INTEGRATED ENVIRONMENTAL SOLUTIONS

14359

John Players Wind EIAR

Pedestrian Comfort CFD Analysis

Report P4

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Figures

1 Executive Summary

Steady state CFD simulations were performed to study the impact of wind movement on pedestrian comfort at the proposed redevelopment of the former Player Wills site in Dublin.

For the analysis, 8 steady state CFD simulations were performed, one each for the 8 main wind directions – N, NE, E, SE, S, SW, W and NW. The wind speed was set to the annual average wind speed for Dublin. The wind was assumed to have the characteristics associated with wind flowing through a city centre.

The results obtained from these simulations were extrapolated along the annual weather data for Dublin 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 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 (m/s)
S1	Typical Pedestrian	20
S2	Sensitive Pedestrian	15

1.1 Sitting and Standing Comfort Results (C4 and C3)

The Lawson's sitting comfort criteria states that the local air speed at designated locations should not exceed 4m/s for more than 5% of the duration analysed. The Lawson's standing comfort criteria states that the local air speed at designated locations should not exceed 6m/s for more than 5% of the duration analysed.

The results of the annual analysis for sitting and standing criterion are observed in the top left hand and top right hand corner of images in section 7.1 respectively. The images of section 7.2 show the results of the analysis of sitting and standing criterion carried out for the warmer months of summer and autumn.

1.1.1 Ground Amenity Spaces

The site generally shows excellent compliance with the Lawson's Sitting Comfort Criteria. The wind speed across the site is generally lower than 4m/s for more than 95% of the year as per the sitting criterion's requirement.

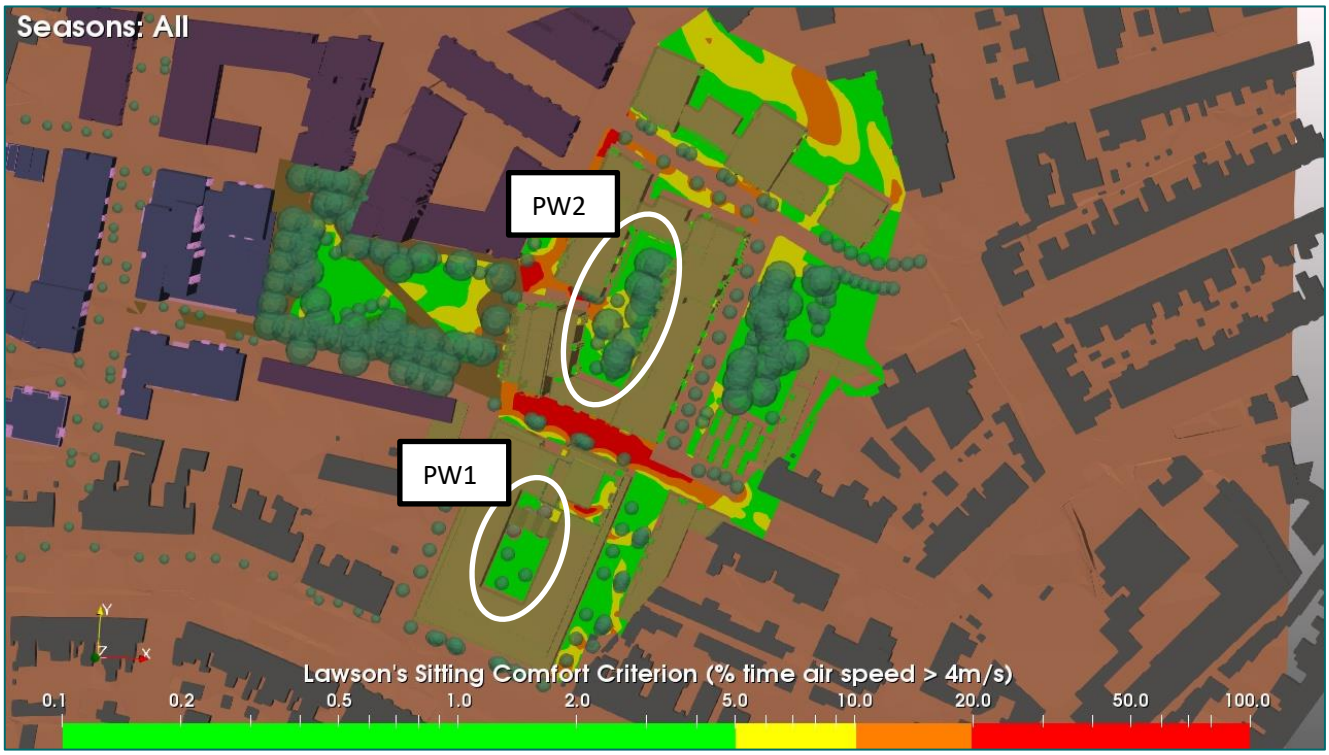


Figure 1: Sitting Comfort Criteria: Players Wills site

As observed in Figure 1, the courtyard of PW1 is quite compliant to the sitting and standing comfort criteria. Similarly, the courtyard of PW2 also shows good compliance with the sitting comfort criterion. The vegetation implemented in these areas helped to break the wind flow.

There are 2 locations where the sitting comfort criterion is exceeded. These locations are marked in white ovals in the Figure 2 below.

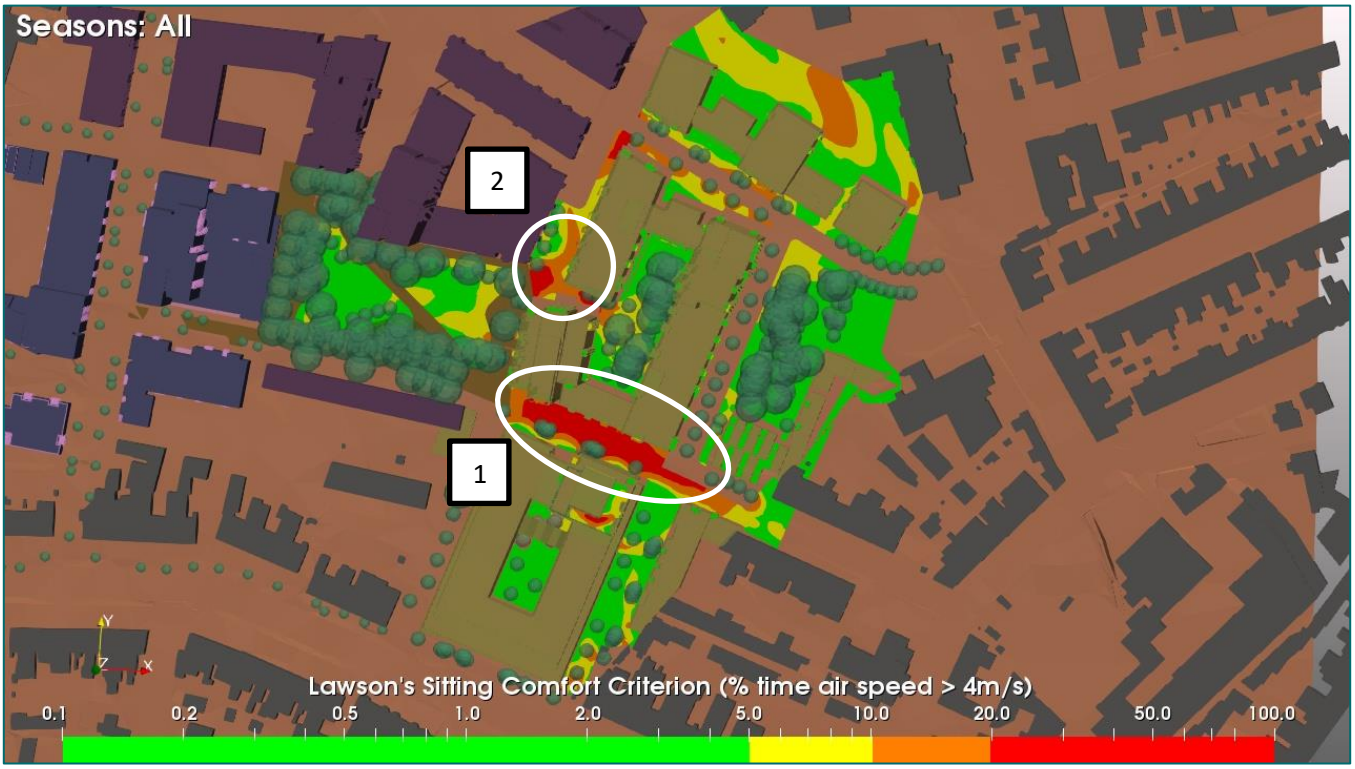


Figure 2: Sitting Comfort Criteria: Players Wills site

Figure 3: Standing Comfort Criteria: Players Wills site

The 1st location is the ground space between block PW1 and PW2. This passage is susceptible to the prevailing westerly and southwesterly winds causing a wind tunnel effect between the buildings.

The 2nd location is to the west side of the entrance to PW2 block. This passage is also subject to the same westerly and southwesterly wind but is accelerated by passing through tall trees present on the play amenity area.

Both Locations show much improved results for the standing comfort criterion as seen in Figure 3 where the threshold is 6m/s. So it can be deduced that even if the wind speed exceeds 4m/s, it is also unlikely to exceed 6m/s. Thus it can be concluded that it is generally acceptable for leisure activities.

1.1.2 Balconies

As observed in section 7.1, more than 95% of the balconies fully achieve the requirements of the Lawson's sitting comfort criterion for the full year. The wind speed is generally lower than 4m/s for more than 95% of the year as per the criterion's requirement.

Figure 4 and Figure 5 shows the north-west facing balconies of the PW2 block, for sitting and standing comfort results respectively.

We can observe these are marginally above the threshold of 4m/s for sitting criteria but are definitely under 6m/s of the standing criterion. We can infer when the air speed exceeds 4m/s, it is unlikely to exceed 6m/s. Thus, the exceedance of sitting criteria can be termed marginal and not major.

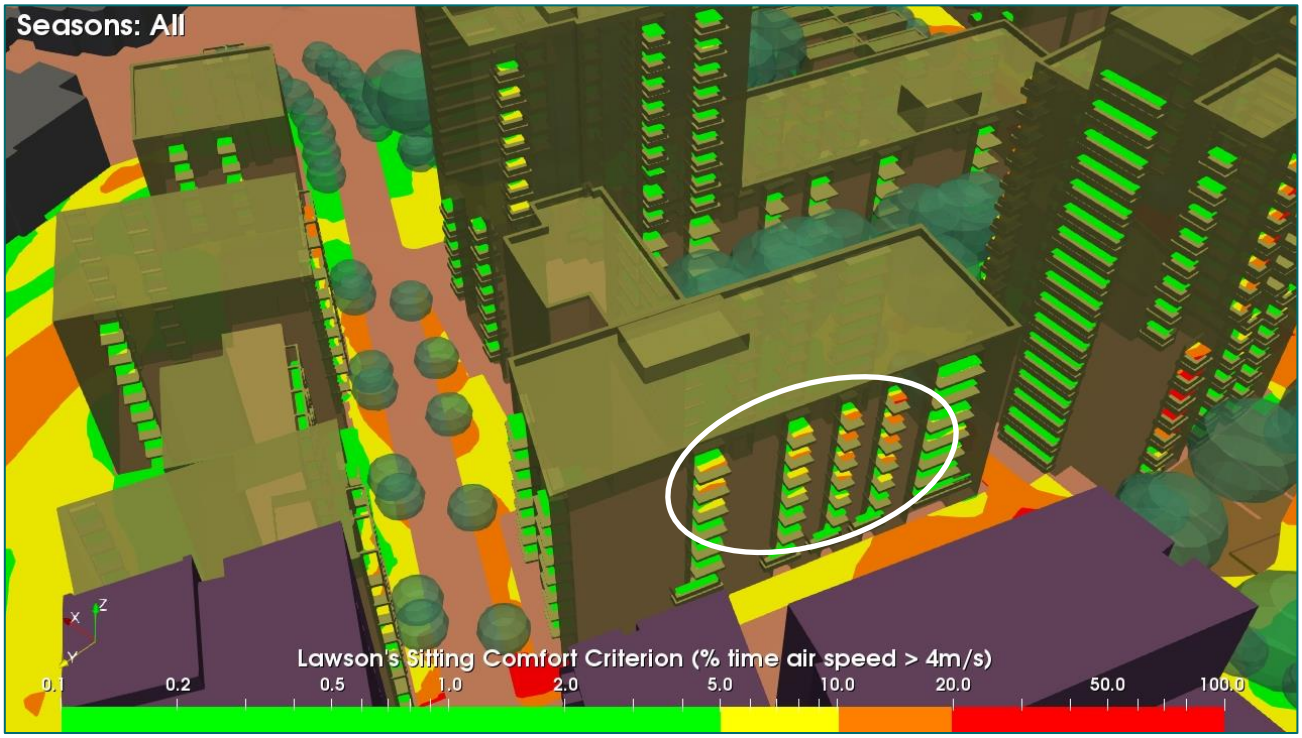


Figure 4: Sitting Comfort Criterion: balconies of block PW2

Figure 5: Standing Comfort Criterion: balconies of block PW2

Figure 6 and Figure 7 shows the south facing and east facing balconies of the Tower of PW2 block, for sitting and standing comfort results respectively.

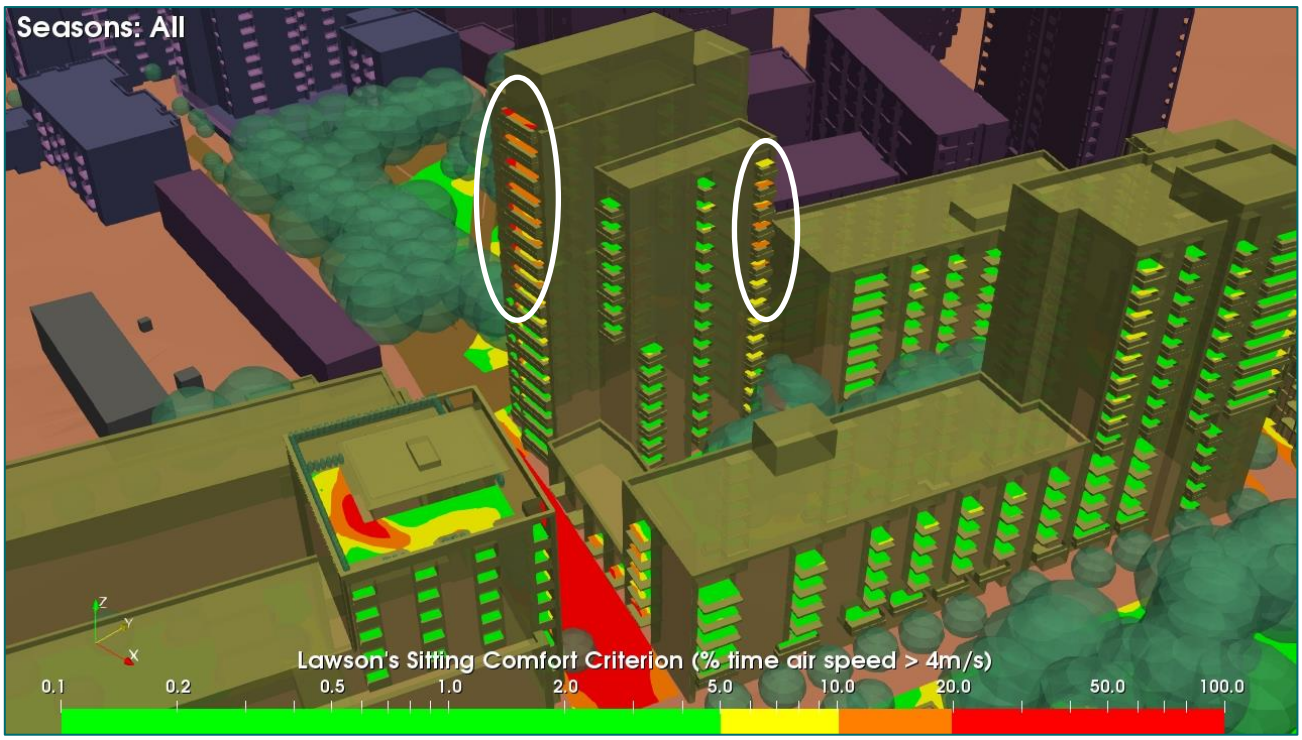


Figure 6: Sitting Comfort Criterion: balconies of block PW2

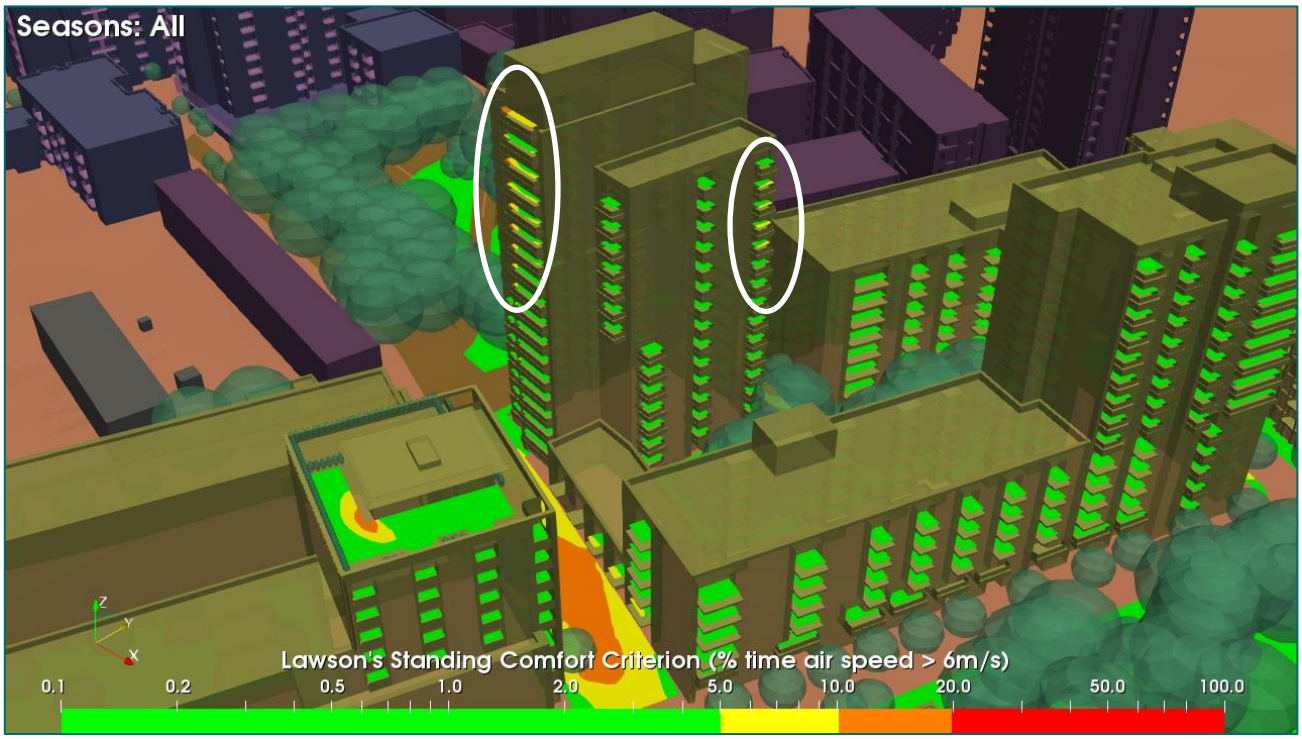


Figure 7: Standing Comfort Criterion: balconies of block PW2

These balconies are susceptible to the high-level winds flowing from the prevalent westerly and southwesterly direction. However, these are only marginally above the threshold of 4m/s for sitting criteria but are under 6m/s, which is a threshold for standing comfort. These balconies are effectively compliant to the standing comfort criteria.

Figure 8 and Figure 9 shows the west facing balconies of the Tower of PW2 block, for sitting and standing comfort results respectively.

Figure 8: Sitting Comfort Criterion: balconies of block PW2

Figure 9: Standing Comfort Criterion: balconies of block PW2

The balconies circled in yellow are susceptible to the winds flowing from the prevalent westerly and southwesterly direction. However, these are only marginally above the threshold of 4m/s for sitting criteria but are under 6m/s, which is a threshold for standing comfort. These balconies are effectively compliant to the standing comfort criteria.

The lower level balconies circled in white are also subject to prevalent westerly and southwesterly wind. The wind is accelerated by passage through tall trees present nearby the play garden amenity area. These are above the threshold of 4m/s for sitting criterion. These balconies are also marginally above the threshold of 6m/s for standing criterion. Increasing the height of protective screen to 1.1m from current 0.8m could help to reduce the impact of wind.

1.1.3 Roof Amenities

Roof amenities of PW4 block shows excellent compliance with the Lawson's Sitting and Standing Comfort Criteria.

Figure 10 and Figure 11 below shows the roof space of PW1 block, for sitting and standing comfort results respectively.

Figure 10: Sitting Comfort Criterion: balconies of block PW2

Figure 11: Standing Comfort Criterion: balconies of block PW2

The roof space shows limited compliance to the sitting comfort criterion. The wind speed exceeded the threshold value of 4m/s but it is under the threshold value of 6m/s, which is criteria for standing comfort criteria. The roof space is subject to direct wind flowing from prevalent westerly direction. The roof space can be considered marginally compliant with the sitting criterion.

1.2 Walking Comfort Results (C1 & C2)

The Lawson's Leisure Walking comfort criteria states that the local air speed at designated locations should not exceed 8m/s for more than 5% of the duration analysed. The Lawson's Business Walking comfort criteria stipulates that the local air speed at designated locations should not exceed 10m/s for more than 5% of the duration analysed.

The results of the annual analysis for walking criteria are observed in the bottom images in section 7.1. The site generally shows excellent compliance with the Lawson's Leisure and Business Walking Comfort Criteria.

1.3 Safety Criteria Results (S1 & S2)

The Lawson's Normal Pedestrian safety criteria stipulates that the local air speed at designated locations should not exceed 20m/s for more than 0.01% of the duration analysed. The Lawson's Sensitive Pedestrian safety criteria stipulates that the local air speed at designated locations should not exceed 15m/s for more than 0.01% of the duration analysed.

The site shows excellent compliance with both of the safety criteria – normal and sensitive pedestrians. The Sensitive pedestrian safety criterion applies to the vulnerable people like OAP and children.

2 Development Description

DBTR-SCR1 Fund, a Sub-Fund of the CWTC Multi Family ICAV intend to apply to An Bord Pleanála for permission for a mixed-use Build to Rent Strategic Housing Development at the former 'Player Wills' site (2.39 hectares) and adjoining lands (0.67 hectares) under the control of Dublin City Council. A public park, public road and works to South Circular Road and to facilitate connections to municipal services at Donore Avenue are proposed on the Dublin City Council land. The former 'Player Wills' site incorporates Eircode's: D08 T6DC, D08 PW25, D08 X7F8 and D08 EK00 and has frontage onto South Circular Road, St. Catherine's Avenue and Donore Avenue, Dublin 8. The Dublin City Council undeveloped land adjoins the former 'Player Wills' site to the west and the former 'Bailey Gibson' site to the east. The total area of the proposed development site is 3.06 hectares.

The design rationale is to create and deliver a high quality, sustainable, residential led mixed use strategic housing development within this inner city brownfield site which respects its setting and maximises the site's natural attributes while achieving maximum efficiency of existing infrastructure. The Proposed Site Layout is illustrated on Drawing No. PL0003 contained within the architectural suite of drawings.

The development will consist of;

i. the demolition of all buildings (15,454 sq.m GFA), excluding the original fabric of the former Player Wills Factory, to provide for the development of a mixed use(residential, community, arts and culture, creche, food and beverage and retail) scheme comprising predominantly build to rent apartment dwellings (492 no.) together with a significantly lesser quantity of single occupancy shared accommodation private living areas (240 no.), with an average private living floor area of 24.6 sq.m (double the minimum private living space size required for single occupancy shared accommodation) and a arts/culture/community hub within the repurposed ground floor of the former factory building;

ii. change of use, refurbishment, modifications and alterations to the former Player Wills Factory building (PW1) to include the removal of 1 no. later addition storey (existing 4th storey) and the later addition rear (northern) extension, retention and modification of 3 no. existing storeys and addition of 2 no. storeys set back on the building's south, east and west elevations with an 8-storey projection (max. height 32.53m) on the north eastern corner, with a cumulative gross floor area of 17,630 sq.m including ancillary uses, comprising;

   a. at ground floor 852 sq.m of floor space dedicated to community, arts and cultural and exhibition space together with artist and photography studios (Class 1 and Class 10 Use), 503 sq.m of retail floor space (Class 1 Use), 994 sq.m of café/bar/restaurant floor space, 217 sq.m of co-working office floor space (Class 3 Use) and ancillary floor space for welfare facilities, waste management and storage;

   b. 240 no. single occupancy shared accommodation private living areas, distributed over levels 1-4, including 2 no. rooms of 30 sq.m, 49 no. rooms of 25 sq.m; 14 no. rooms of 23 sq.m, 58 no. rooms of 22.5 sq.m, 8 no. rooms of 20 sq.m, 104 no. rooms of 19 sq.m and 5 no. disabled access (Part M) rooms (3 no. 32 sq.m and 2 no. 26 sq.m); 21 no. kitchen/dining areas, and, 835 sq.m of dedicated shared accommodation services, amenities and facilities distributed across levels 1-4, to accommodate uses including lounge areas, entertainment (games) area, 2 no. external terraces (Level 03 and 04), laundry facilities, welfare facilities and waste storage;

   c. 47 no. build-to rent apartments distributed across levels 1-7 including 12 no. studio apartments; 23 no. 1 bed apartments, 8 no. 2 bed apartments: and, 4 no. 3-bed apartments;

   d. 1,588 sq.m of shared (build to rent and shared accommodation) services, amenities and facilities including at ground floor reception/lobby area, parcel room, 2 no. lounges and administration facilities; at Level 01 entertainment area, TV rooms, entertainment (games room), library, meeting room, business centre; at Level 02 gym and storage and at Level 07, a lounge area.

   e. Provision of communal amenity outdoor space as follows; PW1 - 450 sq.m in the form of roof terraces dedicated to shared accommodation and 285 sq.m roof terrace for the proposed apartments .

   f. a basement (190 sq.m) underlying the proposed 8-storey projection to the northeast of PW1 to accommodate plant.

iii. the construction of 445 no. Build to Rent apartment units, with a cumulative gross floor area of 48,455 sq.m including ancillary uses distributed across 3 no. blocks (PW 2, 4 and 5) comprising;
   a. PW2 (45,556 sq.m gross floor area including ancillary uses) - 415 no. apartments in a block ranging in height from 2-19 storeys (max. height 63.05m), incorporating 16 no. studio units; 268 no. 1 bed apartments, 93 no. 2 bed apartments and 38 no. 3-bed apartments. At ground floor, 2 no. retail unts (combined 198 sq.m) (Class 1 use), and a café/restaurant (142 sq.m). Tenant services, amenities and facilities (combined 673 sq.m) distributed across ground floor (lobby, mail room, co-working and lounge area), Level 06 (terrace access) and Level 17 (lounge). Provision of communal amenity open space including a courtyard of 1,123 sq.m and roof terraces of 1,535 sq.m
   b. Double basement to accommodate car parking, cycle parking, waste storage, general storage and plant.
   c. PW4 (1,395 sq.m gross floor area including ancillary uses) - 9 no. apartments in a part 2-3 storey block (max. height 10.125m) comprising, 2 no. 2-bed duplex apartment units and 7 no. 3-bed triplex apartment units. Provision of communal amenity open space in the form of a courtyard 111 sq.m
   d. PW5 (1,504 sq.m gross floor area including ancillary uses) - 21 no. apartments in a 4 storey block (max. height 13.30m) comprising 12 no. studio apartments, 1 no. 1-bed apartment, 5 no. 2-bed apartments, and 3 no. 3-bed apartments. Provision of communal amenity space in the form of a courtyard 167sq.m. Provision of communal amenity open space in the form of a courtyard 167 sq.m

iv. the construction of a childcare facility (block PW4) with a gross floor area of 275 sq.m and associated external play area of 146 sq.m;

v. the provision of public open space with 2 no. permanent parks, 'Players Park' (3,960 sq.m) incorporating active and passive uses to the northwest of the former factory building on lands owned by Dublin City Council; 'St. Catherine's Park' (1,350 sq.m)a playground, to the north east of the Player Wills site adjacent to St. Catherine's National School. A temporary public park (1,158 sq.m) to the northeast of the site set aside for a future school extension. The existing courtyard (690 sq.m) in block PW1 (former factory building) to be retained and enhanced and a public plaza (320 sq.m) between proposed blocks PW and PW4.

vi. 903 no. long-stay bicycle parking spaces, with 861 no. spaces in the PW2 basement and 42 no. spaces at ground level in secure enclosures within blocks PW4 and PW5. 20 no. spaces reserved for non-residential uses and 110 no. short-stay visitor bicycle spaces provided at ground level.

vii. 4 no. dedicated pedestrian access points are proposed to maximise walking and cycling, 2 no. from South Circular Road, 1 no. from St. Catherine's Avenue and 1 no. from Donore Avenue.

viii. in the basement of PW2, 148 no. car parking spaces to serve the proposed build to rent apartments including 19 no. dedicated disabled parking spaces and 6 no. motorcycle spaces. 20 no. spaces for a car sharing club ('Go Car' or similar). 10% of parking spaces fitted with electric charging points.

ix. in the basement of PW2, use for 81 no. car parking spaces (1,293 sq.m net floor area) including 5 no. dedicated disabled parking spaces, 3 no. motorcycle spaces and 10% of parking spaces fitted with electric charging points to facilitate residential car parking associated with future development on neighbouring lands. The area will not be used for carparking without a separate grant of permission for that future development. In the alternative, use for additional storage (cage/container) for residents of the proposed development.

x. 37 no. surface level car parking spaces including 3 no. disabled access and 3 no. creche set down spaces and 10% fitted with electric charging points. 2 no. loading bays and 2 no. taxi set-down areas.

xi. development of internal street network including a link road (84m long x 4.8m wide) to the south of the proposed 'Players Park' on land owned by Dublin City Council that will provide connectivity between the former 'Bailey Gibson' site and the 'Player Wills' site.

xii. vehicular access will be provided via Donore Avenue with a one-way exit provided onto South Circular Road to the east of block PW1(the former factory building);

xiii. replacement and realignment of footpaths to provide for improved pedestrian conditions along sections of Donore Avenue and South Circular Road and realignment of centreline along sections of Donore Avenue with associated changes to road markings;

xiv. a contra-flow cycle lane is proposed at the one-way vehicular exit to the east of PW1 (former factory building) to allow 2-way cycle movements via this access point;

xv. decommissioning of existing 2 no. ESB substations and the construction of 2 no. ESB substations and associated switch rooms, 1 no. single ESB substation in PW 1 (43.5 sq.m) and 1 no. double ESB substation in PW2 (68 sq.m);

xvi. the construction of a waste and water storage building (combined 133 sq.m, height 4.35m) to the west of building PW1;

xvii. all ancillary site development works; drainage, rooftop solar photovoltaics (20 no. panels total), landscaping, boundary treatment and lighting.

3 Weather Data

The analysis is based on the 'DublinIWEC.epw' weather file. The variation of wind speed recorded in the weather file is shown in Figure 12 below. Figure 13 shows the wind direction variation and Figure 14 shows the wind rose.

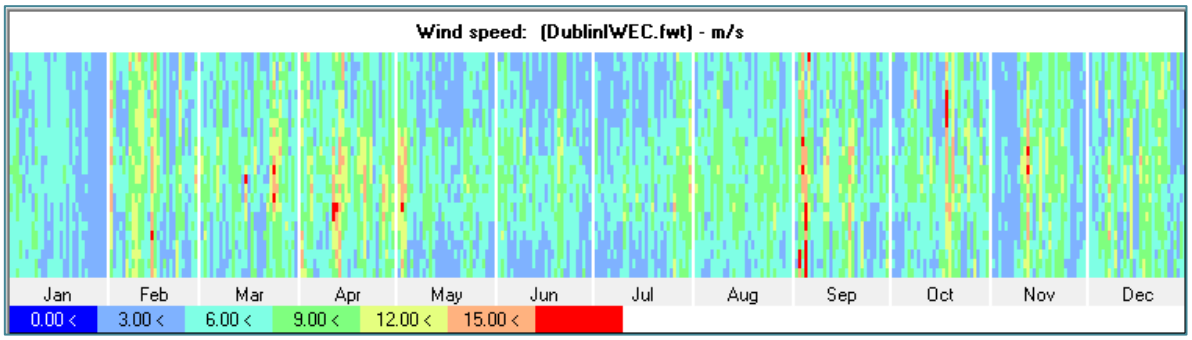


Figure 12: Wind speed variation as per DublinIWEC.epw

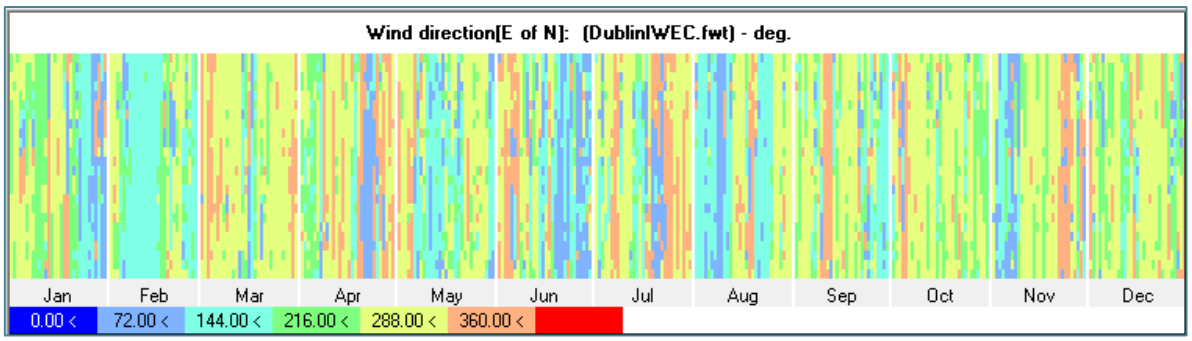


Figure 13: Wind direction variation as per DublinIWEC.epw

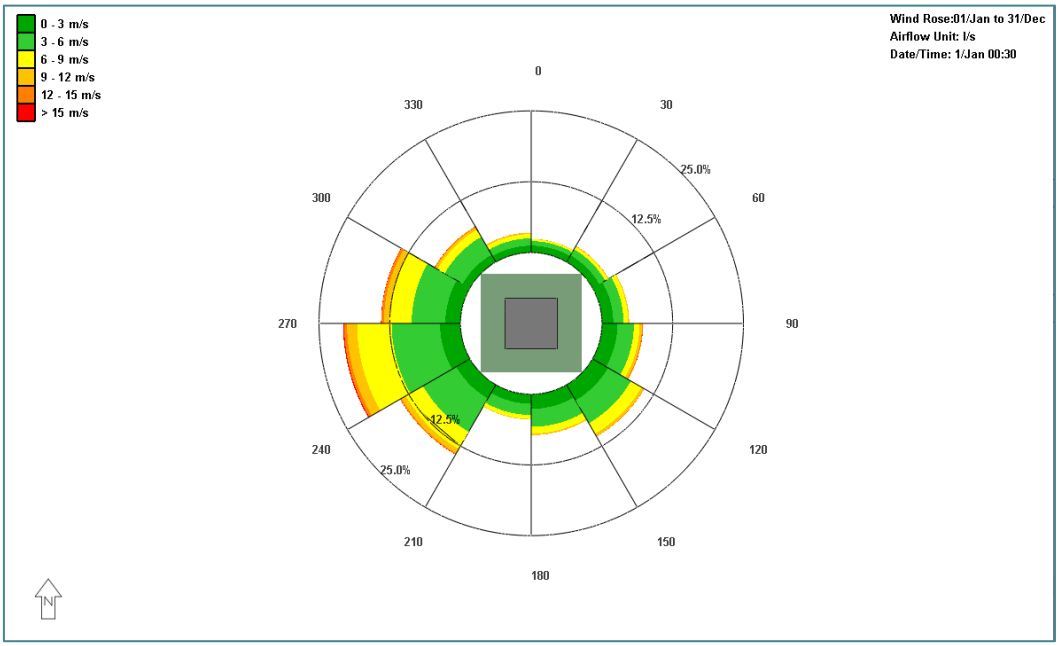


Figure 14: Wind rose as per DublinIWEC.epw

Based on this, the mean wind speed recorded was **5m/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 15.

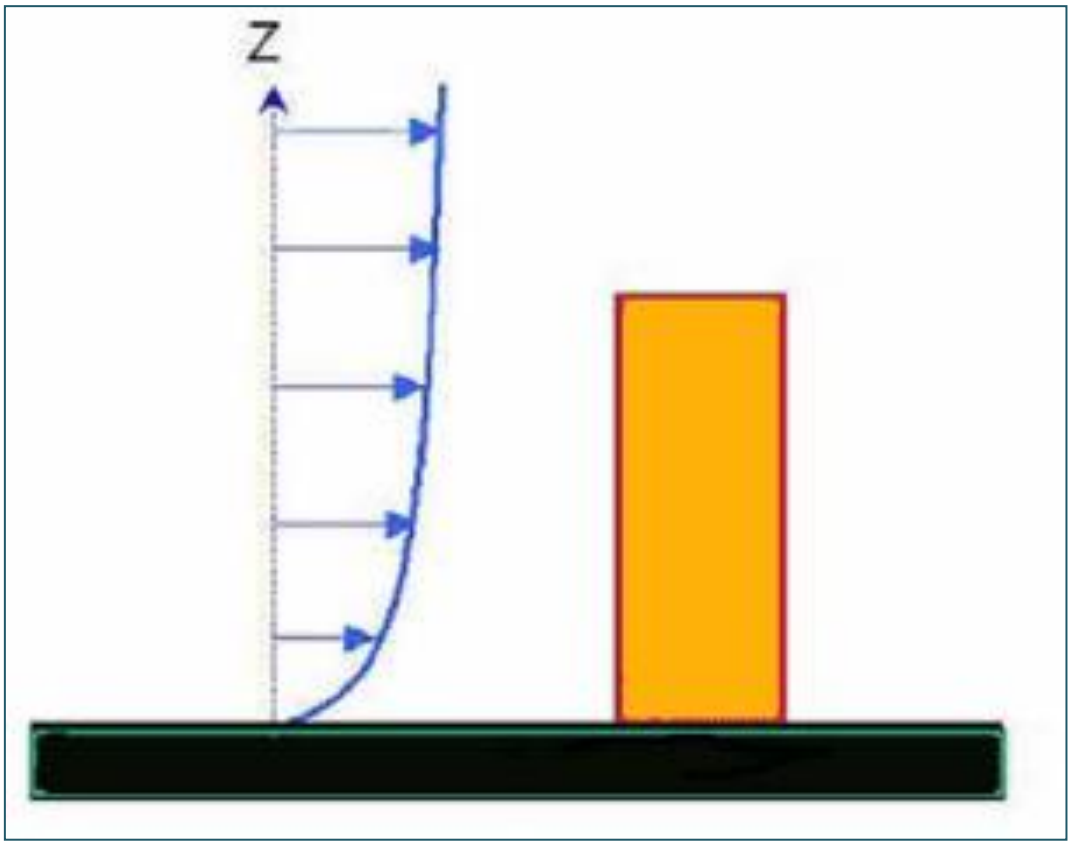


Figure 15: Typical velocity profile of an atmospheric boundary layer

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:

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

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 16 below shows the shape of the wind boundary profile.

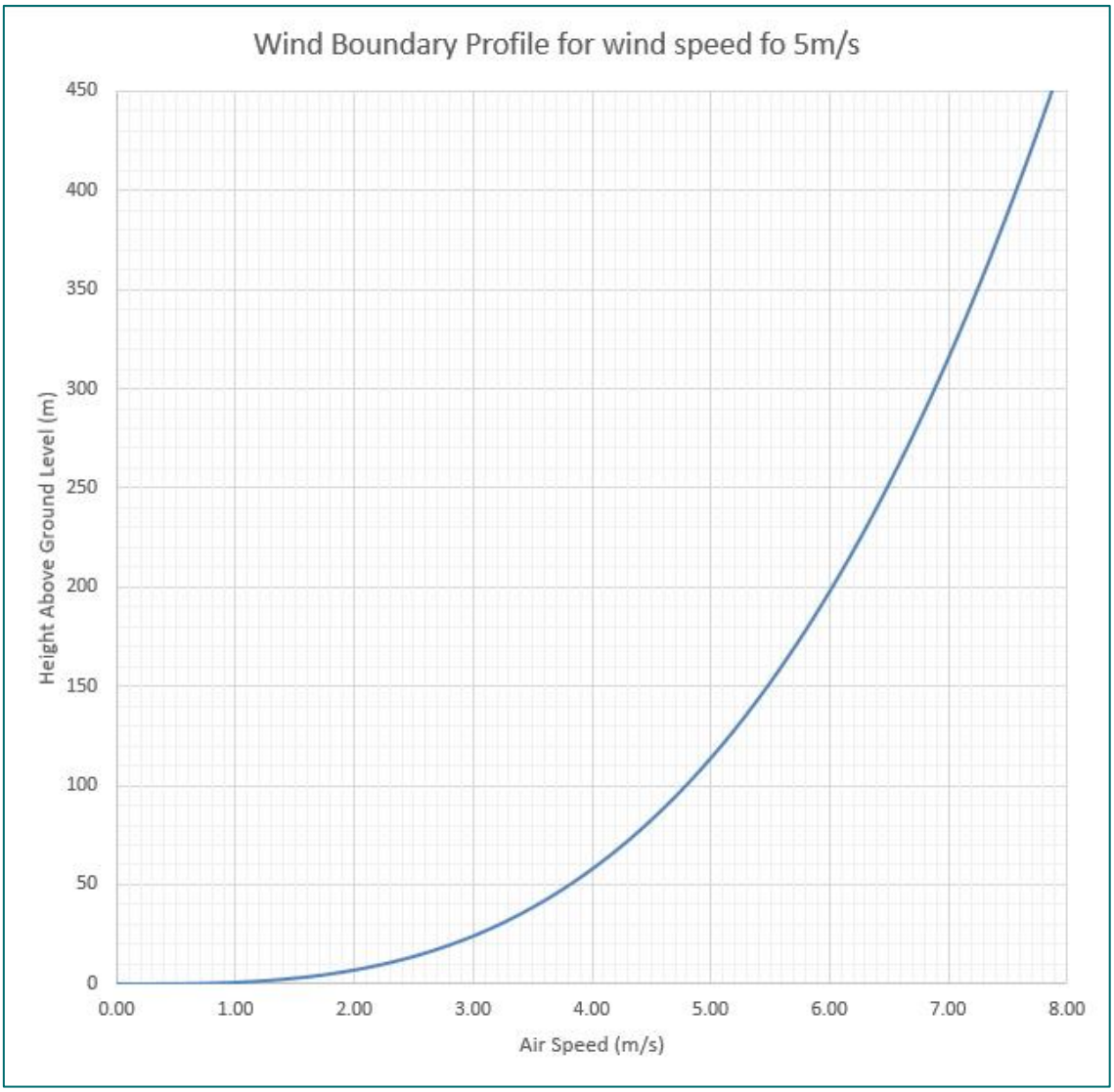


Figure 16: Wind boundary profile for the CFD simulations using annual average wind speed

5 Pedestrian Comfort Calculation Methodology

The methodology for the analysis was as follows:

1) The annual mean wind speed was determined from the 'DublinIWEC' 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.

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 17 to 32 show the geometry as modelled.

Figure 17: Plan view of the entire site

Figure 18: View of the entire site from the south

Figure 19: View of the entire site from the west

Figure 20: View of the entire site from the north

Figure 21: View of the entire site from the east

Figure 22: View of the different sites

Figure 23: Closer view of buildings in Player Wills plot from the south

Figure 24 Closer view of buildings in Player Wills plot from the southwest

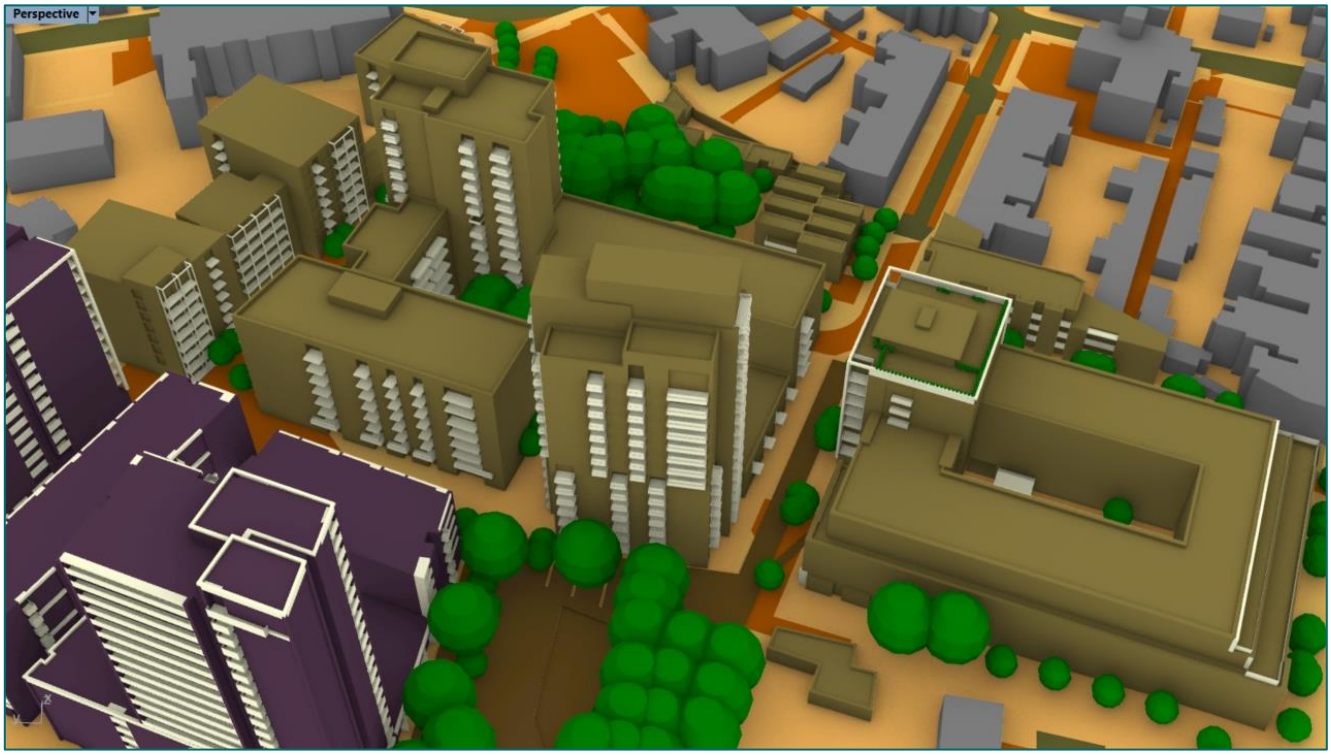


Figure 25: Closer view of buildings in Player Wills plot from the west

Figure 26: Closer view of buildings in Player Wills plot from the northwest

Figure 27: Closer view of buildings in Player Wills plot from the north

Figure 28: Closer view of buildings in Player Wills plot from the northeast

Figure 29: Closer view of buildings in Player Wills plot from the east

Figure 30: Closer view of buildings in Player Wills plot from the southeast

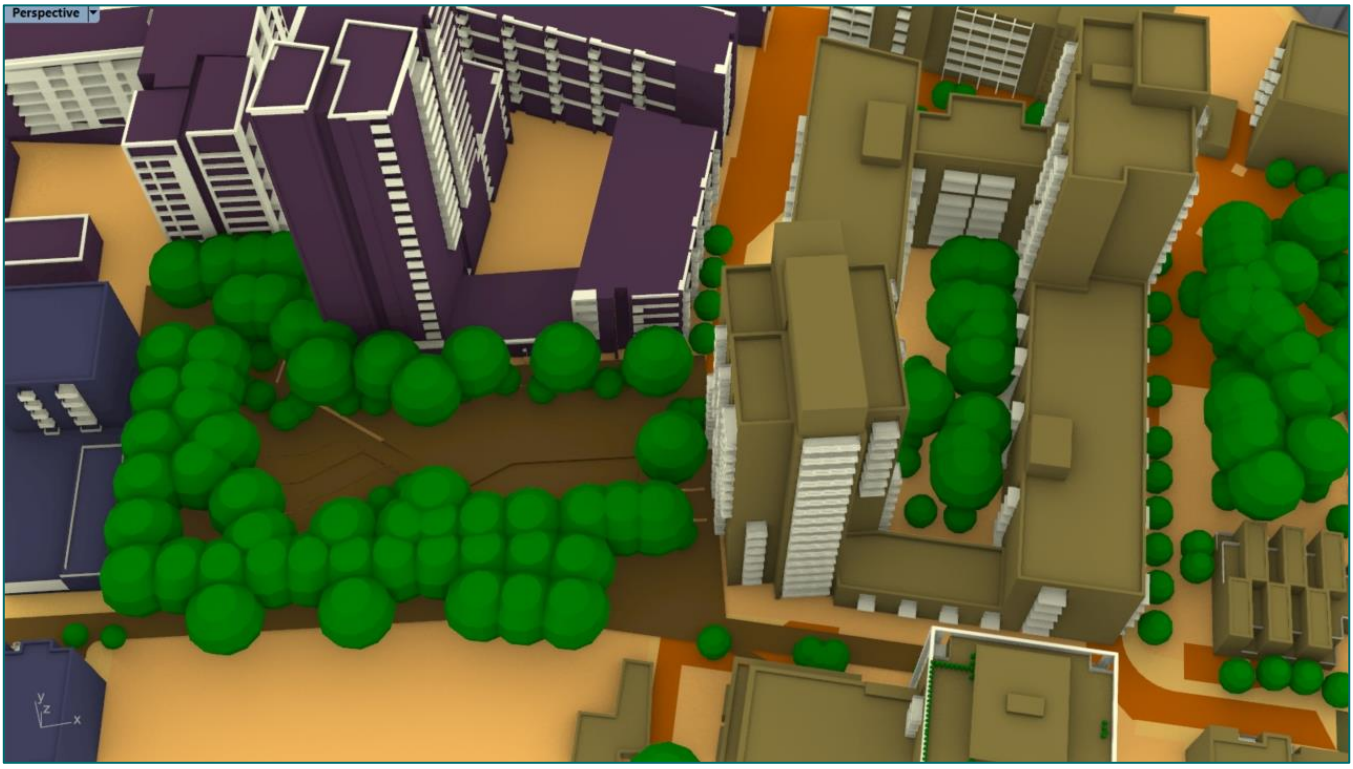


Figure 31: Closer view of the amenities present to the west of the players wills site

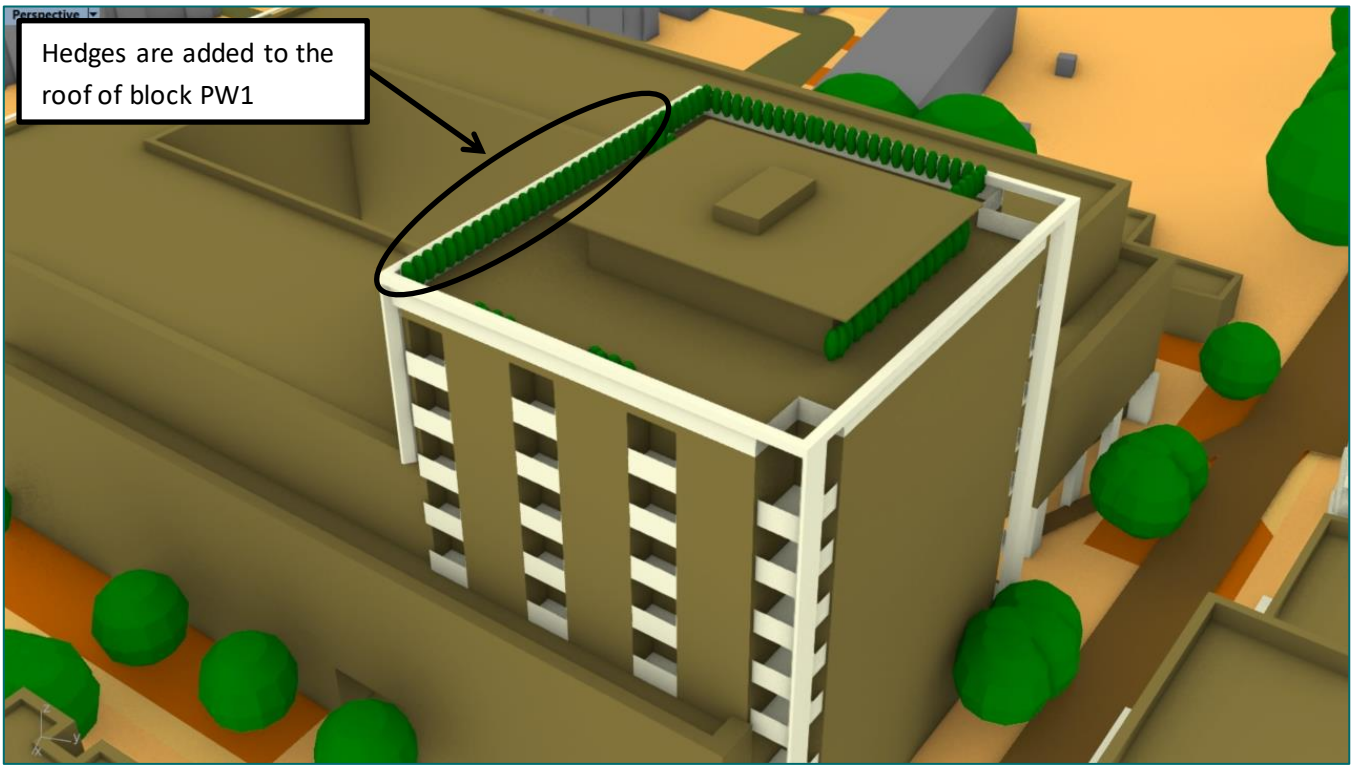


Figure 32: View of the newly added hedges to the roof of block PW1

6.2 Designated Locations for Analysis

Figures 33 to 37 show the designated locations with all lying 1.5m above the immediate ground/floor level. Balcony locations are lying at 1.1m above the immediate floor level.

Figure 33: Area of Interest: Ground level

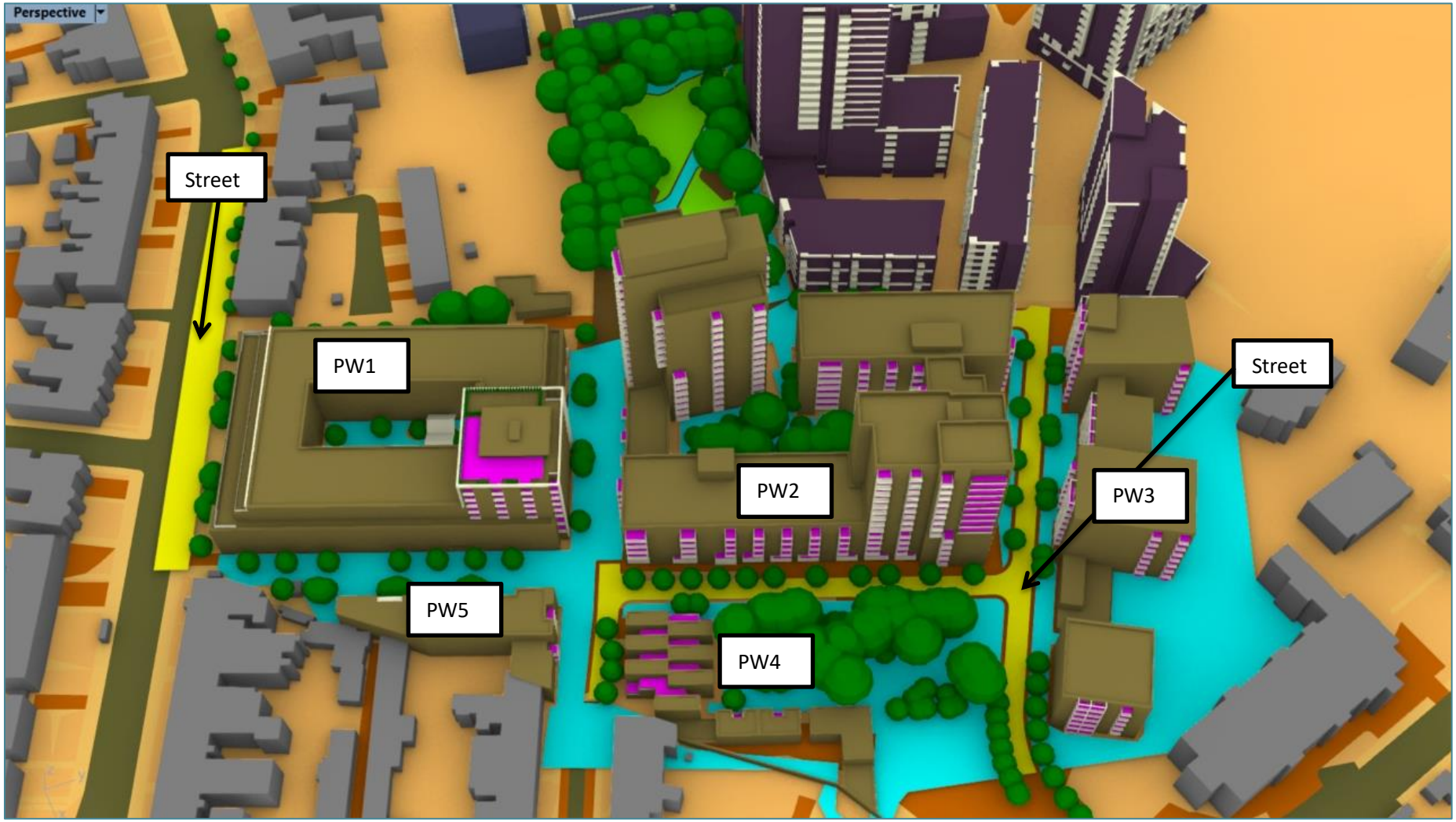


Figure 34: Area of Interest: Street

Figure 35: Area of Interest: Ground level

Figure 36: Area of Interest: Balconies

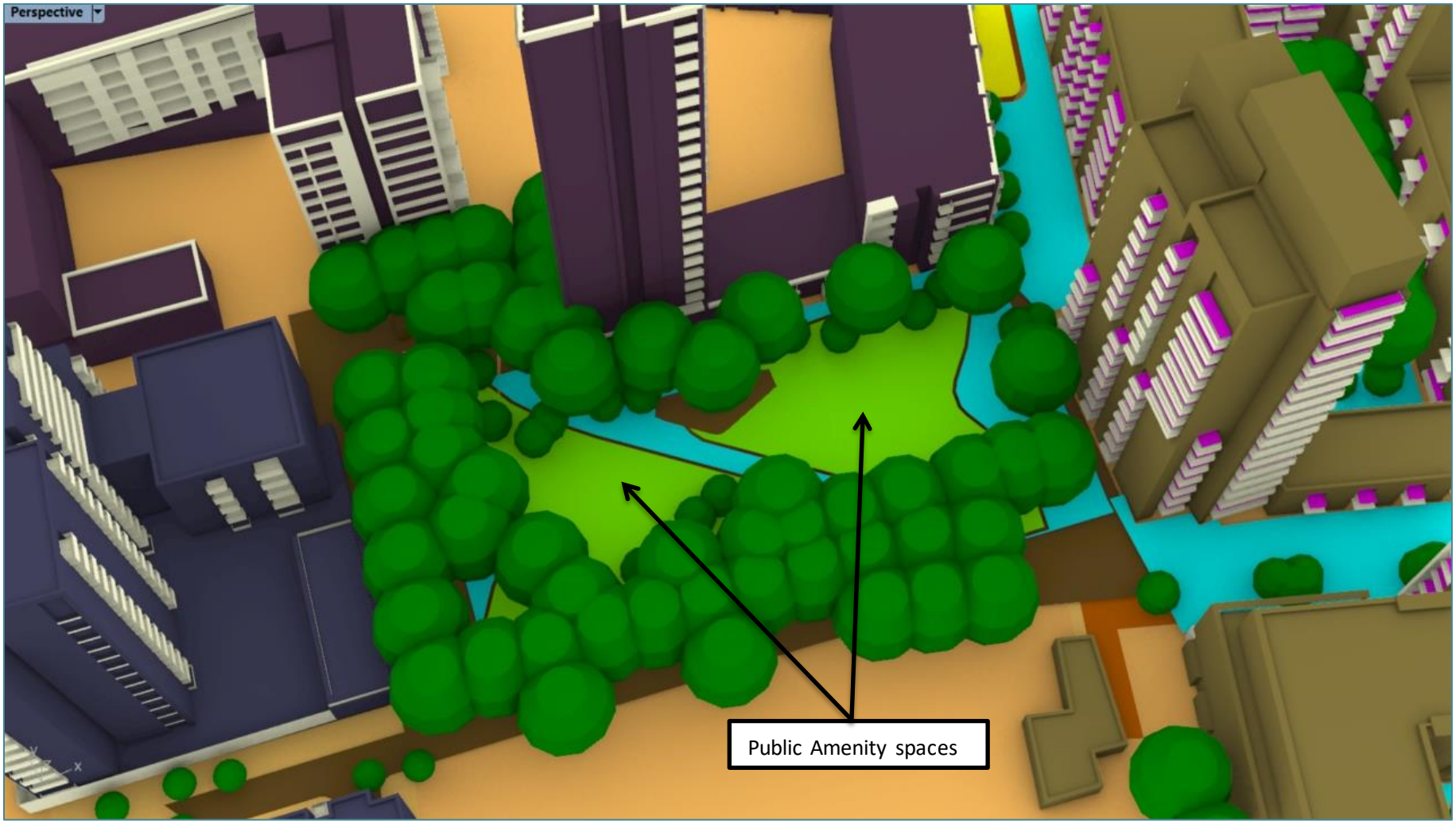


Figure 37: Area of Interest: Public amenity spaces

6.3 Comfort Activities

The following table lists the various activities according to the amenity type will be focused mainly in the simulation.

Amenity Area	Business Walking Activity	Leisurely Walking Activity	Standing Activity	Sitting Activity
Ground level amenities	✓	✓	✓	✓
Balconies of all plots	✓	✓	✓	✓
Streets	✓	✓		

7 Results

7.1 Comfort Criteria: All Seasons

Figures 38 to 46 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 for all seasons. The threshold values are 4m/s, 6m/s, 8m/s and 10m/s respectively.

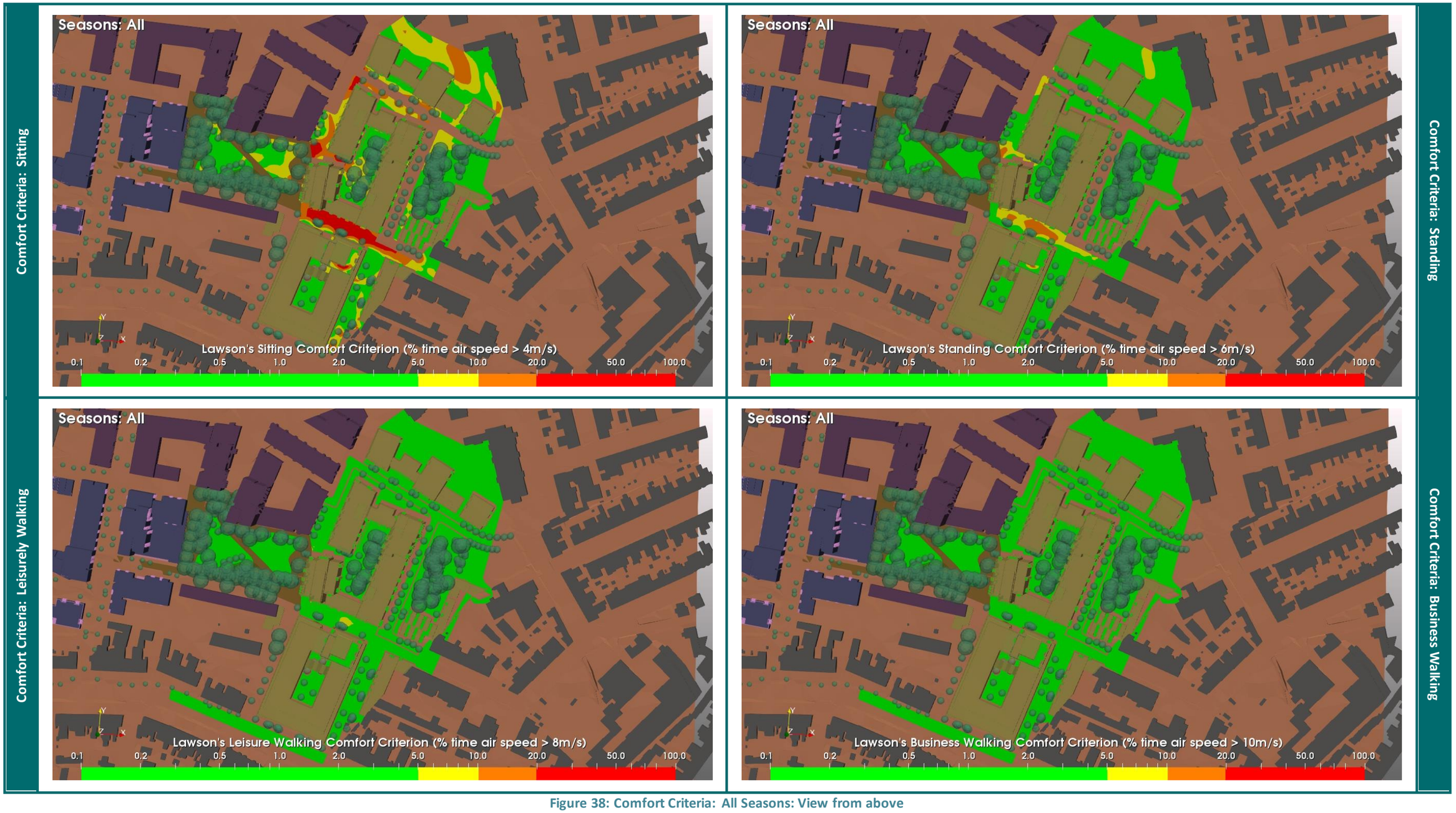
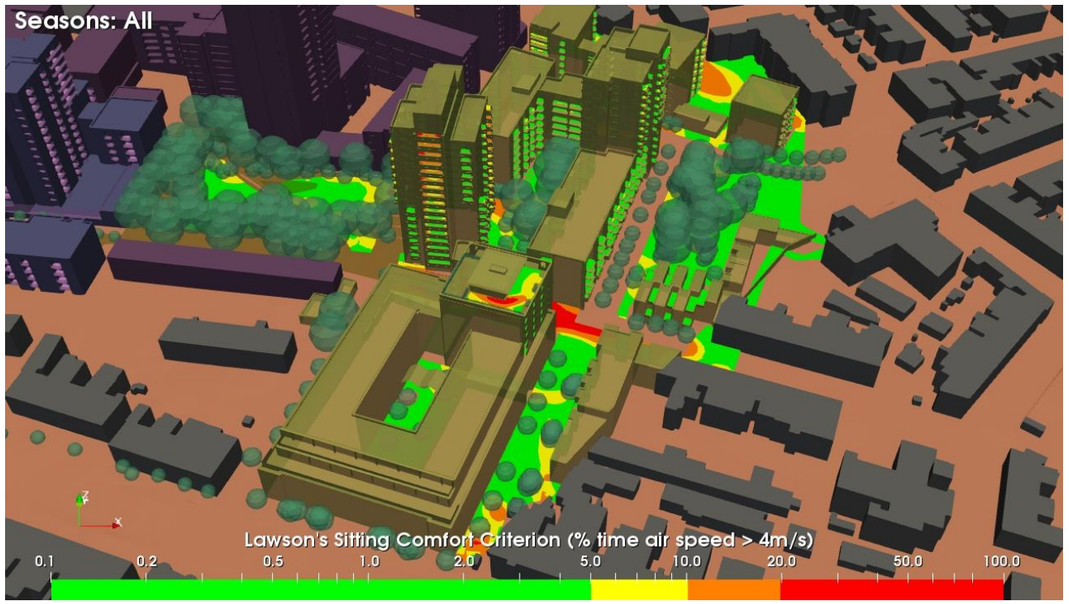
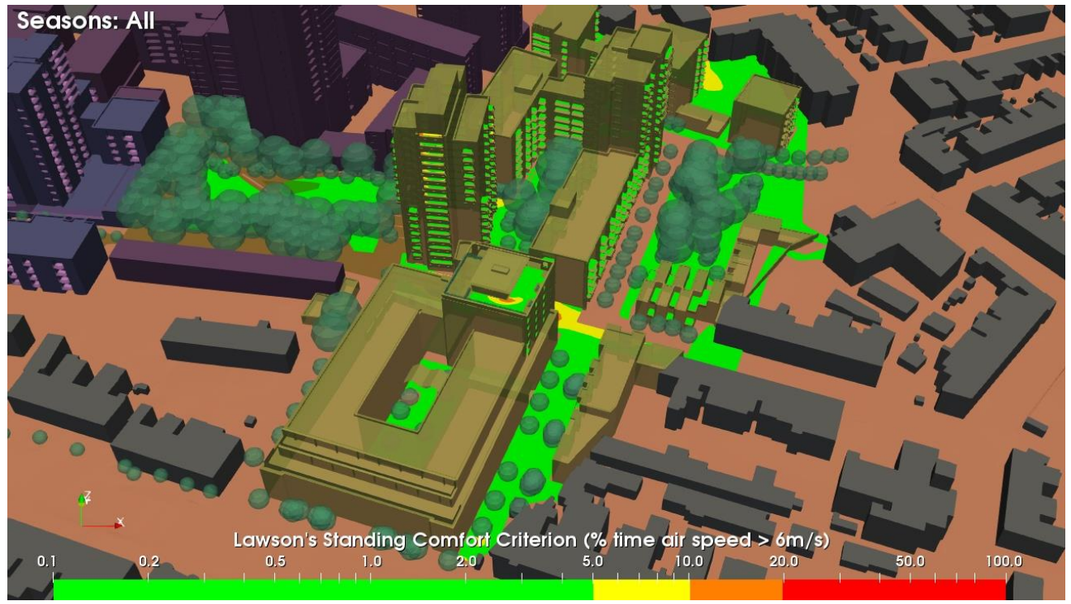


Figure 38: Comfort Criteria: All Seasons: View from above

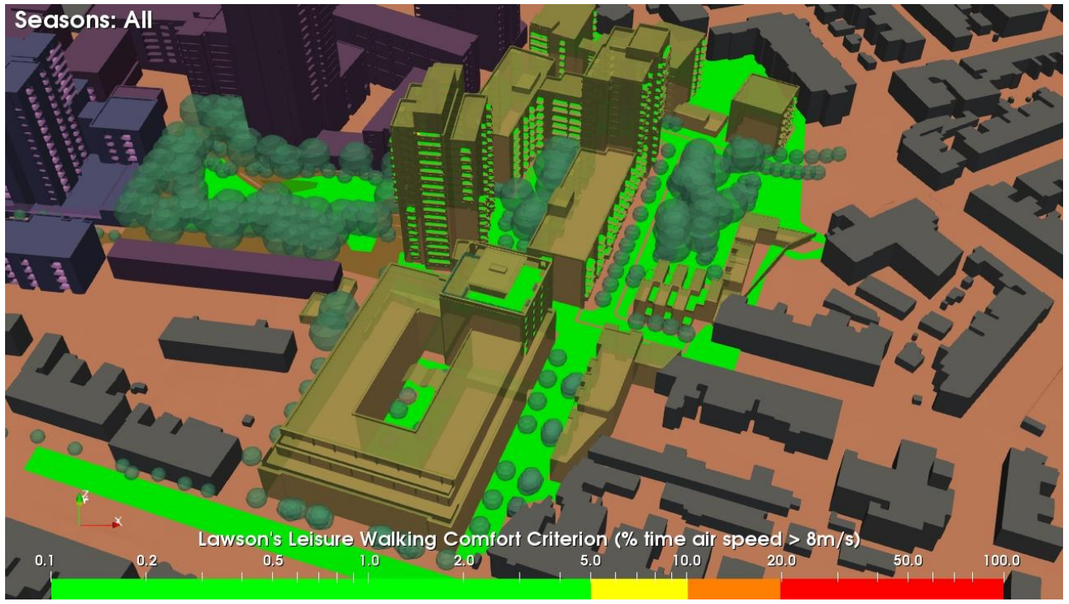
Comfort Criteria: Sitting



Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking



Comfort Criteria: Business Walking

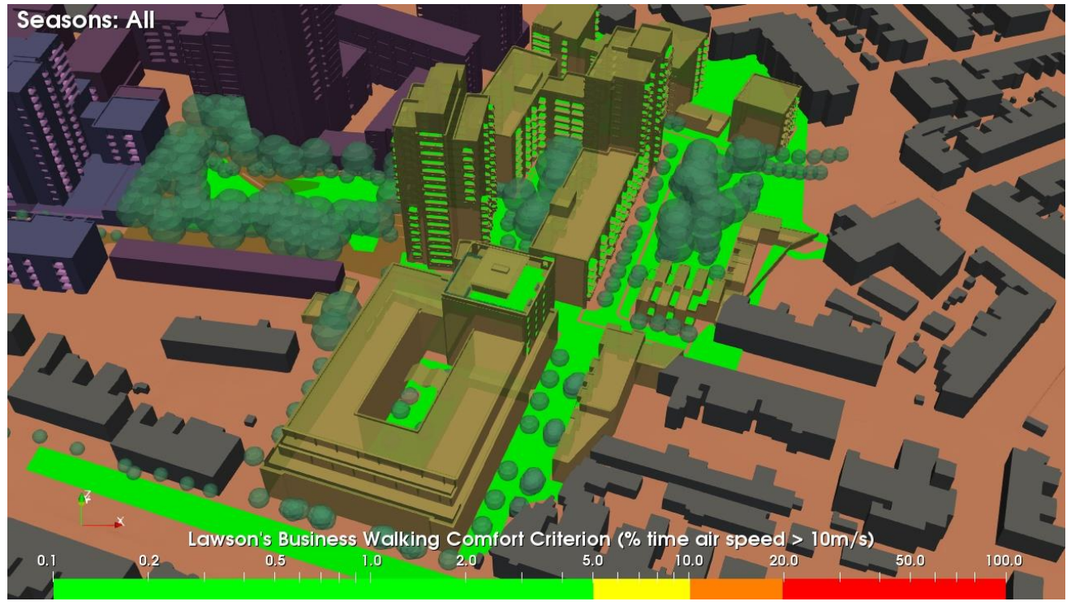
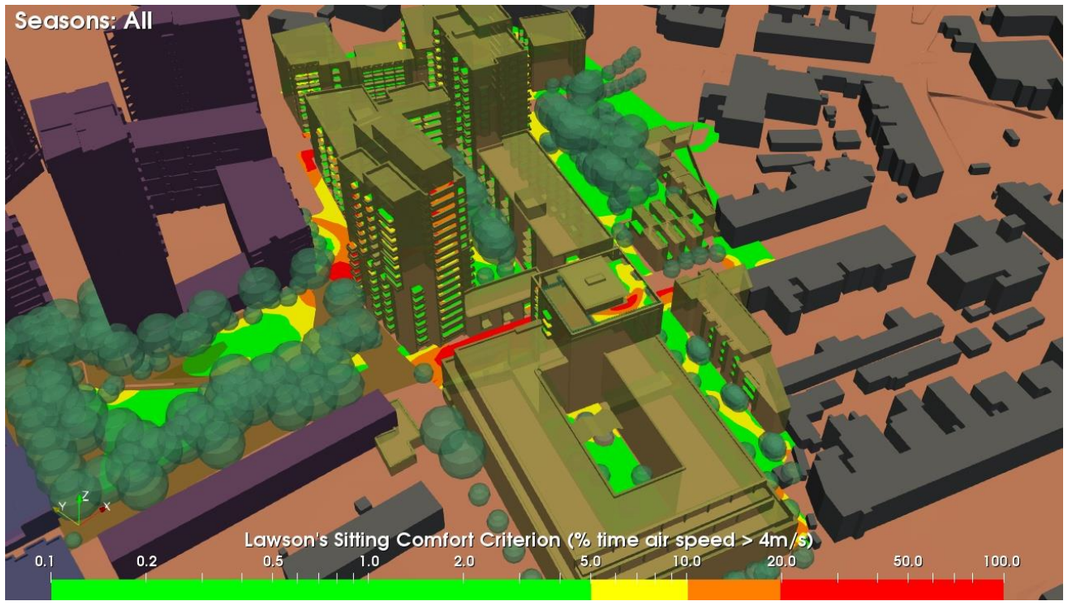
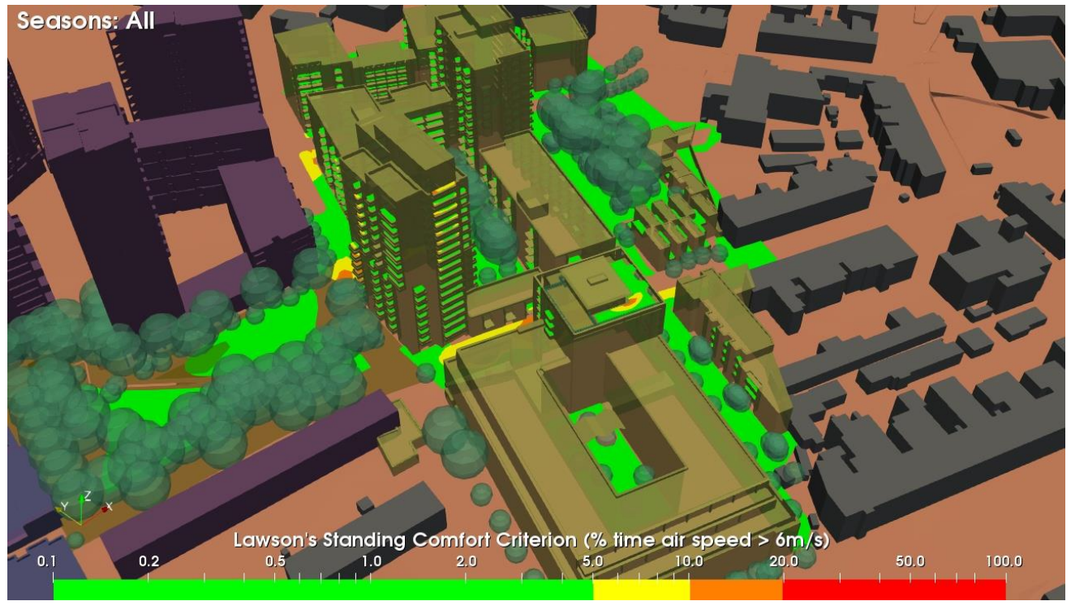


Figure 39: Comfort Criteria: All Seasons: View from the south

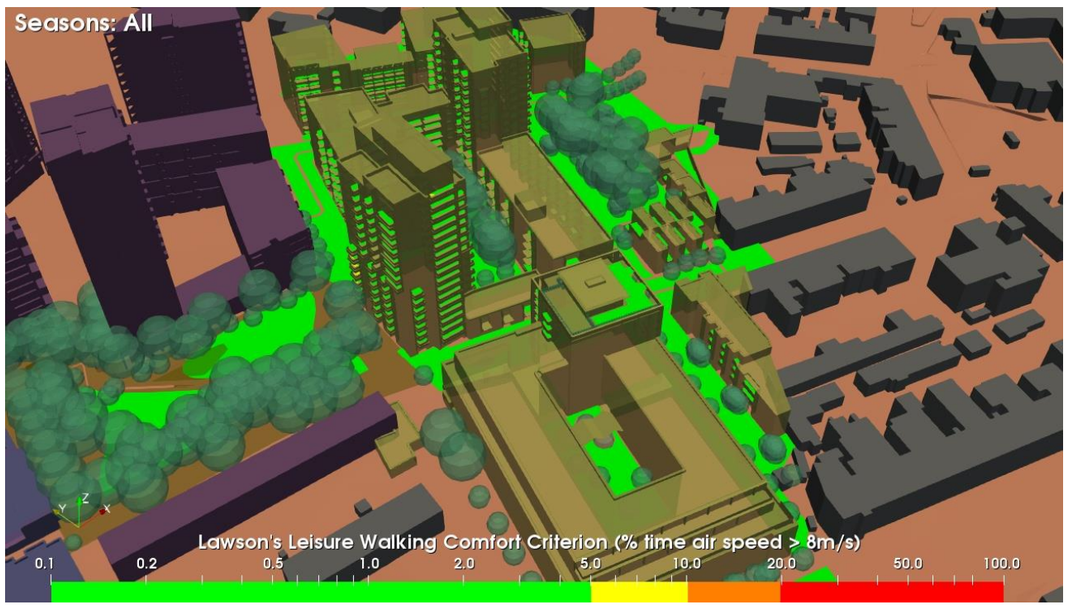
Comfort Criteria: Sitting



Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking



Comfort Criteria: Business Walking

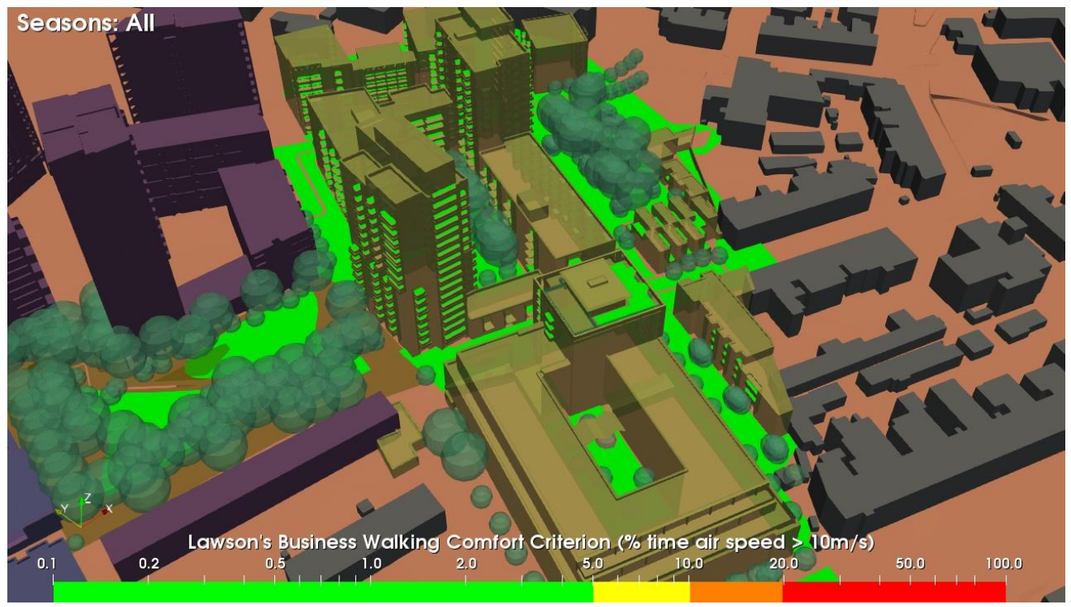
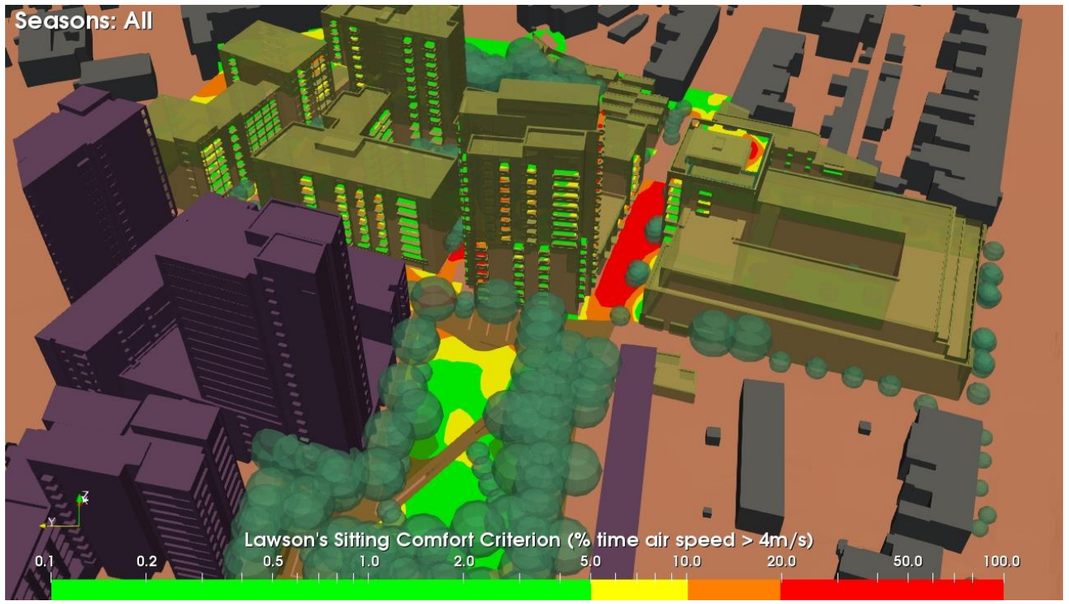
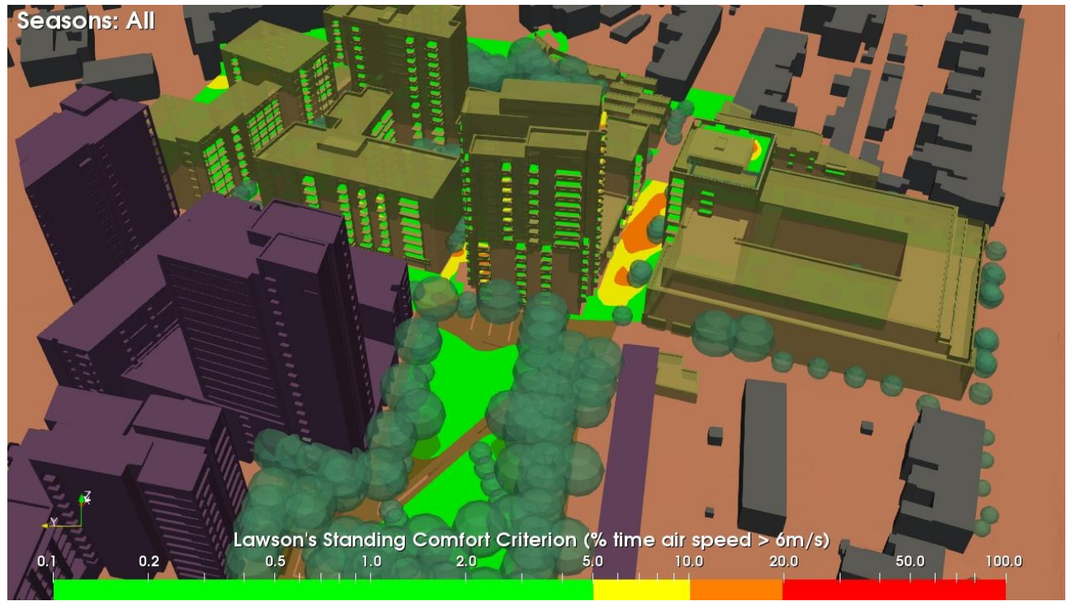


Figure 40: Comfort Criteria: All Seasons: View from the southwest

Comfort Criteria: Sitting



Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking

Comfort Criteria: Business Walking

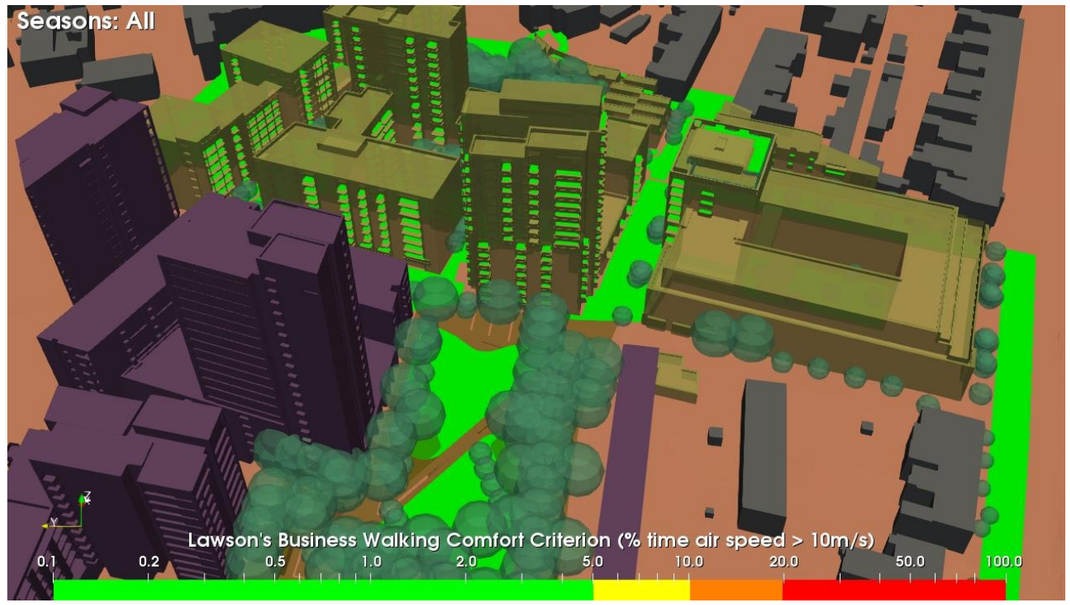
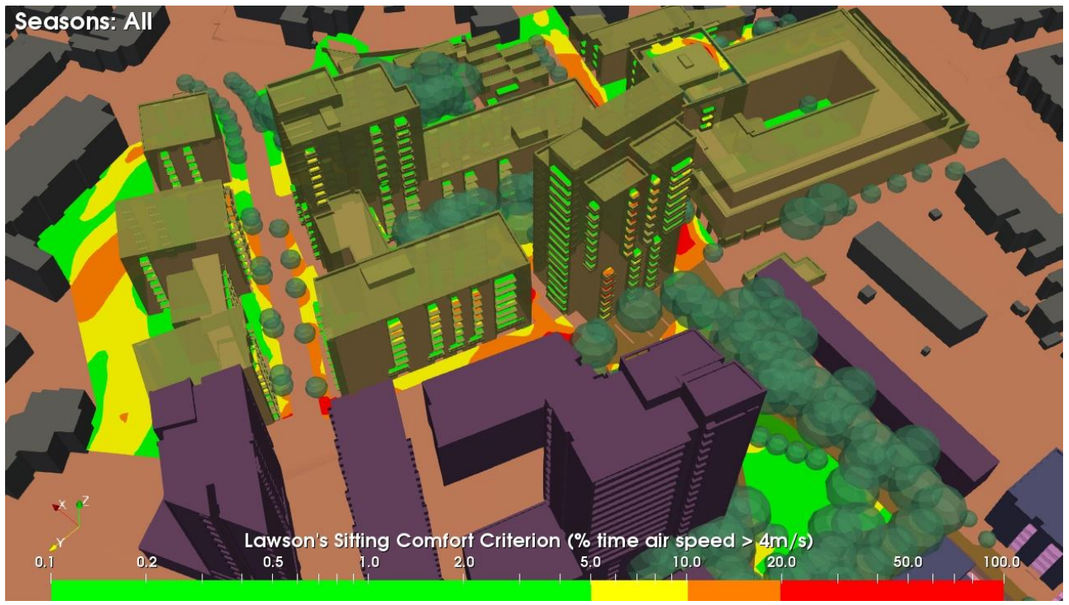
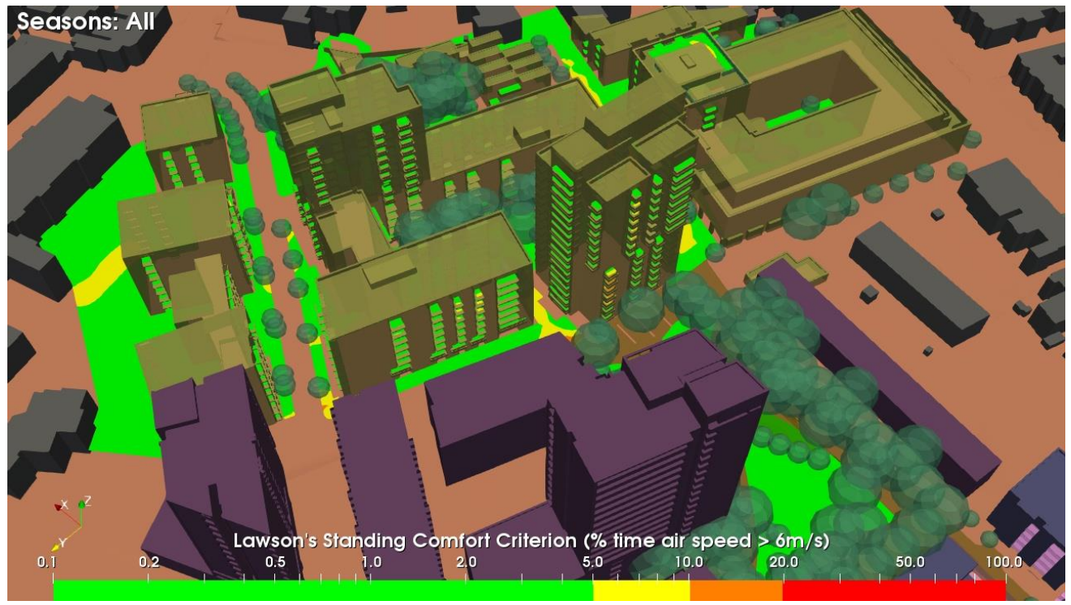


Figure 41: Comfort Criteria: All Seasons: View from the west

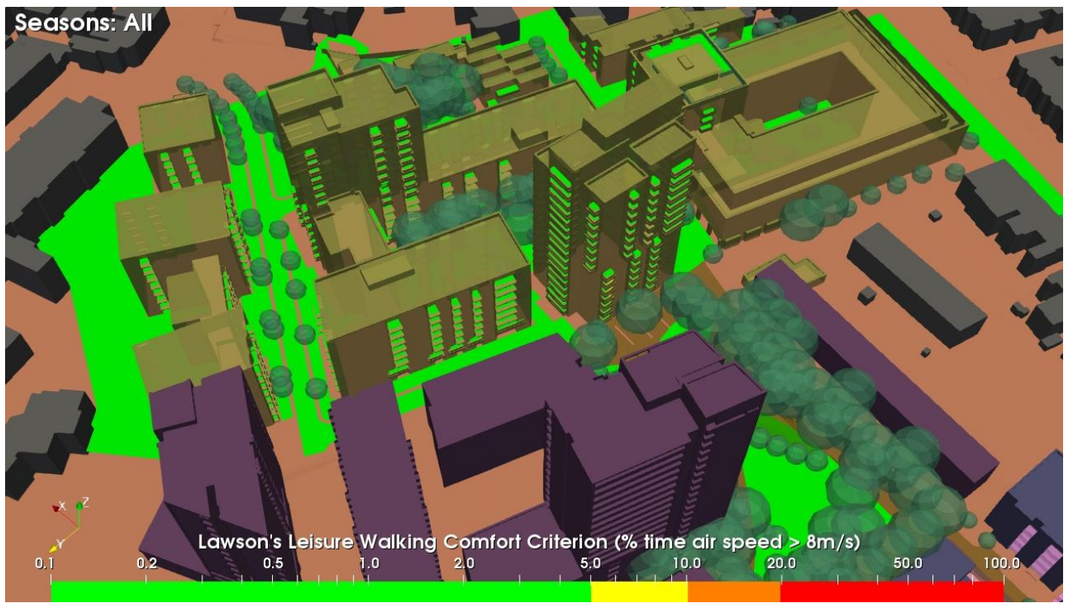
Comfort Criteria: Sitting



Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking



Comfort Criteria: Business Walking

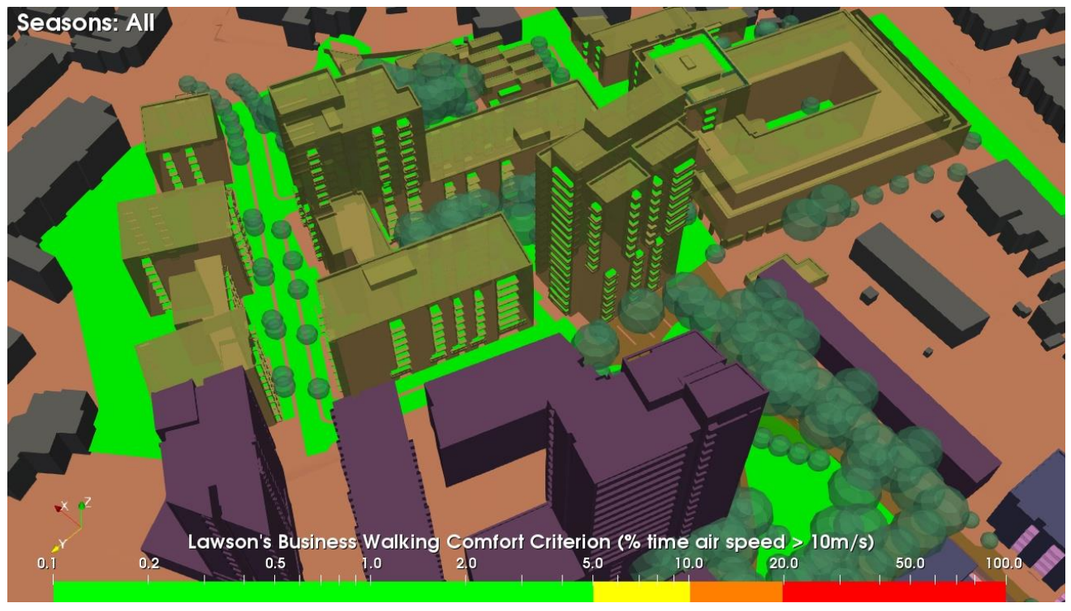
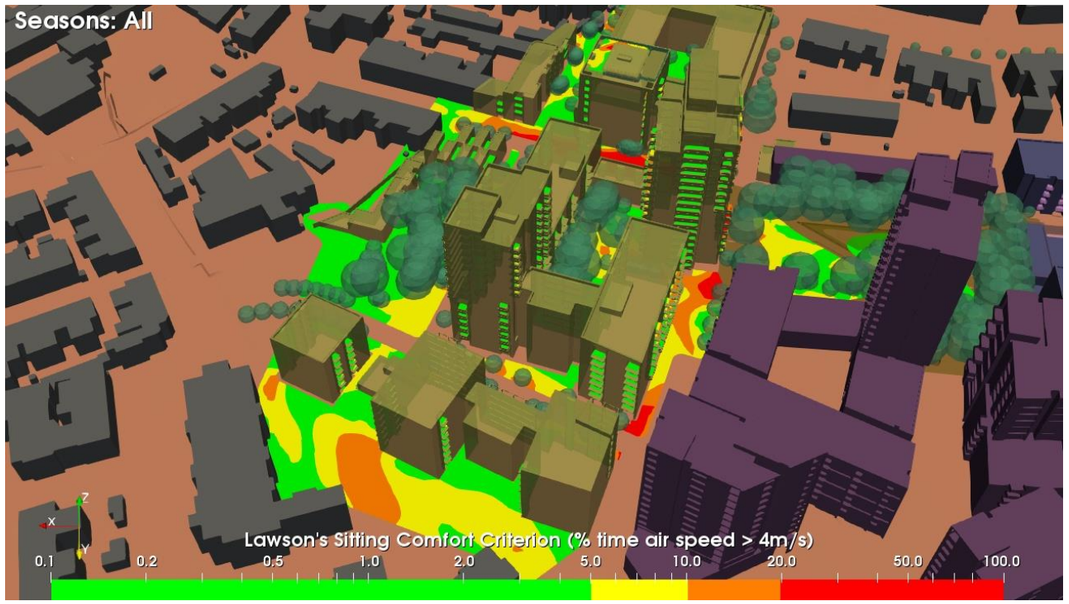
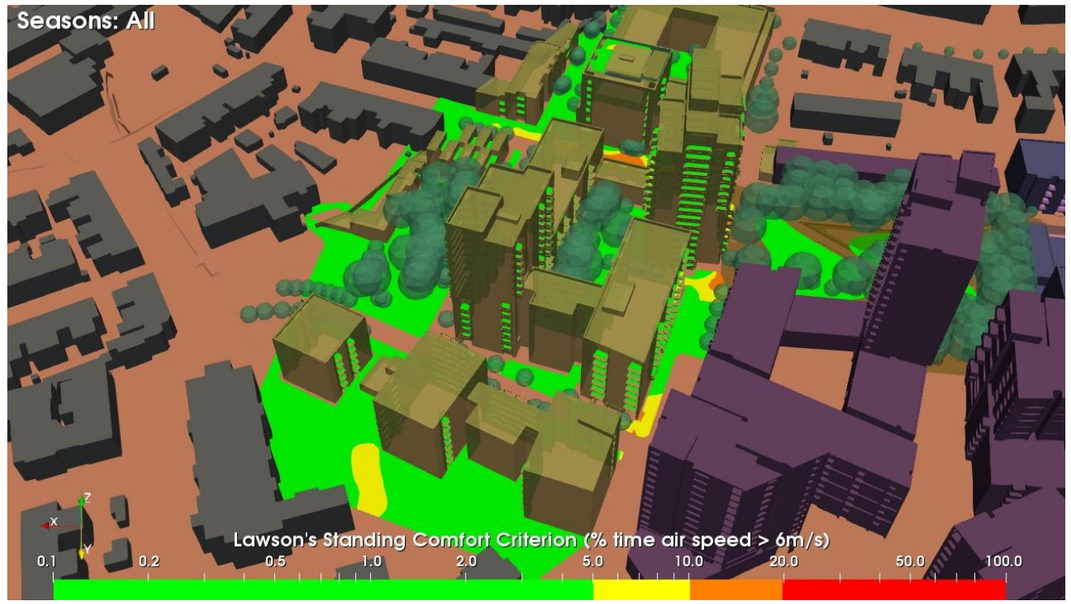


Figure 42: Comfort Criteria: All Seasons: View from the northwest

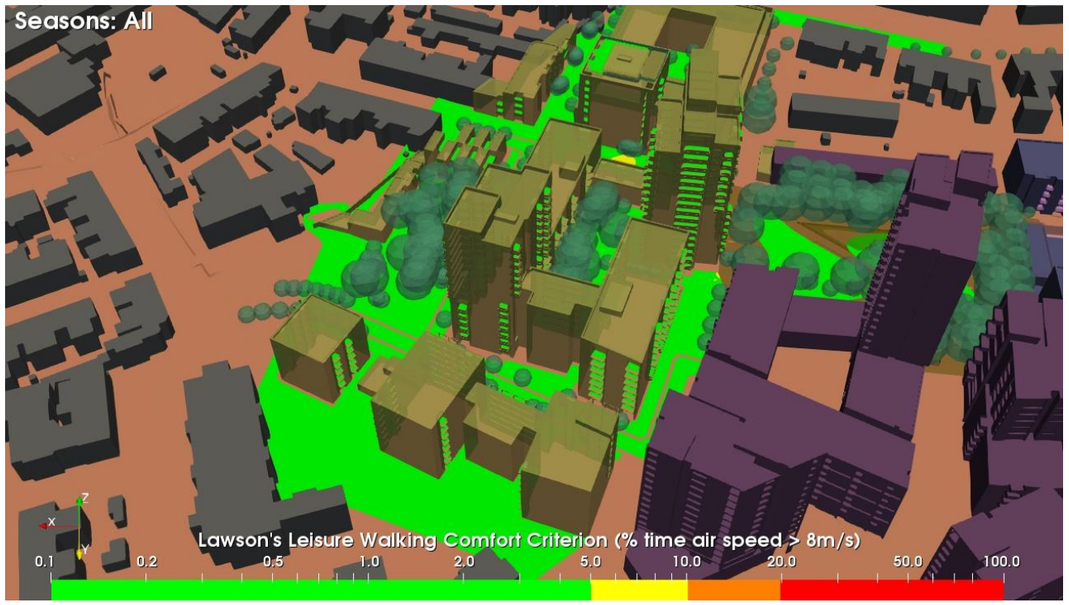
Comfort Criteria: Sitting



Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking



Comfort Criteria: Business Walking

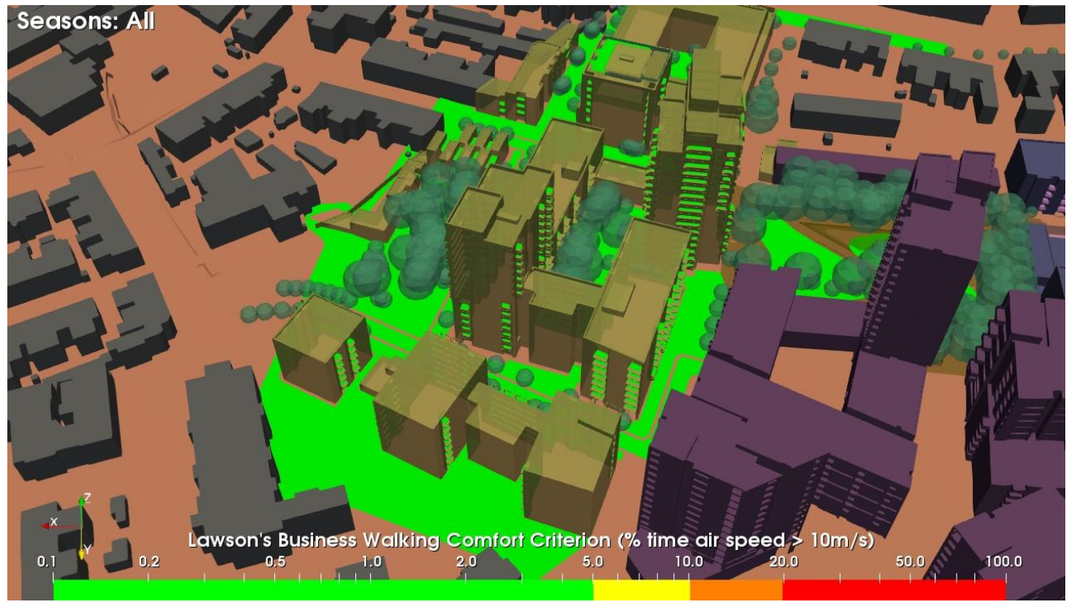
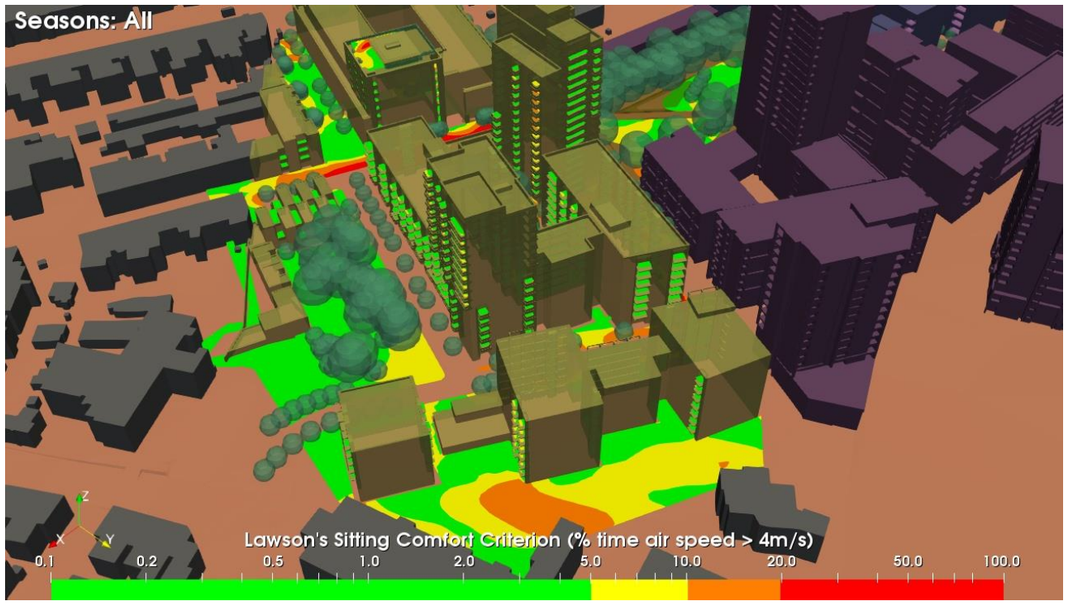


Figure 43: Comfort Criteria: All Seasons: View from the north

Comfort Criteria: Sitting



Comfort Criteria: Standing

Comfort Criteria: Leisurely Walking

Comfort Criteria: Business Walking

Figure 44: Comfort Criteria: All Seasons: View from the northeast

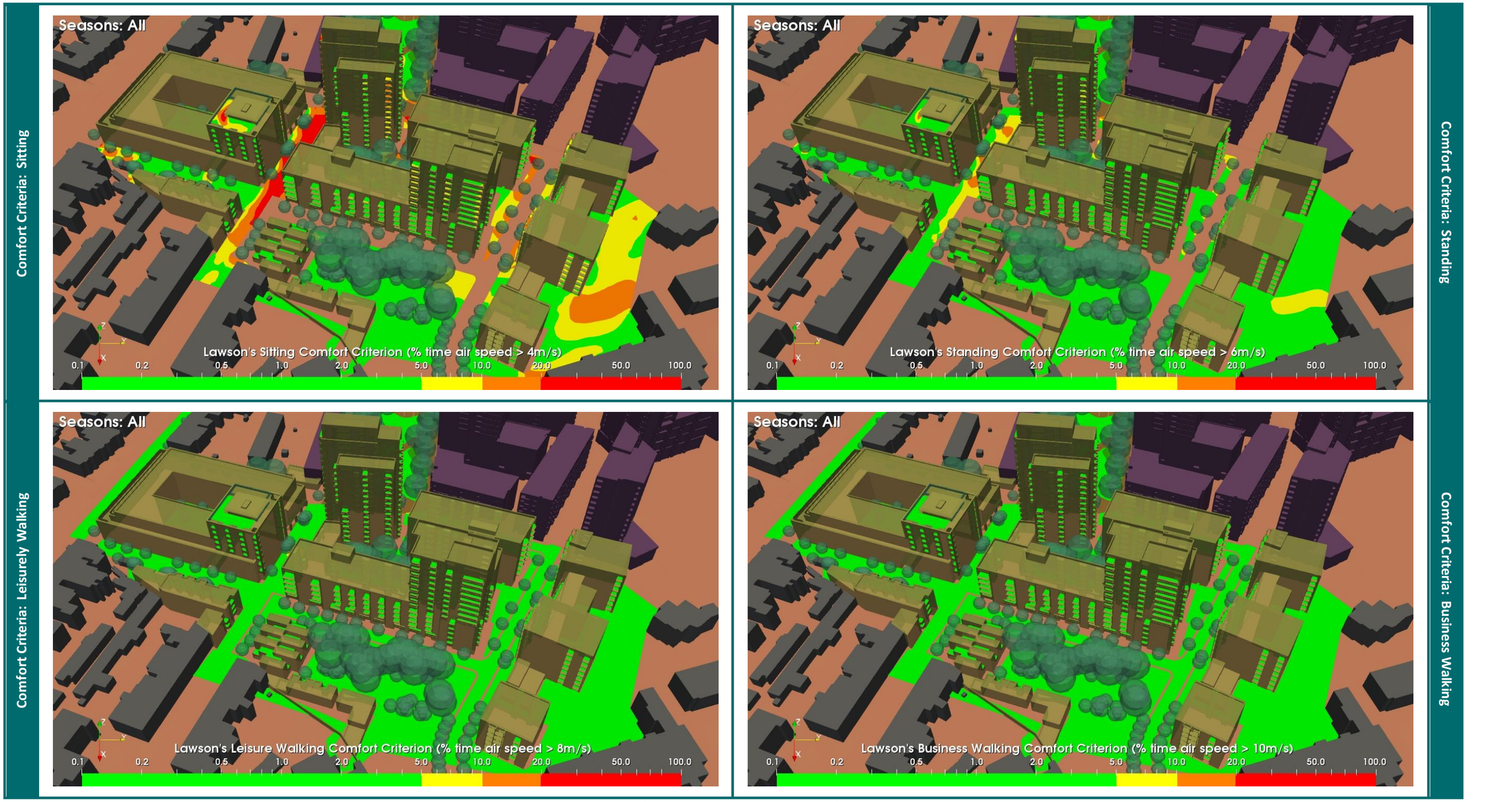
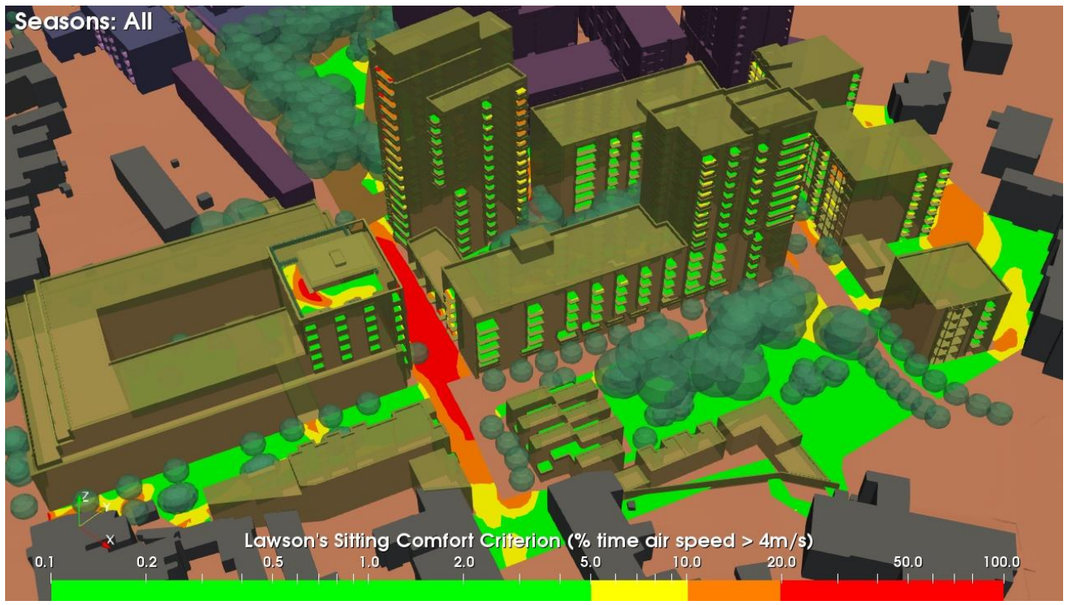
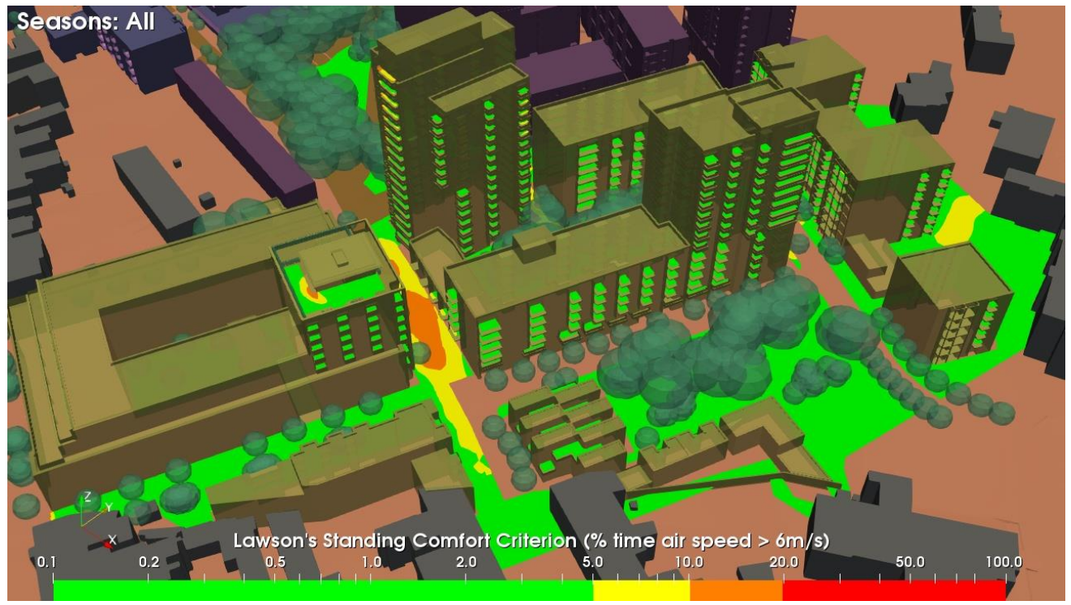


Figure 45: Comfort Criteria: All Seasons: View from the east

Comfort Criteria: Sitting



Comfort Criteria: Standing



Comfort Criteria: Leisurely Walking

Comfort Criteria: Business Walking

Figure 46: Comfort Criteria: All Seasons: View from the southeast

7.2 Comfort Criteria: Summer and Autumn Seasons

Figures 47 to 55 show the percentage of the year the hourly wind speed exceeds the threshold value for the comfort criteria such as Sitting and Standing for summer and autumn seasons. The threshold values are 4m/s, 6m/s respectively.

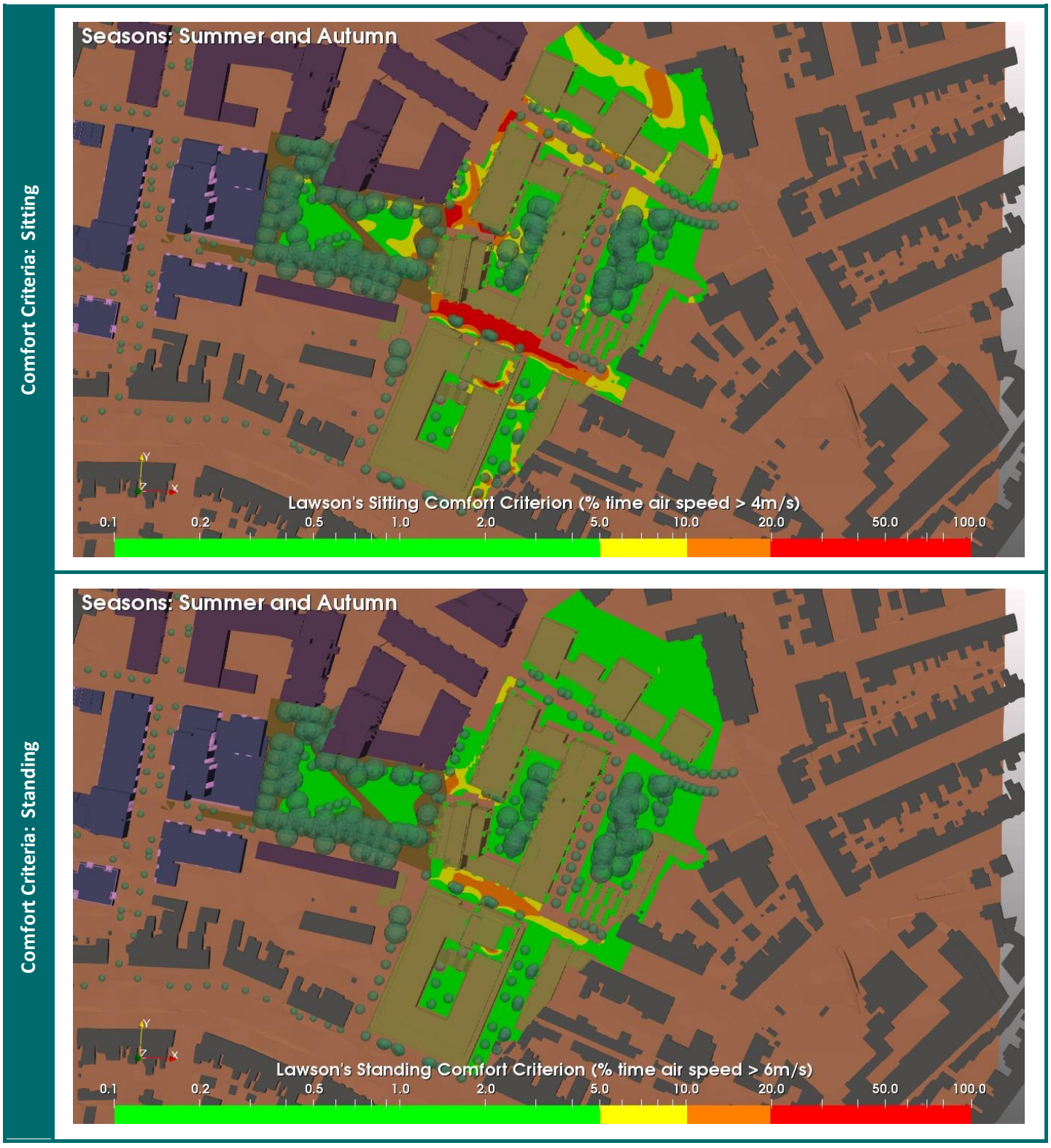


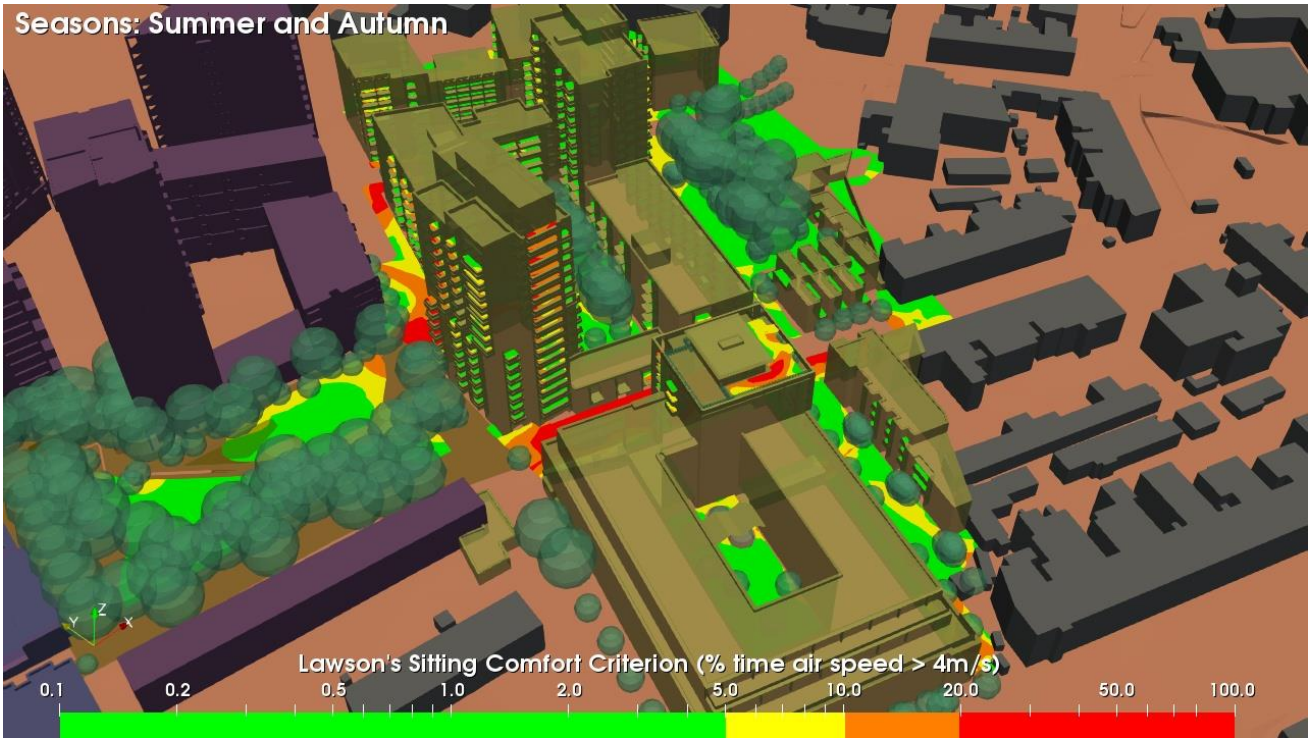
Figure 47: Comfort Criteria: Summer and Autumn Season: View from above

Comfort Criteria: Sitting

Comfort Criteria: Standing

Figure 48: Comfort Criteria: Summer and Autumn Season: View from the south

Comfort Criteria: Sitting



Comfort Criteria: Standing

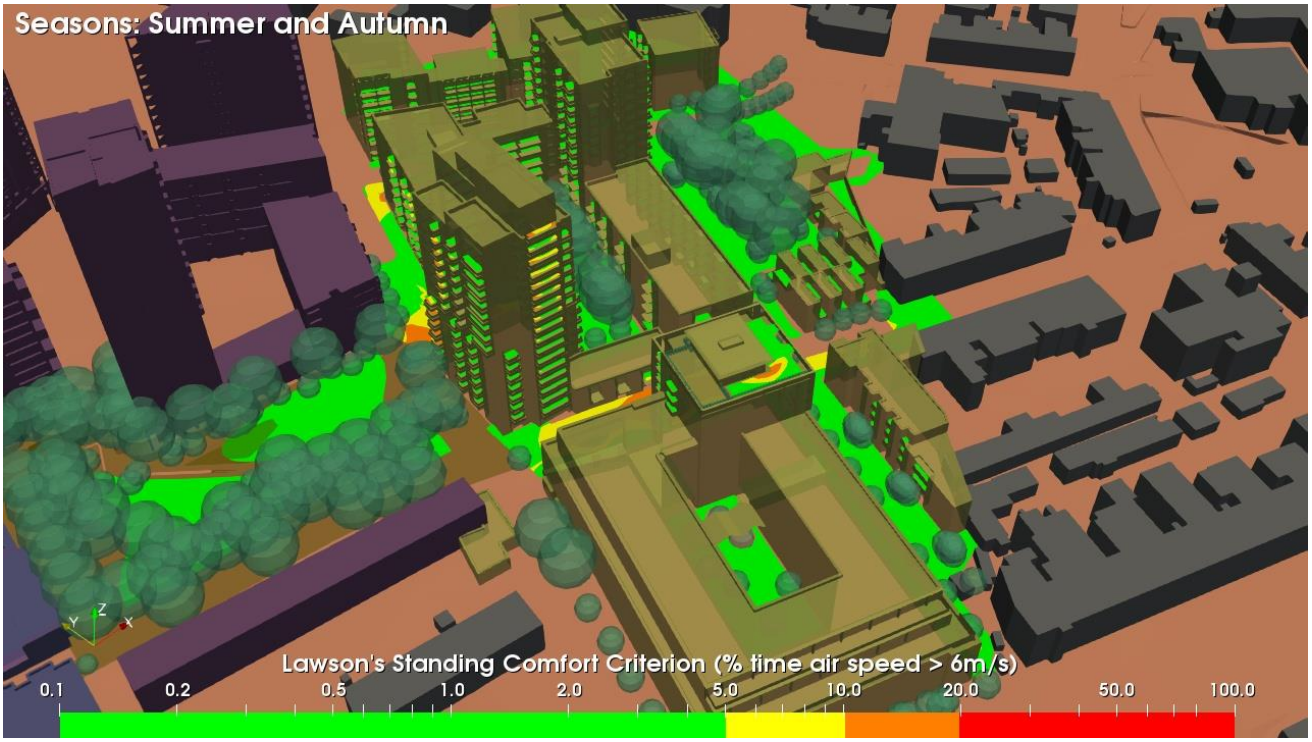


Figure 49: Comfort Criteria: Summer and Autumn Season: View from the southwest

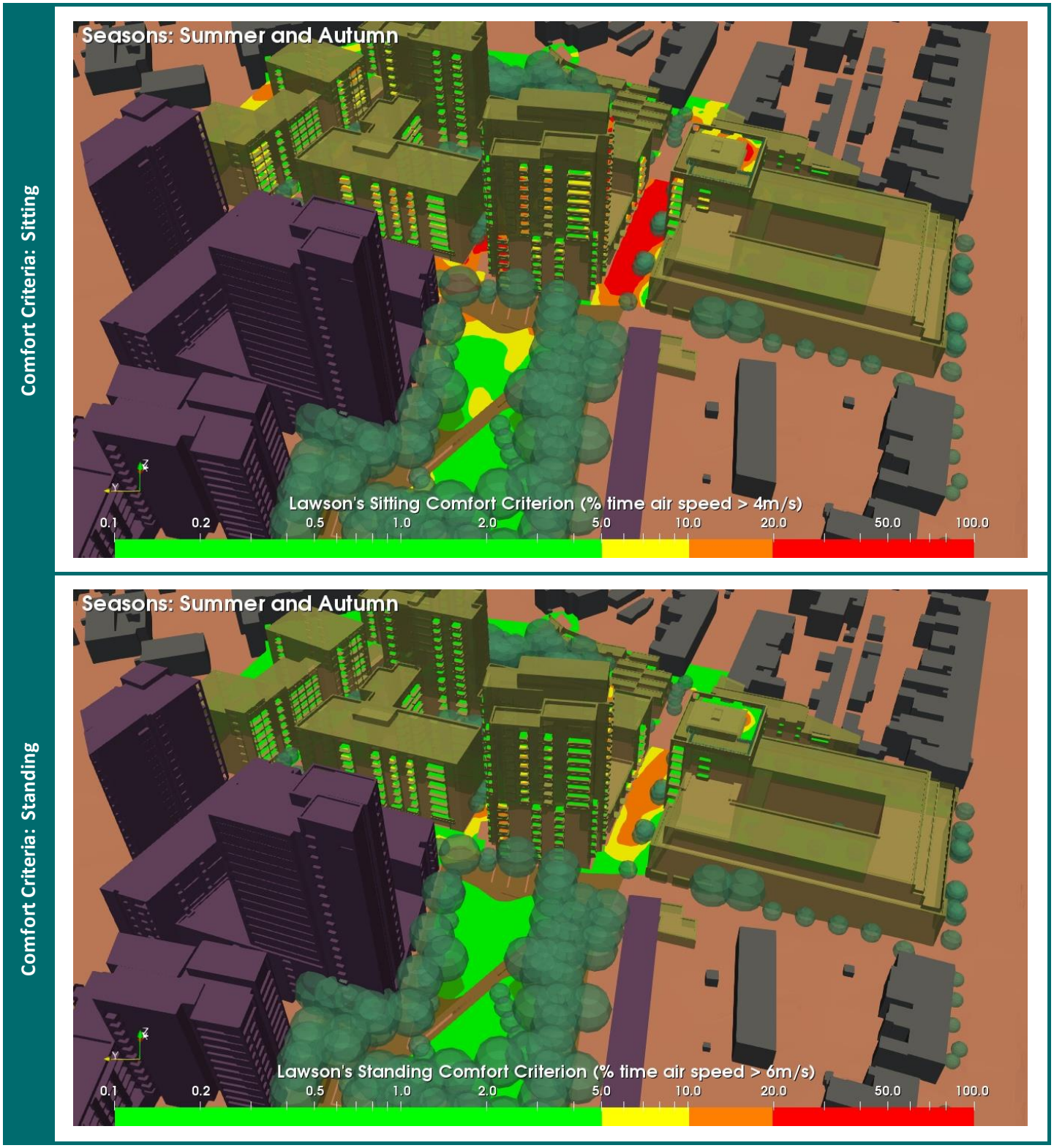
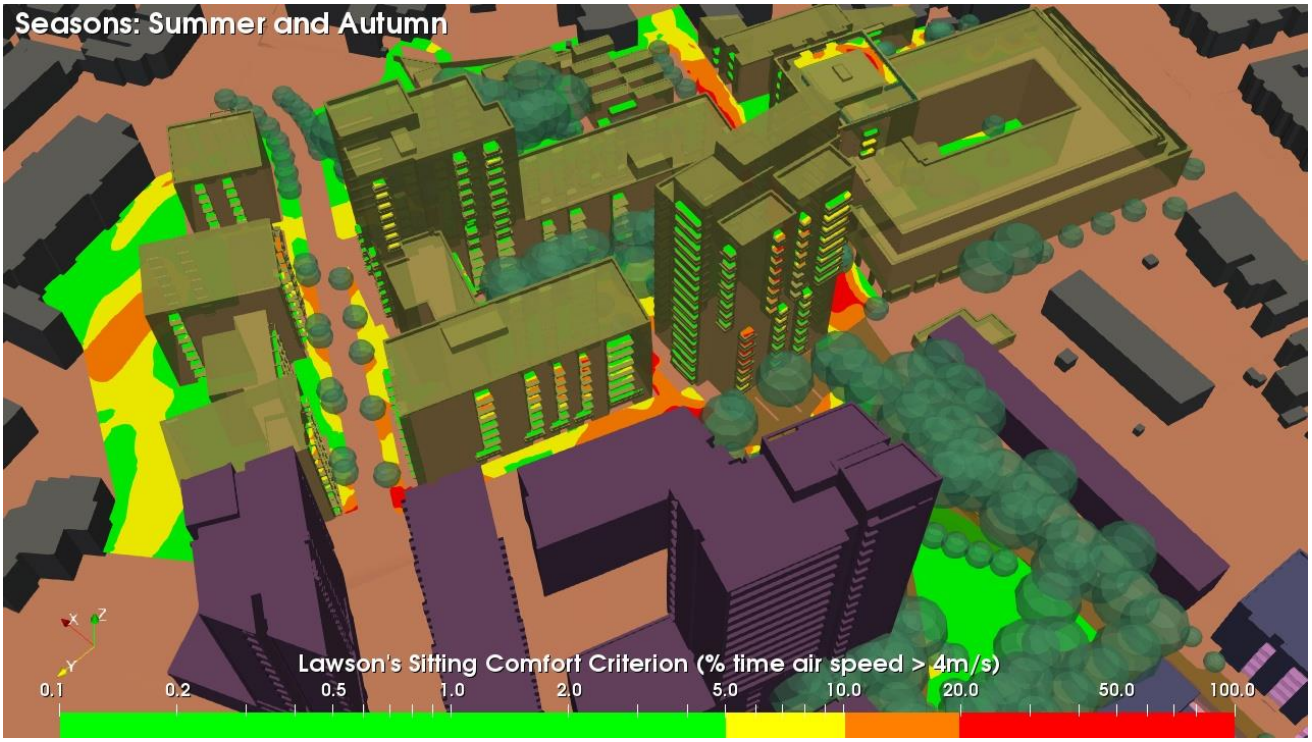


Figure 50: Comfort Criteria: Summer and Autumn Season: View from the west

Comfort Criteria: Sitting



Comfort Criteria: Standing

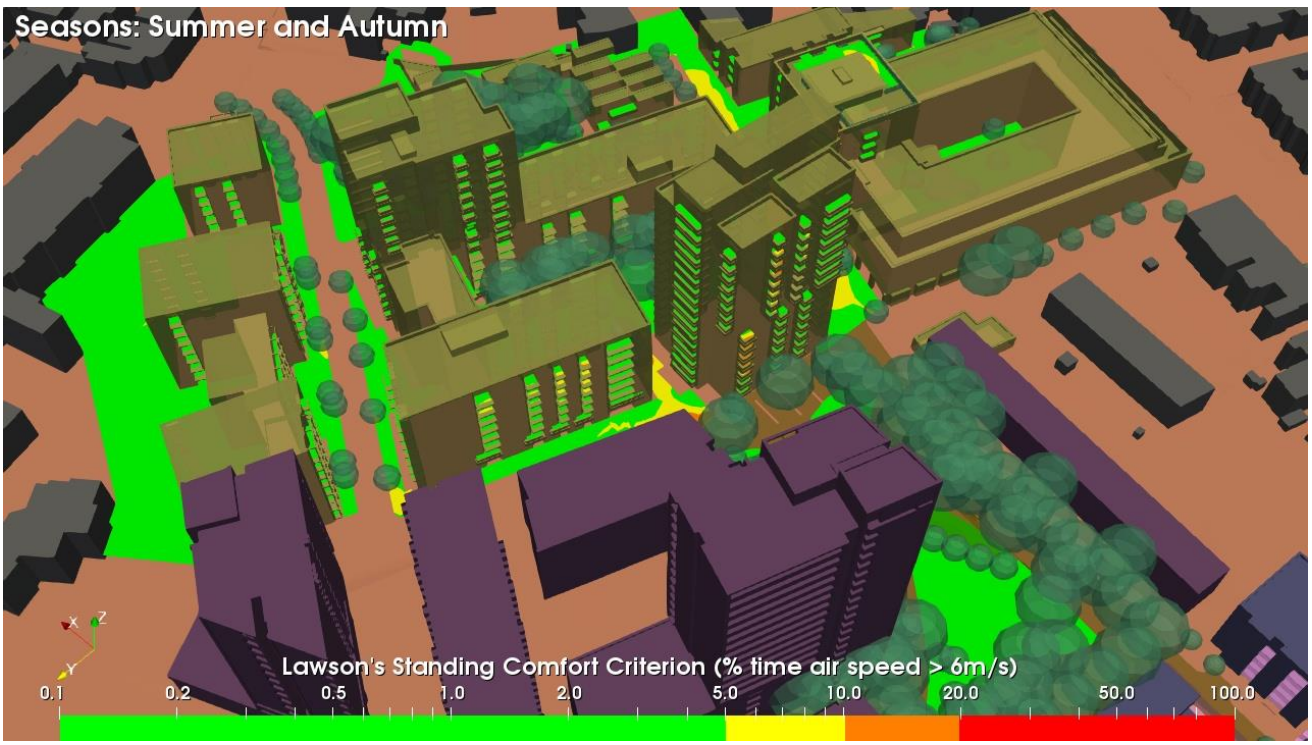
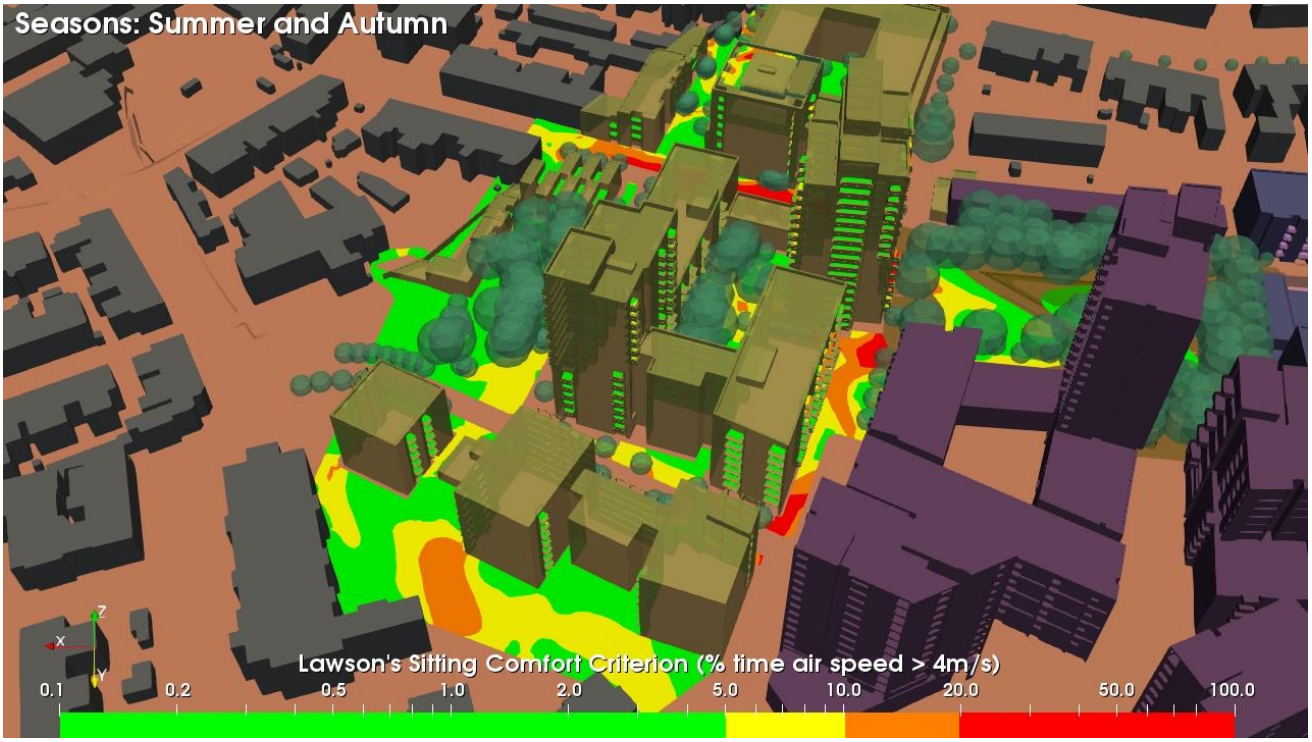


Figure 51: Comfort Criteria: Summer and Autumn Season: View from the northwest

Comfort Criteria: Sitting



Comfort Criteria: Standing

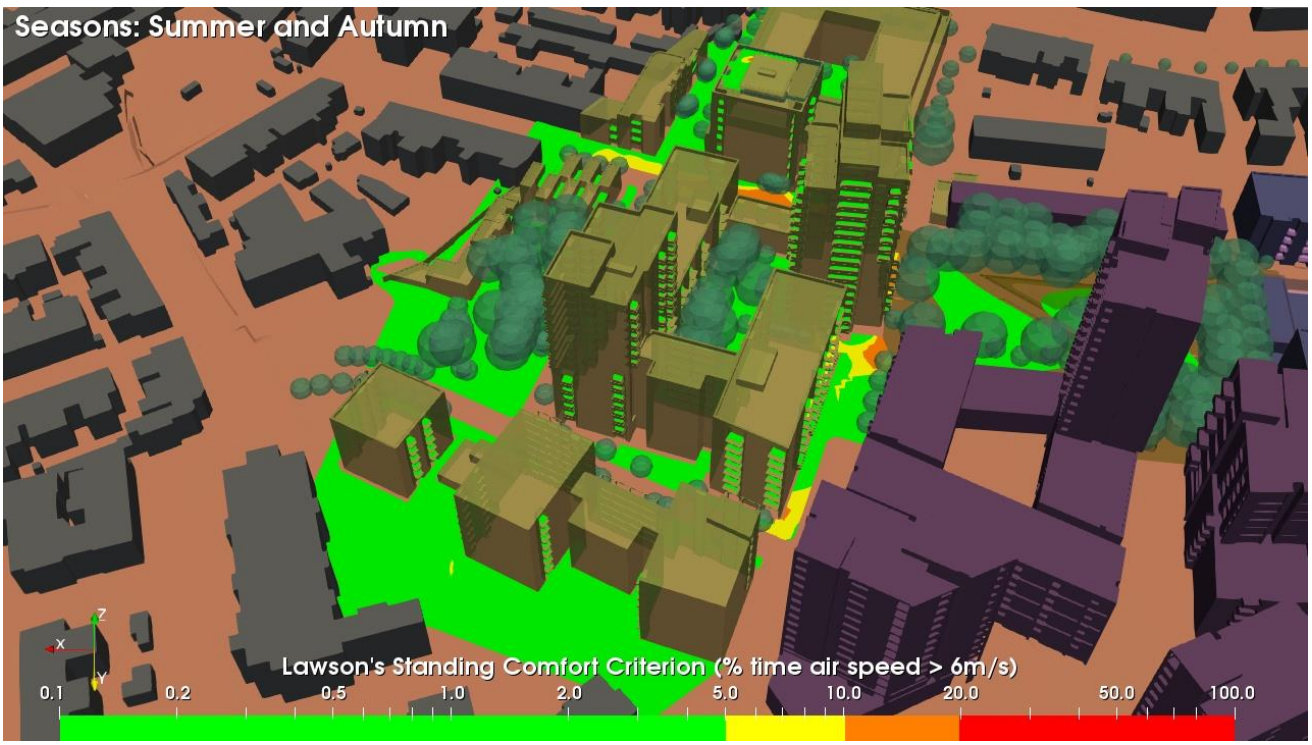
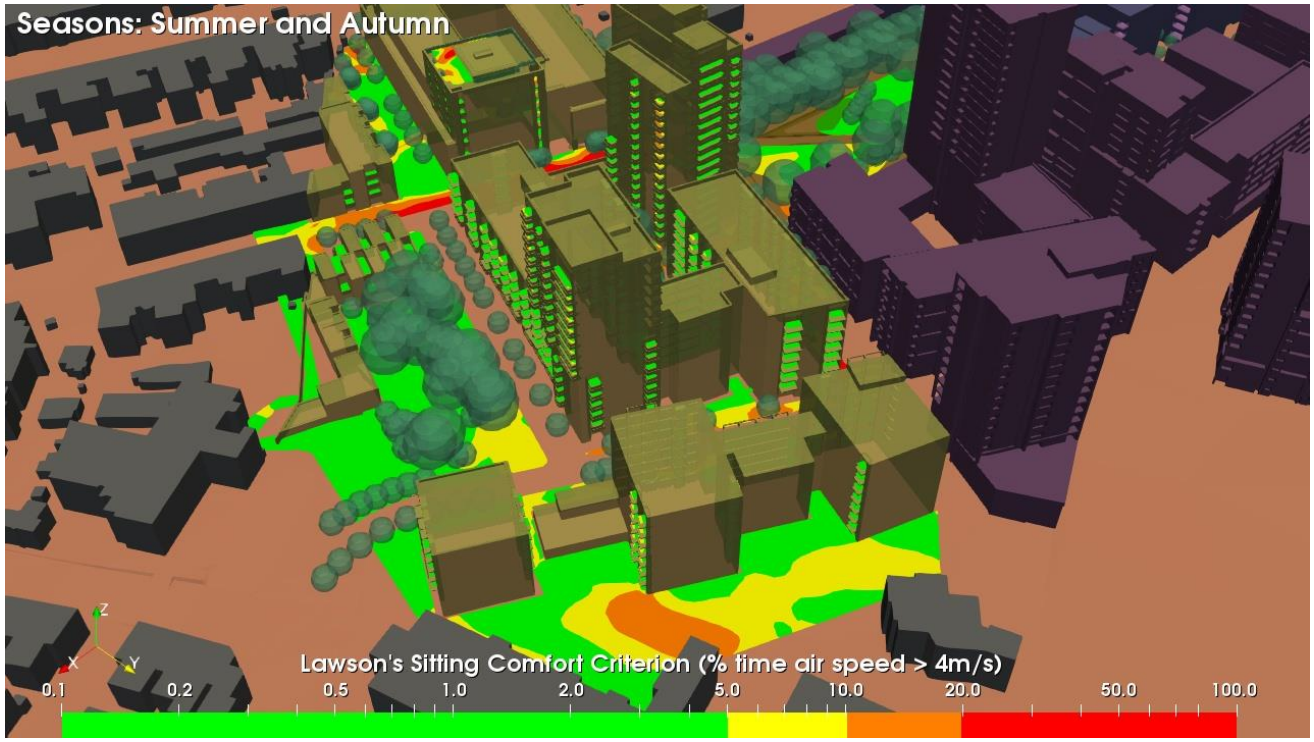


Figure 52: Comfort Criteria: Summer and Autumn Season: View from the north

Comfort Criteria: Sitting



Comfort Criteria: Standing

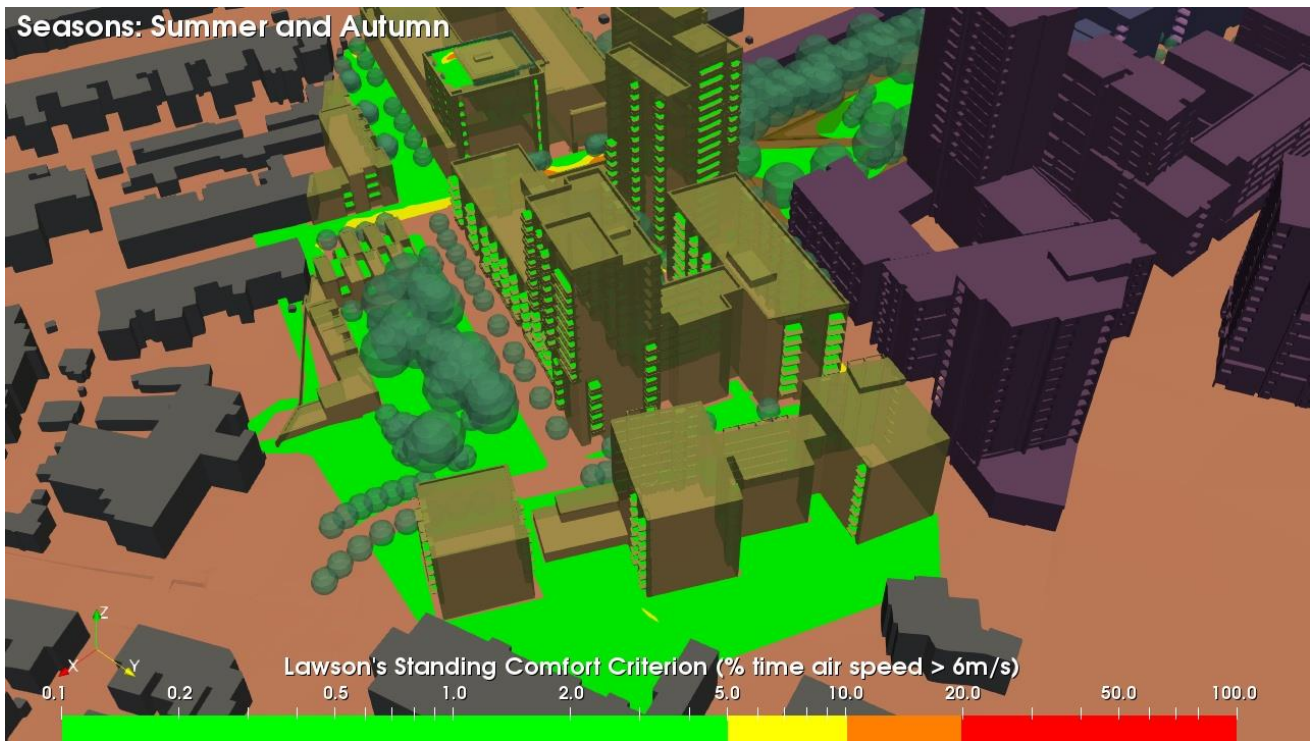
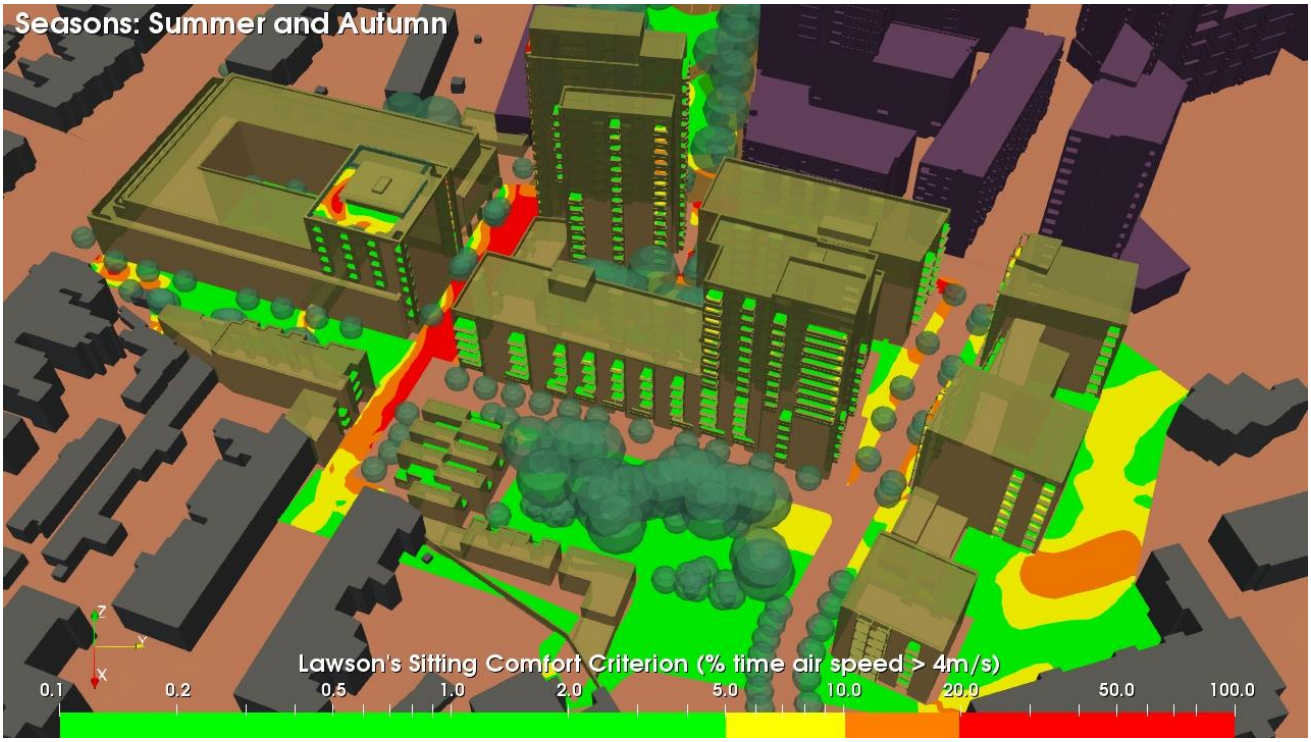


Figure 53: Comfort Criteria: Summer and Autumn Season: View from the northeast

Comfort Criteria: Sitting



Comfort Criteria: Standing

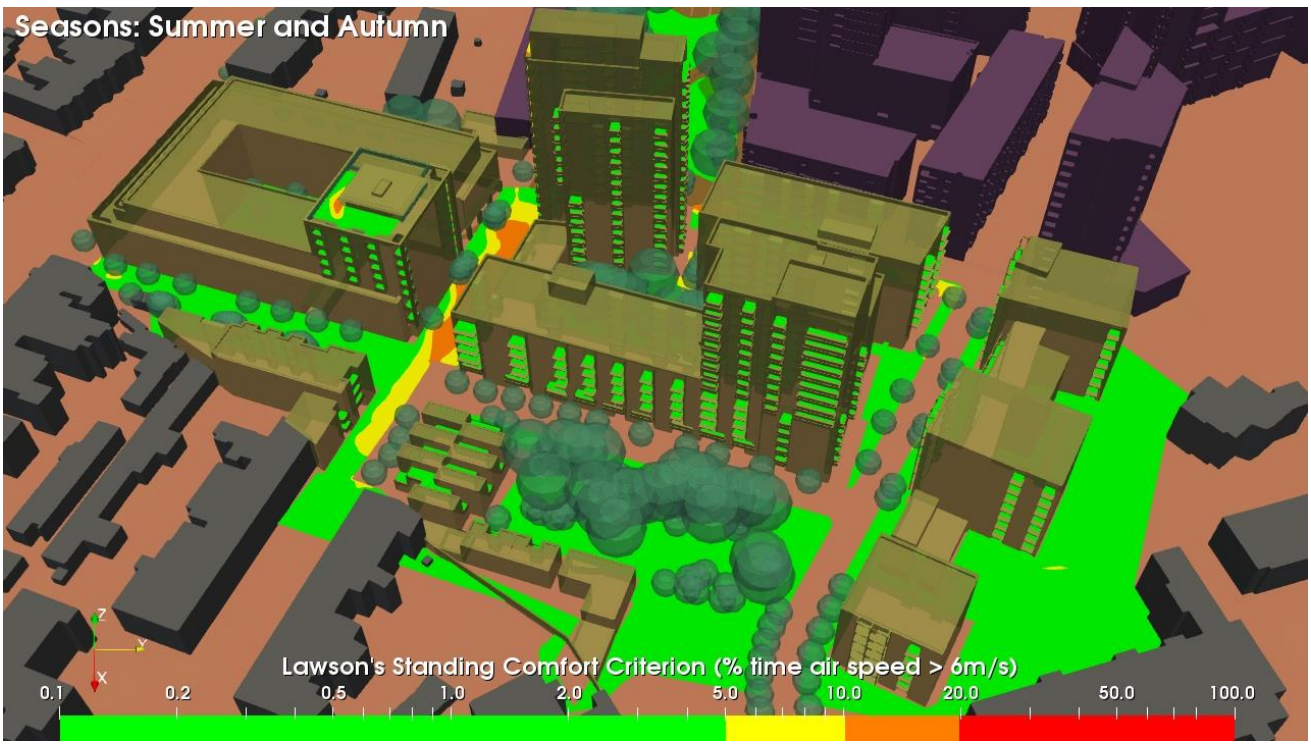


Figure 54: Comfort Criteria: Summer and Autumn Season: View from the east

Comfort Criteria: Sitting

Comfort Criteria: Standing

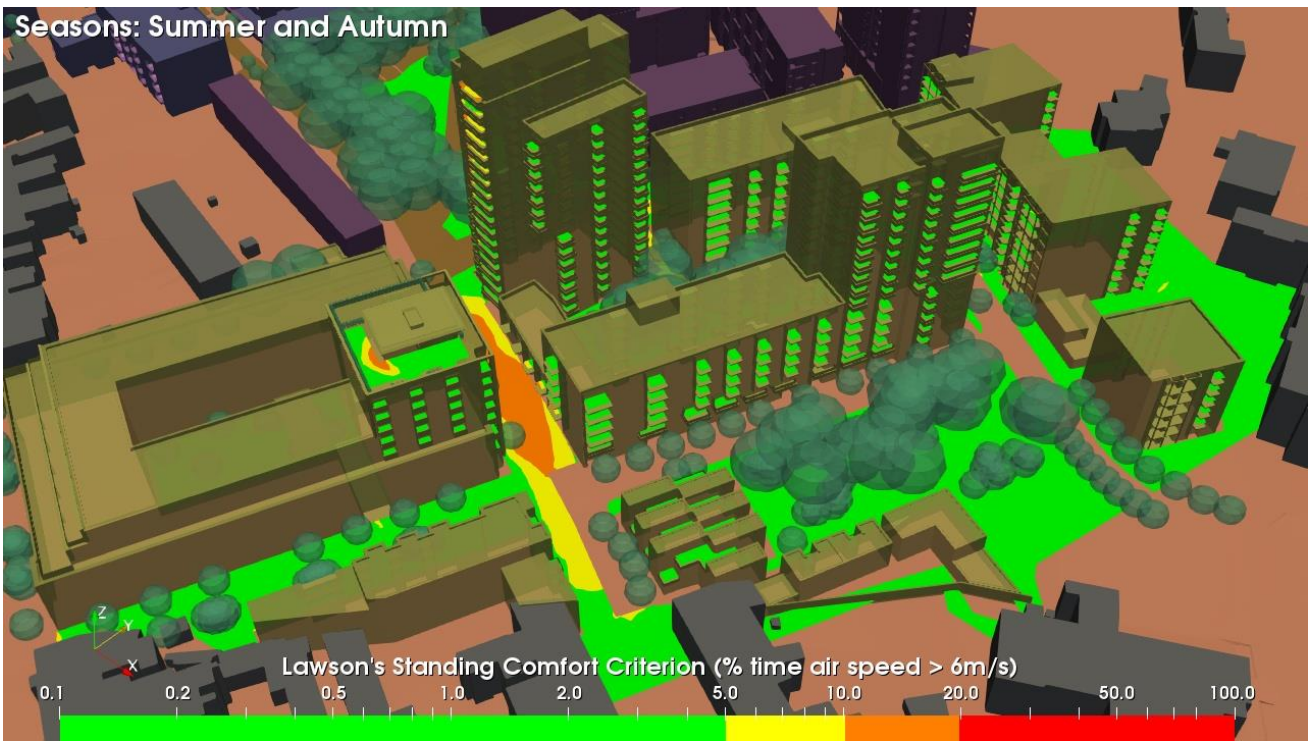


Figure 55: Comfort Criteria: Summer and Autumn Season: View from the southeast

7.3 Safety Criteria: All Seasons

Figure 56 to 64 show the percentage of the year the hourly wind speed exceeds the threshold value for the safety criteria for all seasons. The threshold values are 20m/s for normal pedestrian and 15m/s for sensitive pedestrian.

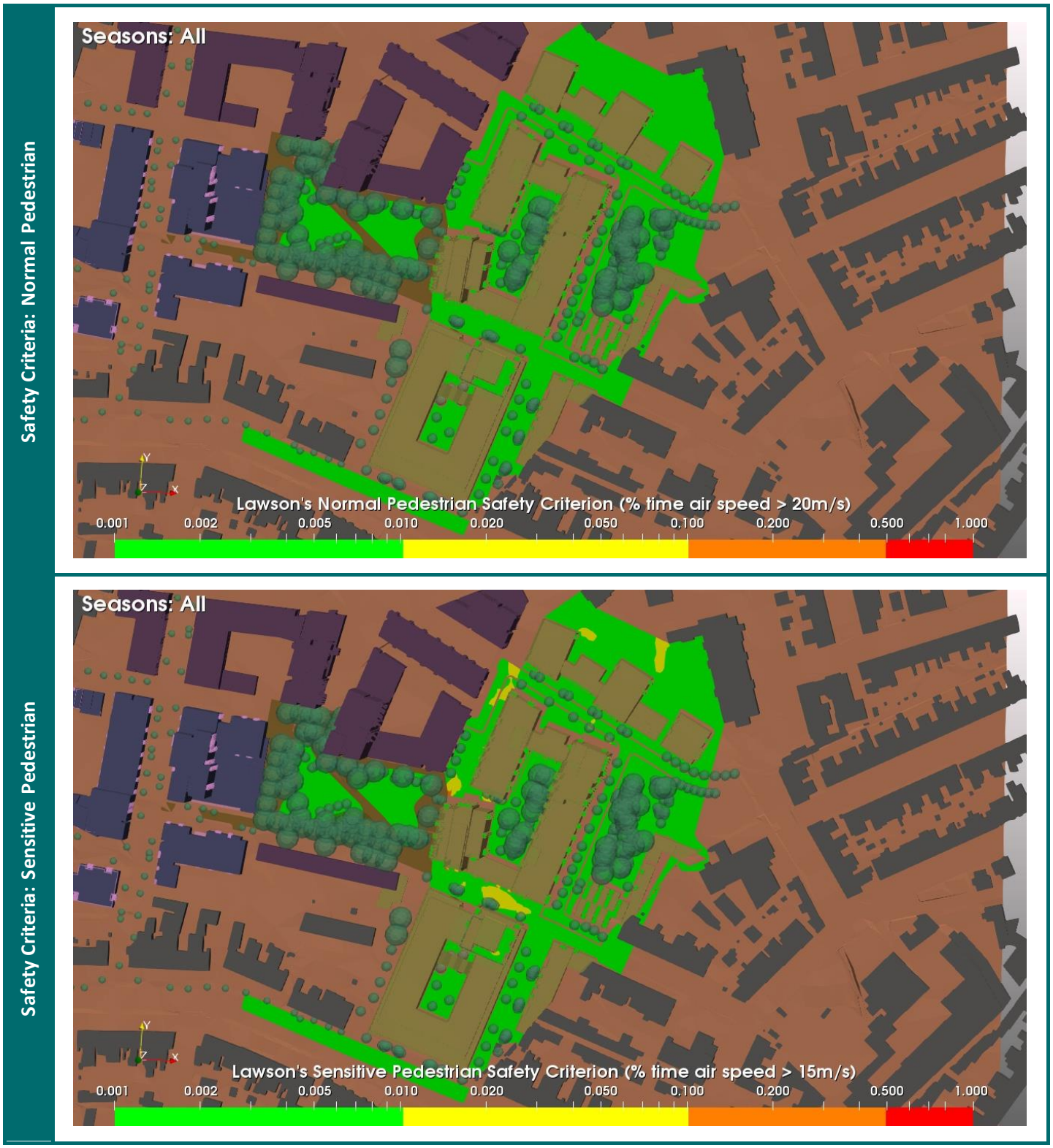
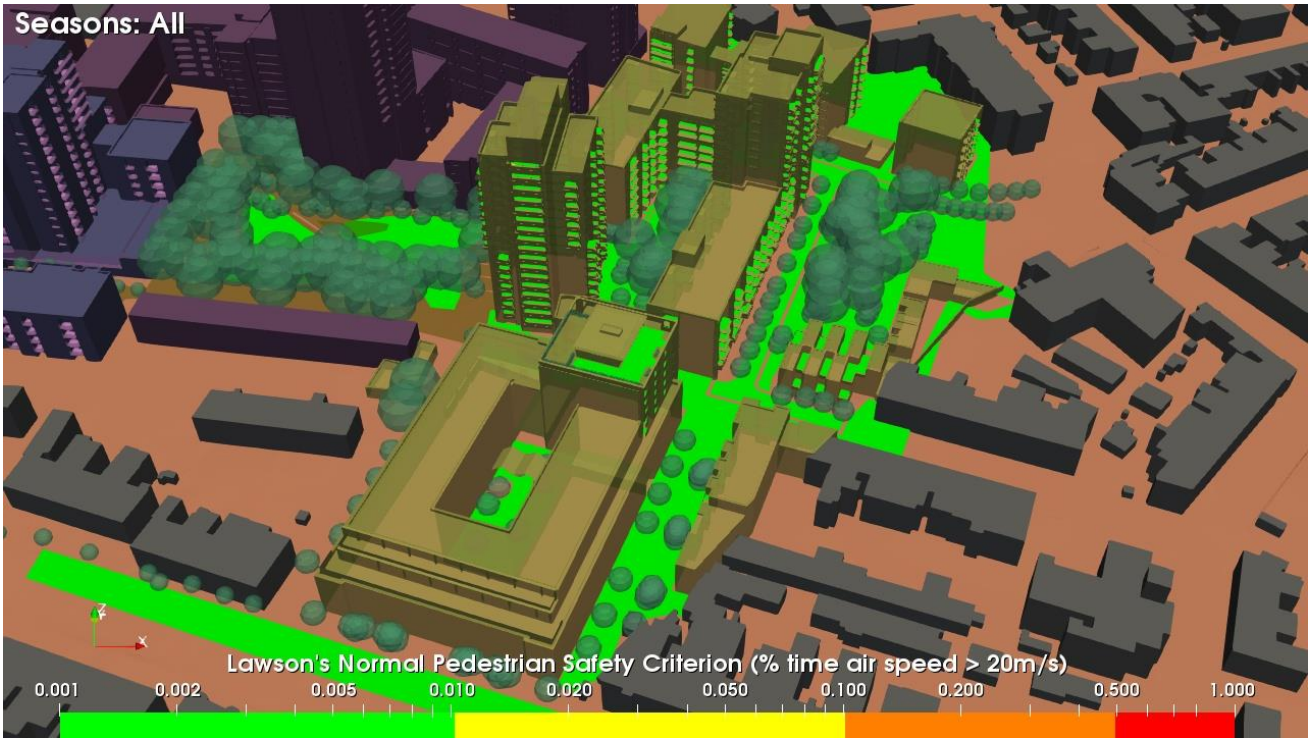


Figure 56: Safety Criteria: All Season: View from above

Safety Criteria: Normal Pedestrian



Safety Criteria: Sensitive Pedestrian

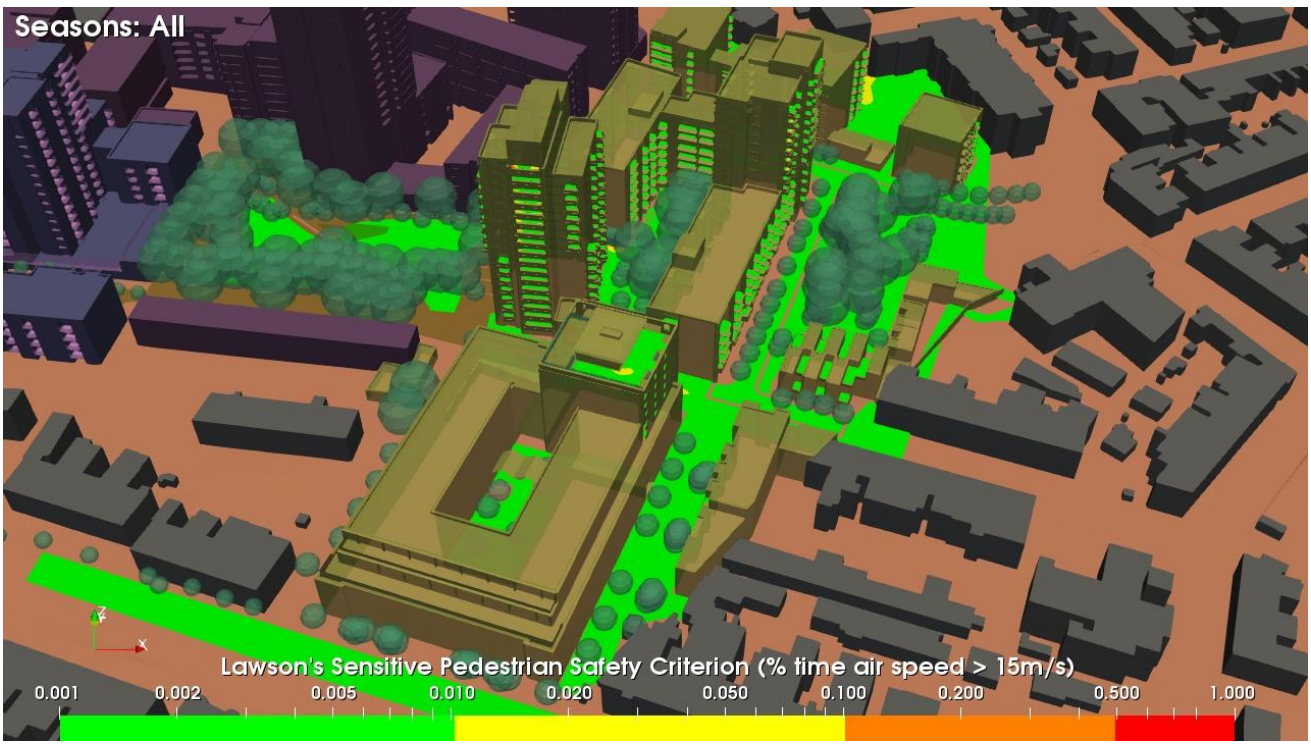


Figure 57: Safety Criteria: All Season: View from the south

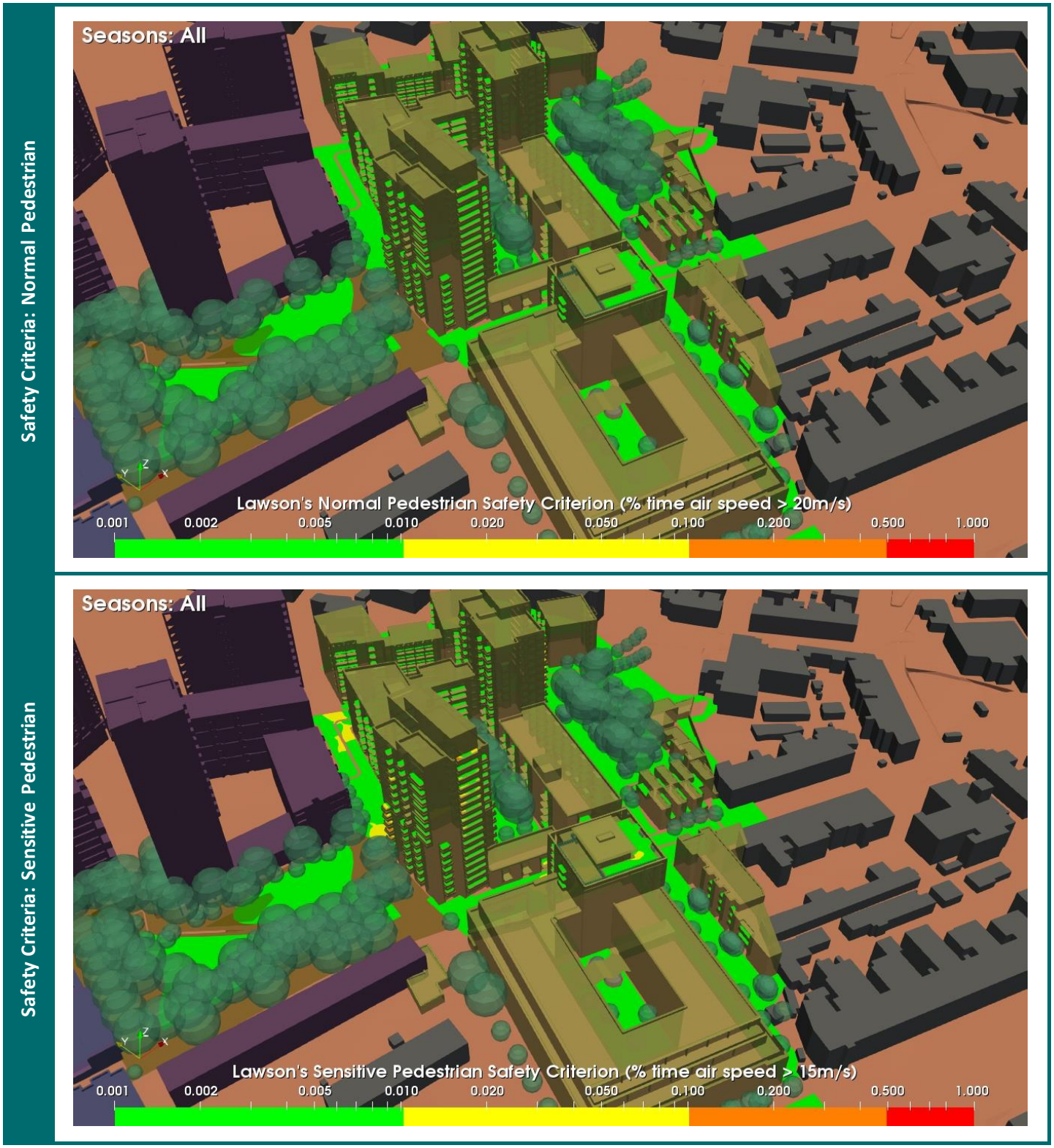


Figure 58: Safety Criteria: All Season: View from the southwest

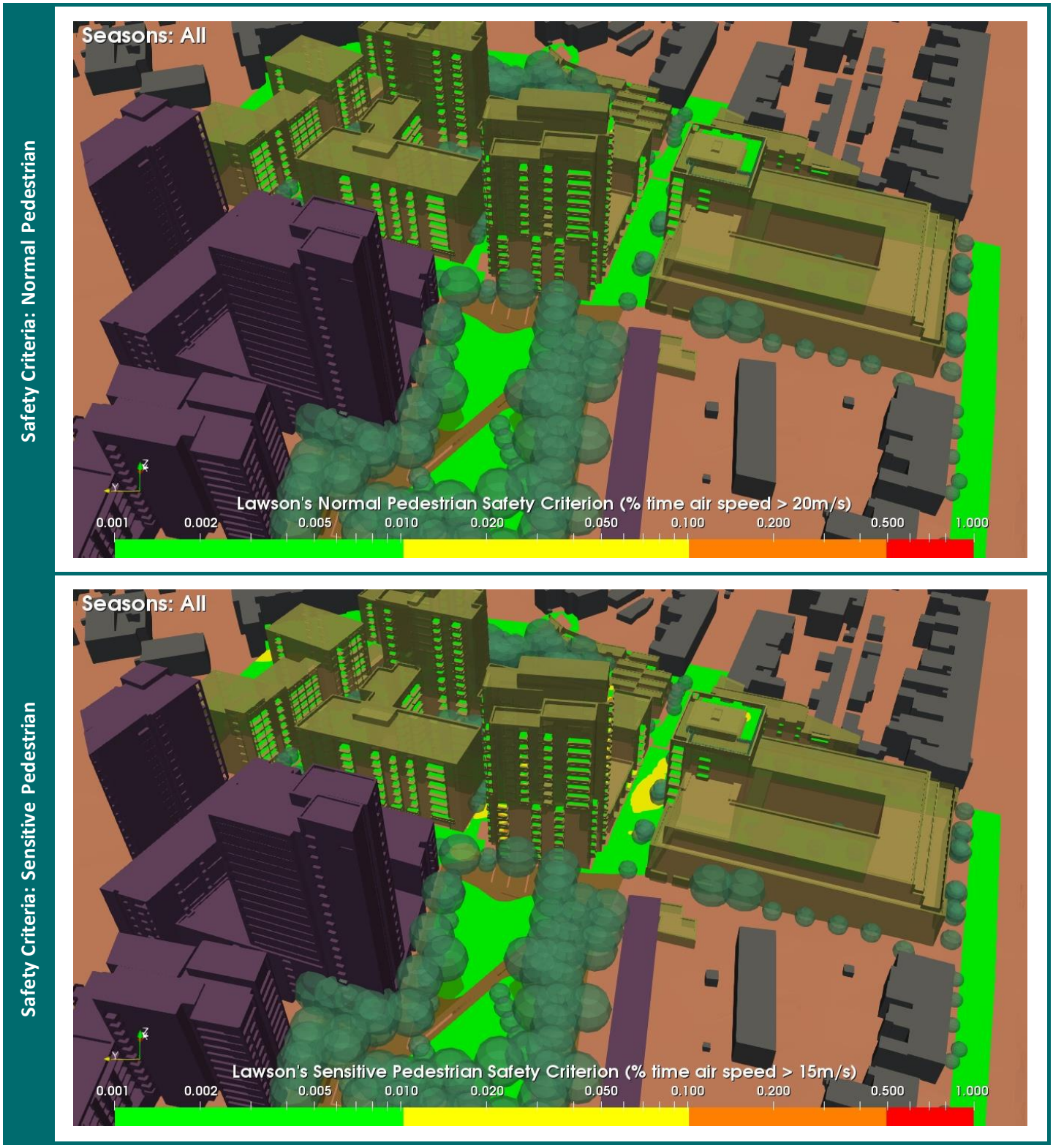
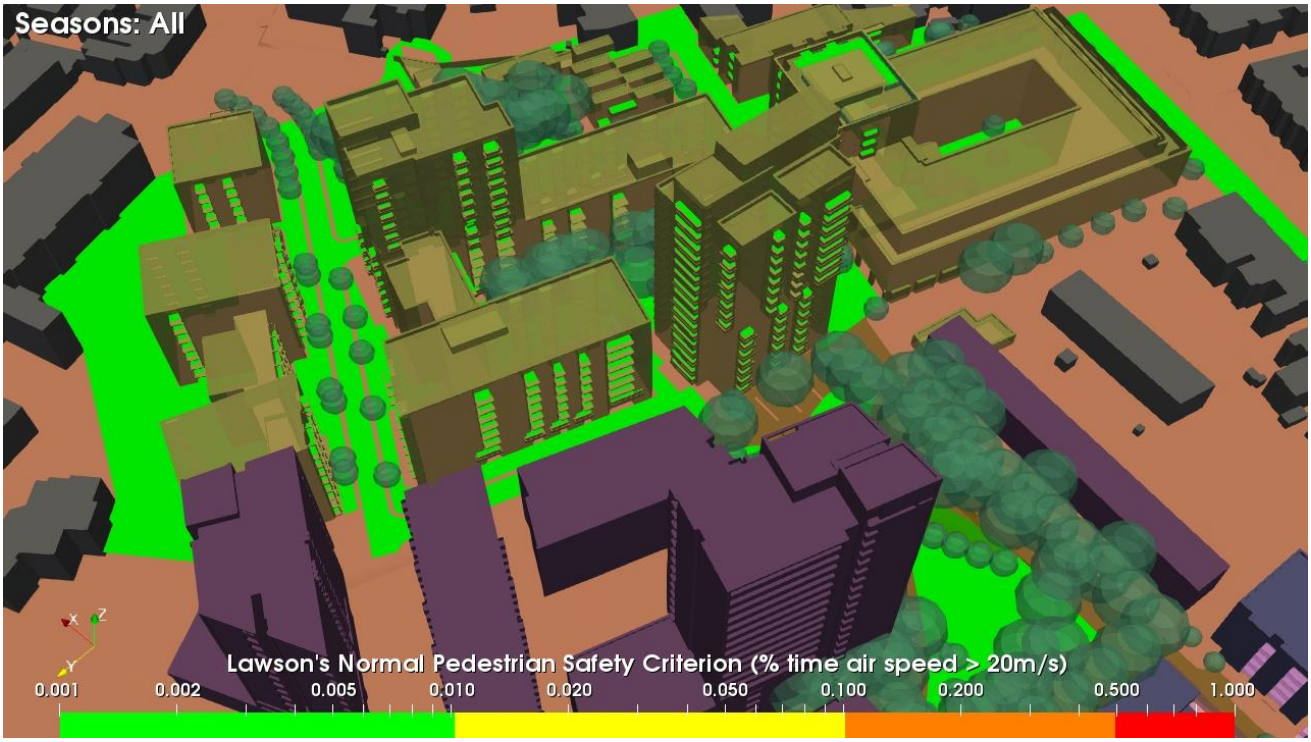


Figure 59: Safety Criteria: All Season: View from the west

Safety Criteria: Normal Pedestrian



Safety Criteria: Sensitive Pedestrian

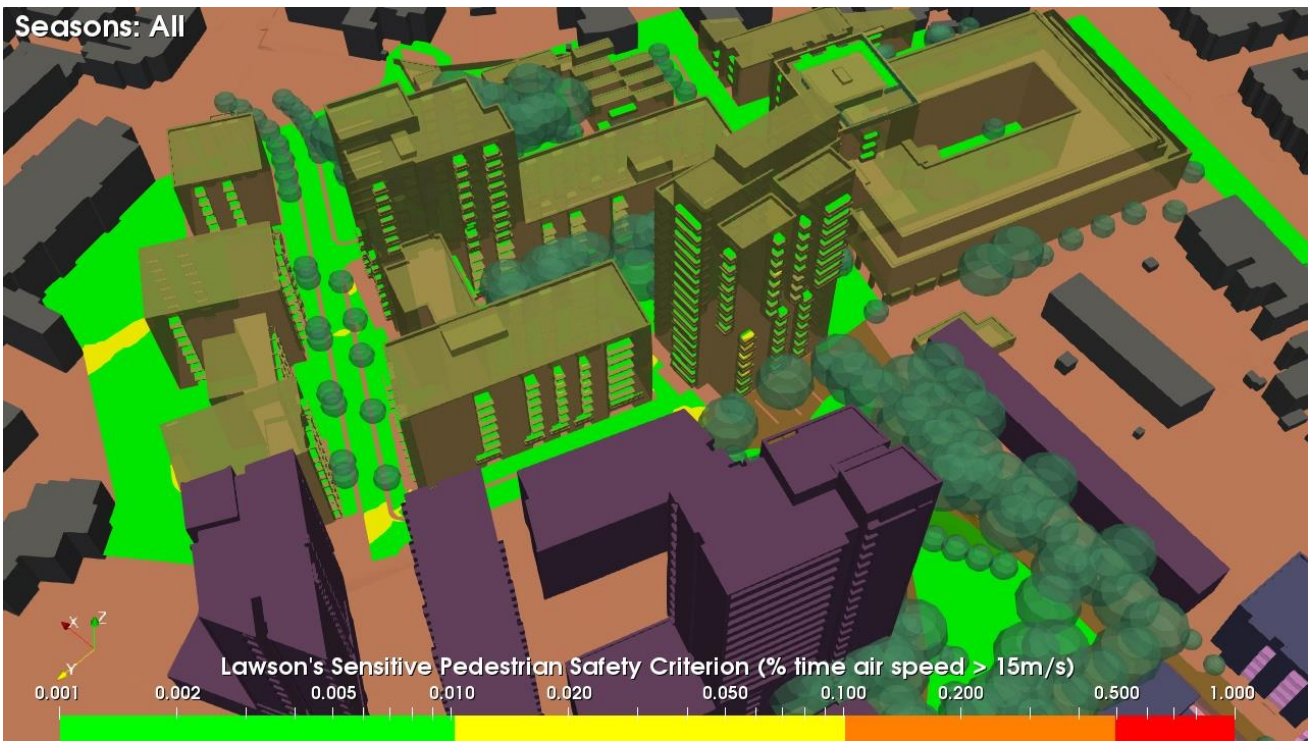


Figure 60: Safety Criteria: All Season: View from the northwest

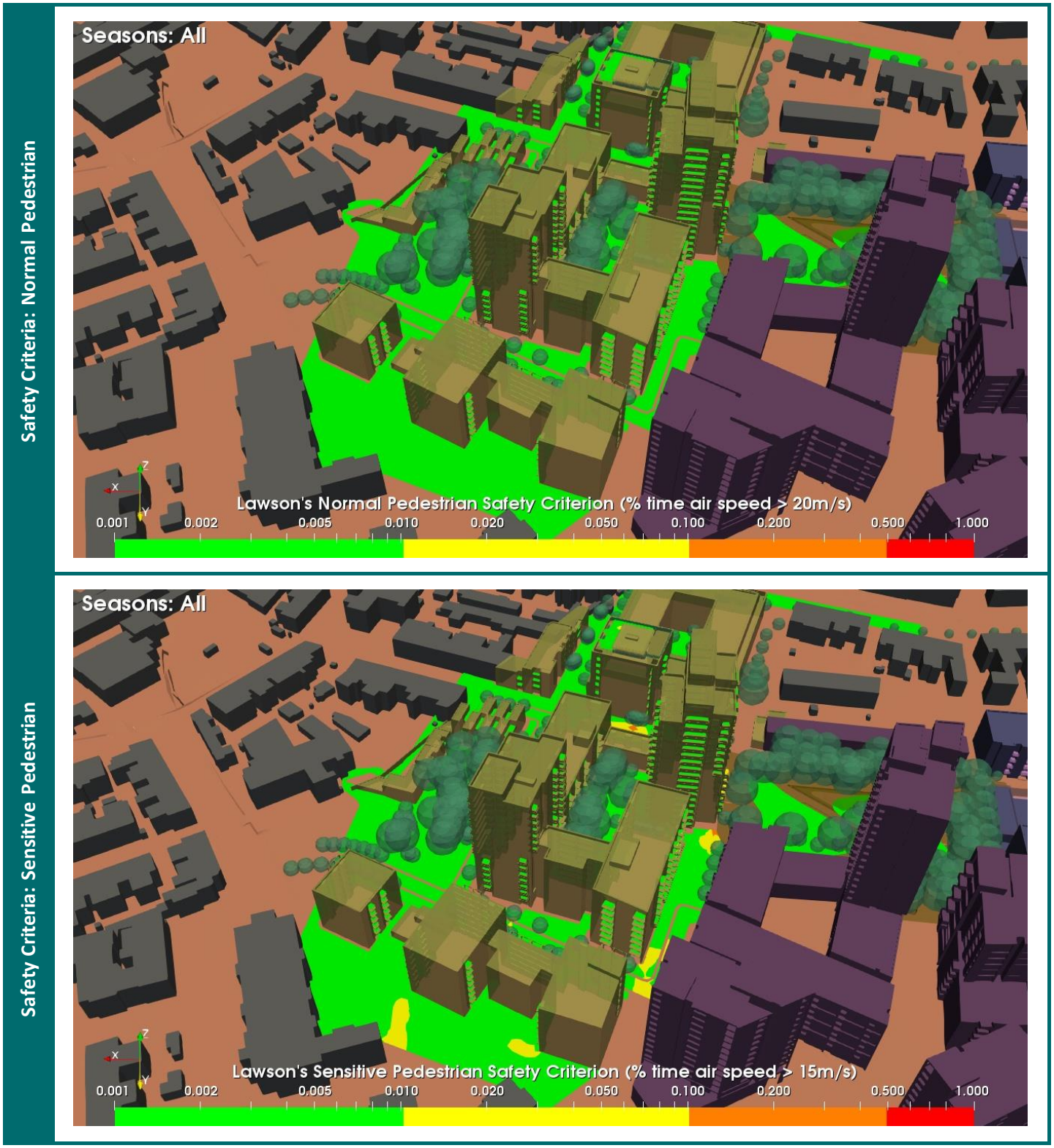


Figure 61: Safety Criteria: All Season: View from the north

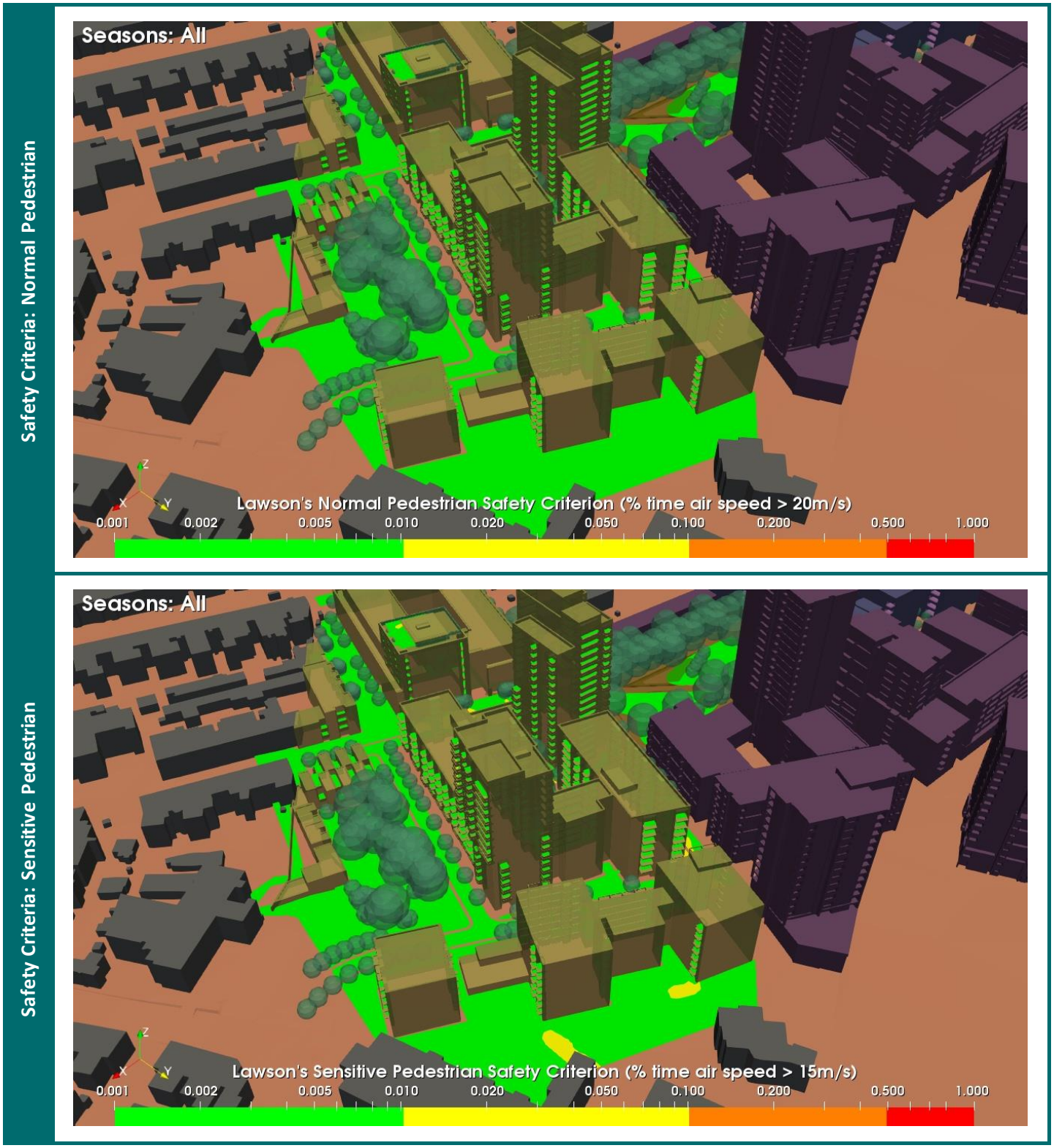
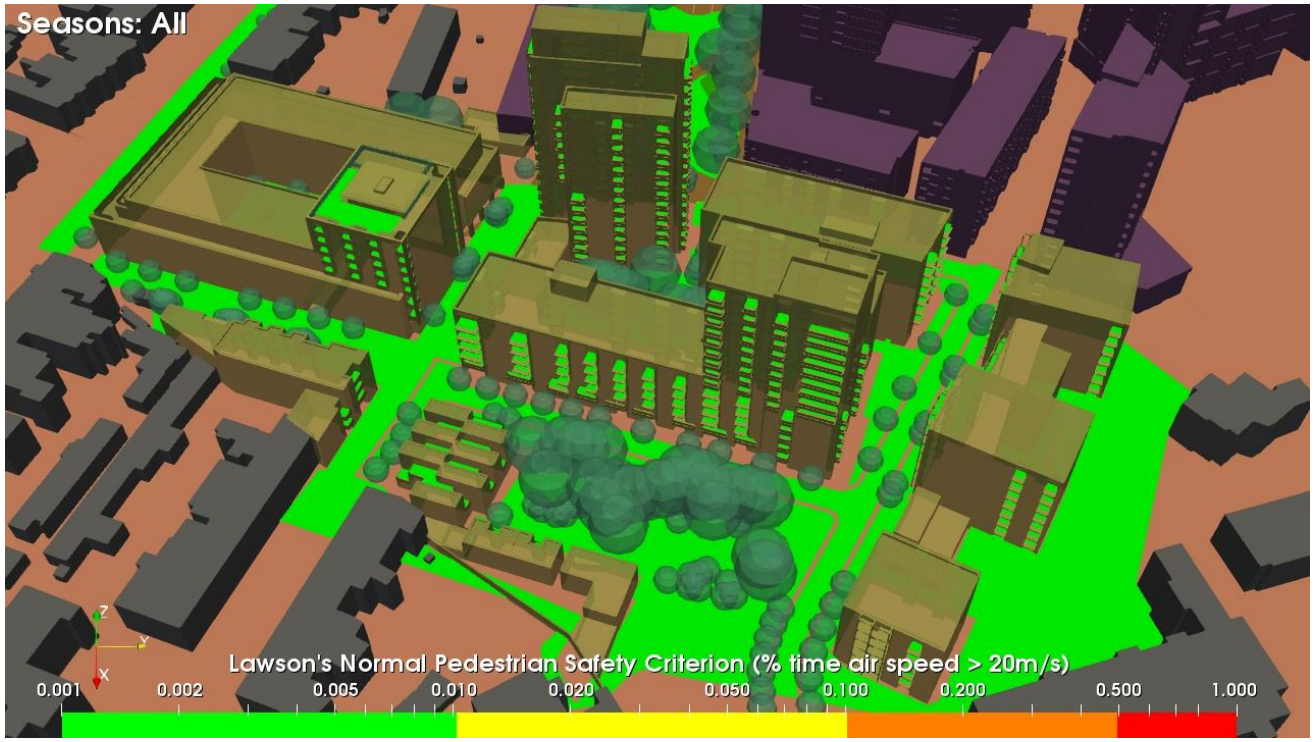


Figure 62: Safety Criteria: All Season: View from the northeast

Safety Criteria: Normal Pedestrian



Safety Criteria: Sensitive Pedestrian

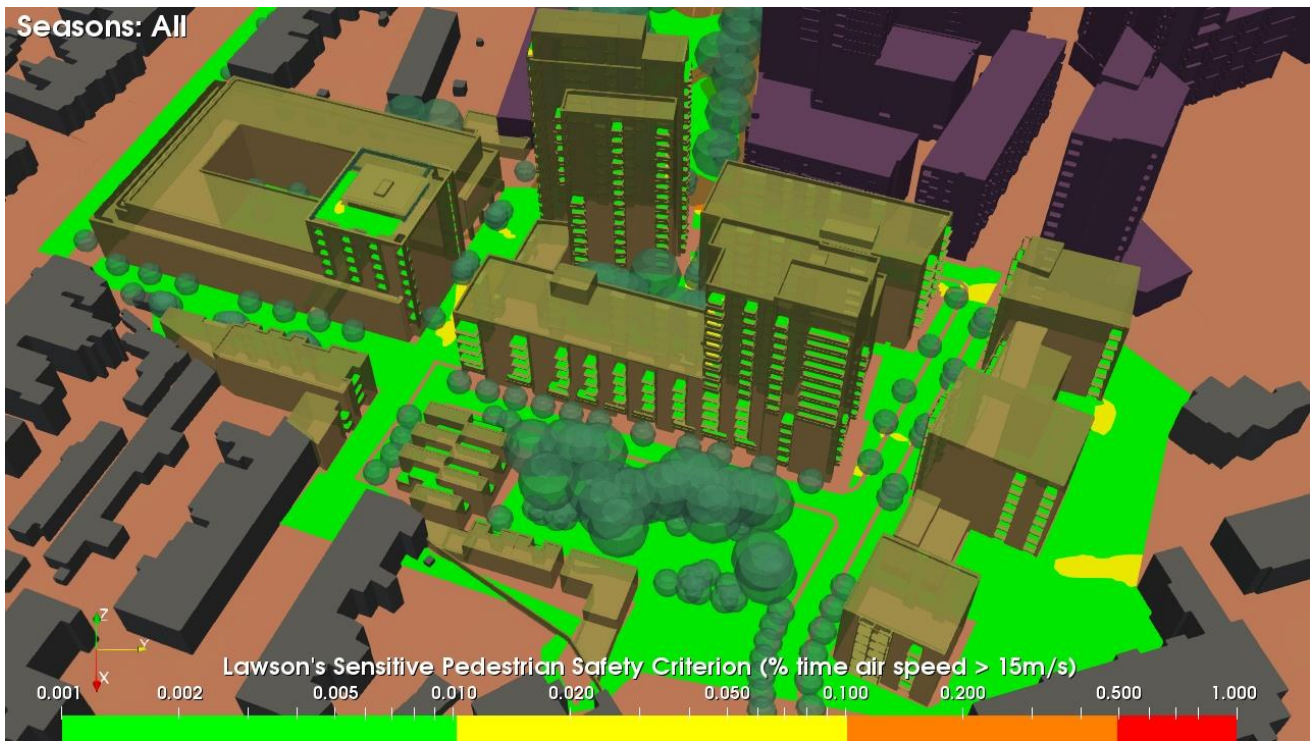


Figure 63: Safety Criteria: All Season: View from the east

Safety Criteria: Normal Pedestrian

Safety Criteria: Sensitive Pedestrian

Figure 64: Safety Criteria: All Season: View from the southeast

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