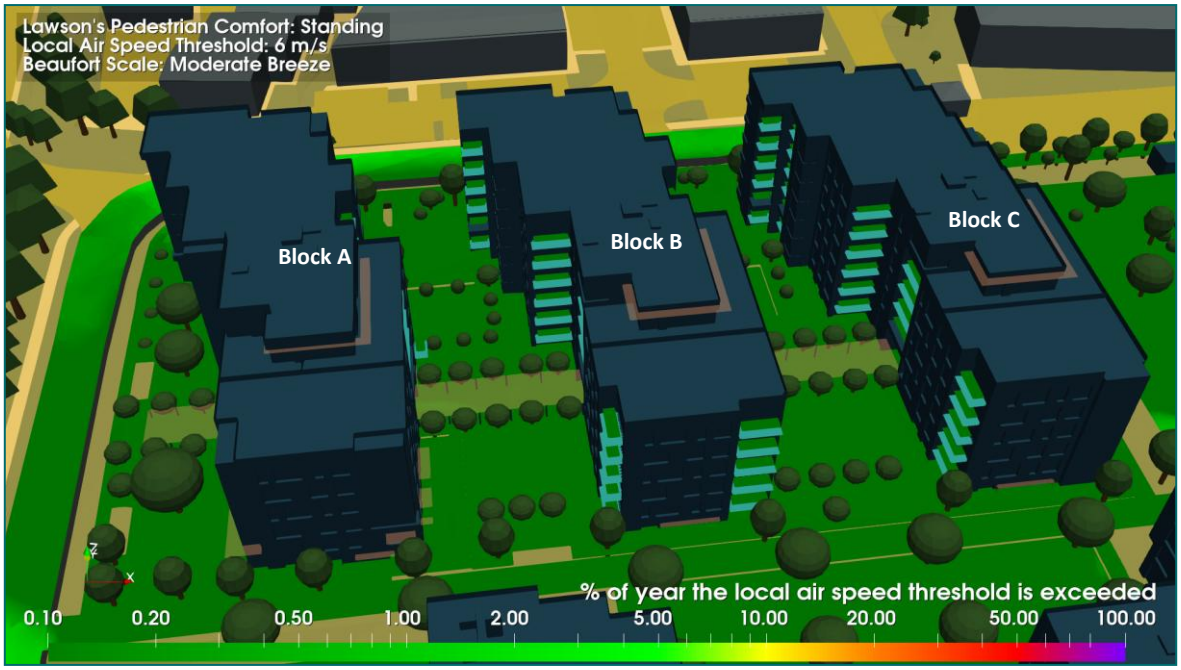


Figure 3: Standing Comfort Criterion - Balconies - Block A (View from the South)

Figure 4: Sitting Comfort Criterion - Balconies Block A (View from the East)

Figure 5: Standing Comfort Criterion - Balconies - Block A (View from the East)

3.2.1.2 Block B & Block C

Figure 6 to Figure 11 illustrate Lawson's Sitting and Standing Comfort Criteria results for the balconies of Block B and Block C. All balconies are equipped with railings and do not consist of a solid wind screen. The results demonstrate excellent compliance and fully meet the requirements of Lawson's Sitting and Standing Comfort Criterion for the full year. The local air speed does not exceed 4m/s and 6m/s for more than 5% of the year as per the criterion's requirement.

No further mitigation measures are recommended.

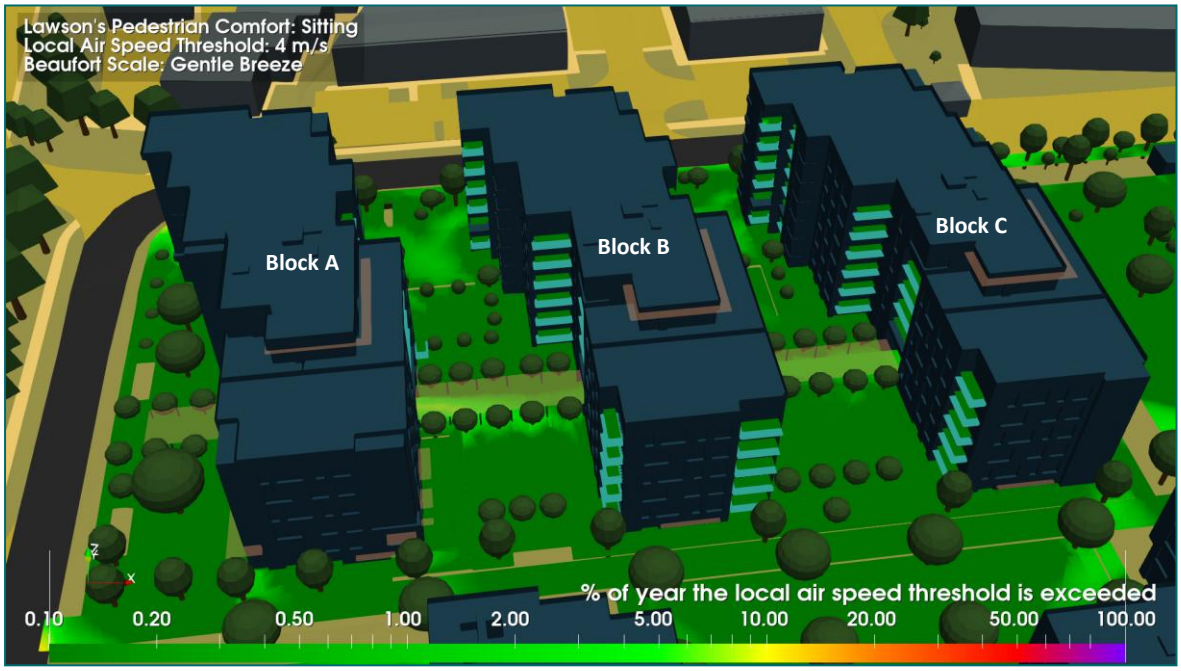


Figure 6: Sitting Comfort Criterion - Balconies - Block B & Block C (View from the South)

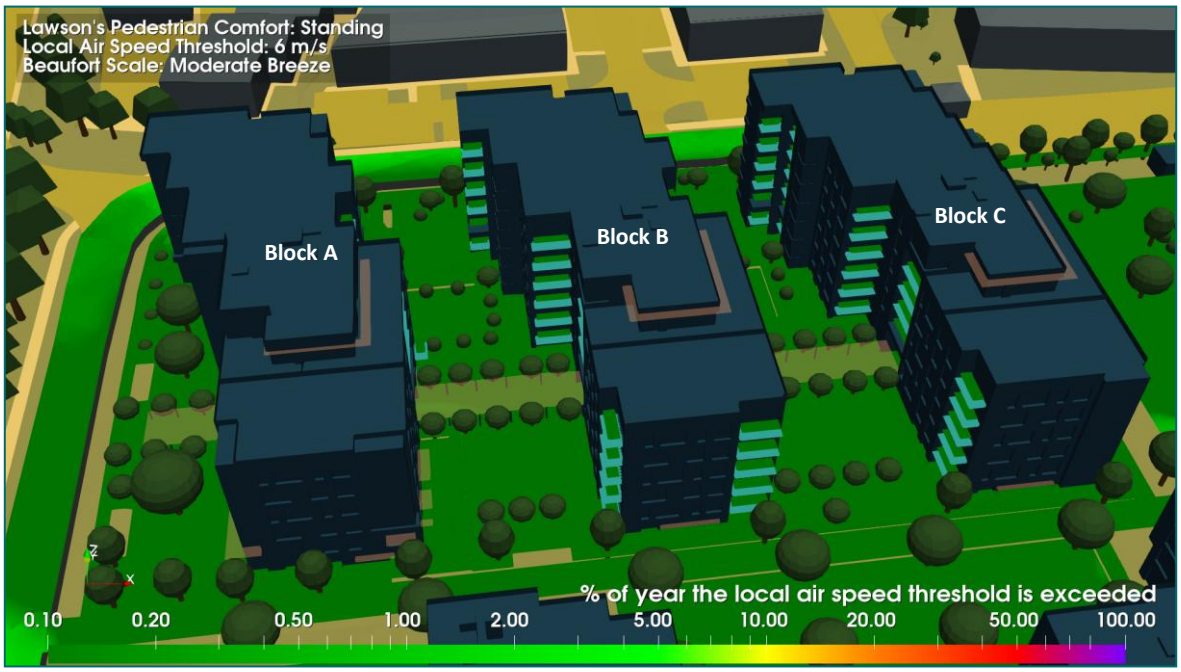


Figure 7: Standing Comfort Criterion - Balconies - Block B & Block C (View from the South)

Figure 8: Sitting Comfort Criterion - Balconies - Block B & Block C (View from the Southwest)

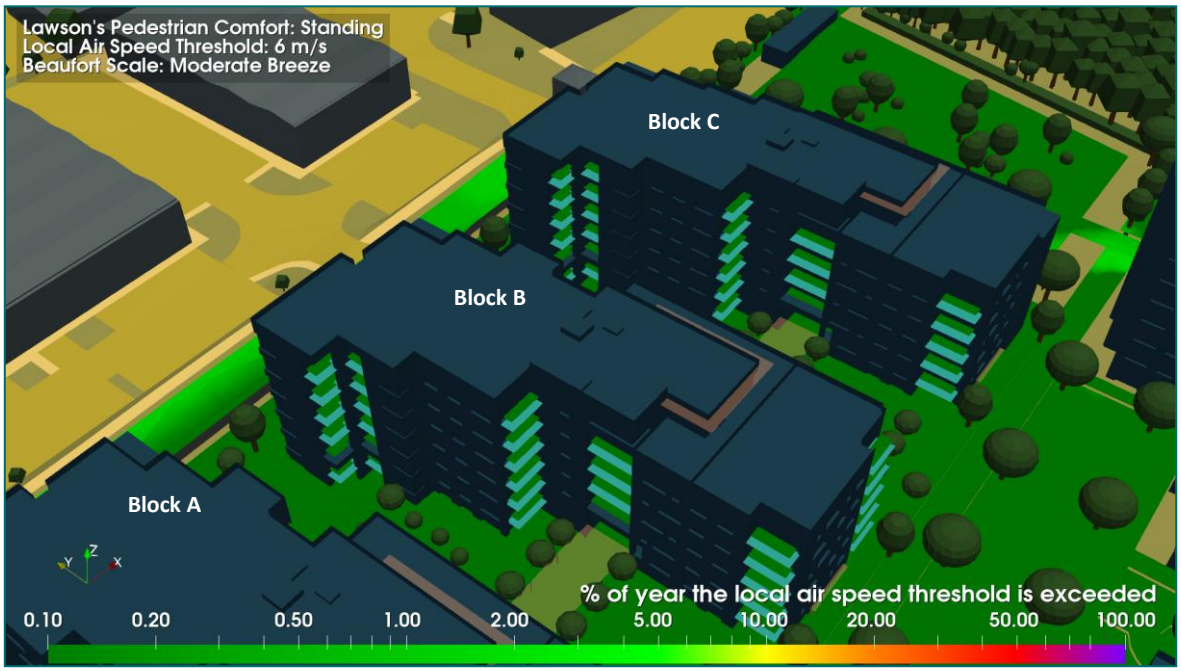


Figure 9: Standing Comfort Criterion - Balconies - Block B & Block C (View from the Southwest)

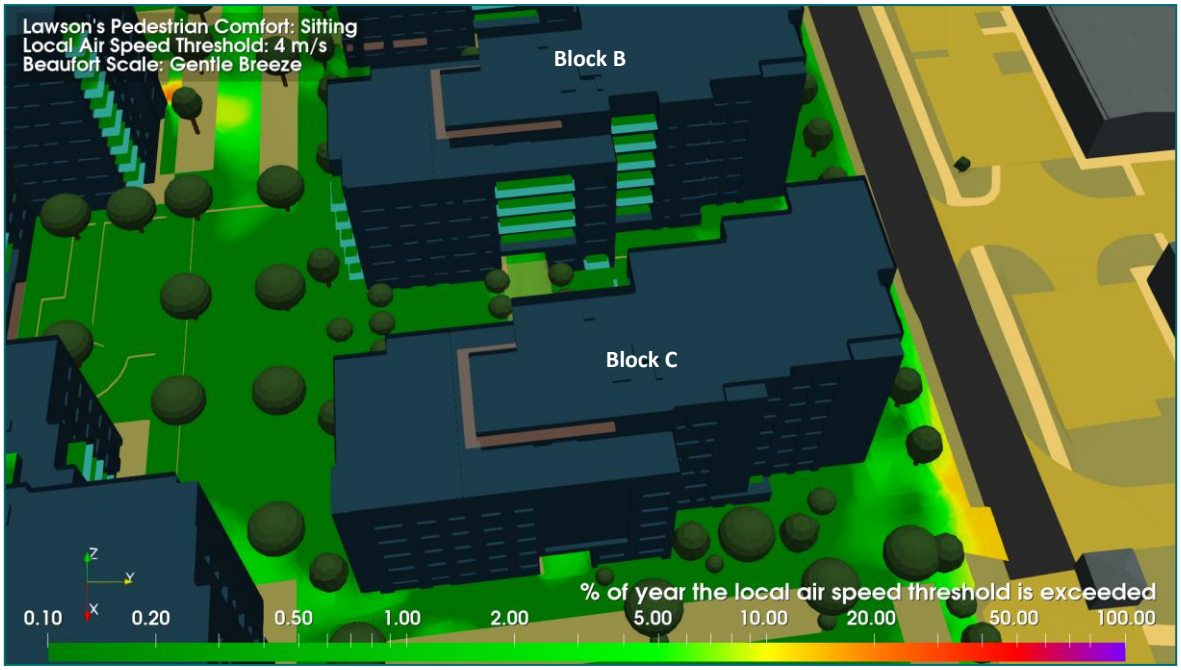


Figure 10: Sitting Comfort Criterion - Balconies - Block B & Block C (View from the East)

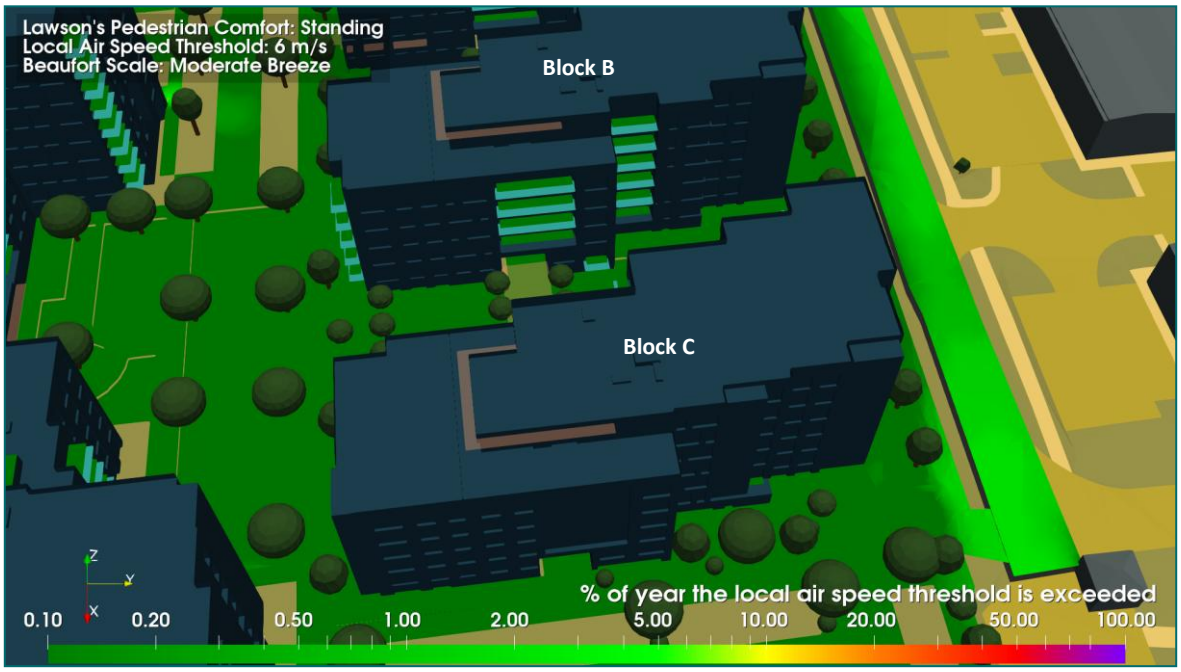


Figure 11: Standing Comfort Criterion - Balconies - Block B & Block C (View from the East)

3.2.1.3 Block D & Block E

Figure 12 to Figure 13 illustrate Lawson's Sitting and Standing Comfort Criteria results for the balconies of Block D & Block E. All balconies are equipped with railings and do not consist of a solid wind screen. The results demonstrate excellent compliance and fully meet the requirements of Lawson's Sitting and Standing Comfort Criterion for the full year. The local air speed does not exceed 4m/s and 6m/s for more than 5% of the year as per the criterion's requirement.

No further mitigation measures are recommended.

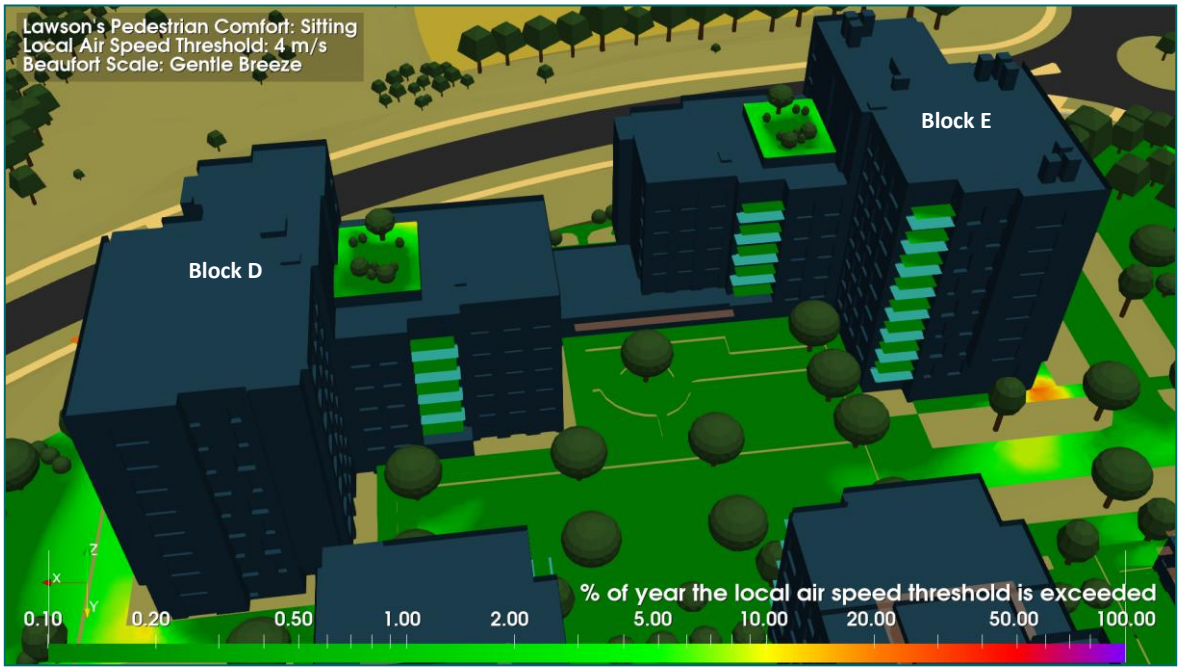


Figure 12: Sitting Comfort Criterion - Balconies - Block D & Block E (View from the North)

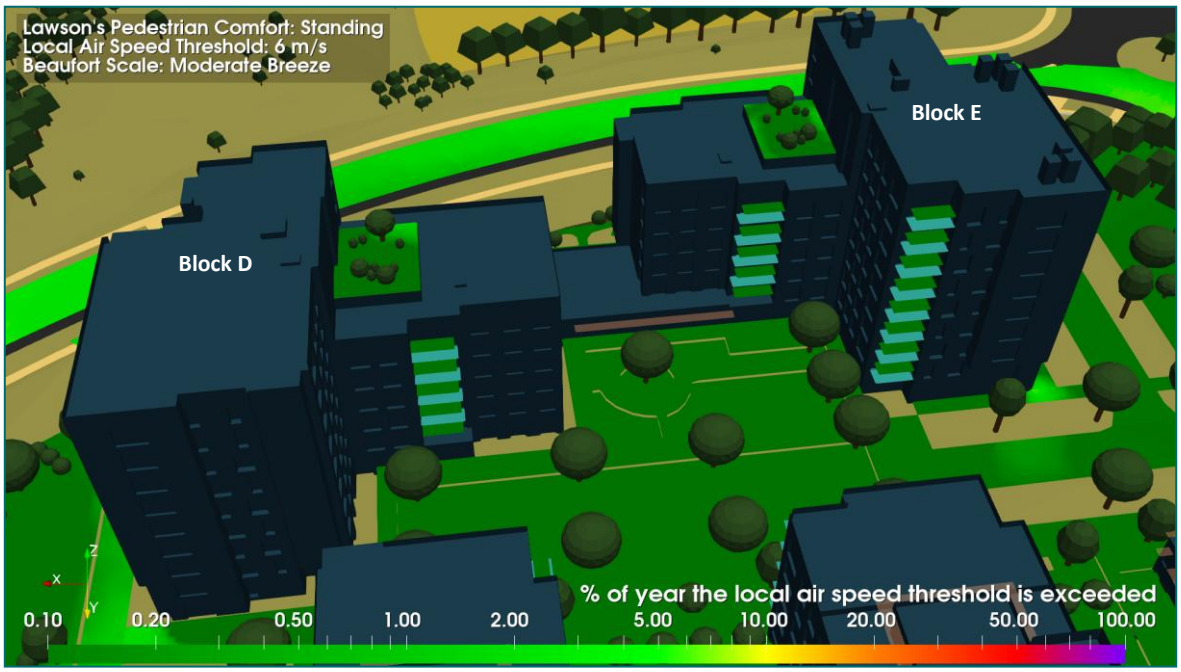


Figure 13: Standing Comfort Criterion - Balconies - Block D & Block E (View from the North)

3.2.2 Open Space

3.2.2.1 Public Open Space near Block A

Figure 14 and Figure 15 Illustrate Lawson's Sitting and Standing Comfort Criteria results for the public open space near Block A. The results demonstrate excellent compliance and fully meet the requirements of Lawson's Sitting and Standing Comfort Criterion for the full year. The local air speed does not exceed 4m/s and 6m/s for more than 5% of the year as per the criterion's requirement.

No further mitigation measures are recommended.

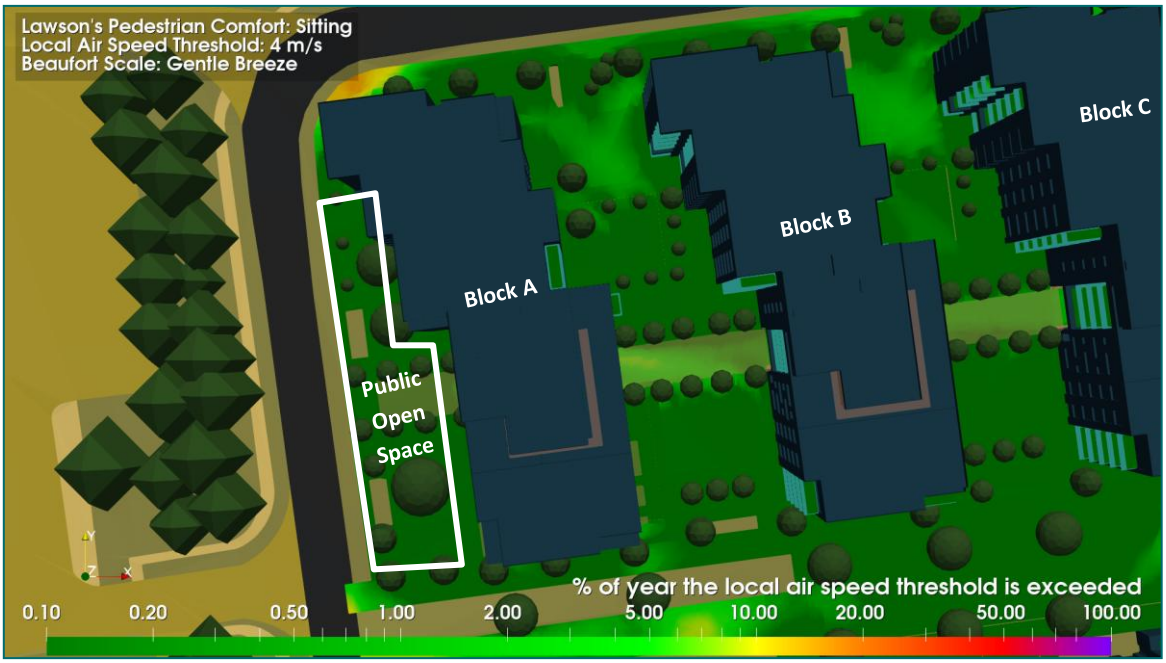


Figure 14: Sitting Comfort Criterion - Public Open Space

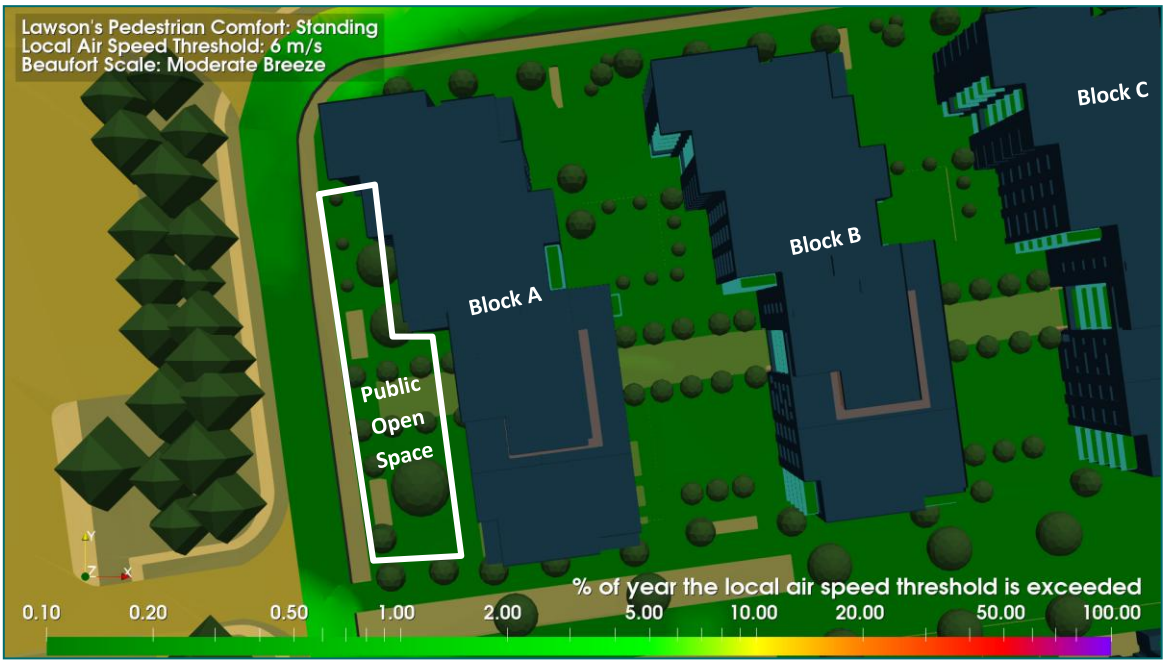


Figure 15: Standing Comfort Criterion - Public Open Space

3.2.2.2 Communal Open Space

Figure 16 and Figure 17 illustrate Lawson's Sitting and Standing Comfort Criteria results for the communal open spaces between Block A, Block B and Block C.

The results demonstrate excellent compliance and fully meet the requirements of Lawson's Sitting and Standing Comfort Criterion for the full year. The local air speed does not exceed 4m/s and 6m/s for more than 5% of the year as per the criterion's requirement.

No further mitigation measures are recommended.

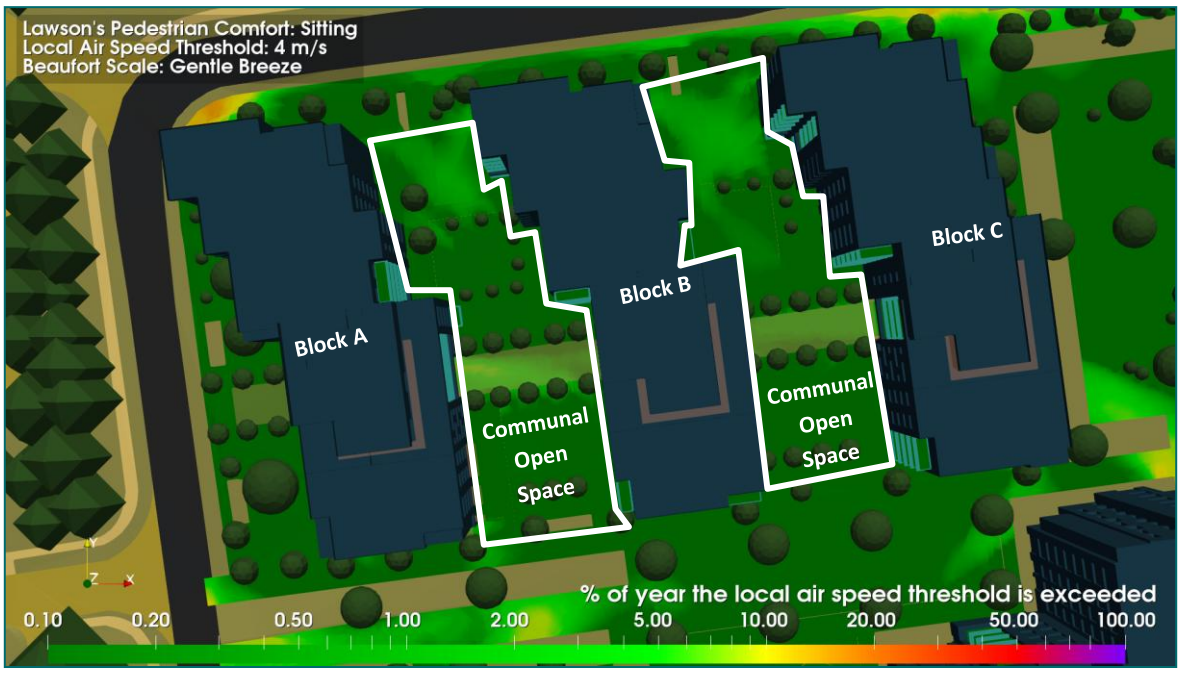


Figure 16: Sitting Comfort Criterion - Communal Open Space

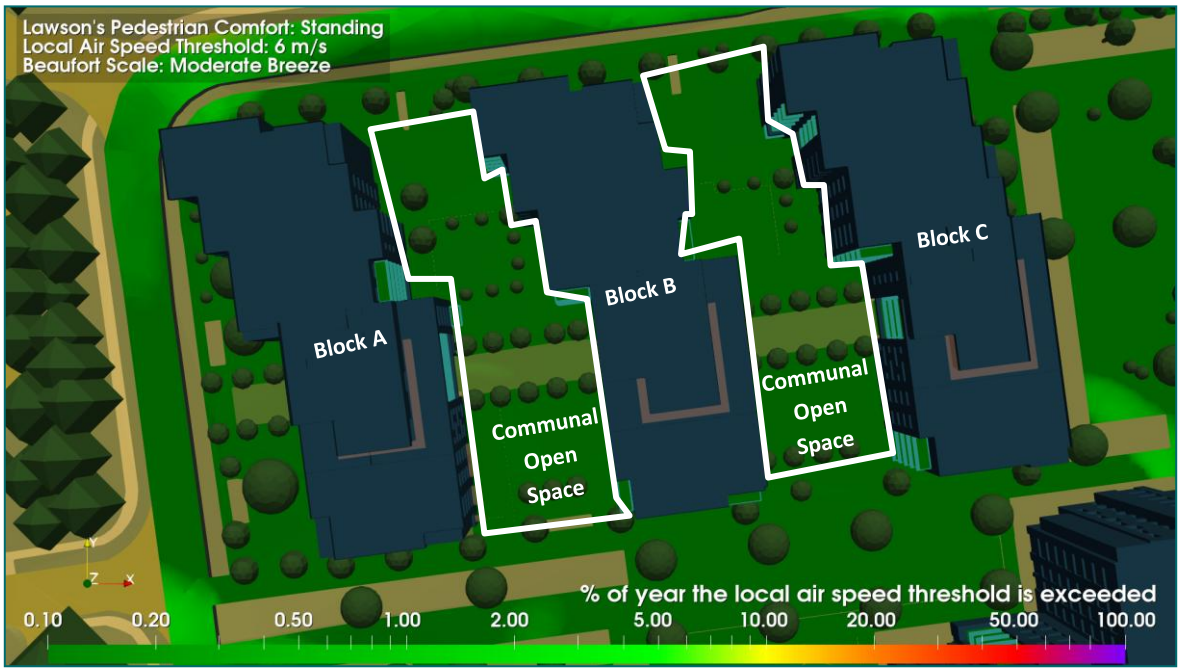


Figure 17: Standing Comfort Criterion - Communal Open Space

3.2.2.3 Public Open Space near Block D and E

Figure 18 and Figure 19 illustrate Lawson's Sitting and Standing Comfort Criteria results for the Public open space located on the northwest of Block D, located towards the west of Block E, outlined in blue and orange, respectively. The results demonstrate excellent compliance and fully meet the requirements of Lawson's Sitting and Standing Comfort Criterion for the full year. The local air speed does not exceed 4m/s and 6m/s for more than 5% of the year as per the criterion's requirement.

No further mitigation measures are recommended.

Figure 18: Sitting Comfort Criterion - Public Open Space near Block D & E

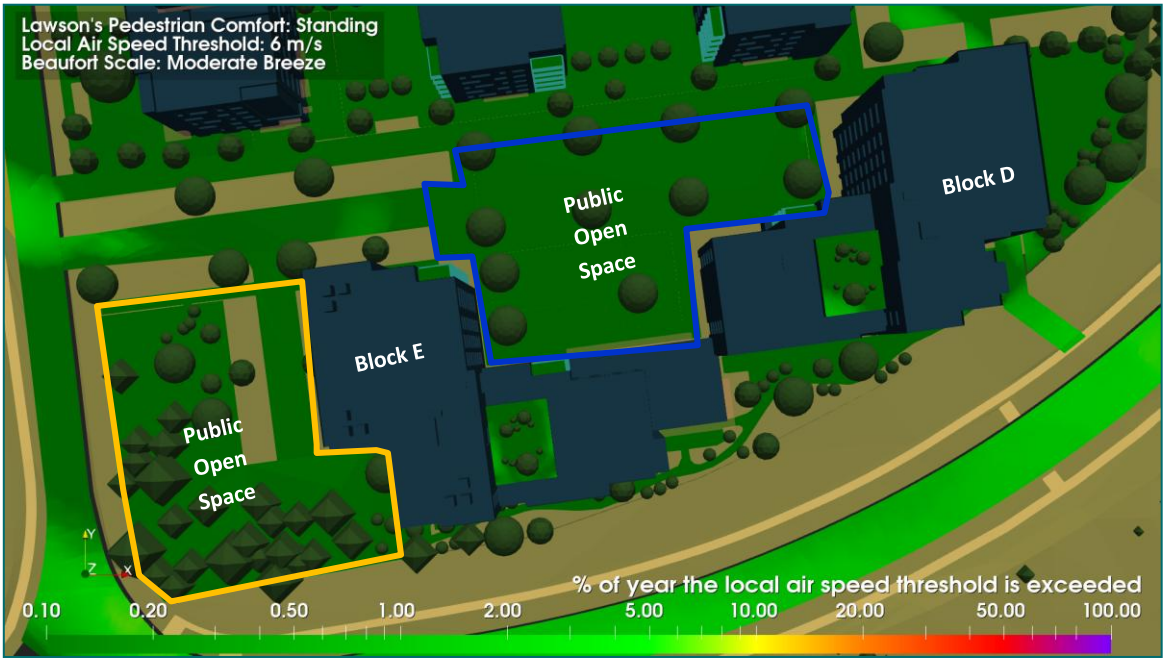


Figure 19: Standing Comfort Criterion - Public Open Space near Block D & E

3.2.2.4 Public Open Space East of Block C & D

Figure 20 and Figure 21 illustrate Lawson's Sitting and Standing Comfort Criteria results on the open space located on the east of Block C and Block D.

The results demonstrate excellent compliance and fully meet the requirements of Lawson's Sitting and Standing Comfort Criterion for the full year. The local air speed does not exceed 4m/s and 6m/s for more than 5% of the year as per the criterion's requirement.

No further mitigation measures are recommended.

Figure 20: Sitting Comfort Criterion - Public Open Space East of Block C & D

Figure 21: Standing Comfort Criterion - Public Open Space East of Block C & D

3.2.3 Terrace Amenities

Figure 22 and Figure 23 illustrate Lawson's Sitting and Standing Comfort Criteria results on the terrace amenities located on the 6th floor level of Block D and Block E, surrounded by the 1.5m high glass balustrade. The results demonstrate excellent compliance and fully meet the requirements of Lawson's Sitting and Standing Comfort Criterion for the full year. The local air speed does not exceed 4m/s and 6m/s for more than 5% of the year as per the criterion's requirement.

No further mitigation measures are recommended.

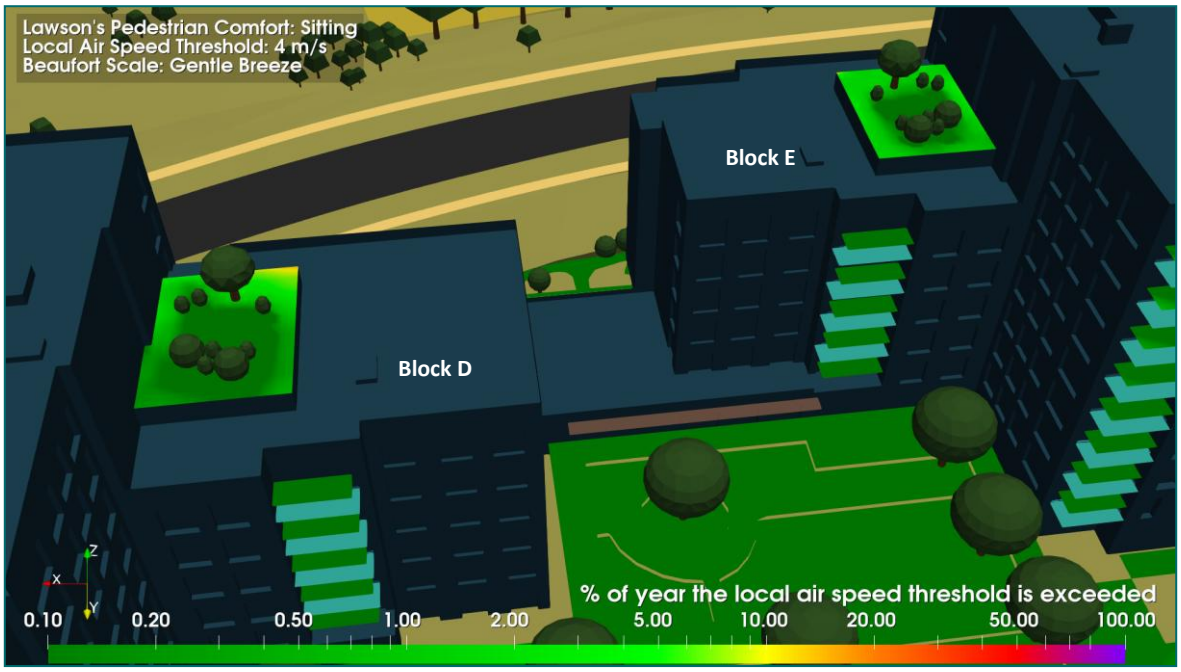


Figure 22: Sitting Comfort Criterion - Terrace Amenities - Block D and E

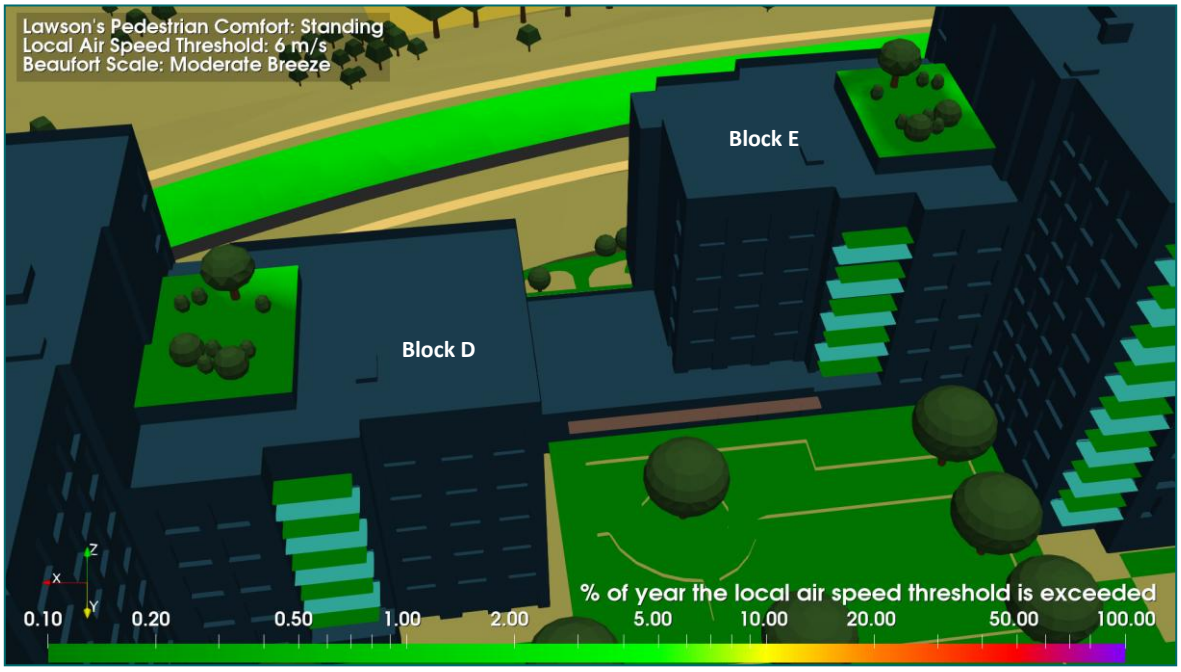


Figure 23: Standing Comfort Criterion - Terrace Amenities - Block D and E

3.3 Walking Comfort Results

The Lawson's Leisure Walking Comfort Criterion states that the local air speed at designated locations should not exceed 8 m/s for more than 5% of the analysed duration along the various walkways around the development. Additionally, the Lawson's Business Walking Comfort Criterion states the local air speed at designated locations should not exceed 10 m/s for more than 5% of the analysed duration along the various walkways around the development. The results demonstrate excellent compliance with the requirements of Lawson's Leisure Walking and Business Walking Comfort Criterion. The local air speed does not exceed 8 m/s or 10 m/s for more than 5% of the year, respectively. The following Figure 24 and Figure 25 illustrate the results of walking comfort criteria.

Figure 24: Leisure Walking Comfort Criterion (View from Above)

Figure 25: Business Walking Comfort Criterion (View from Above)

3.3.1.1 Building Entrance

Figure 26 to Figure 29 illustrates Lawson's Leisure and Business Walking Comfort Criteria results at the building entrances. The results demonstrate excellent compliance with the requirements of Lawson's Leisure Walking and Business Walking Comfort Criterion. The local air speed does not exceed 8 m/s or 10 m/s for more than 5% of the year.

No further mitigation measures are recommended.

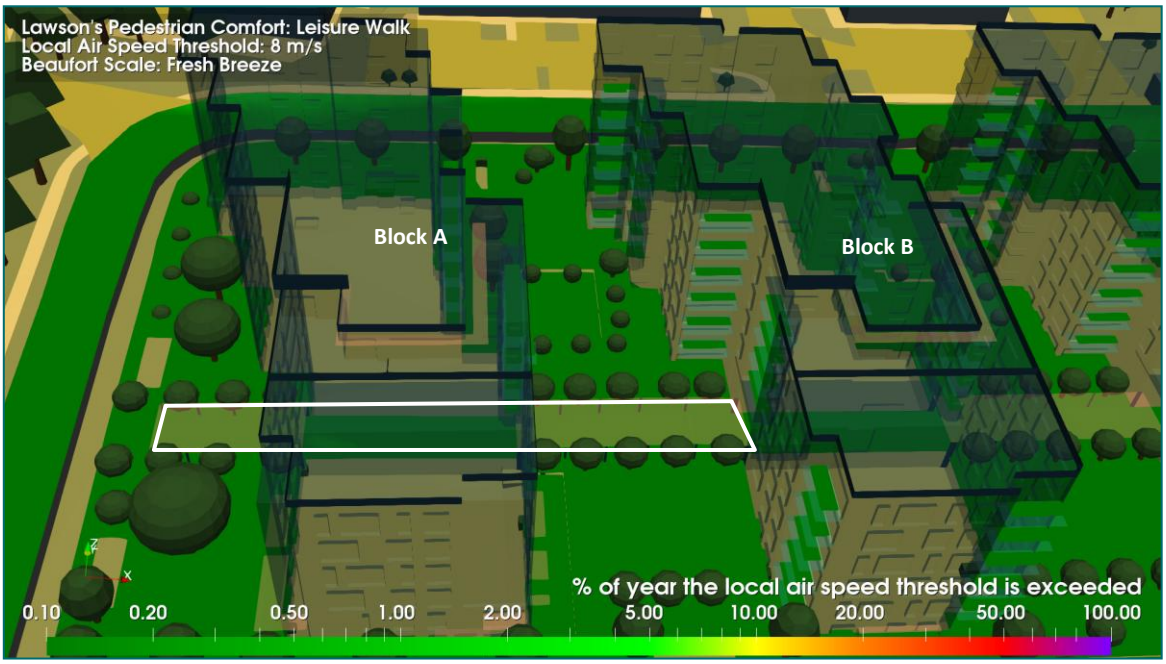


Figure 26: Leisure Walking Comfort Criterion (View from the South)

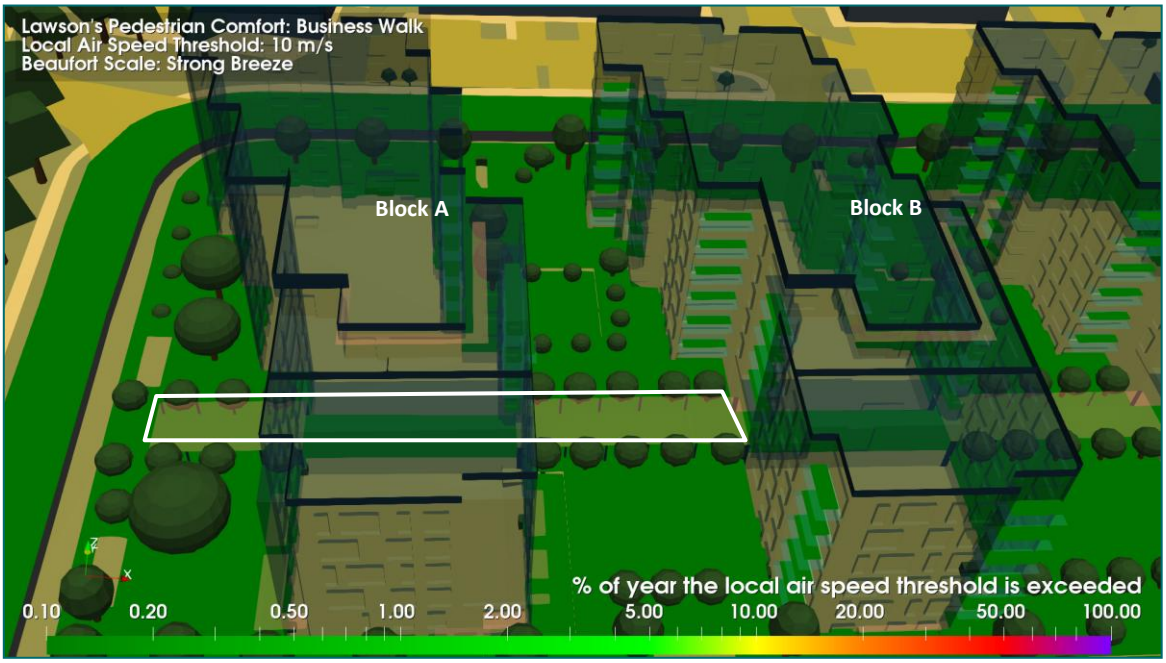


Figure 27: Business Walking Comfort Criterion (View from the South)

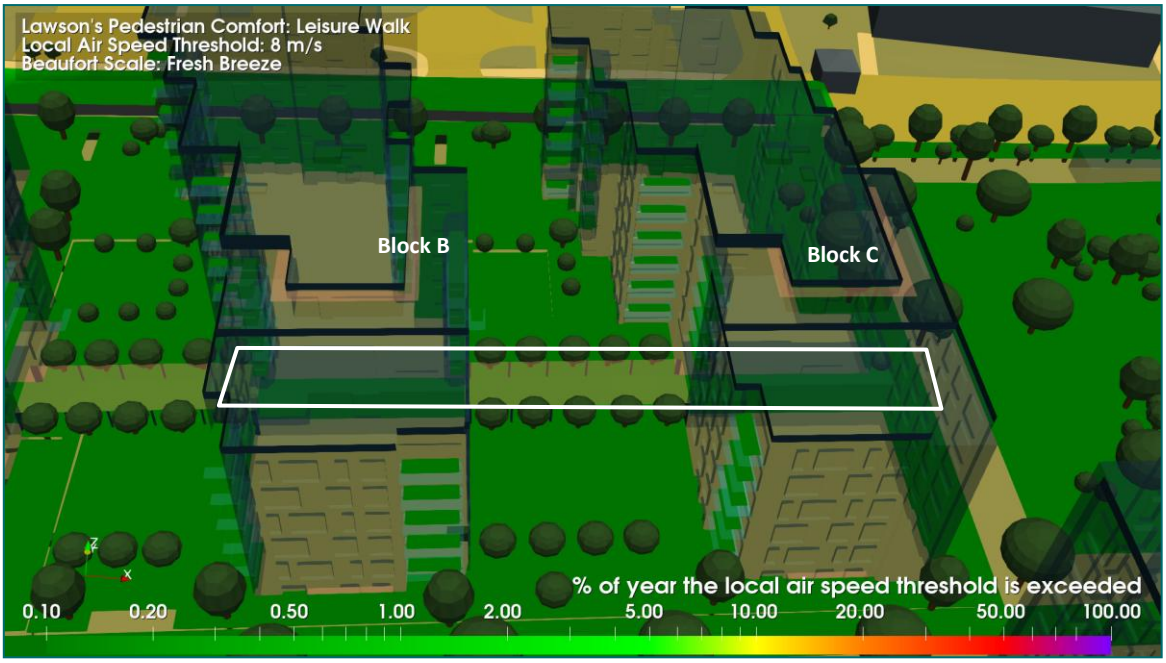


Figure 28: Leisure Walking Comfort Criterion (View from the South)

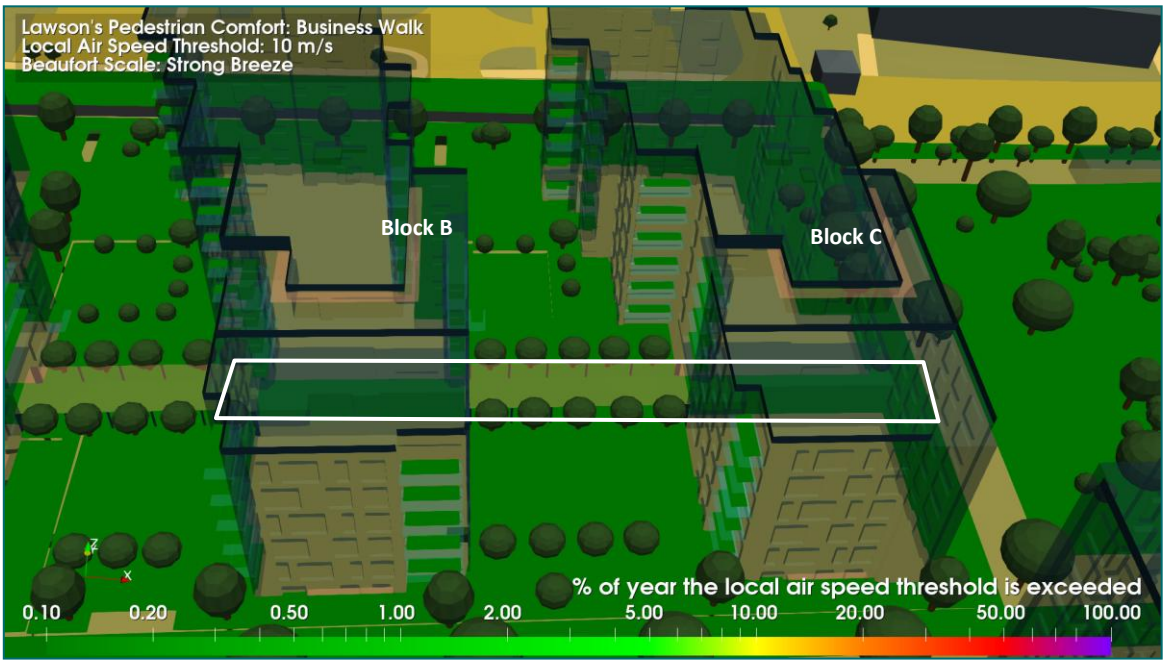


Figure 29: Business Walking Comfort Criterion (View from the South)

3.4 Safety Criteria

The Lawson's Normal Pedestrian Safety Criterion states the local air speed at designated locations should not exceed 20 m/s for more than 0.01% of the duration analysed. Additionally, the Lawson's Sensitive Pedestrian Safety Criterion states the local air speed at designated locations should not exceed 15 m/s for more than 0.01% of the duration analysed. The Sensitive Pedestrian Safety Criterion applies to the vulnerable population, such as elderly or infirmed persons and children. Note the limit of the criterion is 0.01% and not 5% as with the comfort criterion.

These criteria also apply to various walkways and areas around the development, as access to and from the buildings is always required, irrespective of weather conditions. Figure 30 and Figure 31 illustrate the results of the safety criteria assessment. The results of the normal and sensitive pedestrian are observed to be below 0.01% of the year. Therefore, all areas of the proposed development demonstrate compliance with the pedestrian safety criterion.

Figure 30: Sensitive Pedestrian Safety Criterion (View from Above)

Figure 31: Normal Pedestrian Safety Criterion (View from Above)

4 Weather Data

The analysis is based on the 'IRL_ST_Dublin.AP.039620_TMYx.2009-2023.epw' weather file. The variation of wind speed recorded in the weather file is illustrated in Figure 32 below. Figure 33 illustrates the wind direction variation, and Figure 34 illustrates the wind rose.

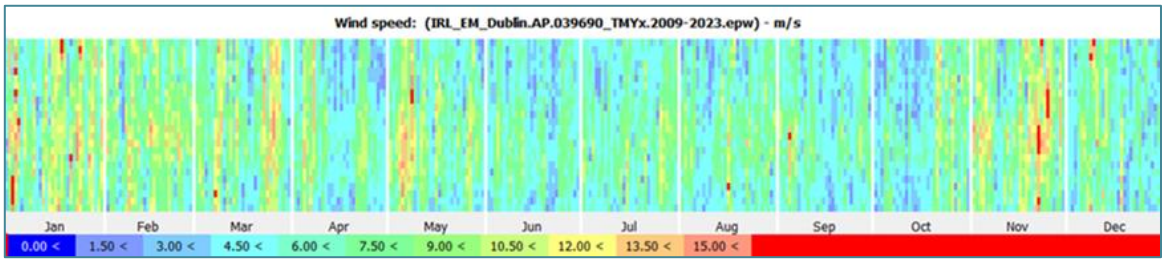


Figure 32: Wind Speed Variation

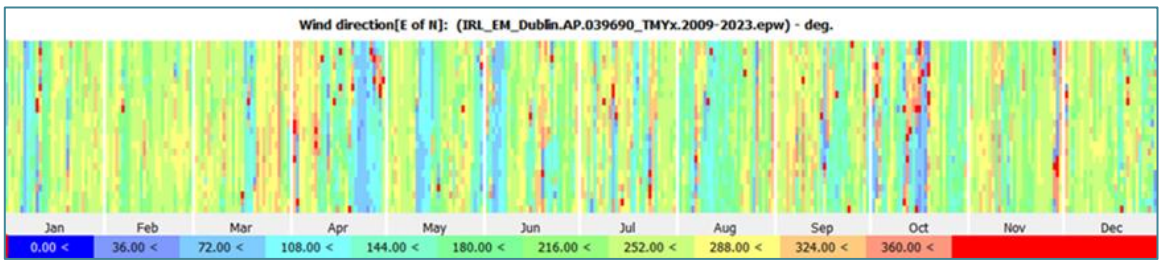


Figure 33: Wind Direction Variation

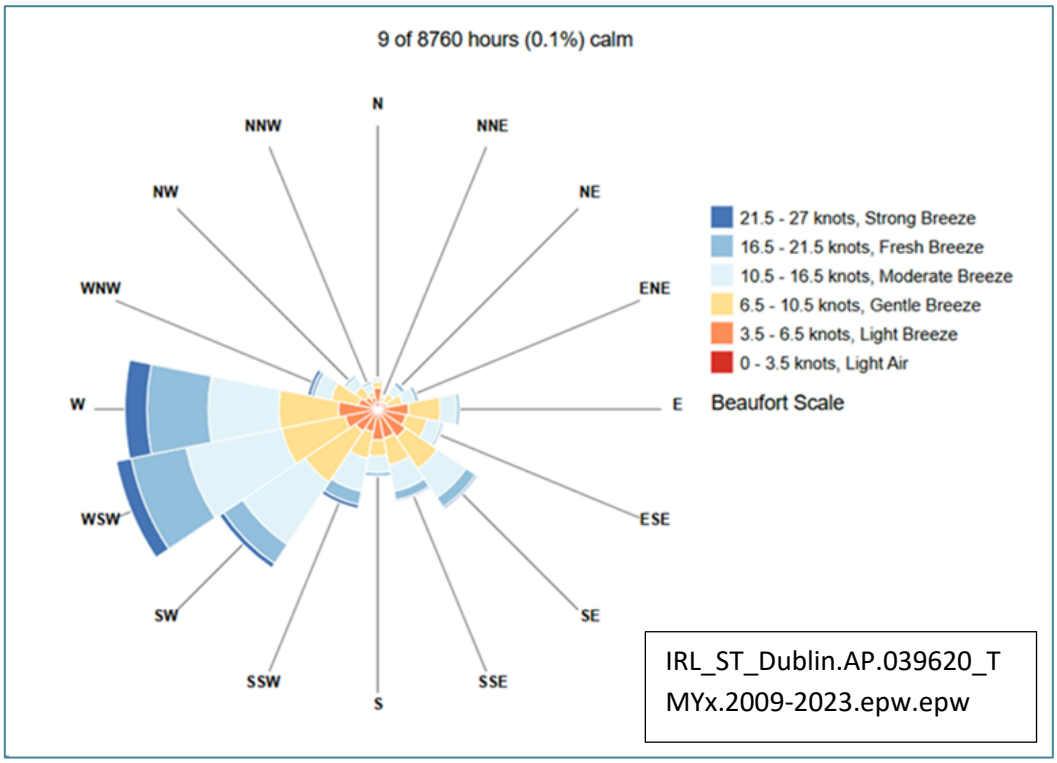


Figure 34: Wind Rose

Based on the analysis of the weather file, the mean wind speed recorded is **5.7m/s** with a westerly prevailing direction.

5 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), refer to Figure 35.

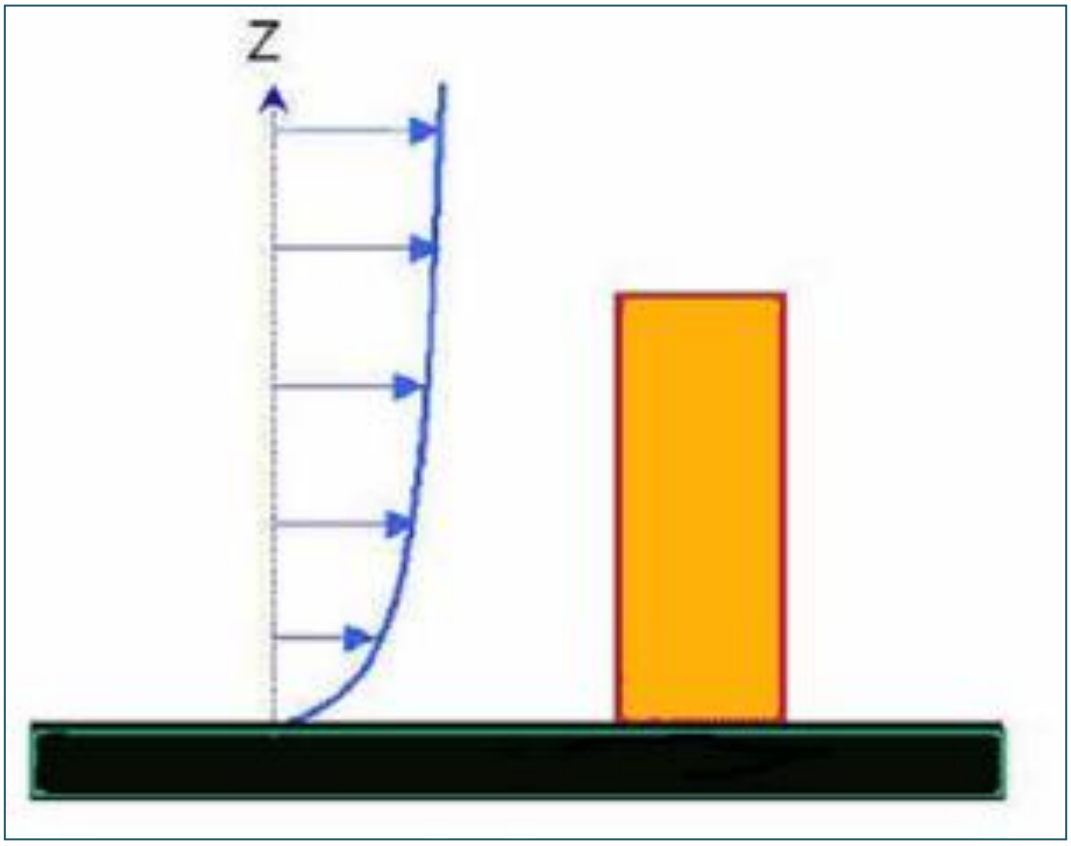


Figure 35: Typical velocity profile of an atmospheric boundary layer

In the 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, i.e. open country, urban, and city centre.

The wind speed $\mathbf{U_H}$ at height **H** above the ground is given by the following equation:

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

Where,

a = Exponent in power law wind speed profile for local building terrain

δ = Fully developed strong wind atmospheric boundary layer thickness (m)

$\mathbf{a_{met}}$ = 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 outlined in Table 1.

Table 1: Atmospheric Boundary Layer Parameters

Terrain Category	Description	a	δ
1	Large city centres have 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 this project, the atmospheric boundary layer corresponding to terrain category 2 was used, i.e., an urban/suburban type of site. The met data was obtained based on category 3 terrain at a height of 10m.

6 Methodology for Pedestrian Comfort Calculation

The methodology for the analysis is as follows:

1) The annual mean wind speed was determined from the 'IRL_ST_Dublin.AP.039620_TMYx.2009-2023.epw' weather file.
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.

6.1 Lawson Pedestrian Comfort/Safety Criteria

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

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

The following table outlines the values for Lawson's Pedestrian Comfort Assessment Criteria for various pedestrian 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 outlines 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 to be exceeded more than 0.01% of the year.

The median wind speed recorded is 5.7 m/s for Dublin's climatic conditions. That means, for 50% of the year, the wind speed is higher than 5.7 m/s. The Lawson's Sitting Criterion requires the local air speed to be more than 4 m/s for no more than 5% of the year. Thus, the Lawson's Sitting Criterion presents a task of being 10 times better than the climatic conditions at the location of interest.

7 CFD Model

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

7.1 Model Geometry

Figure 36 to Figure 51 illustrate the modelled geometry.

Figure 36: Plan view of the site

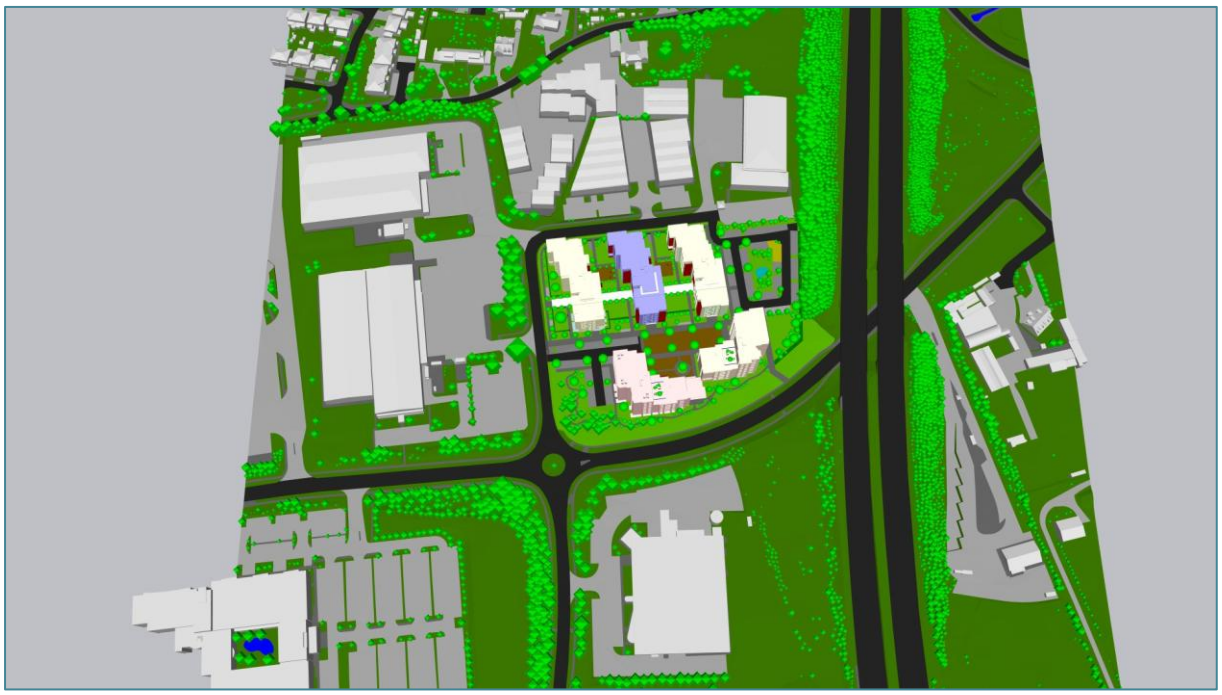


Figure 37: View of the site from the South

Figure 38: View of the site from the West

Figure 39: View of the site from the North

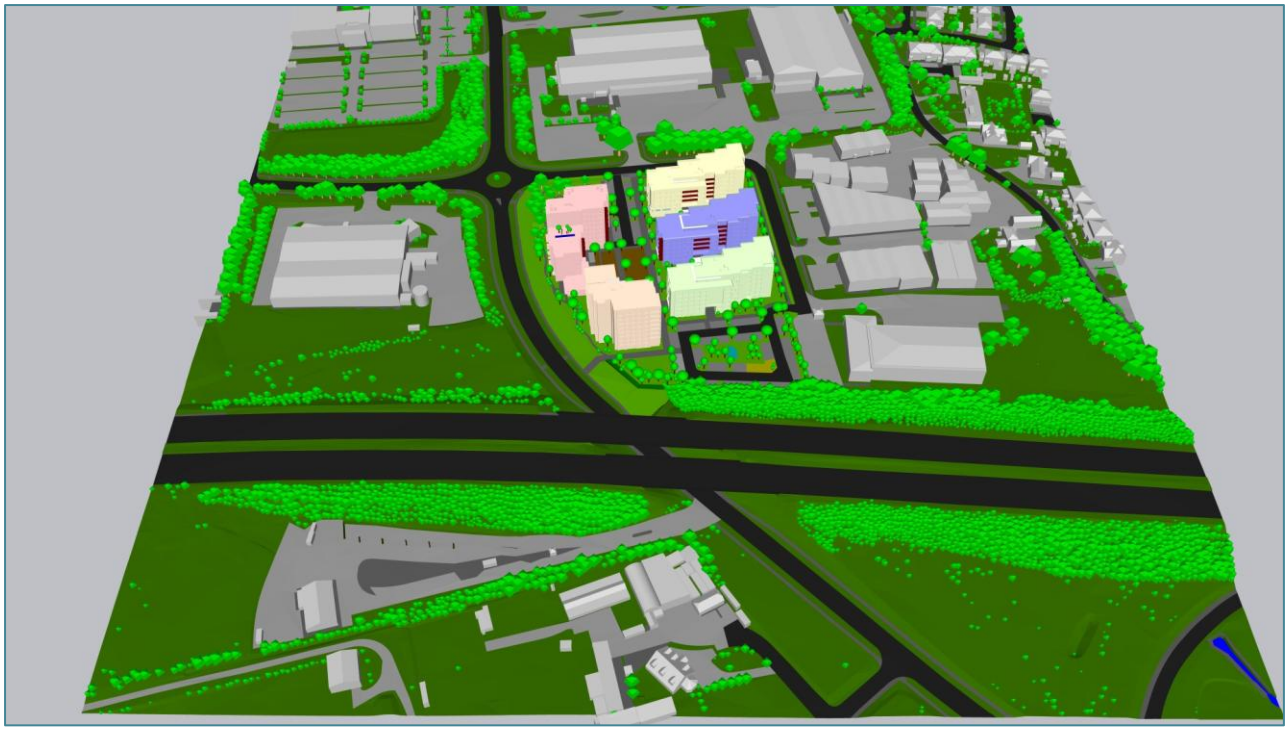


Figure 40: View of the site from the East

Figure 41: Plan view of the Main Buildings

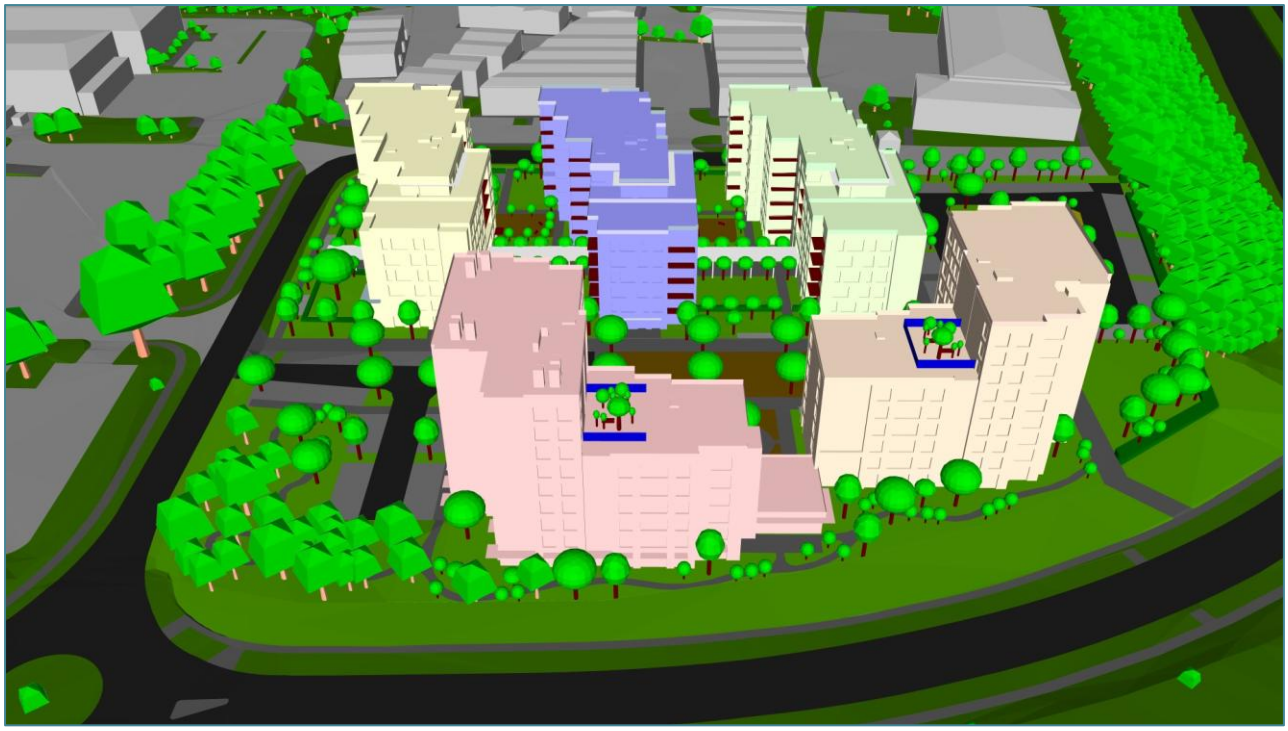


Figure 42: Closer view of the site from the South

Figure 43: Closer view of the site from the West

Figure 44: Closer view of the site from the North

Figure 45: Closer view of the site from the East

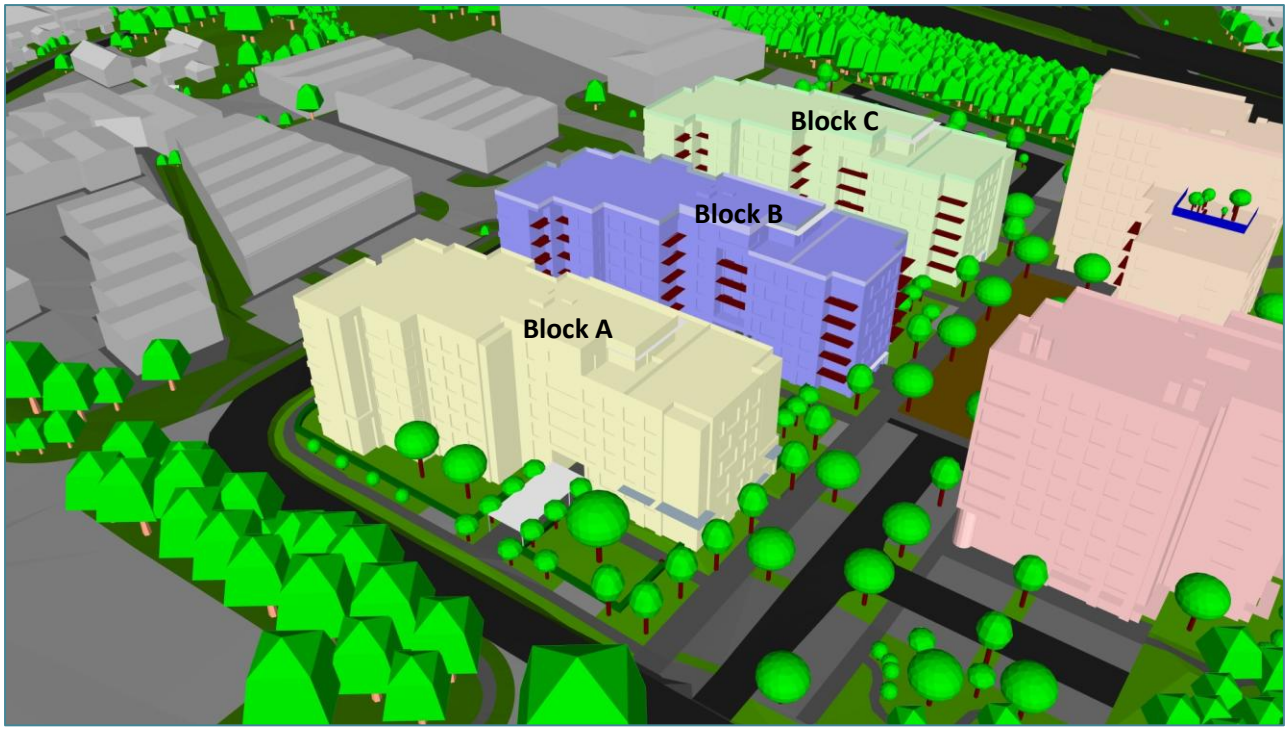


Figure 46: View of Block A, B & C from the Southwest

Figure 47: View of Block A, B & C from the Northwest

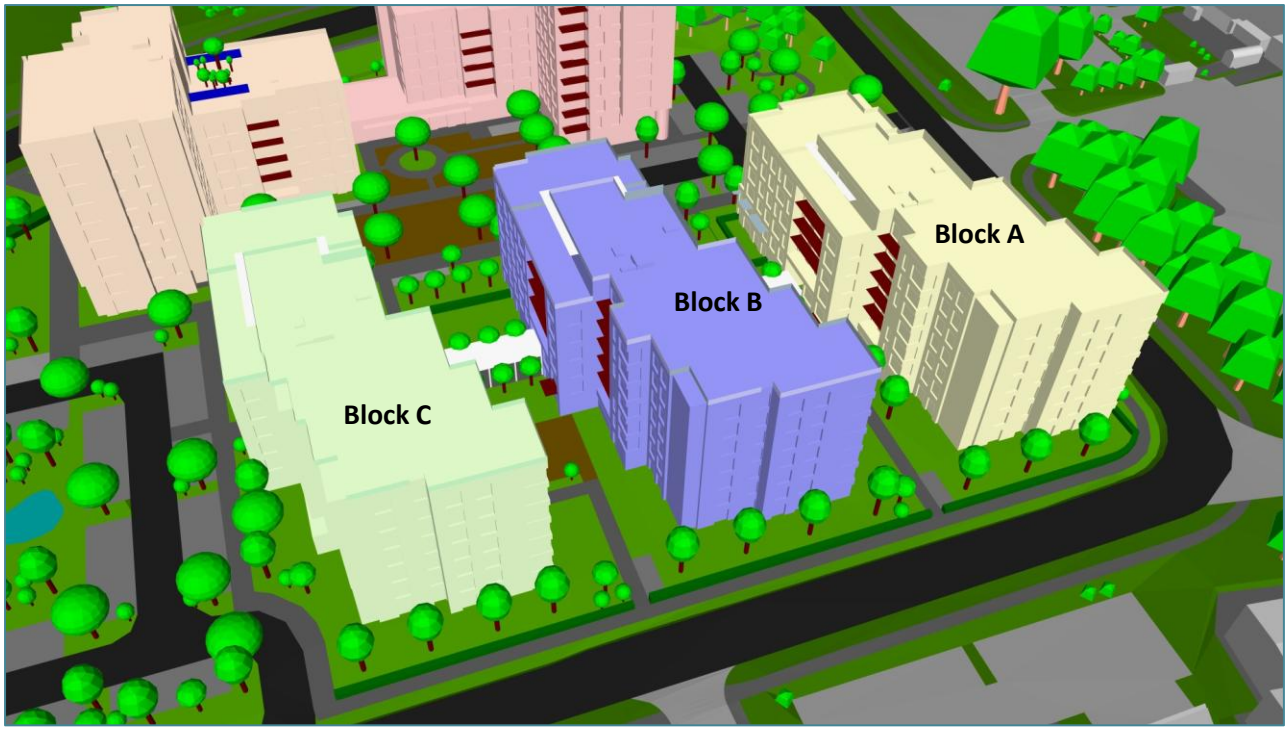


Figure 48: View of Block A, B & C from the Southeast

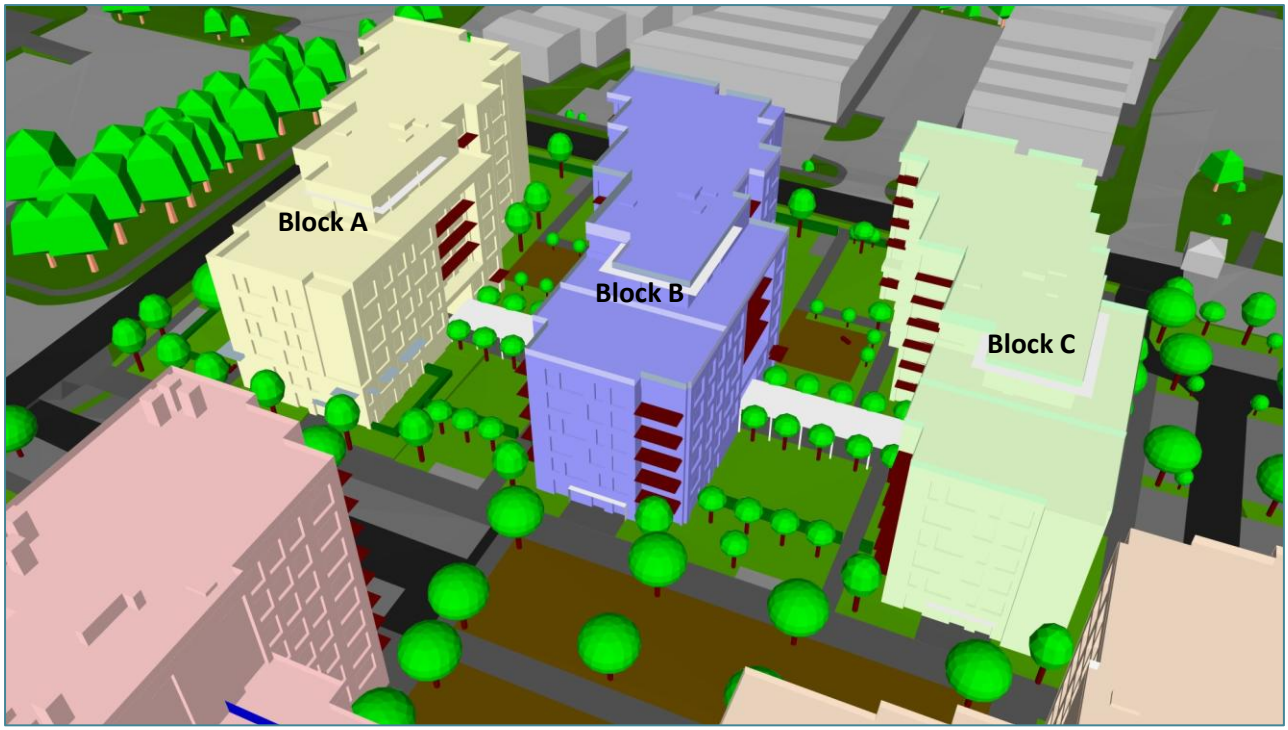


Figure 49: View of Block A, B & C from the Southeast

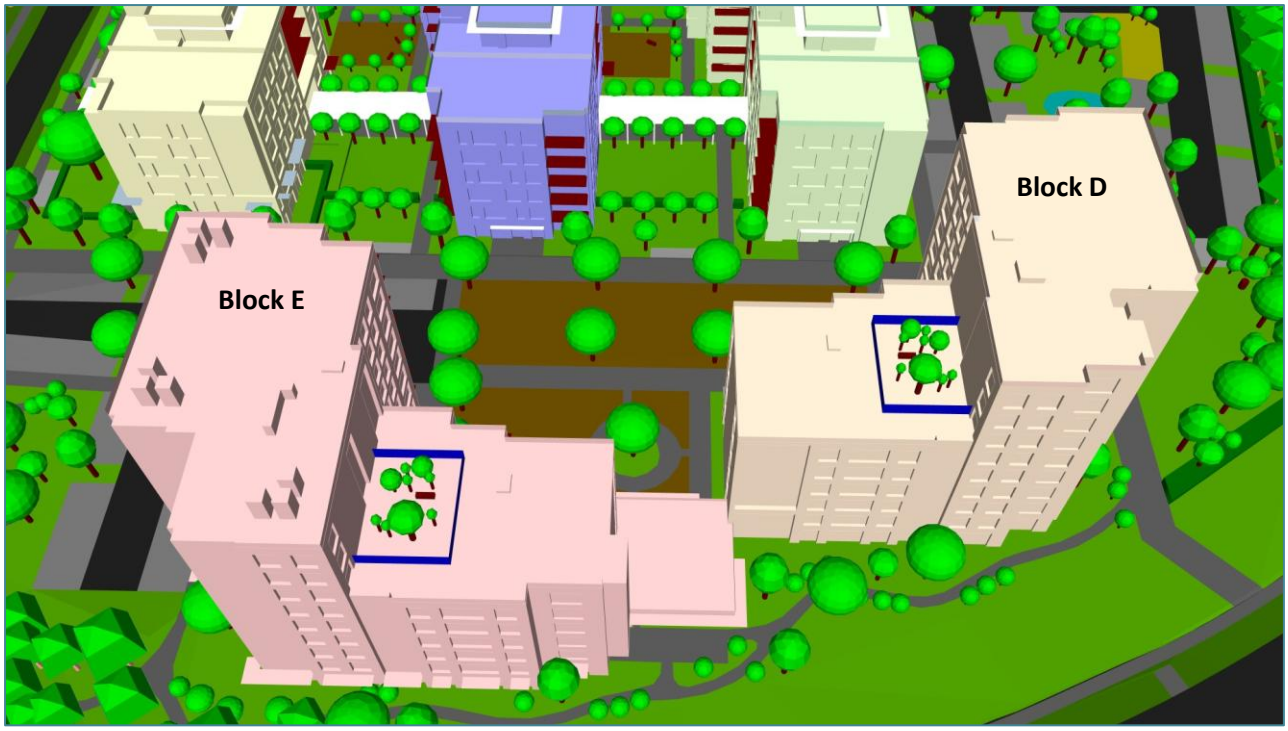


Figure 50: View of Block D & E from the South

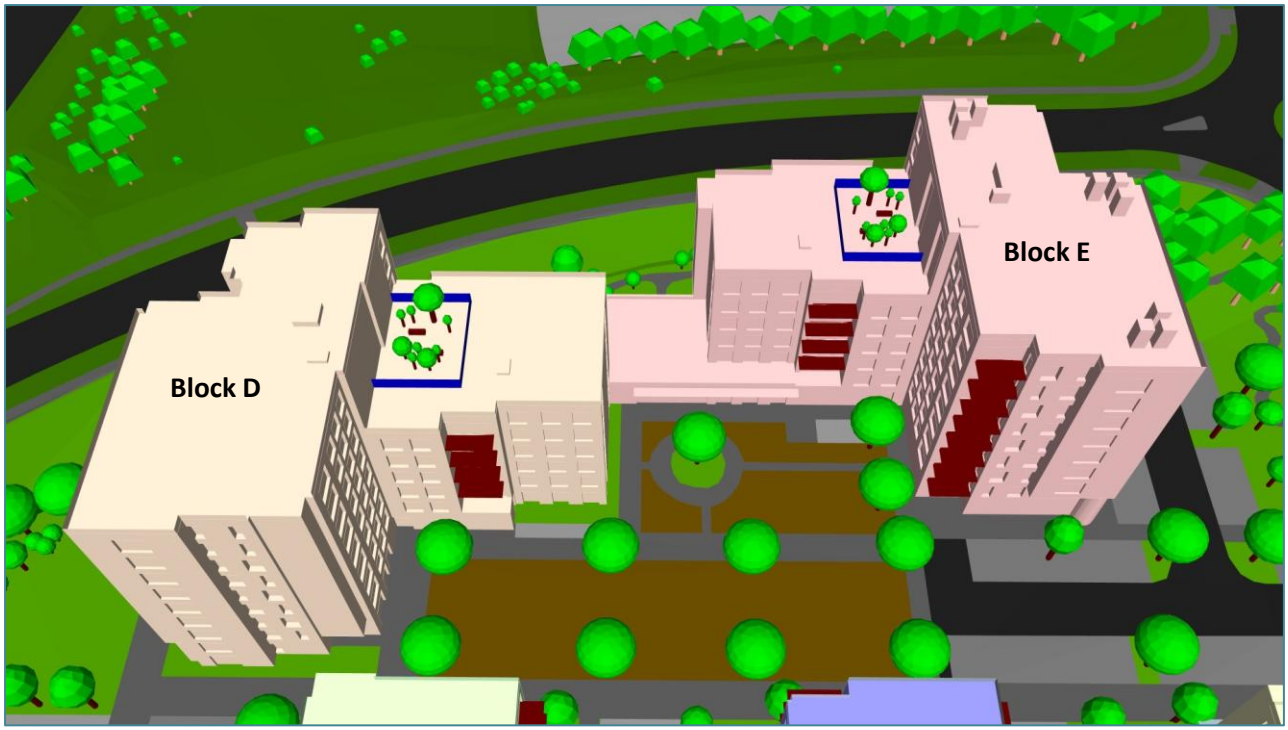


Figure 51: View of Block D and E from the North

8 Conclusion

The site shows the typical behaviour of any site in Dublin, with direct exposure to the southern-to-western arc of winds, which account for 80% of total winds across the year. The landscape design and site layout result in the site performing well with respect to wind comfort.

It was observed that:

1. The balconies on all blocks show excellent results and fully meet the requirements of the Sitting and Standing Comfort criteria.

2. All Public Open spaces show excellent results and fully meet the requirements of the Sitting and Standing Comfort Criteria.

3. The Terrace amenities show excellent results and fully meet the requirements of the Sitting and Standing Comfort Criteria.

4. Overall results of the Walking comfort show excellent compliance with Lawson's Leisure Walking and Business Walking Comfort criteria.

5. The Lawson's Normal and Sensitive Pedestrian Safety Criteria are achieved throughout the site.

The site meets Lawson's Standing and Sitting criteria when used together in all amenity spaces. It also meets Lawson's Walking criteria requirements on all walkways across the site.

9 Appendix

9.1 Comfort Criteria

Figure 52 to Figure 60 illustrate 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 for all seasons. The threshold values are 4 m/s, 6 m/s, 8 m/s and 10 m/s respectively.

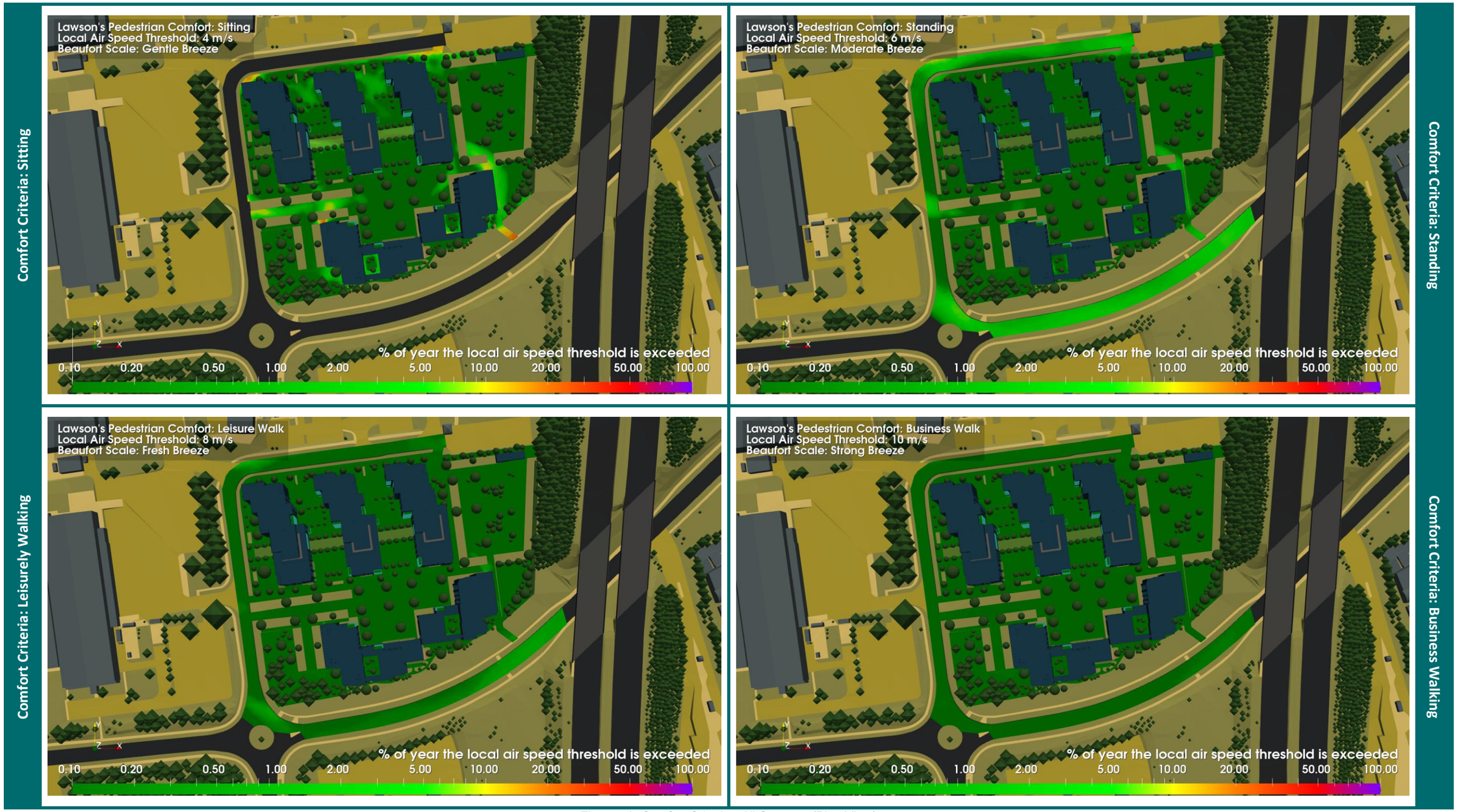
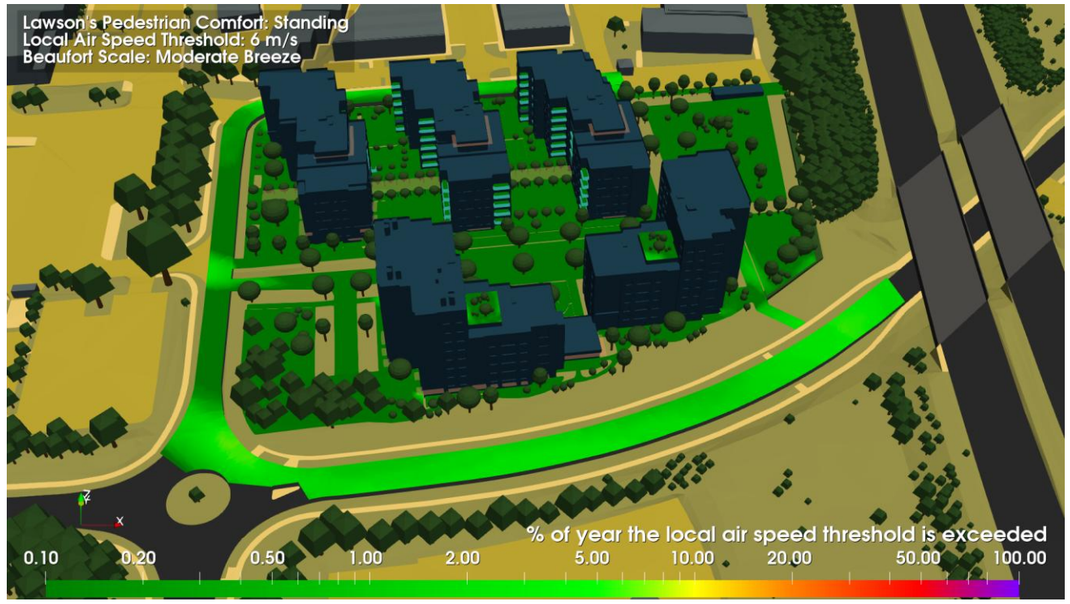


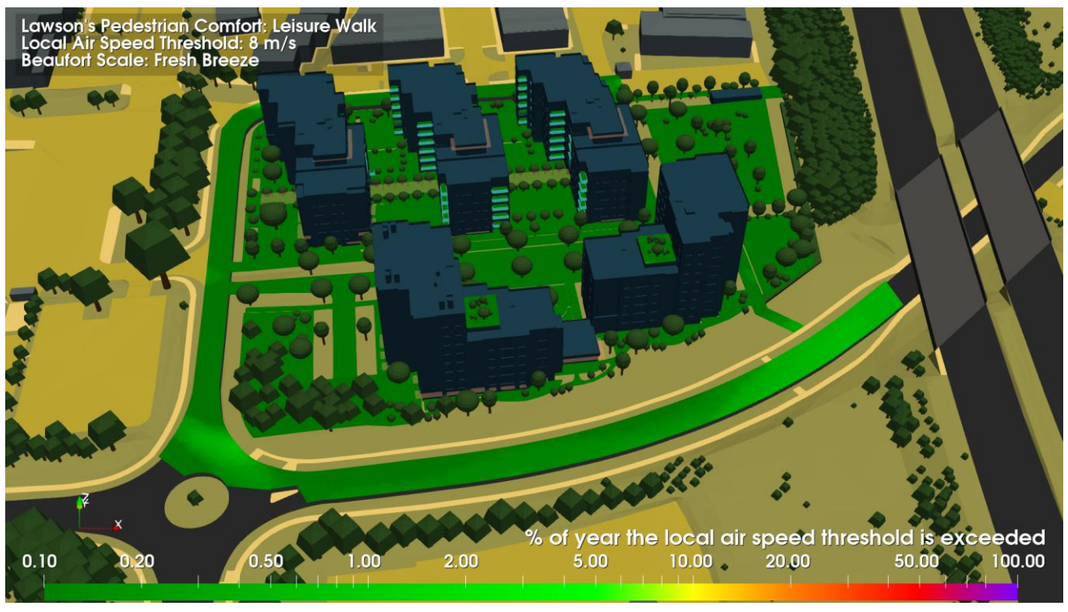
Figure 52: Comfort Criteria - All Seasons (Plan View)

Comfort Criteria: Sitting

Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking



Comfort Criteria: Business Walking

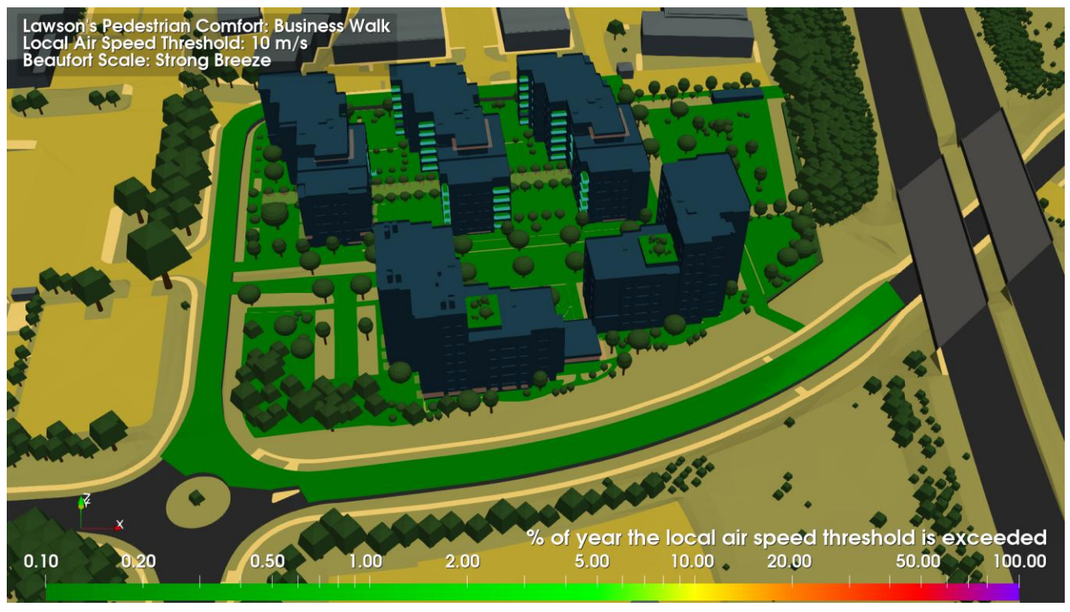


Figure 53: Comfort Criteria (View from the South)

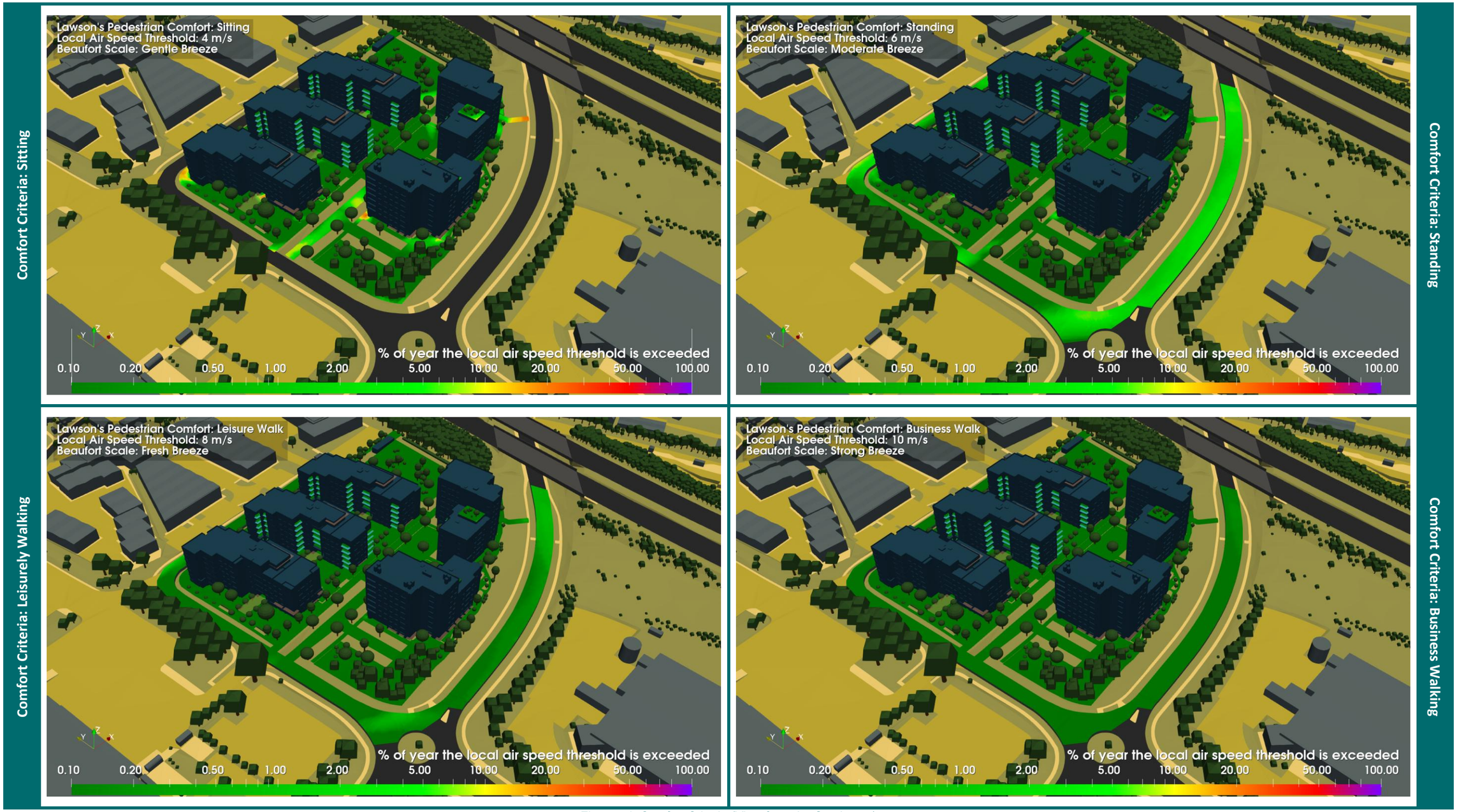


Figure 54: Comfort Criteria (View from the Southwest)

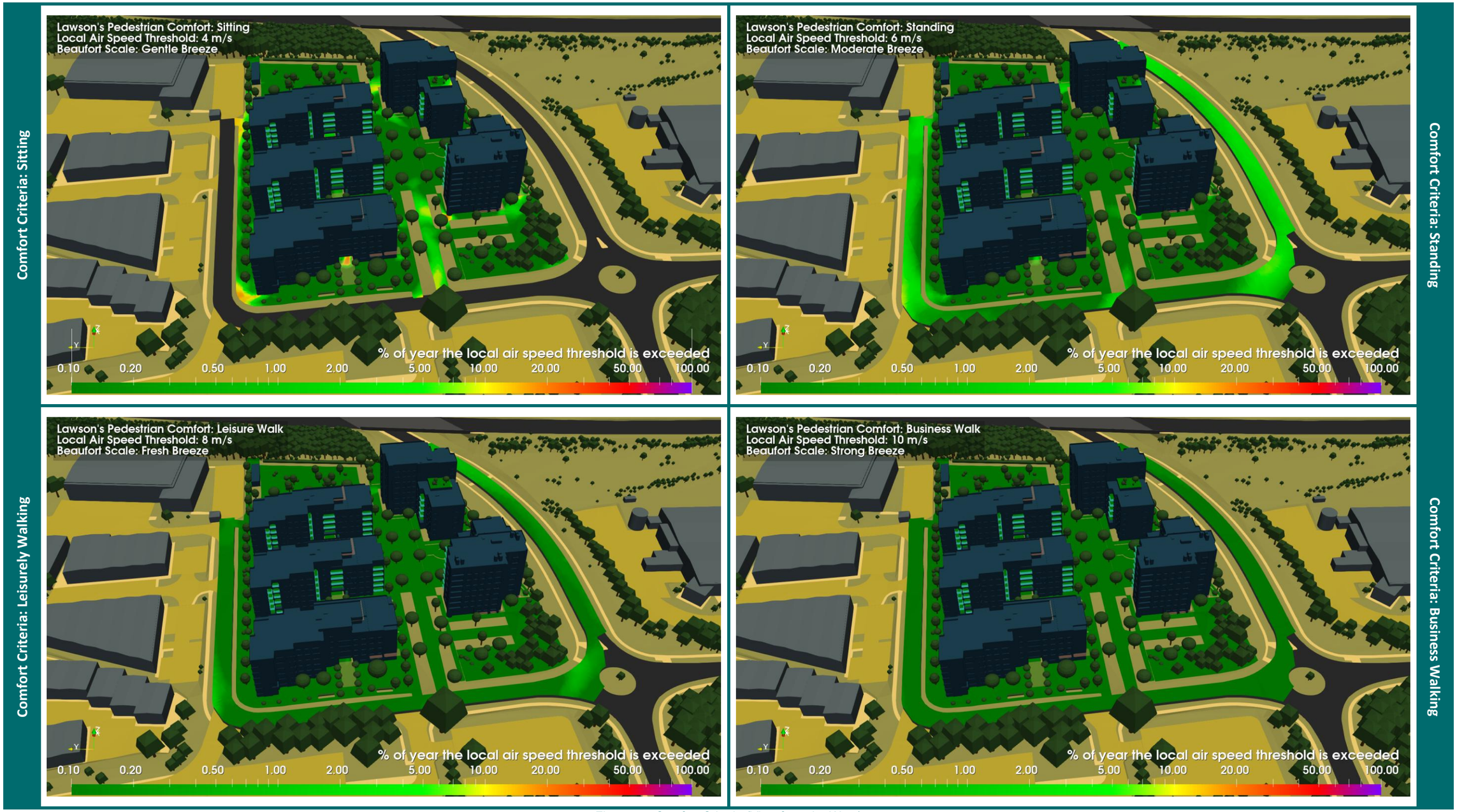
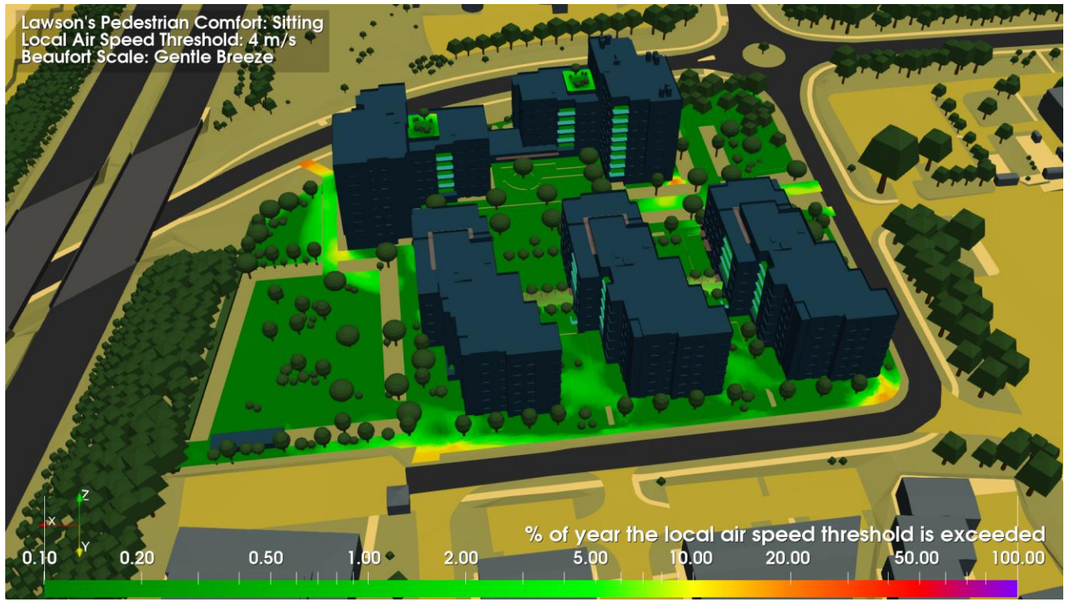
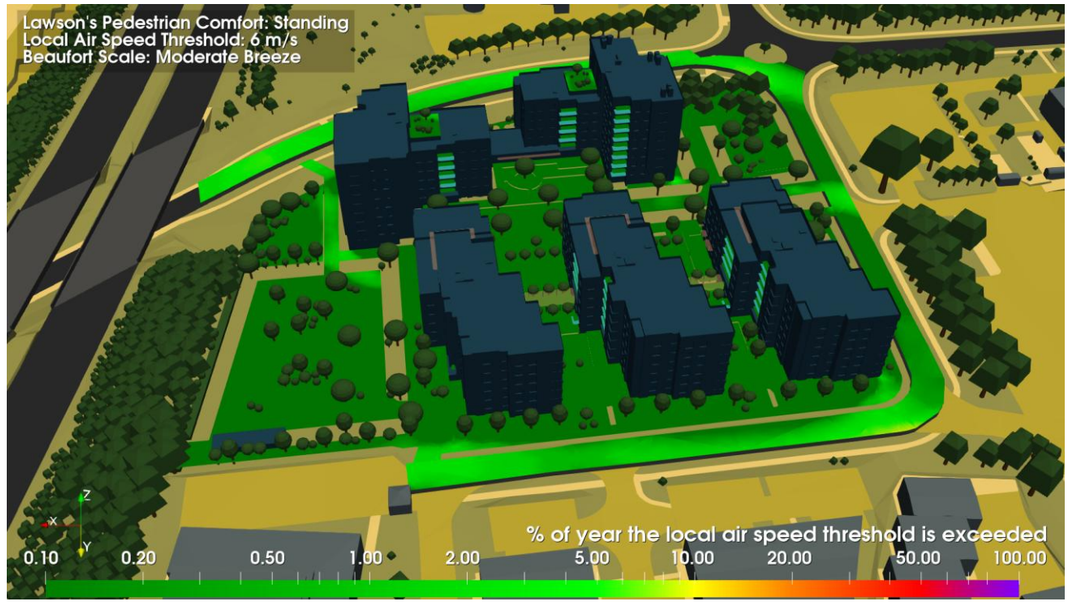


Figure 55: Comfort Criteria (View from the West)

Figure 56: Comfort Criteria (View from the Northwest)

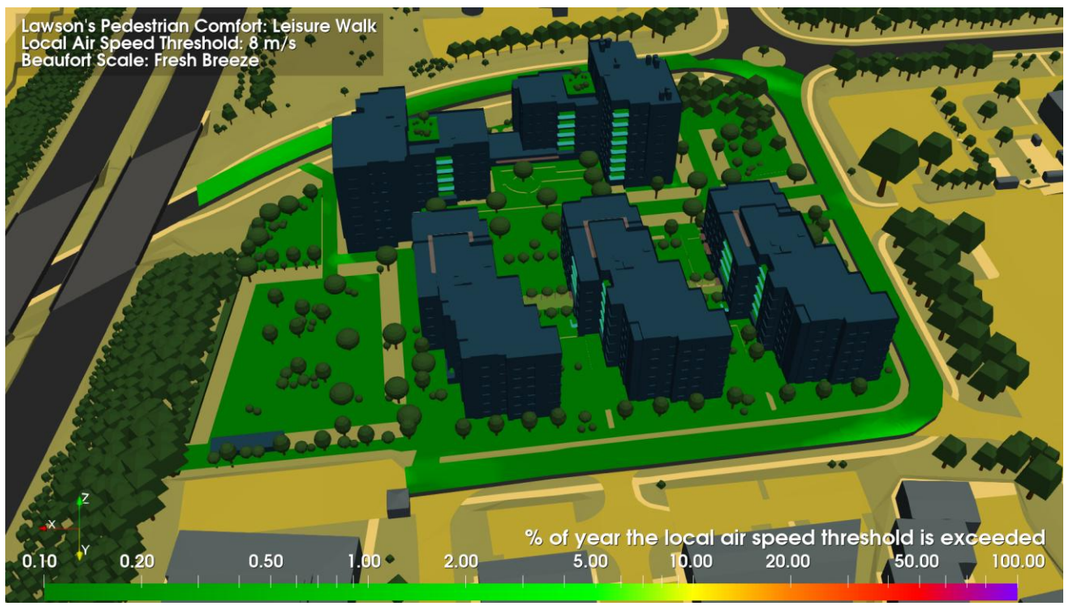
Comfort Criteria: Sitting

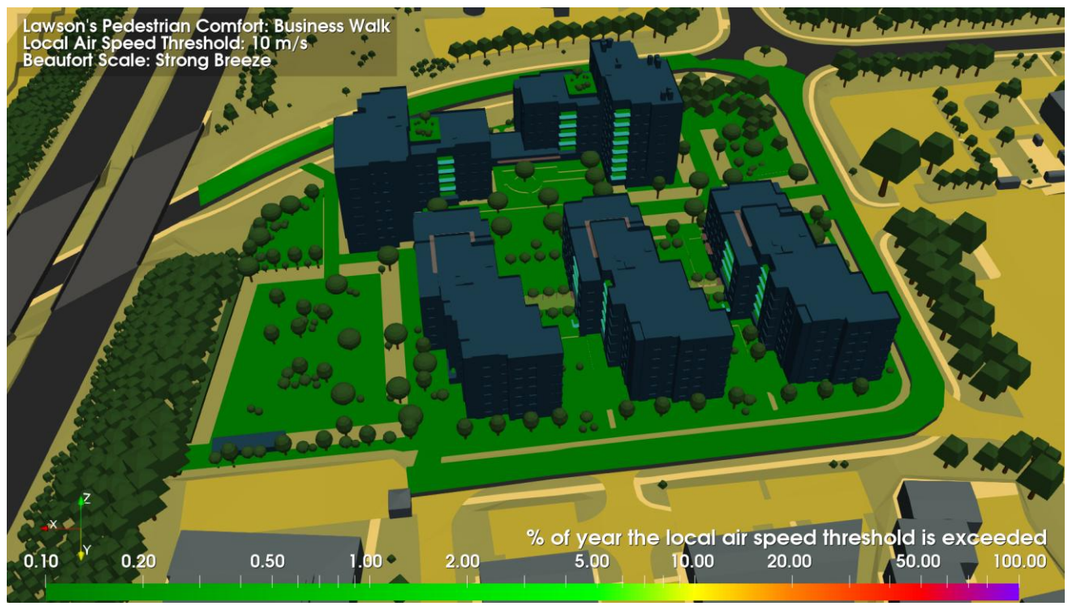




Comfort Criteria: Standing

Comfort Criteria: Leisurely Walking





Comfort Criteria: Business Walking

Figure 57: Comfort Criteria (View from the North)

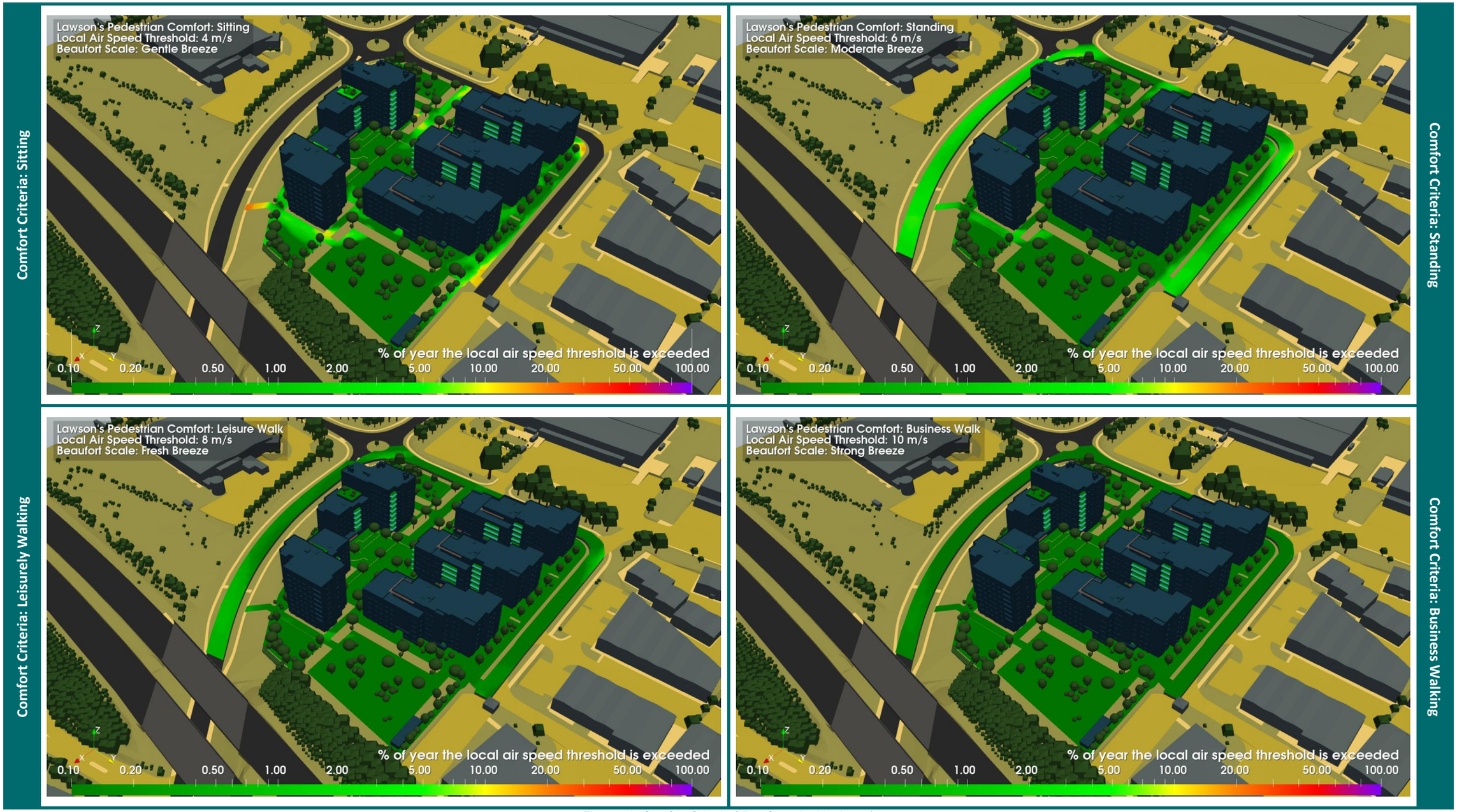


Figure 58: Comfort Criteria (View from the Northeast)

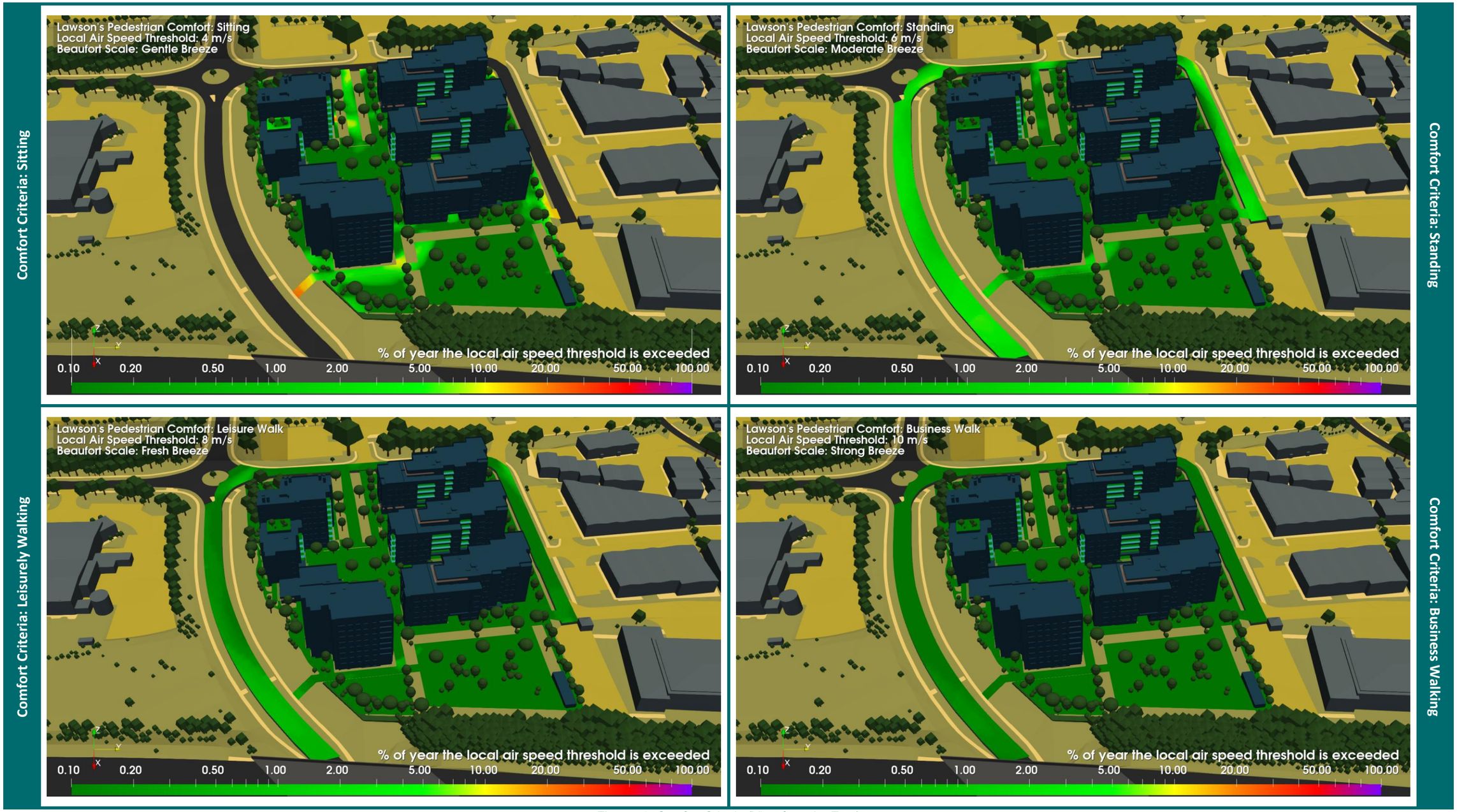


Figure 59: Comfort Criteria (View from the East)

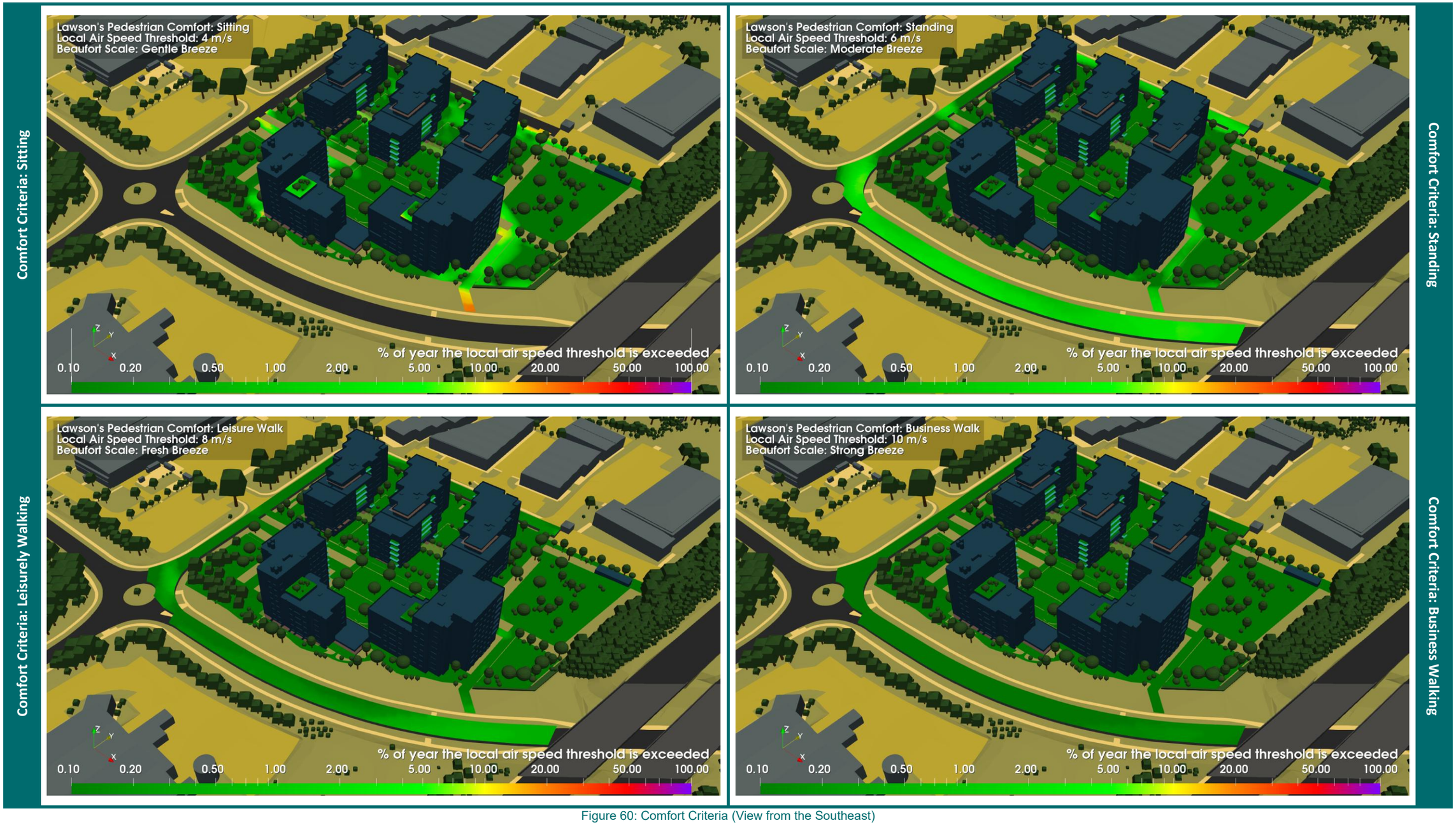


Figure 60: Comfort Criteria (View from the Southeast)

9.2 Safety Criteria

Figure 61 to Figure 69 illustrate the percentage of the year the hourly wind speed exceeds the threshold value for the safety criteria for all seasons. The threshold values are 20 m/s for a normal pedestrian and 15 m/s for a sensitive pedestrian.

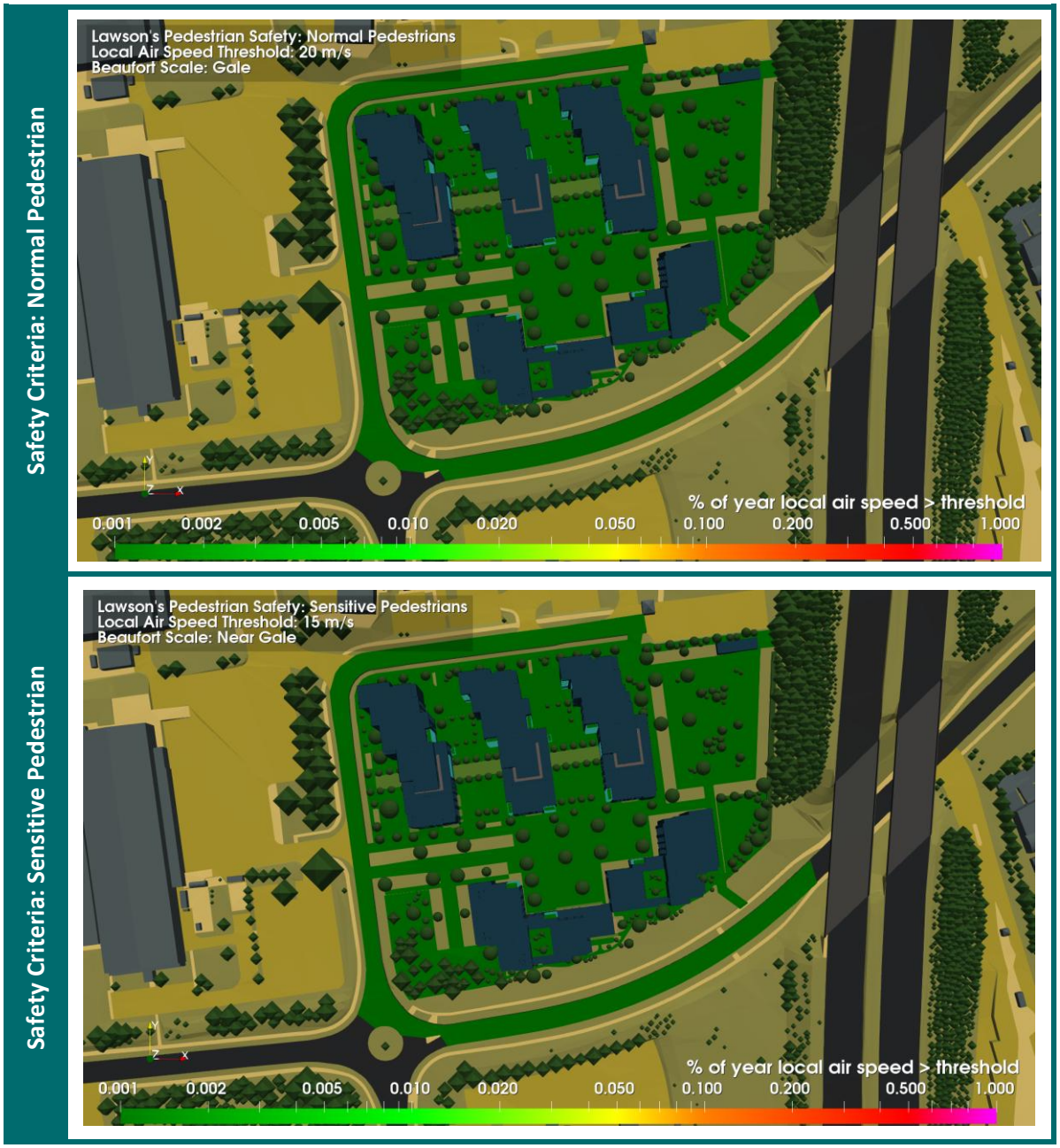


Figure 61: Safety Criteria (Plan View)

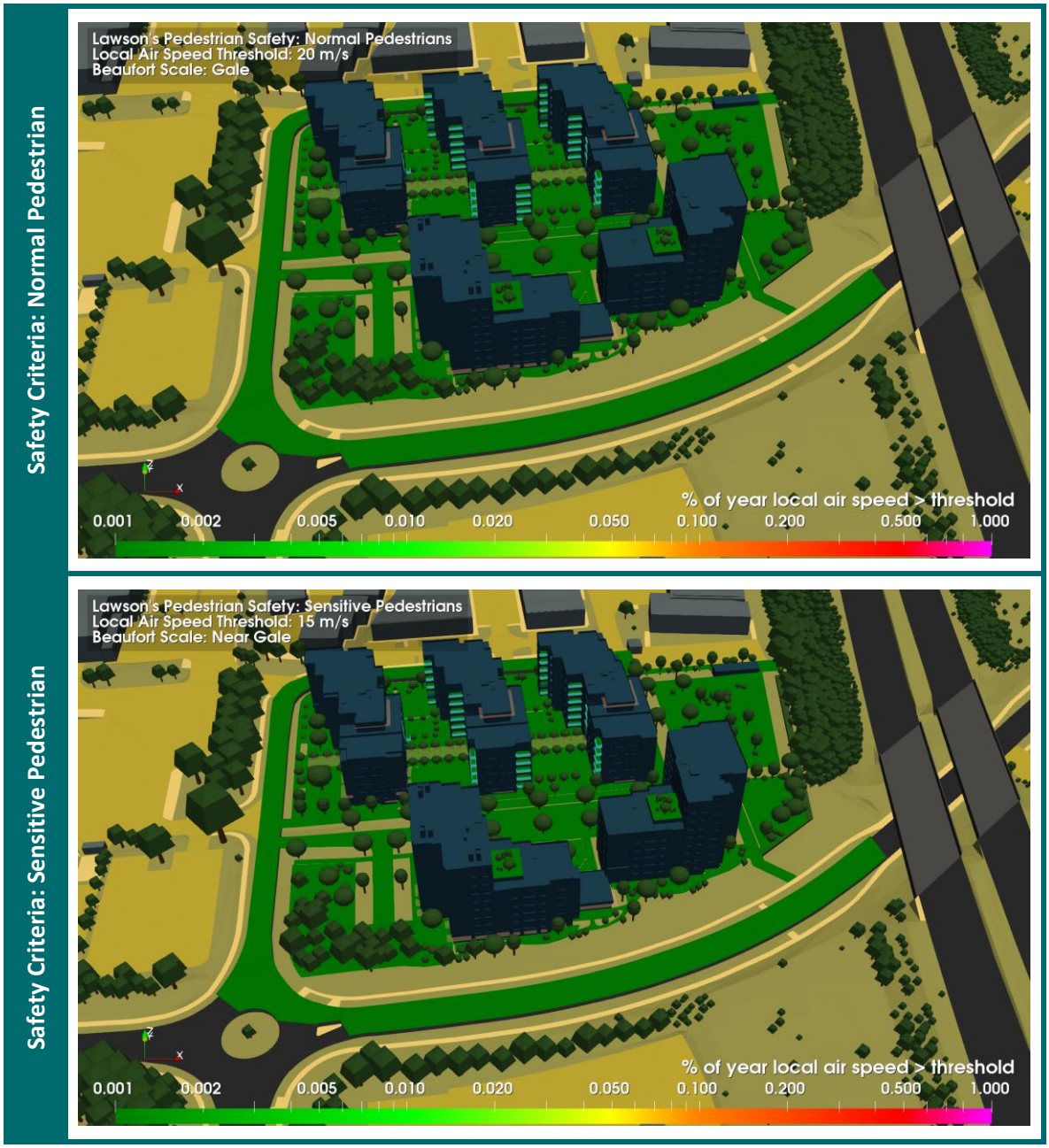


Figure 62: Safety Criteria (View from the South)

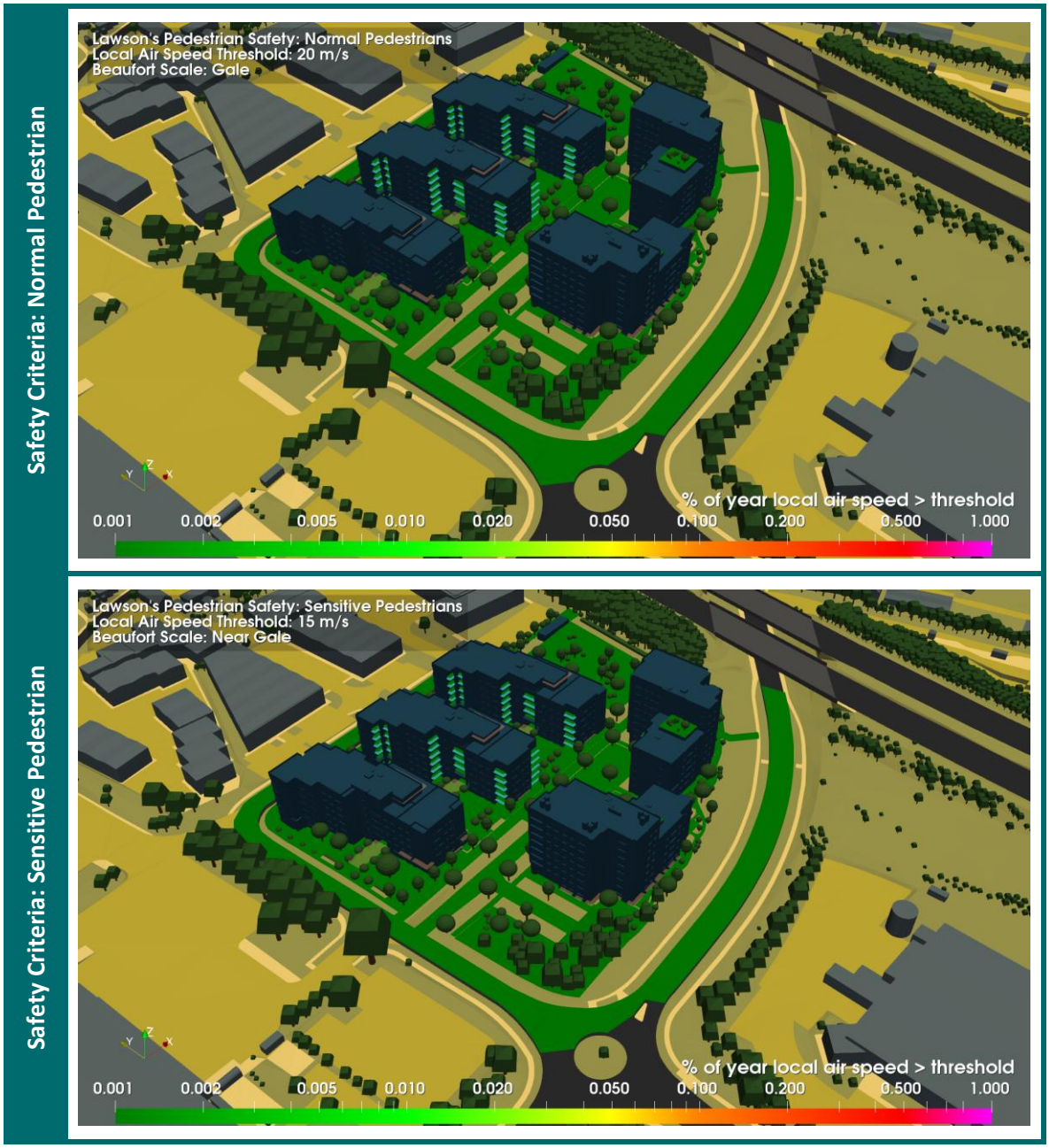


Figure 63: Safety Criteria (View from the Southwest)

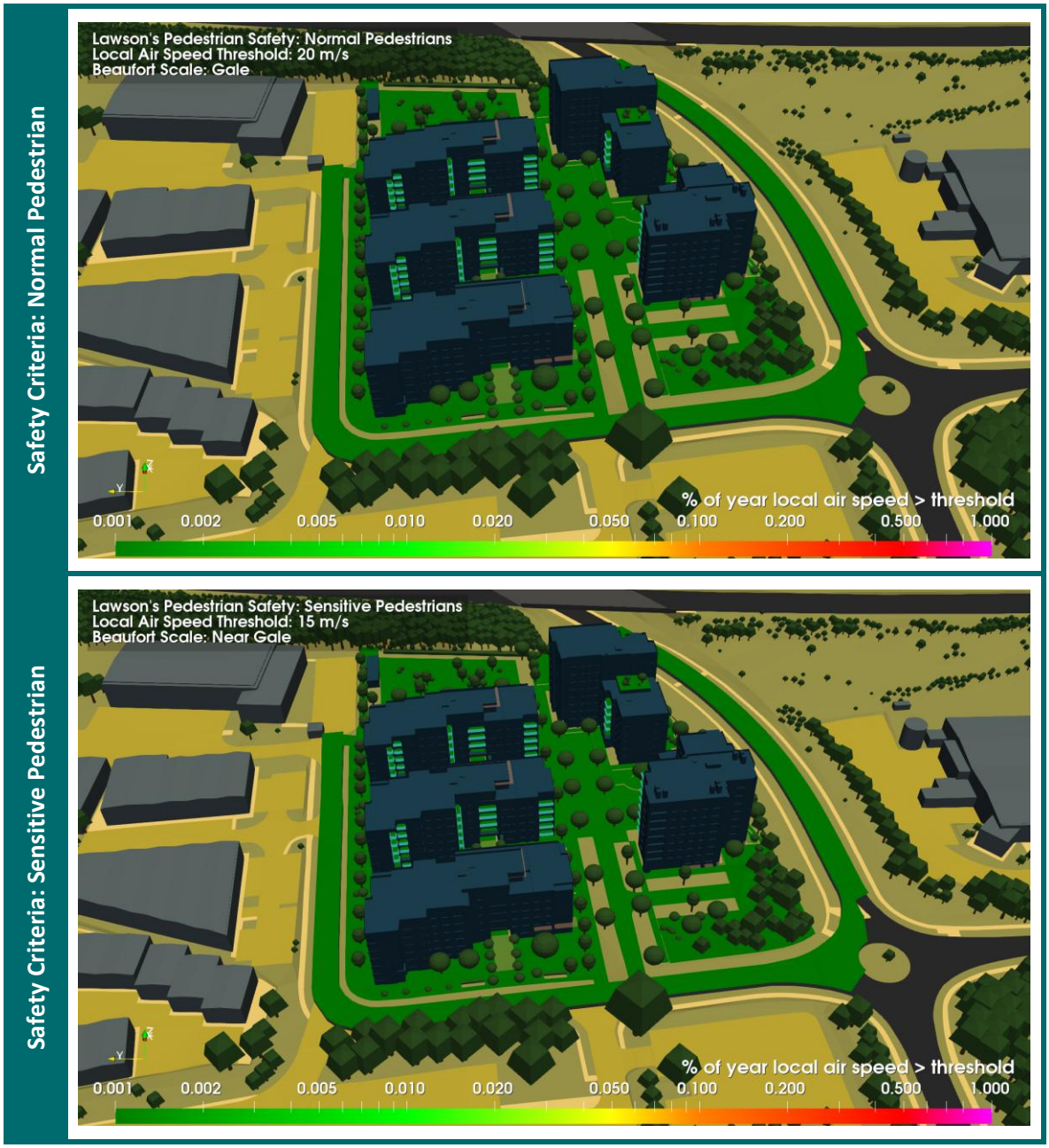


Figure 64: Safety Criteria (View from the West)

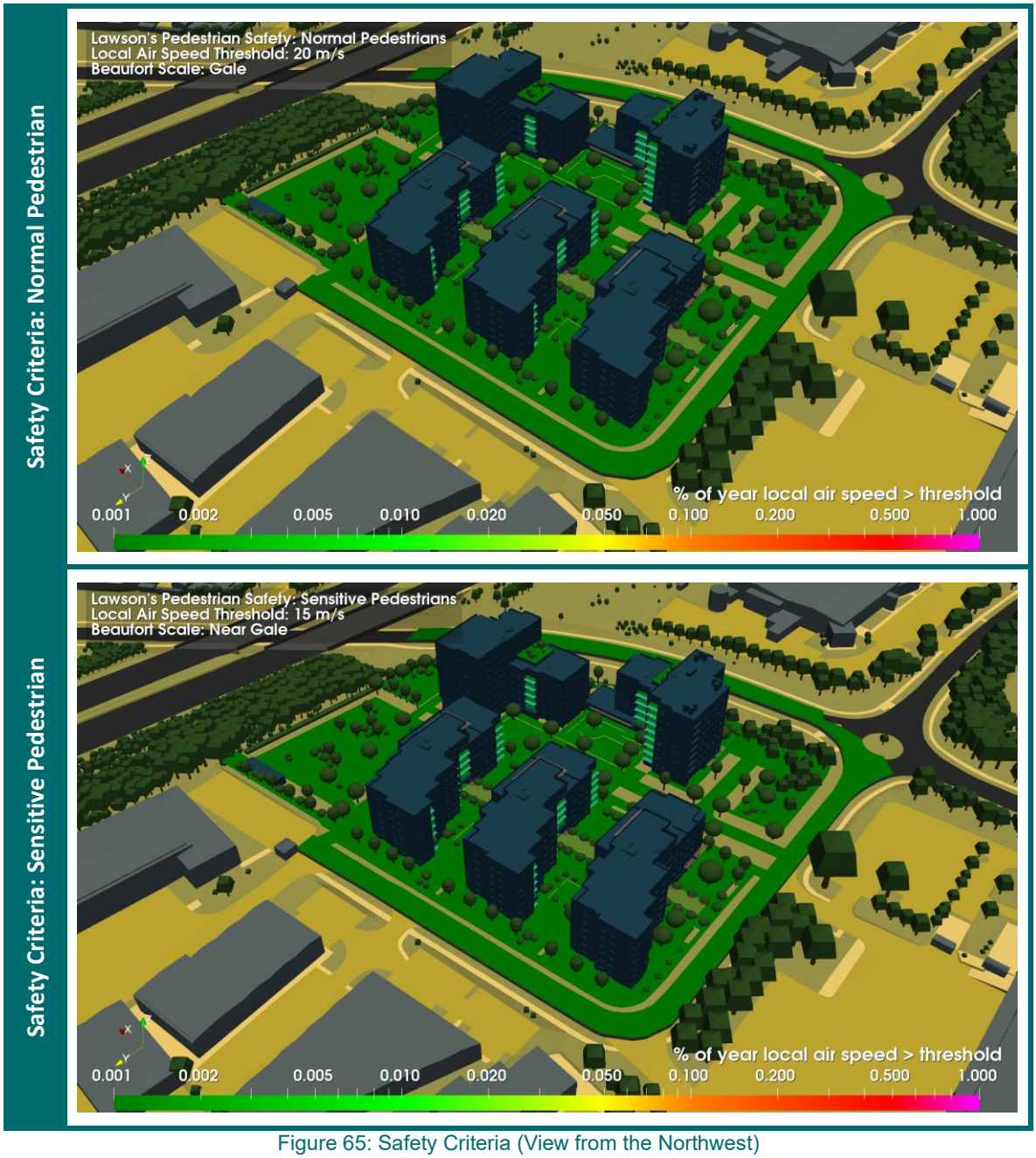


Figure 65: Safety Criteria (View from the Northwest)

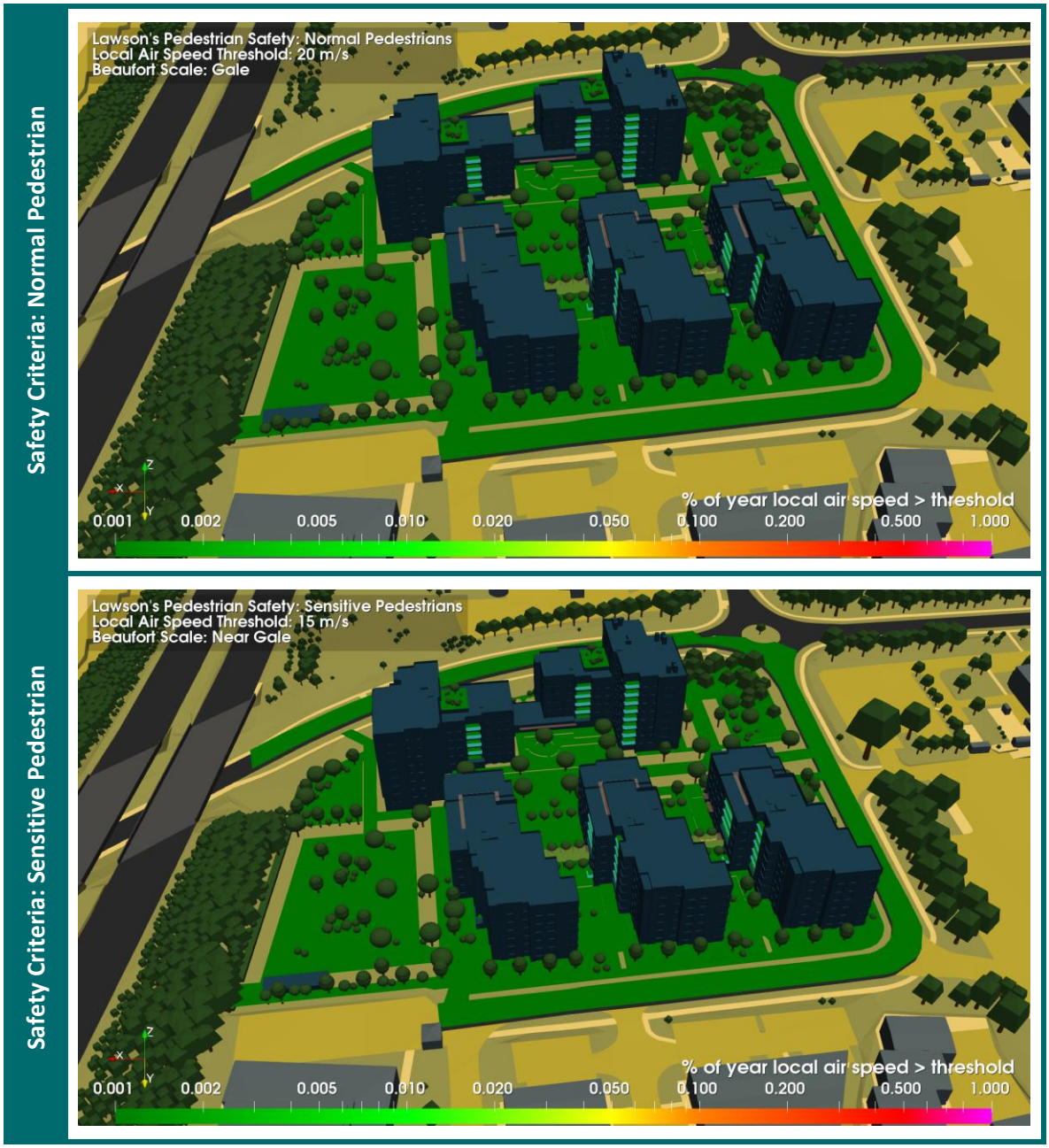


Figure 66: Safety Criteria (View from the North)

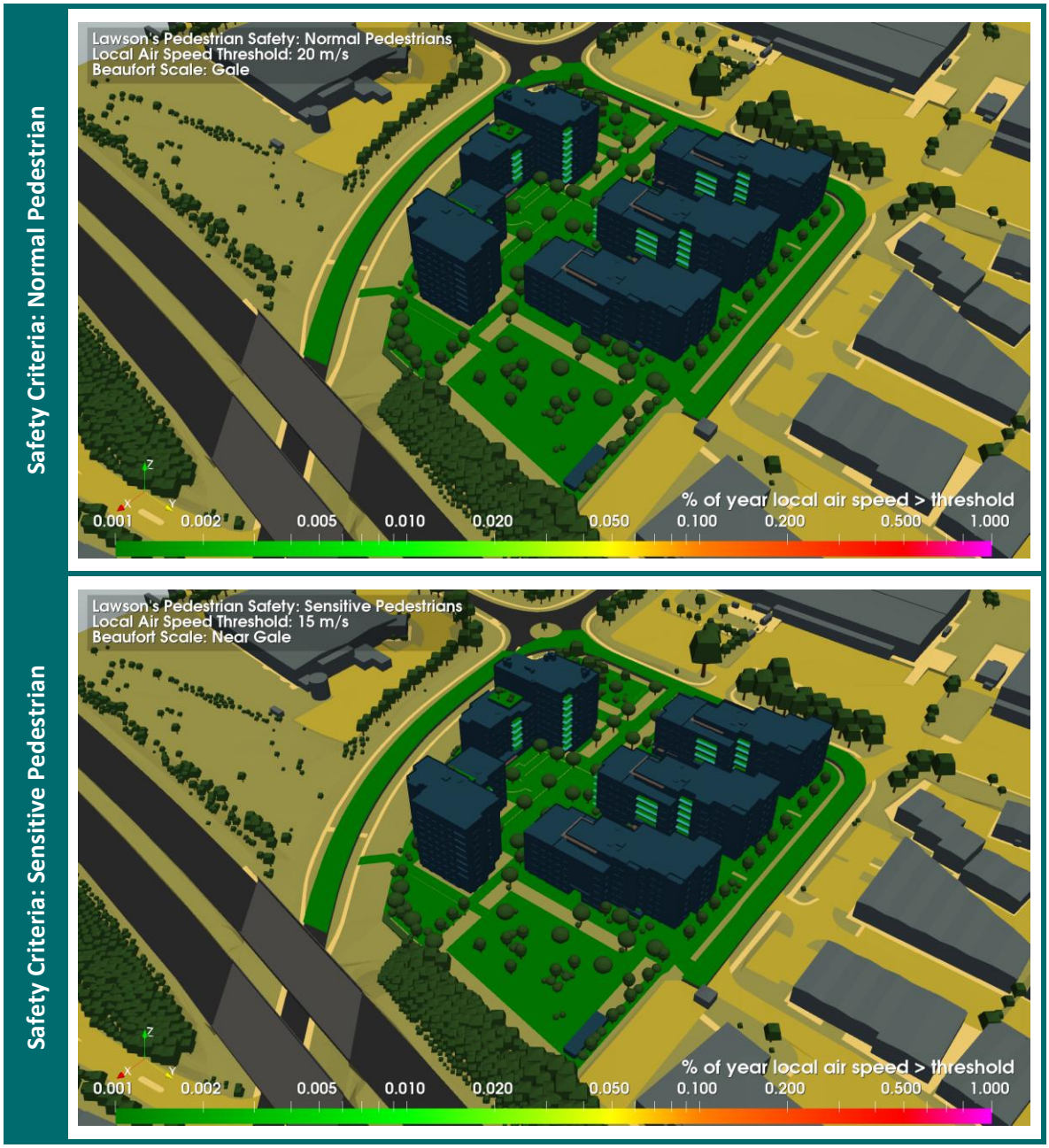


Figure 67: Safety Criteria (View from the Northeast)

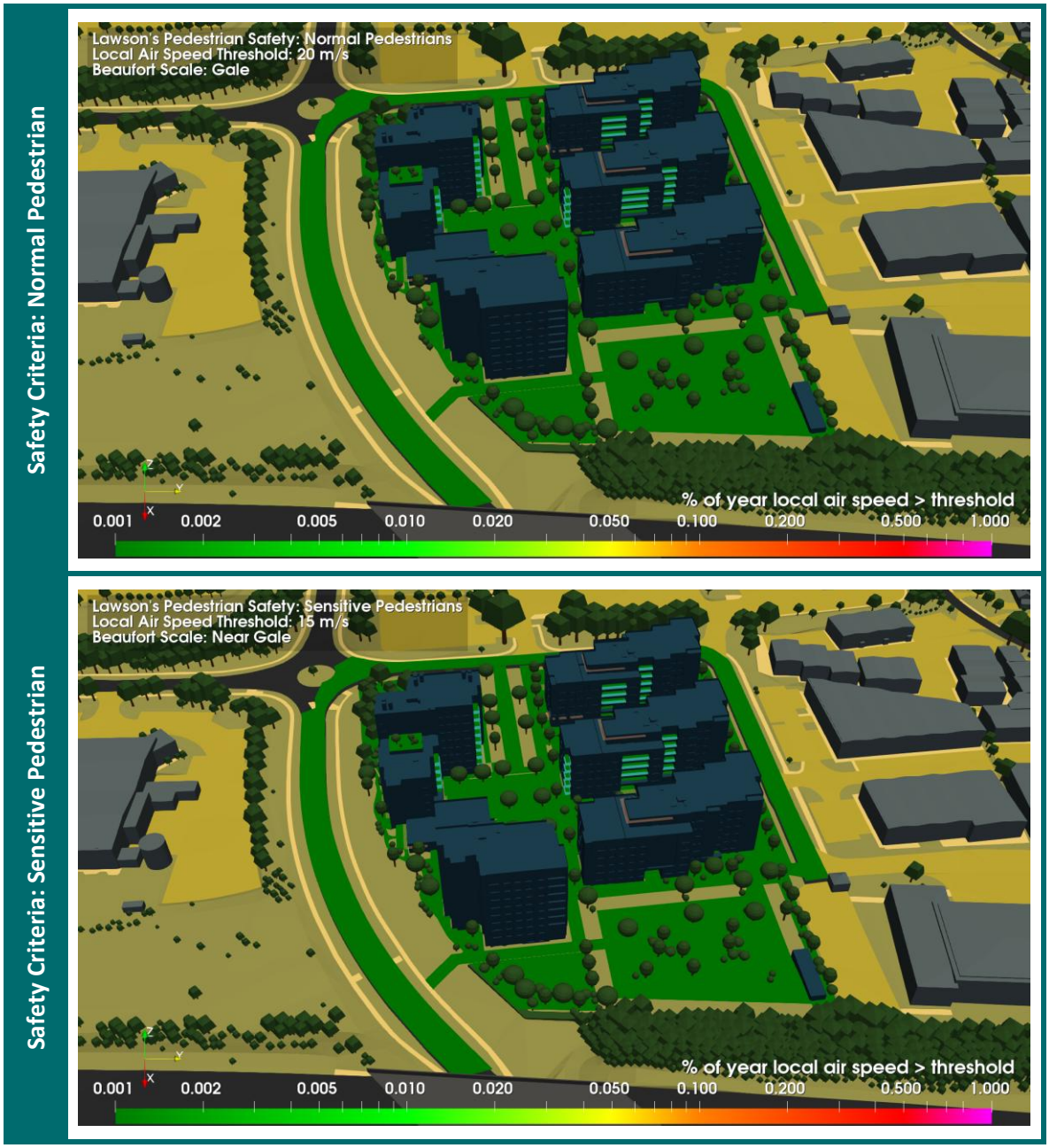


Figure 68: Safety Criteria (View from the East)

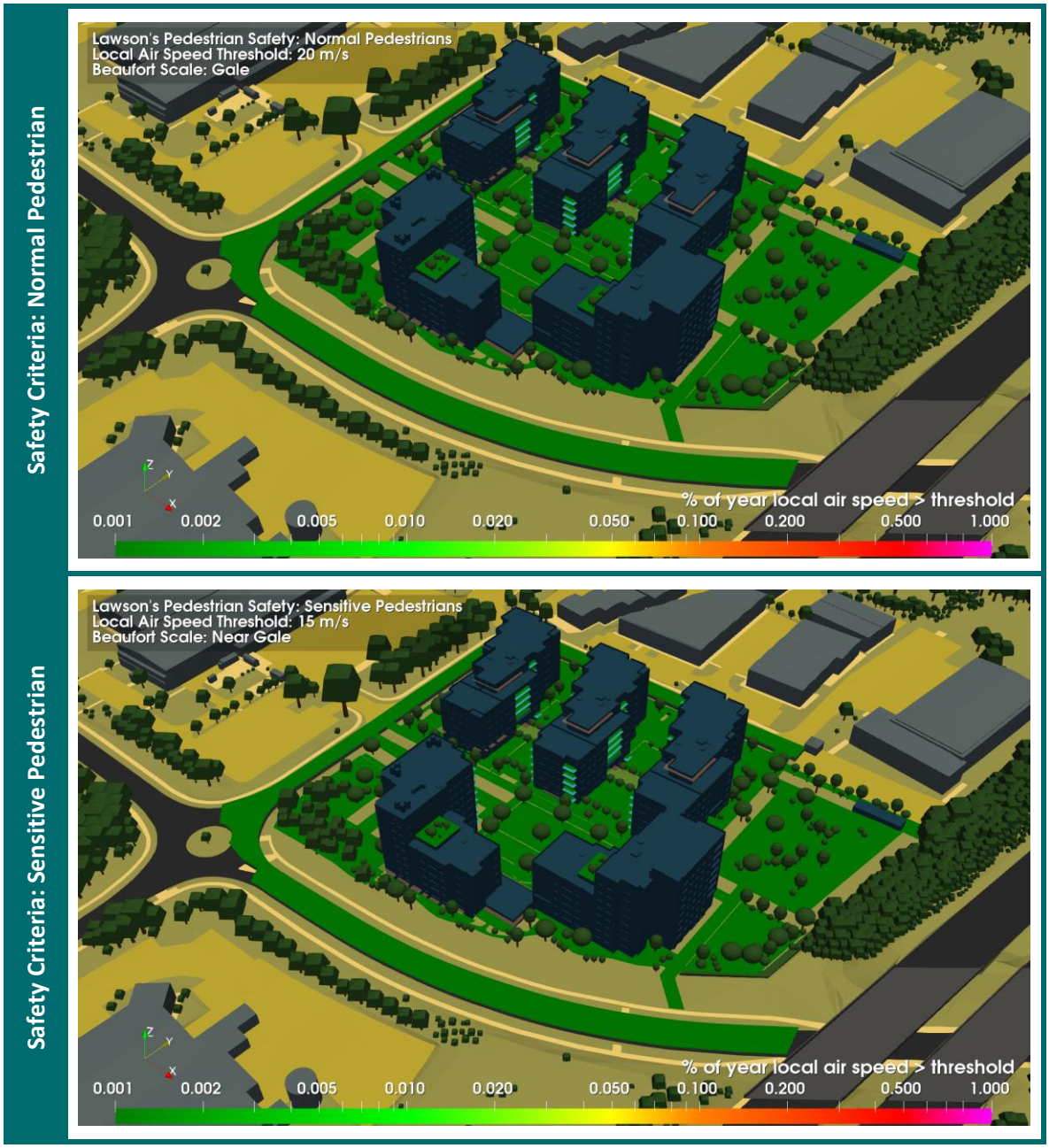


Figure 69: Safety Criteria (View from the Southeast)