11 Wind & Microclimate

11.1. Introduction

B-Fluid Limited has been commissioned by 'Homeland Silverpines Limited' to carry out a Wind and Micro-climate Modelling to support the An Bord Pleanala application for planning permission for a strategic housing development on a site of approx. (2.74 ha) at (1) 'Saint Joseph's House', Brewery Road, Stillorgan, Co. Dublin (A94 Y7F4); (2) 'Madona House', Silverpines, Stillorgan, Blackrock, Co. Dublin (A94 Y230); and (3) Properties at 'Woodleigh' (D18 F3F4), 'Cloonagh' (D18 P5P9), 'Souk El Raab' (D18 Y6C5), 'Wellbrook' (D18 H0C6), 'Calador' (D18 W1Y2), 'Alhambra' (D18 E3C4), 'Dalwhinnie' (D18 P2P4), 'Annaghkeen' (D18 Y2W1) and 'The Crossing' (D18 W8 W2); all located at Leopardstown Road, Dublin 18.

The development will consist of a new residential and mixed use scheme to include apartments, residential amenity space, a café and a childcare facility.

Figure 11.1 shows a 3D view of the proposed development.

Figure 11.1 Proposed development

This Chapter is completed by Dr. Cristina Paduano, Dr. Patrick Okolo and Dr. Arman Safdari.

Dr. Cristina Paduano is a Chartered Engineer (CEng) and member of Engineers Ireland who specialises in computational fluid dynamics applications for urban environment and the construction industry with over 15 years of experience. She holds a PhD in Mechanical Engineering from Trinity College Dublin, with M.Eng and B.Eng in Aerospace Engineering.

Dr. Patrick Okolo is a Chartered Engineer (CEng) and member of Engineers Ireland who specialises in computational fluid dynamics applications for the urban environment and in wind tunnel measurements for the aerospace industry. He holds a PhD in Aeroacoustics from Trinity College Dublin, a M.Sc. and B.Sc. in Aeronautical Engineering.

Dr. Arman Safdari is a CFD Modelling Engineer who specialises in computational fluid dynamics applications. He is an expert in airflow modelling, heat and mass transfer and multi-phase flow simulations. He holds a PhD in Mechanical Engineering from Pusan National University, a M.Sc. and B.Sc. in Mechanical Engineering.

Wind microclimate studies identify the possible wind patterns around the existing environment and proposed development under mean and peak wind conditions typically occurring in Dublin.

This assessment is performed through advanced Computational Fluid Dynamics (CFD) which is a numerical method used to simulate wind conditions and its impact on the development and to identify areas of concern in terms of downwash/funnelling/downdraft/critical flow accelerations that may likely occur. The Advanced CFD numerical algorithms applied here are solved using high performance computing cluster.

These results are utilized by Homeland Silverpines Limited design team to configure the optimal layout for Proposed development for the aim of achieving a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian) and not to introduce any critical wind impact on the surrounding areas and on the existing buildings.

The next sections describe in details the wind and microclimate modelling performed, it's methodology and assumptions which B-Fluid Ltd. has adopted for this study, together with impacts of the proposed development on the existing environment.

Objective of Wind and Microclimate Modelling

CFD wind modelling is adopted to identify areas of concern in terms of critical flows and areas where pedestrian safety and comfort could be compromised. Pedestrian Wind Comfort and Safety Studies are conducted to predict, assess and, where necessary, mitigate the impact of the residential development on pedestrian level wind conditions. The objective is to maintain comfortable and safe pedestrian level wind conditions that are appropriate for the season and the intended use of pedestrian areas. Pedestrian areas include side-walks, street frontages, pathways, building entrance areas, open spaces, amenity areas, outdoor sitting areas, and accessible roof top areas among others.

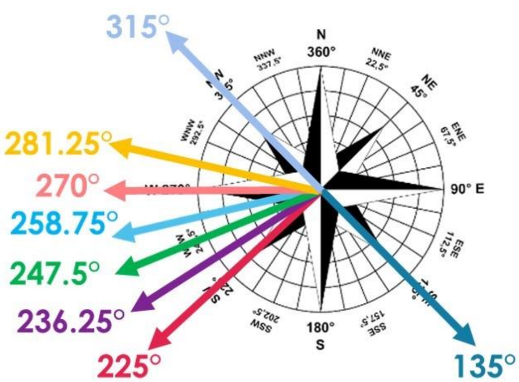
For this purpose, 18 different wind scenarios and directions have been studied as shown in Table 11.1 in order to take into consideration all the different relevant wind directions. In particular, a total of 18 compass directions on the wind rose are selected. For each direction, the reference wind speed is set to the 5% exceedance wind speed for that direction, i.e. the wind speed that is exceeded for over 5% of the time whenever that wind direction occurs.

Dublin Wind Scenarios And Directions		
Velocity (*m/s*)	**Direction (deg)**	**Frequency**
5.601	225	11.233
4.626	135	6.849
5.847	236.25	6.792
6.049	258.75	6.747
6.034	247.5	6.689
5.888	270	5.662

4.994	315	4.338
5.503	281.25	3.904
4.974	292.5	3.436
5.357	213.75	3.288
4.736	123.75	3.105
4.406	146.25	2.751
5.101	303.75	2.648
5.246	112.5	2.500
4.121	157.5	2.386
4.581	101.25	2.340
4.169	45	2.180
3.558	90	2.135

Table 11.1: Summary of wind speeds in Dublin with directions and frequency of occurrence per year

This modelling study focuses on reporting 8 no. worst cases and most relevant wind speeds frequently happen in Dublin, which are the speeds and directions showing the most critical wind speeds relevant to the development. The 8 no. modelled scenarios reported in this study are presented in Figure 11.2.



Velocity (m/s)	Direction (°)	Frequency
5.601	225	11.233
4.626	135	6.849
5.847	236.25	6.792
6.049	258.75	6.747
6.034	247.5	6.689
5.888	270	5.662
4.994	315	4.338
5.503	281.25	3.904

Figure 11.2: Summary of 8 Wind Scenarios Reported

Policies applicable and Guidelines for Wind Microclimate Studies

Good wind microclimate conditions are necessary for creating outstanding public spaces. Adverse wind effects can reduce the quality and usability of outdoor areas, and lead to safety concerns in extreme cases.

According to *Urban Development and Building Heights – Guidelines for Planning Authorities* (Government of Ireland, 2018), specific impact assessment of the microclimatic effects should be performed for *"buildings taller than prevailing building heights in urban areas"* (p. 13), where standard building height is considered to be 6 – 8 storeys. Above this height, buildings are considered 'taller', by Dublin standards. Usually, the recommended approach to wind microclimate studies is based on building height, as prescribed by the *Wind Microclimate Guidelines for Developments in the City of London* (City of London, 2019) as presented for example in Figure 11.3.

Building Height	Recommended Approach to Wind Microclimate Studies
Similar or lower than the average height of surrounding buildings **Up to 25m**	Wind studies are not required, unless sensitive pedestrian activities are intended (e.g. around hospitals, transport hubs, etc.) or the project is located on an exposed location
Up to double the average height of surrounding buildings **25m to 50m**	Computational (CFD) Simulations **OR** Wind Tunnel Testing
Up to 4 times the average height of surrounding buildings **50m to 100m**	Computational (CFD) Simulations **AND** Wind Tunnel Testing
High Rise **Above 100m**	**Early Stage Massing Optimization:** Wind Tunnel Testing OR Computational (CFD) Simulations **Detailed Design:** Wind Tunnel Testing **AND** Computational (CFD) Simulations to demonstrate the performance of the final building design

Figure 11.3.: Recommended Approach to Wind Microclimate Studies based on Building Height, as prescribed by the Wind Microclimate Guidelines for Developments in the City of London (August 2019)

Computational fluid dynamics (CFD) tools can create high quality output that provide a good understanding of fundamental flow features. The CFD models must include a detailed three-dimensional representation of the proposed development.

Maximum cell sizes near critical locations (e.g. entrances, corners, etc.) must be 0.3m or smaller. Sufficient cells should be also used between buildings with a minimum of 10 across a street canyon. However, the cell size of buildings away from the target can be larger to allow for modelling efficiency. The CFD models should represent all surrounding buildings that are within 400m from the centre of the site. Other taller buildings outside of this zone that could have an influence on wind conditions within the project site should be included for wind directions where they are upwind of the project site. The models must contain at least 3 prism layers below 1.5m height, to capture near-ground effects.

CFD analysis also reports conditions in areas away from the site where cumulative effects of a cluster of tall buildings could lead to adverse wind conditions.

11.2. Study Methodology

<u>Acceptance Criteria</u>

Pedestrian Comfort Pedestrian Wind Comfort is measured in function of the frequency of wind speed threshold exceeded based on the pedestrian activity. The assessment of pedestrian level wind conditions requires a standard against which measured or expected wind velocities can be compared.

Only gust winds are considered in the safety criterion. These are usually rare events but deserve special attention in city planning and building design due to their potential impact on pedestrian safety. Gusts cause the majority of cases of annoyance and distress and are assessed in addition to average wind speeds. Gust speeds should be divided by 1.85 and these "gust equivalent mean" (GEM) speeds are compared to the same criteria as for the mean hourly wind speeds. This avoids the need for different criteria for mean and gust wind speeds.

The following criteria are widely accepted by municipal authorities as well as the international building design and city planning community:

- Discomfort criteria: Relates to the activity of the individual.
  Onset of discomfort:
  - Depends on the activity in which the individual is engaged and is defined in terms of a mean hourly wind speed (or GEM) which is exceeded for 5% of the time.

- Distress criteria: Relates to the physical well-being of the individual.
  Onset of distress:
  - 'Frail Person Or Cyclist': equivalent to an hourly mean speed of 15 m/s and a gust speed of 28 m/s (62 mph) to be exceeded less often than once a year. This is intended to identify wind conditions which less able individuals or cyclists may find physically difficult. Conditions in excess of this limit may be acceptable for optional routes and routes which less physically able individuals are unlikely to use.

  - 'General Public': A mean speed of 20 m/s and a gust speed of 37 m/s (83 mph) to be exceeded less often than once a year. Beyond this gust speed, aerodynamic forces approach body weight and it rapidly becomes impossible for anyone to remain standing. Where wind speeds exceed these values, pedestrian access should be discouraged.

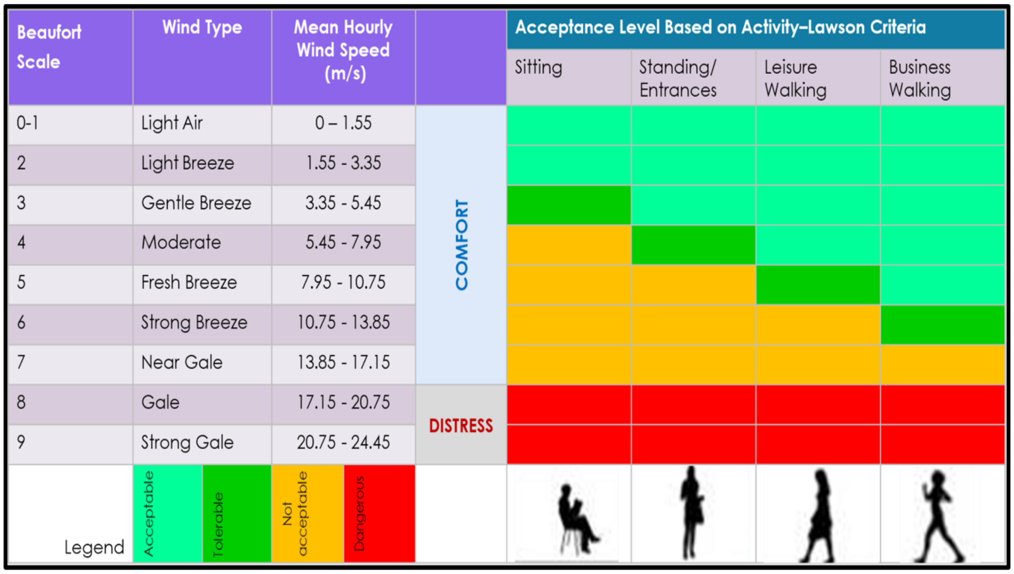
The above criteria set out six pedestrian activities and reflect the fact that calm activity requires calm wind conditions, which are summarised by the Lawson scale, shown in Figure 11.4. Lawson scale assesses pedestrian wind comfort in absolute terms and defines the reaction of an average person to the wind. Each wind type is associated to a number, corresponding to the Beaufort scale, which is represented in Figure 11.5. Beaufort scale is an empirical measure that relates wind speed to observed conditions at sea or on land. A 20% exceedance is used in these criteria to determine the comfort category, which suggests that wind speeds would be comfortable for the corresponding activity at least 80% of the time or four out of five days.

These criteria for wind forces represent average wind tolerances. They are subjective and variable depending on thermal conditions, age, health, clothing, etc. which can all affect a person's perception of a local microclimate. Moreover, pedestrian activity alters between winter and summer months. The criteria assume that people will be suitably dressed for the time of year and individual activity. It is reasonable to assume, for instance, that areas designated for outdoor seating will not be used on the windiest days of the year.
Weather data measured are used to calculate how often a given wind speed will occur each year over a specified area. Pedestrian comfort criteria are assessed at 1.5m above ground level. Unless in extremely unusual circumstances, velocities at pedestrian level increase as you go higher from ground level.

A breach of the distress criteria requires a consideration of:

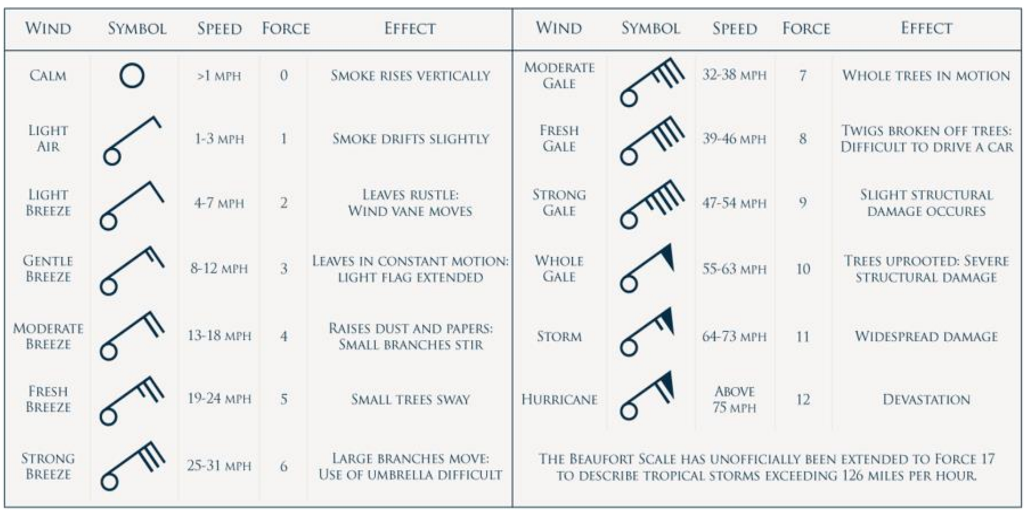
- whether the location is on a major route through the complex,
- whether there are suitable alternate routes which are not distressful.

If the predicted wind conditions exceed the threshold, then conditions are unacceptable for the type of pedestrian activity and mitigation measure should be implemented into the design.



Beaufort Scale	Wind Type	Mean Hourly Wind Speed (m/s)		Acceptance Level Based on Activity–Lawson Criteria			
				Sitting	Standing/ Entrances	Leisure Walking	Business Walking
0-1	Light Air	0 – 1.55	COMFORT				
2	Light Breeze	1.55 - 3.35					
3	Gentle Breeze	3.35 - 5.45					
4	Moderate	5.45 - 7.95					
5	Fresh Breeze	7.95 - 10.75					
6	Strong Breeze	10.75 - 13.85					
7	Near Gale	13.85 - 17.15					
8	Gale	17.15 - 20.75	DISTRESS				
9	Strong Gale	20.75 - 24.45					
Legend	Acceptable / Tolerable	Not acceptable / Dangerous					

Figure 11.4.: Lawson Scale



Wind	Symbol	Speed	Force	Effect
Calm		>1 mph	0	Smoke rises vertically
Light Air		1-3 mph	1	Smoke drifts slightly
Light Breeze		4-7 mph	2	Leaves rustle: Wind vane moves
Gentle Breeze		8-12 mph	3	Leaves in constant motion: Light flag extended
Moderate Breeze		13-18 mph	4	Raises dust and papers: Small branches stir
Fresh Breeze		19-24 mph	5	Small trees sway
Strong Breeze		25-31 mph	6	Large branches move: Use of umbrella difficult
Moderate Gale		32-38 mph	7	Whole trees in motion
Fresh Gale		39-46 mph	8	Twigs broken off trees: Difficult to drive a car
Strong Gale		47-54 mph	9	Slight structural damage occures
Whole Gale		55-63 mph	10	Trees uprooted: Severe structural damage
Storm		64-73 mph	11	Widespread damage
Hurricane		Above 75 mph	12	Devastation

The Beaufort scale has unofficially been extended to force 17 to describe tropical storms exceeding 126 miles per hour.

Figure 11.5.: Beaufort Scale

Modelling Method

Computational Fluid Dynamics (CFD) is a numerical technique to simulate fluid flow, heat and mass transfer, chemical reaction and combustion, multiphase flow, and other phenomena related to fluid flows. CFD modelling includes three main stages: pre-processing, simulation and post-processing as described in Figure 11.6. The Navier-Stokes equations, used within CFD analysis, are based entirely on the application of fundamental laws of physics and therefore produce extremely accurate results providing that the scenario modelled is a good representation of reality.

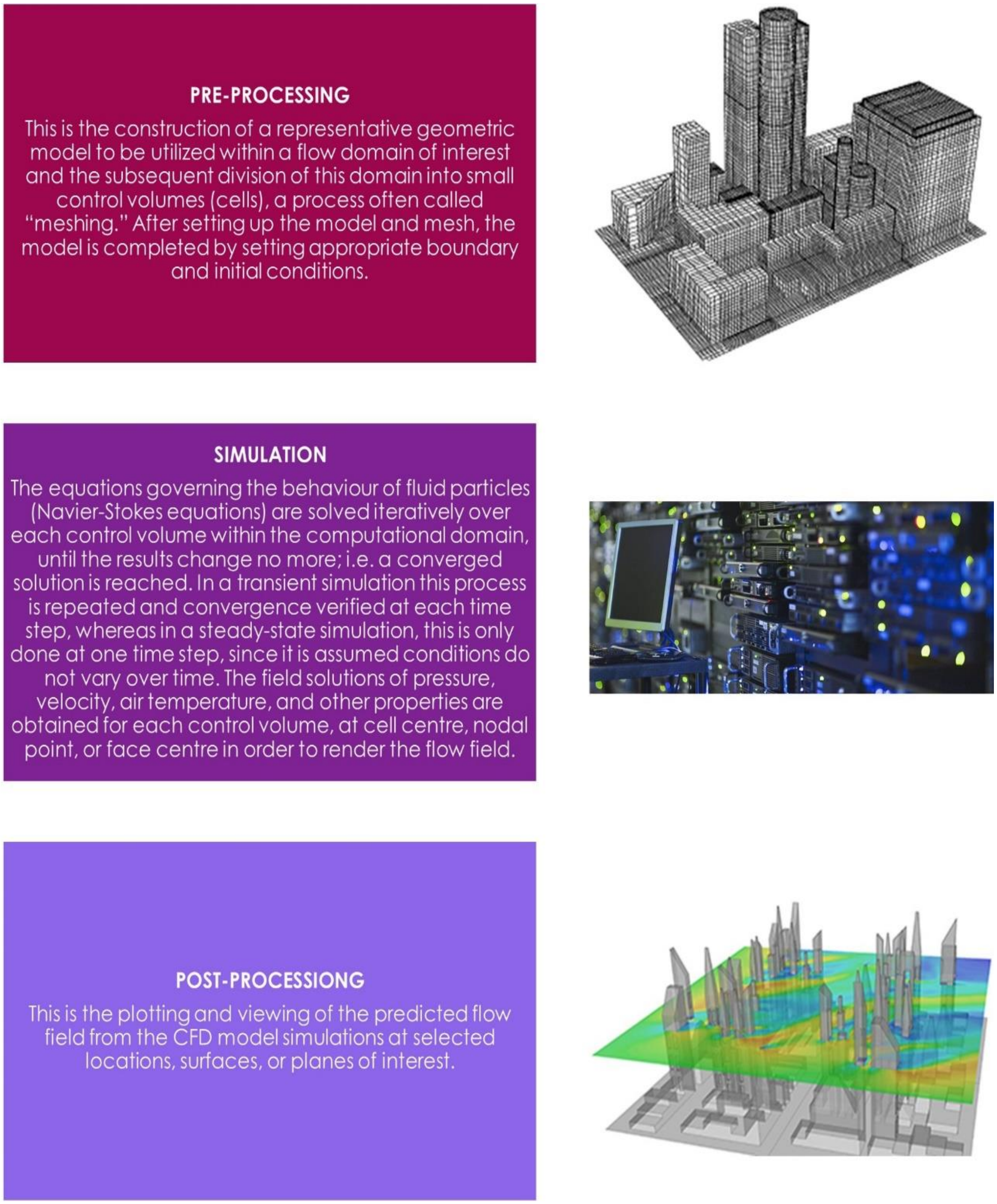


Figure 11.6.: CFD Modelling Process Explanation

OpenFOAM Numerical Solver Details

This report employs OpenFoam Code, which is based on a volume averaging method of discretization and uses the post-processing visualisation toolkit Paraview version 5.5. OpenFoam is a CFD software code released and developed primarily by OpenCFD Ltd, since 2004. It has a large user base across most areas of engineering and science, from both commercial and academic organisations.

OpenFOAM CFD code has capabilities of utilizing a Reynolds Averaged Navier-Stokes (RANS) approach, Unsteady Reynolds Averaged Navier-Stokes (URANS) approach, Detached Eddy Simulation (DES) approach, Large Eddy Simulation (LES) approach or the Direct Numerical Simulation (DNS) approach, which are all used to solve anything from complex fluid flows involving chemical reactions, turbulence and heat transfer, to acoustics, solid mechanics and electromagnetics. Quality assurance is based on rigorous testing. The process of code evaluation, verification and validation includes several hundred daily unit tests, a medium-sized test battery run on a weekly basis, and large industry-based test battery run prior to new version releases. Tests are designed to assess regression behaviour, memory usage, code performance and scalability.

The OpenFOAM solver algorithm directly solves the mass and momentum equations for the large eddies that comprise most of the fluid's energy. By solving the large eddies directly no error is introduced into the calculation.

To reduce computational time and associated costs the small eddies within the flow have been solved using the widely used and recognised Smagorinsky Sub-Grid Scale (SGS) model. The small eddies only comprise a small proportion of the fluids energy therefore the errors introduced through the modelling of this component are minimal.

The error introduced by modelling the small eddies can be considered of an acceptable level. Computational time will be reduced by modelling the small eddies (compared to directly solving).

11.3. The Existing Receiving Environment (Baseline)

In this chapter, wind impact has been assessed on the existing receiving environment considered as the existing buildings and the topography of the site prior to construction of the proposed development. A statistical analysis of 30 years historical weather wind data has been carried out to assess the most critical wind speeds, directions and frequency of occurrence of the same. The aim of this assessment has been to identify the wind microclimate of the area that may cause critical conditions for pedestrians comfort criteria.

Figure 11.7.: Existing Receiving Environment (Baseline Situation)

<u>Site Location and Surrounding Area</u>

The proposed development will be situated near Leopardstown Road, Dublin 18. The Existing Environment site is shown in Figure 11.7. The area considered for the existing environment and proposed development assessment comprises a 3km² area around the Proposed development as shown in Figure 11.8 and Figure 11.9.

Figure 11.8: Proposed development Site Location and Existing Environment

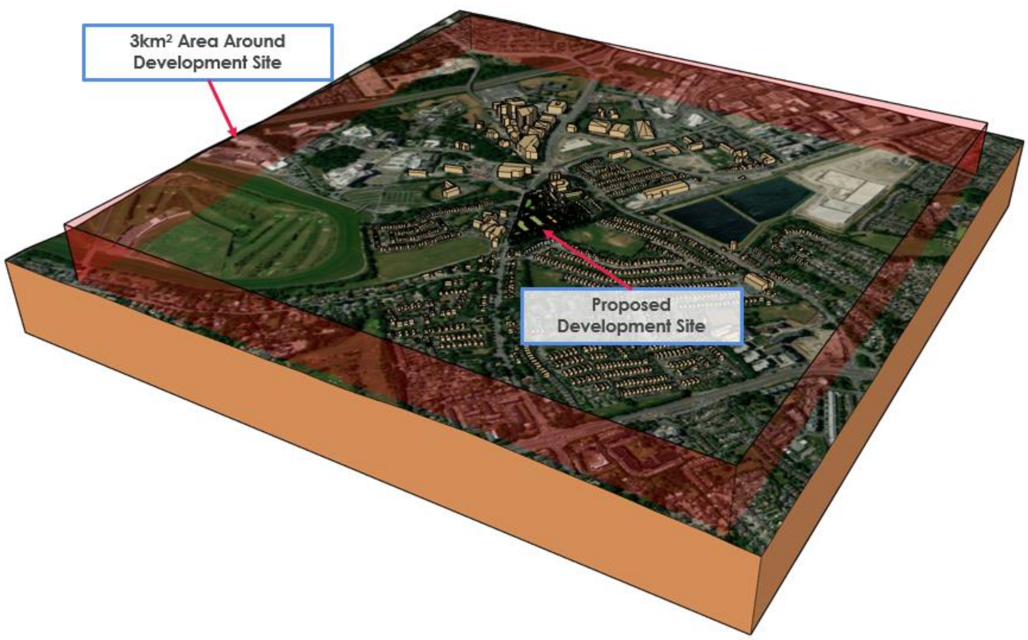


Figure 11.9.: Extents of Analysed Existing Environment Around Proposed development (a 3km² area is shown as a red box around the development)

Topography and Built-in Environment

Figure 11.10. shows an aerial photograph of the terrain surrounding the construction site at Proposed development.

The Proposed development site is located in Dublin 18. The site is located within 600m from both Sandyford and Central Park Luas stops as well as having a Quality Bus Corridor along Leopardstown

Road (for more detailed refer to Berwick Pines Traffic and Transport Assessment & Mobility Management Plan report by ILTP). The Proximity to Sandyford and Central Park also serves to provide nearby employment and Amenities local to the site.

The area surrounding the site can be characterised as Inner suburban. Some shelter effect can be expected for wind approaching from directions within this sector. All the wind directions considered for this study are in this connection "urban winds" and no distinction will be made between them.

Figure 11.10.: Built-in Environment Around Construction Site at Proposed development

<u>Wind and Microclimate Conditions</u>

This analysis consider the whole development being exposed to the typical wind condition of the site. The building is oriented as shown in the previous sections. The wind profile is built using the annual average of meteorology data collected at Dublin Airport Weather Station. Figure 11.11. shows on the map the position of the proposed development and the position of Dublin Airport.

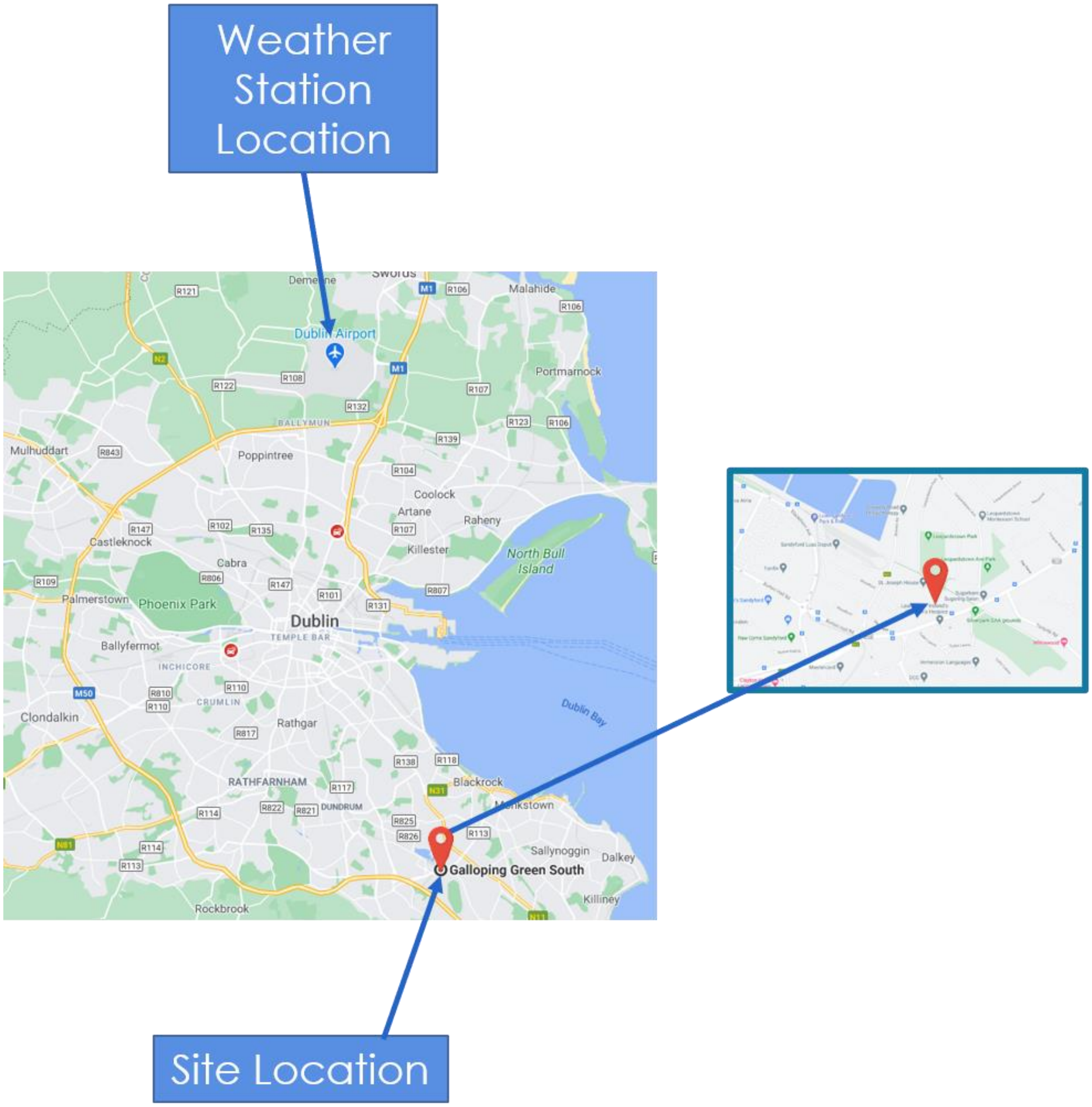


Figure 11.11.: Map showing the position of Proposed development and Dublin Airport

Regarding the transferability of the available wind climate data following considerations have been made:

- Terrain: The meteorological station is located in the flat open terrain of the airport, whereas the development site is located in an urban area surrounded with buildings up to 15m height.
- Mean Wind Speeds: Due to the different terrain environment, the ground-near wind speeds (at pedestrian level) will be lower at the construction site compared to the meteorological station at the airport.
- Wind Directions: The landscape around the development site can in principle be characterized as flat terrain. Isolated elevations in the near area of the development should have no influence on the wind speed and wind directions. With respect to the general wind climate no significant influence is expected. Based on the above considerations it can be concluded that the data from the meteorological station at Dublin Airport are applicable for the desktop assessment of the wind comfort at the development site.

Wind Conditions

The assessment of the wind comfort conditions at the new development will be based on the dominating wind directions throughout a year (annual wind statistic).

As stated above, the local wind climate is determined from historical meteorological data recorded at Dublin Airport. Two different data sets are analysed for this assessment as follows:

- The meteorological data associated with the maximum daily wind speeds recorded over a 30 year period between 1990 and 2020 and,
- The mean hourly wind speeds recorded over a 10 year period between 1990 and 2020. The data is recorded at a weather station at the airport, which is located 10m above ground or 71mOD.

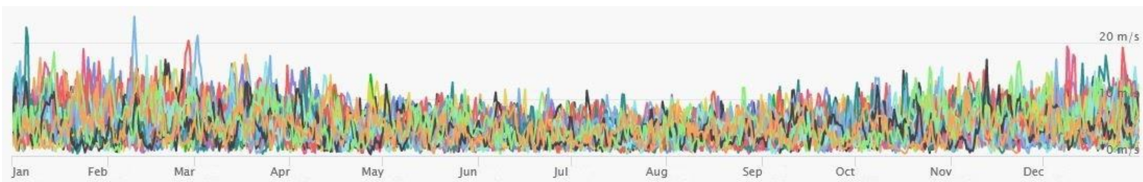


Figure 11.12.: Local Wind Conditions - Wind Speed - 1990-2020

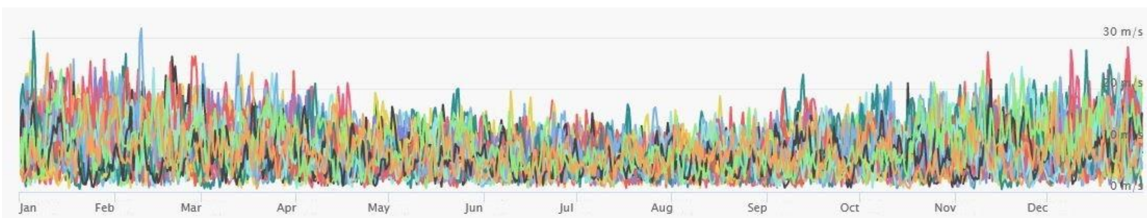


Figure 11.13.: Local Wind Conditions - Wind Gust - 1990-2020

Figure 11.14., presenting the wind speed diagram for Dublin, shows the days per month, during which the wind reaches a certain speed. In Figure 11.15., the wind rose for Dublin shows how many hours per year the wind blows from the indicated direction, confirming how the predominant directions are WSW, W, and SW.

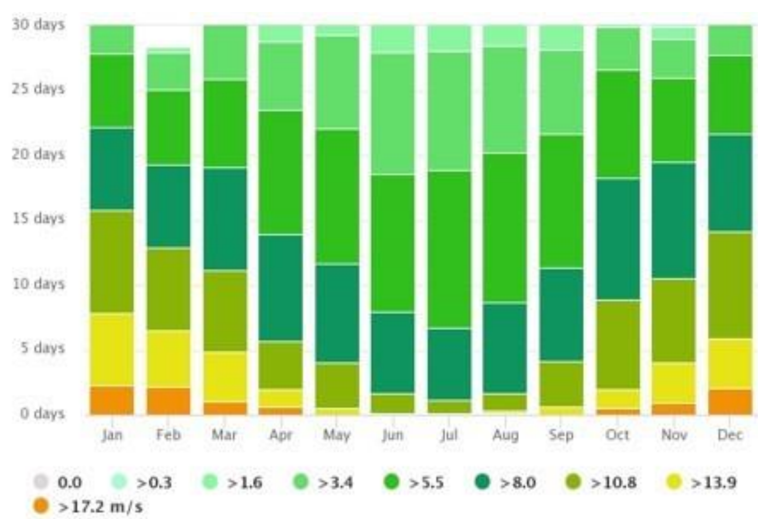


Figure 11.14.: Dublin Wind Speed Diagram

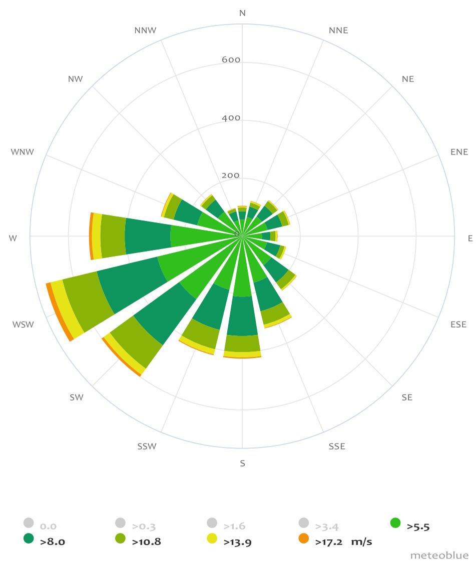


Figure 11.15.: Dublin Wind Rose

Based on the criterion of occurrence frequency the main wind directions to be considered in pedestrian wind comfort assessment are presented in Figure 11.16. and listed below in descending order of dominance:

1. South-West with most frequent wind speeds around 6m/s (all year).
2. South-East
3. West-South-West.

The analysis will mainly focus on the large sector of prevailing wind directions of winds from above. Other wind directions will be discussed if deemed necessary for the study.

Velocity (m/s)	Direction (°)	Frequency
5.601	225	11.233
4.626	135	6.849
5.847	236.25	6.792
6.049	258.75	6.747
6.034	247.5	6.689
5.888	270	5.662
4.994	315	4.338
5.503	281.25	3.904
4.974	292.5	3.436
5.357	213.75	3.288
4.736	123.75	3.105
4.406	146.25	2.751
5.101	303.75	2.648
5.246	112.5	2.500
4.121	157.5	2.386
4.581	101.25	2.340
4.169	45	2.180
3.558	90	2.135
4.801	202.5	2.021
3.689	78.75	1.963
3.627	168.75	1.495
4.285	67.5	1.370
4.863	56.25	1.279
4.042	191.25	1.199
4.630	326.25	1.164
3.844	11.25	1.142
4.418	337.5	1.062
4.787	348.75	0.982
4.006	22.5	0.959
3.555	180	0.879
4.059	33.75	0.845
0.700	0	0.011
Selected Conditions : 32	Total Coverage : **95.35 %**	

Figure 11.16.: Main Wind Directions Occurrence Frequency

Mean and Maximum Wind Conditions

Examination of the daily wind data reveals that the wind predominantly blows from West and Southwest directions, however, there is a secondary wind from the Southeast. It is apparent that winds from other directions are rare. Maximum daily wind speeds of nearly 30 m/s were recorded in the past 30 years, however, the maximum daily winds are commonly found between 6 m/s and 15 m/s. the strongest winds arise from the West and Southwest.

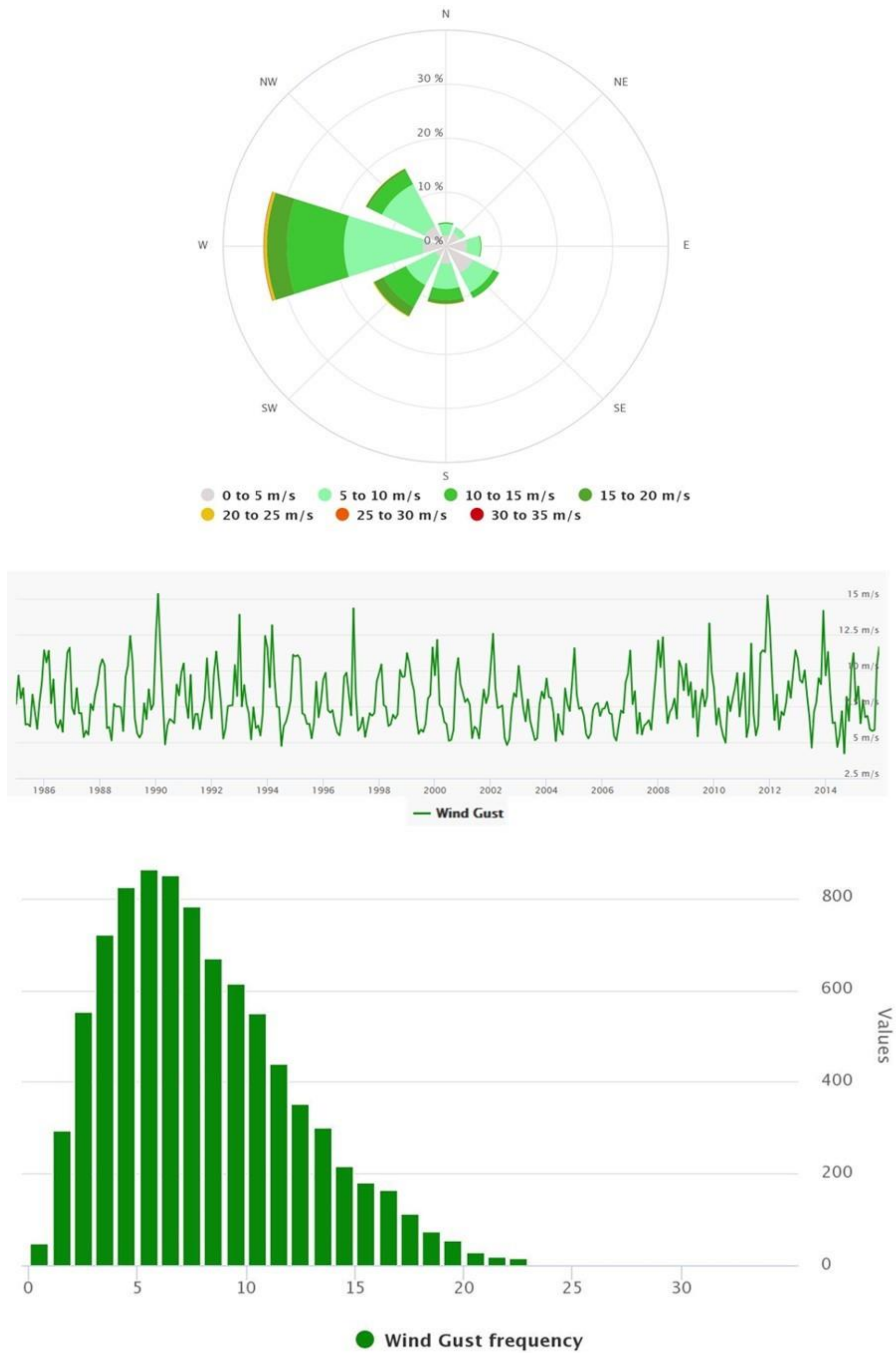


Figure 11.17.: Maximum Wind Conditions

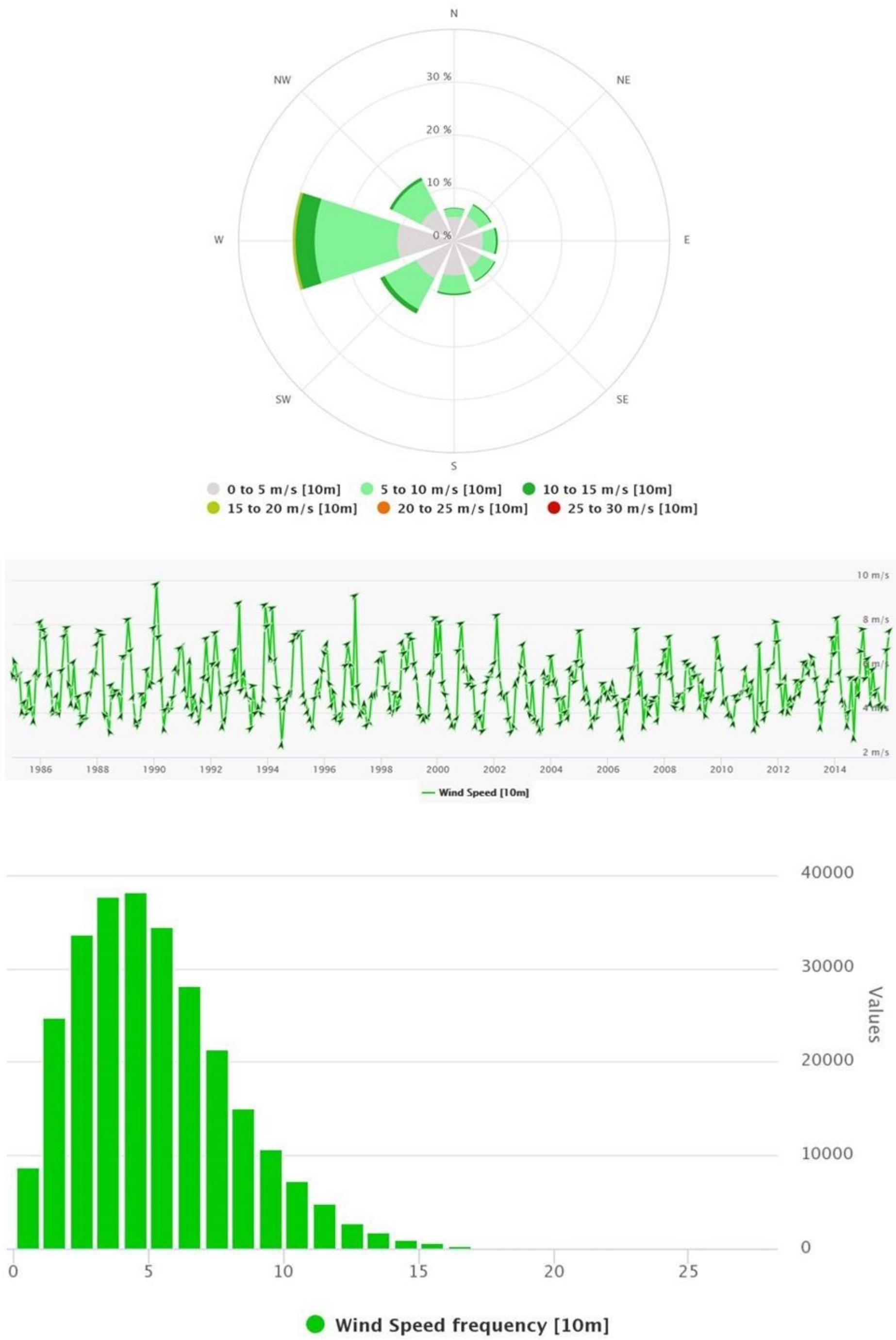


Figure 11.18.: Mean Wind Conditions

<u>Open Area Functions</u>

The assessment of pedestrian wind comfort in urban areas focuses on activities people are likely to perform in the open space between buildings, which are in turn related to a specific function. For example the activity sitting for a long period of time is typically associated with the location of a street café or similar. Such combinations of activity and area can be grouped into four main categories:

A	Sitting for a long period of time; laying steady position; pedestrian sitting; Terrace; street cafe or restaurant; open field theatre; pool
B	Pedestrian standing; standing/sitting over a short period of time; short steady positions; Public park; playing field; shopping street; mall
C	Pedestrian walking; leisurely walking; normal walking; ramble; stroll Walkway; shopping street; mall
D	Objective business walking; brisk or fast walking; Car park; avenue; sidewalk; belvedere

Table 11.2: Main Categories for Pedestrian Activities

Existing Receiving Environment Summary

The wind desktop study of the existing receiving environment showed that:

- The wind profile was built using the annual average of meteorology data collected at Dublin Airport Weather Station. In particular, the local wind climate was determined from historical meteorological data recorded 10 m above ground level at Dublin Airport.

- Different scenarios were selected in order to take into consideration all the different relevant wind directions. In particular, a total of 18 compass directions on the wind rose are selected. For each direction, the reference wind speed is set to the 5% exceedance wind speed for that direction, i.e. the wind speed that is exceeded for over 5% of the time whenever that wind direction occurs.

- The prevailing wind directions for the site are identified in the West, West South-West and South-East with magnitude of approximately 6m/s.

11.4. Characteristics of the Proposed Development

Description of the Proposed Development

Homeland Silverpines Limited, intend to apply to An Bord Pleanala for planning permission for a strategic housing development on a site of approx. (2.74 ha) at (1) 'Saint Joseph's House', Brewery Road, Stillorgan, Co. Dublin (A94 Y7F4); (2) 'Madona House', Silverpines, Stillorgan, Blackrock, Co. Dublin (A94 Y230); and (3) Properties at 'Woodleigh' (D18 F3F4), 'Cloonagh' (D18 P5P9), 'Souk El Raab' (D18 Y6C5), 'Wellbrook' (D18 H0C6), 'Calador' (D18 W1Y2), 'Alhambra' (D18 E3C4), 'Dalwhinnie' (D18 P2P4), 'Annaghkeen' (D18 Y2W1) and 'The Crossing' (D18 W8 W2); all located at Leopardown Road, Dublin 18.

The development will consist of a new residential and mixed use scheme to include apartments, residential amenity space, a café and a childcare facility. A detailed description is now set out as follows:

The proposal provides for the demolition of 10 no. properties and associated outbuildings at 'Madona House' (single storey), 'Woodleigh' (2 storeys), 'Cloonagh' (2 storeys), 'Souk El Raab (2 storeys), 'Welbrook' (2 storeys), 'Calador' (2 storeys), 'Alhambra' (2 storeys), 'Dalwhinnie' (2 storeys), 'Annaghkeen' (2 storeys) and 'The Crossing' (single storey) (combined demolition approx. 2,291.3 sq m GFA).

The new development will provide for (a) the refurbishment, separation and material change of use of Saint Joseph's House (a Protected Structure) from residential care facility to residential use and a childcare facility; and (b) the construction of a new build element to provide for an overall total of 463 no. residential units, residential amenity space and a café.

The overall development proposal shall provide for the following:

- Block A (5 storeys) comprising 49 no. apartments (13 no. 1 bed units, 33 no. 2 bed units and 3 no. 3 bed units);
- Block B (4 - 7 storeys) comprising 88 no. apartments (28 no. 1 bed units, 57 no. 2 bed units and 3 no. 3 bed units);
- Block C (5 - 7 storeys) comprising 115 no. apartments (26 no. studio units, 26 no. 1 bed units and 57 no. 2 bed units and 6 no. 3 bed units);
- Block D (5 - 10 storeys) comprising 157 no. apartments (36 no. studio unit, 40 no. 1 bed units and 81 no. 2 bed units), residential amenity areas of approx. 636 sq m and a café of approx. 49 sq m;
- Block E (St. Joseph's House) (2 storeys) comprising 9 no. apartments (8 no. 2 bed units and 1 no. 3 bed units) and a childcare facility of 282 sq m with associated outdoor play areas of approx. 130 sq m;
- Block F (3 - 6 storeys) comprising 45 no. apartments (23 no. studio units, 10 no. 1 bed units; and 12 no. 2 bed units);

Each new build residential unit (in Blocks A, B, C, D and F) has an associated area of private open space in the form of a terrace/balcony. Open Space proposals for St. Joseph's House (Block E) include a mixture of private terrace/balcony areas and communal open space areas.

The extent of works proposed to Saint Joseph's House (a Protected Structure) include:

- The demolition of a single storey office, conservatory, glazed link, external store, external enclosed escape stairs with associated canopies, toilet extension and 3 no. associated outbuildings to the west of St. Joseph's House (demolition total approx. 158 sq m GFA);

- The removal of external steel gates, all external steel escape stairs, canopies, existing disabled access ramps, concrete steps, an external wall and associated roof area;

- Relocation of external granite steps and the provision of a new raised entrance terrace, concrete steps and ramp areas;

- Replacement of existing rooflights, the addition of roof lights, part new roof / new zinc roof, new external wall and roof to the east of the structure;

- The provision of new door and window openings;

- Modifications to internal layout including the removal of walls and partitions and the addition of new dividing walls.

The Residential Amenity Areas of approx. 636 sq m proposed in Block D comprise a residential club house/multi-purpose room, library/reading room, lounge area, concierge area, office area, post room, fitness club, all at ground floor level of Block D. A terrace lounge area is proposed at fifth floor level of Block D. 2 no. roof garden areas are also proposed at fifth floor level of Blocks C and D (approx. 400 sq m and 408 sq m respectively).

Open Space (approx. 9,885 sq m) is proposed in the form of (a) public open space areas (approx. 6,680 sq m) which include a public plaza/court area, a play area, and woodland trail; and (b) all communal open space areas (approx. 3,205 sq m) which include areas adjacent to St. Joseph's House (Block E), Block D and Block F, a courtyard and play area located between Blocks A and B and roof terraces at fifth floor level of Blocks C and D. Visual amenity open space areas (approx. 1,000 sq m) are also proposed at various locations throughout the development.

Basement Level (approx. 9,445sq m) is proposed with residential access from Blocks A, B, C, D and F. Bin Storage areas, water storage areas, and part attenuation are located at this level. 2 no. ESB Substations, 1 no. ESB Kiosk, 2 no. Switch Rooms, waste storage areas for Block E (St. Joseph's House, A Protected Structure) and bicycle storage areas are proposed at surface level.

A total of 259 no. car parking spaces (232 no. at basement level and 27 no. at surface level) are proposed. At basement level, a total of 30 no. electric vehicles and 202 no. standard parking spaces are provided for. A total of 968 no. bicycle spaces (816 no. at basement level and 152 no. at surface level) and 10 no. motorcycle spaces (all at basement level) are also proposed.

Proposals for vehicular access comprise 1 no. existing vehicular access point via Silver Pines (an existing all movement junction onto Brewery Road) and 1 no. new vehicular access point at the general location of 'Annaghkeen' at Leopardstown Road (a new Left In / Left Out junction arrangement). The new access point along Leopardstown Road will replace 9 no. existing access points at 'Woodleigh', 'Cloonagh', 'Souk El Raab', 'Welbrook', 'Calador', 'Alhambra', 'Dalwhinnie', 'Annaghkeen' and 'The Crossing'. New pedestrian and cyclist linkages are proposed through the site, which provide permeability to Leopardstown Road and the adjoining Greenway. Proposals also provide for the relocation of an existing bus stop along Leopardstown Road.

The associated site and infrastructural works include provision for water services; foul and surface water drainage and connections; attenuation proposals; permeable paving; all landscaping works including tree protection, tree removal and new tree planting; green roofs; boundary treatment;

internal roads and footpaths; and electrical services. Figure 11.19. shows a 3D view of the proposed development.

Figure 11.19.: Proposed development

11.5. Potential Impact of the Proposed Development

Construction Phase

The effects on wind microclimate at the Site during the construction phase have been assessed using professional judgement. As construction of the Proposed Development progresses the wind conditions at the Site would gradually adjust to those of the completed development, and mitigation measures would need to be implemented before completion and operation.

Operational Phase

The construction of the development can potentially calm the existing wind condition in the area by providing further "urban context" to the existing topography, however, some areas can become more critical from a wind acceleration and re-circulation point of view and phenomena such as downwash, funnelling and downdraft can be experienced as well. The development, in principle, offer more drag to the incoming wind profile as detailed in the sections that follow (see "Planetary boundary layer and terrain roughness"). Consequently, the wind at lower level can reduce and modify its flow path directions. However, zones of re-circulations caused by the re-direction of the wind can also be expected, especially in the West South West direction where some funnelling can potentially occur. The potential impact of the development on the local wind microclimate has been assessed through the modelling of different wind scenarios and where areas of critical wind conditions have been detected, appropriate mitigation has been implemented and modelled to verify the reduction of the critical wind conditions and the suitability of the specific area to the designated pedestrian activity.

Planetary Boundary Layer and Terrain roughness

Due to aerodynamic drag, there is a wind gradient in the wind flow just a few hundred meters above the Earth's surface – "the surface layer of the planetary boundary layer".

Wind speed increases with increasing height above the ground, starting from zero, due to the no-slip condition. In particular, the wind velocity profile is parabolic. Flow near the surface encounters obstacles that reduce the wind speed and introduce random vertical and horizontal velocity components. This turbulence causes vertical mixing between the air moving horizontally at one level, and the air at those levels immediately above and below it. For this reason, the velocity profile is given by a fluctuating velocity along a mean velocity value. Figure 11.20. shows the wind velocity profile, as described above.

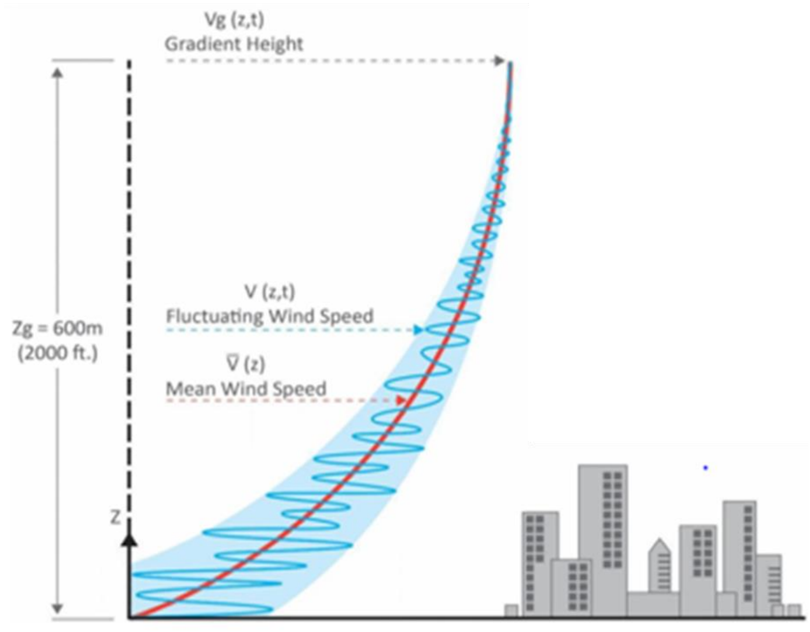


Figure 11.20.: Wind Velocity Profile

Two effects influence the shape of the wind speed profile:

- Contours of the terrain: a rising terrain such as an escarpment will produce a fuller profile at the top of the slope compared with the profile of the wind approaching the slope.
- Aerodynamic 'roughness' of the upstream terrain: natural roughness in the form of woods or man-made roughness in the form of buildings. Obstructions near the ground create turbulence and friction, lowering the average wind speed. The higher the obstructions, the greater the turbulence and the lower the windspeed. As a general rule, windspeed increases with height.

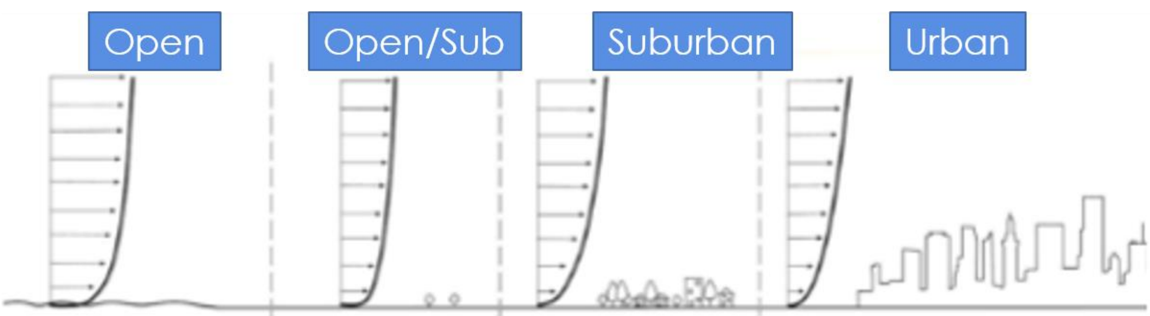


Figure 11.21: Wind Velocity Profile for different terrains

In order to assess the wind conditions in a particular area, it is important to know (Figure 11.22.):

- Weather conditions in the area
- Location and orientation of the site
- Buildings distribution in the area
- Flow patterns at the building

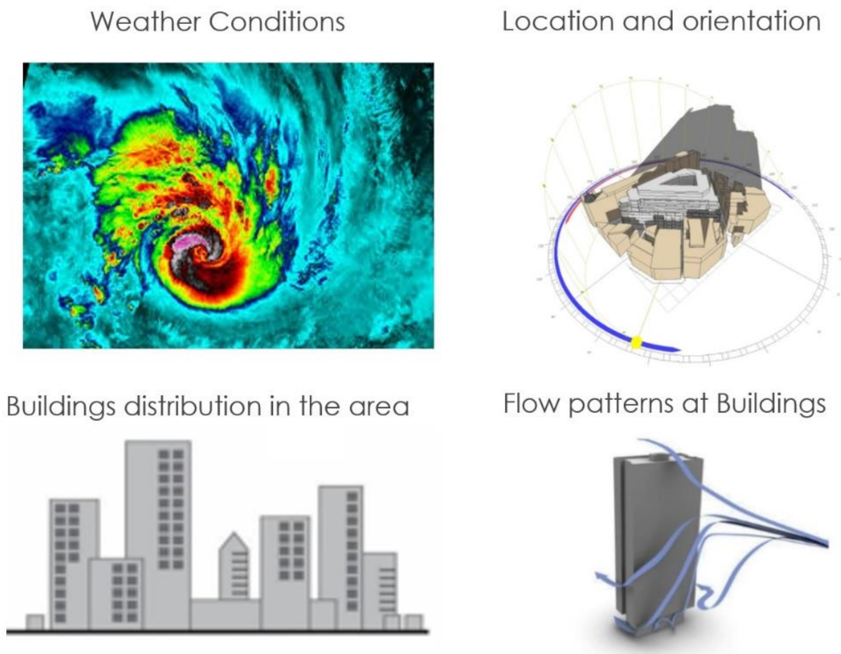


Figure 11.22: Parameters to know for Wind Conditions Assessment

Moreover, it is important to understand key flow features (Figure 11.23.):

- Broad Building Face creates "DOWNWASH"
- Low Building Upwind Increases Wind Effects
- Gaps Between Buildings Increases Wind Velocity
- Low Building Upwind Increases Wind Effects

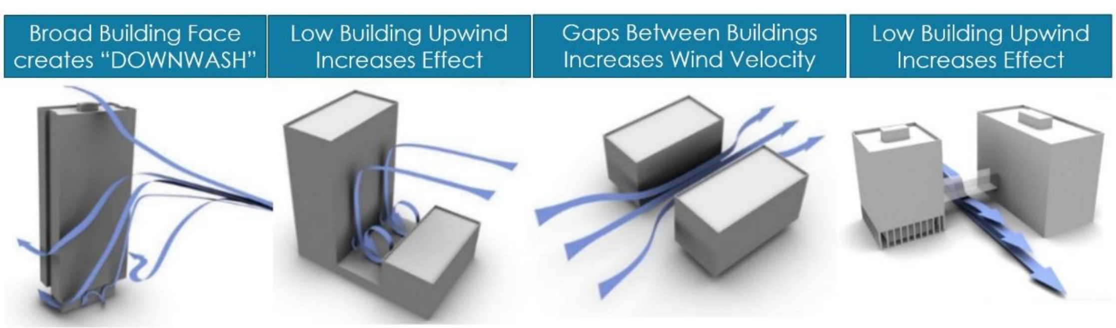


Figure 11.23.: Parameters to know for Wind Conditions Assessment

11.6. Mitigation Measures

Construction Phase

The effects on wind microclimate at the Site during the construction phase have been assessed using professional judgement.

As construction of the Proposed Development progresses the wind conditions at the site would gradually adjust to those of the completed development, and mitigation measures would need to be implemented before completion and operation.

Operational Phase

As stated above, if the wind conditions exceed the threshold, these conditions become unacceptable for favourable pedestrian activities and mitigation measure should be accounted for.

Mitigation measures include:

- Landscaping: the use of vegetation to protect buildings from wind
- Sculptural screening (solid or porous): to either deflect the wind or bleed the wind by removing its energy.
- Canopies and Wind gutters: horizontal canopies are used to deflect the wind and redirect the wind around the building and above the canopy.

In particular, it is possible to summarise the different flow features and the corresponding mitigation option as follows (Figures 6.1 and 6.2):

- **Downwash Effects**: when wind hits the windward face of a tall building, the building tends to deflect the wind downwards, causing accelerated wind speeds at pedestrian level and around the windward corners of the building. This can occur when Tall and wide building facades face the prevailing winds.
- **Downdraft Effects**: When the leeward face of a low building faces the windward face of a tall building, it causes an increase in the downward flow of wind on the windward face of the tall building. This results in accelerated winds at pedestrian level in the space between the two buildings and around the windward corners of the tall building.

- *Mitigation Options*
    - To mitigate unwanted wind effects, it is recommended to introduce a base building or podium with a step back and setting back a tower relative to the base building, the downward wind flow can be deflected, resulting in reduced wind speed at pedestrian level.
    - Landscaping the base building roof and tower step back, wind speeds at grade can be further reduced, and wind conditions on the base building roof can improve.

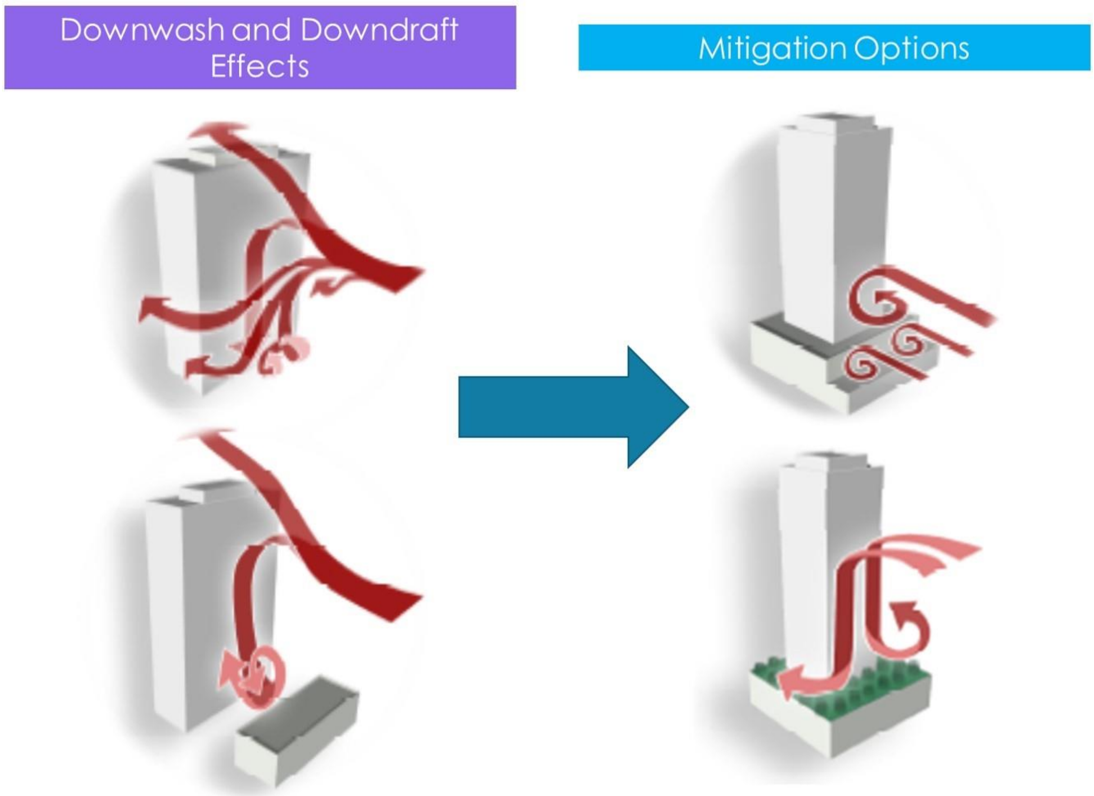


Figure 11.24.: Mitigation Measures for Downwash and Downdraft Effects

- **Funnelling Effects**: Wind speed is accelerated when wind is funnelled between two buildings. This is referred to as the "wind canyon effect". The intensity of the acceleration is influenced by the building heights, size of the facades, building separation distance and building orientation. Similar effect can be noticed when a bridge is connecting two buildings, the wind passing below the bridge is accelerated, therefore pedestrians can experience high uncomfortable velocities of wind.
- *Mitigation Options*:
    - A horizontal canopy on the windward face of a base building can improve pedestrian level wind conditions. Parapet walls around a canopy can make the canopy more effective.
    - Sloped canopies only provide partial deflection of downward wind flow.
    - A colonnade on the windward face of the base building provides the pedestrian with a calm area where to walk while being protected or a breeze walking space outside the colonnade zone.

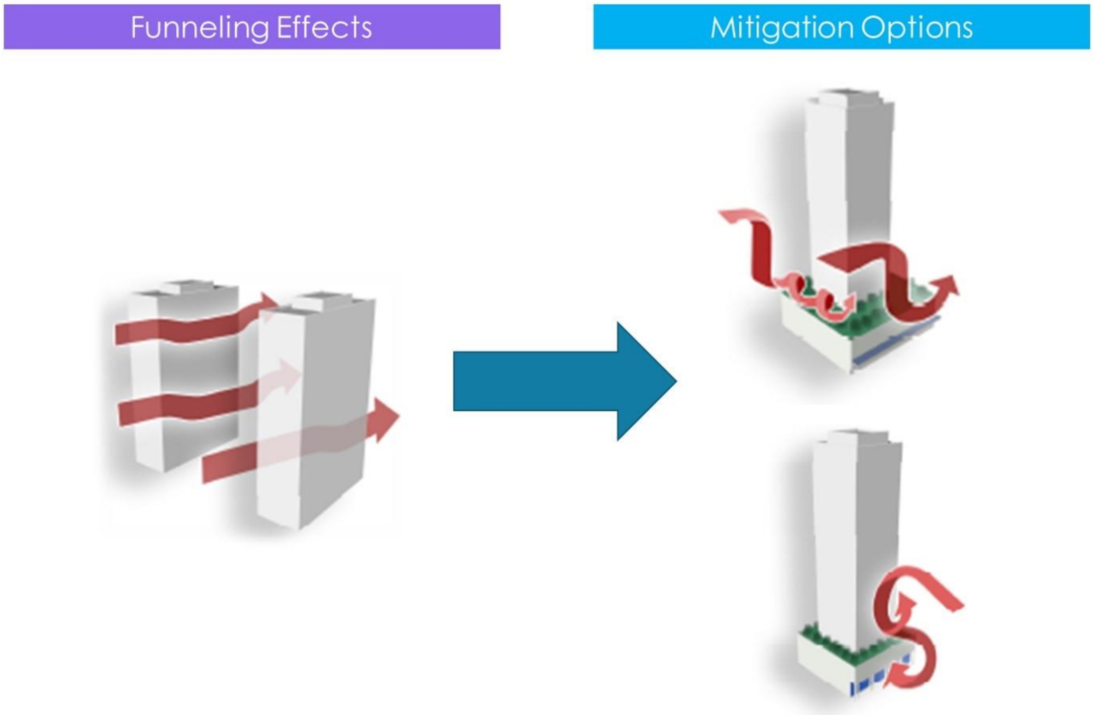


Figure 11.25: Mitigation Measures for Funnelling Effects

Landscape Trees Modelling (Using Porous Media)

Through CFD Modelling, it is possible to implement the effects of landscaping trees on the wind flowing through an urban environment. Urban landscape managers, local councils and architects can now observe and assess the effects of landscaping trees in their urban landscape models. The landscape trees are simulated as comprising effects of porous zones within the urban environments. This is an essential tool for accurately assessing the actual wind speed and pattern at a pedestrian level when landscape are available. Figure from 11.26. to Figure 11.27. show the modelling approach of utilizing porous media within the CFD numeric code to implement the effect of landscape within the Proposed development.

Figure 11.28. shows a plan view of the mitigation measures that will be implemented around the Proposed development at ground floor.

Figure 11.26.: Plan View of the Mitigation Measures that will be implemented around the Proposed development

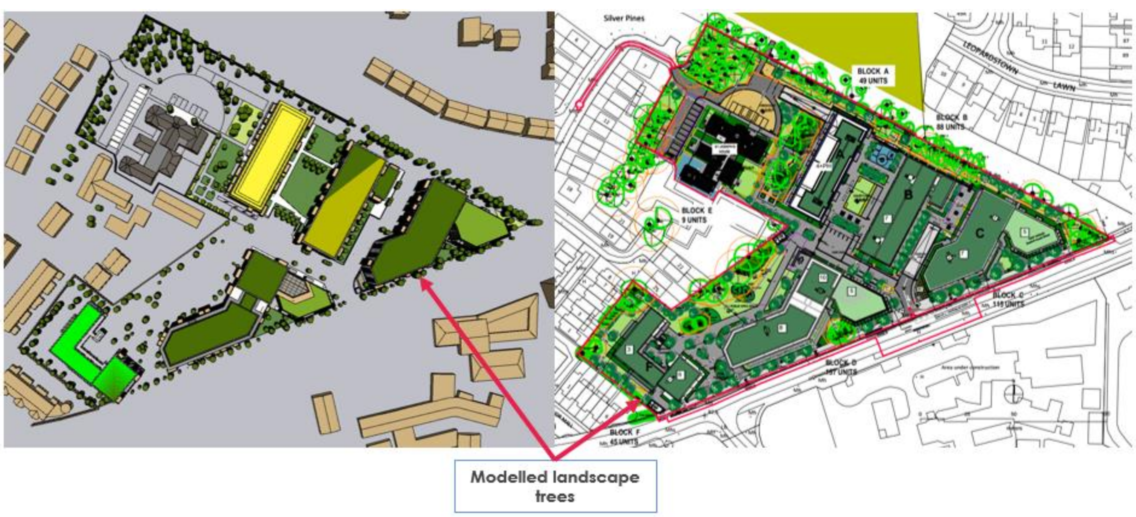


Figure 11.27.: Landscape Masterplan Mitigation Measures for Proposed development

Figure 11.28.: Modelling Landscape Trees As Porous Zones

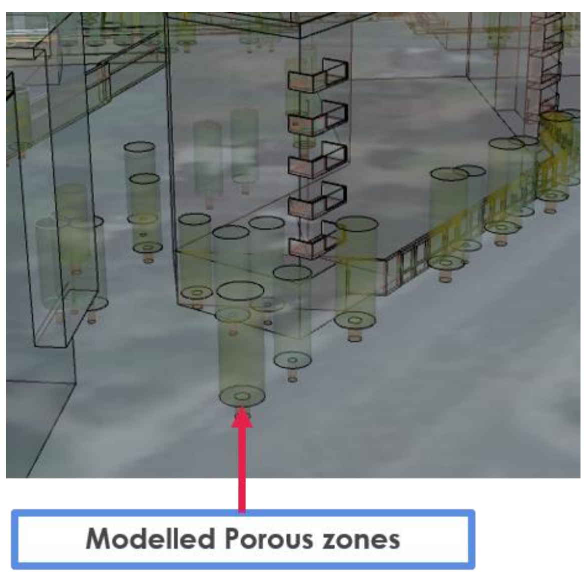


Figure 11.29.: Modelling Landscape Trees As Porous Zones

11.7. Predicted Impacts of the Proposed Development

This section assessed the potential impact of the proposed development on the already existing environment, and the suitability of the proposed development to create and maintain a suitable and comfortable environment for different pedestrian activities.

CFD Model Details of The Proposed Development

This subsection describes all features included in the geometrical and physical representation of Proposed development CFD model. Any object which may have significant impact on wind movement and circulation are represented within the model. To be accurate, the structural layout of the building being modelled should include only the obstacles, blockages, openings and closures which can impact the wind around the building. It is important to remember that a CFD simulation approximates reality, so providing more details of the geometry within the model will not necessarily increase the understanding of the bulk flows in the real environment.

Modelled Geometry

3D views of the proposed development massing model in the domain is presented in Figure 11.30.

The modelled layout and dimensions of the surrounding environment are outlined in the table below (Table 11.3.).

In order to represent reality and consider the actual wind impacting on the site, the modelled area for the wind modelling study comprises a wider urban area of 2km² around the Proposed development, as shown in Figure 11.31.

	Modelled CFD Environment Dimensions		
	Width	Length	Height
CFD Mesh Domain	1500m approx.	1500m approx.	60m approx.

Table 11.3: Modelled Environment Dimensions

3D View of Proposed Development and Surrounding Buildings
South Side View

3D View of Proposed Development and Surrounding Buildings
North Side View

Figure 11.30.: 3D View of the Proposed development and Adjacent Buildings South & North Side View

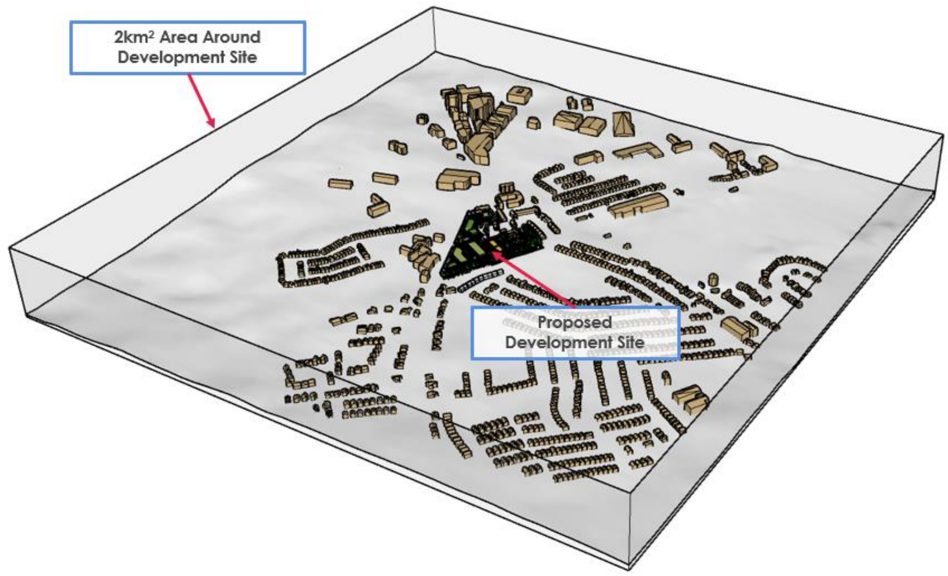


Figure 11.31.: The Proposed development and Adjacent Buildings used in CFD simulations (Approx. 2km² area around the development)

Boundary Conditions

A rectangular computational domain was used for the analysis. The wind directions were altered without changing the computational mesh. For each simulation scenario, an initial wind velocity was set according to the statistical weather data collected in order to consider the worst-case scenario. Building surfaces within the model are specified as 'no slip' boundary conditions. This condition ensures that flow moving parallel to a surface is brought to rest at the point where it meets the surface. Air flow inlet boundaries possess the 'Inlet' wind profile velocity patch boundary condition with its appropriate inflow turbulence intensity and dissipation rates. Air exits the domain at the 'pressure outlet' boundary condition.

The wind velocity data provided by the historical data collection and by the local data measuring are used in the formula below for the logarithmic wind profile to specify the wind velocity profile (wind velocity at different heights) to be applied within the CFD model:

$$v_2 = v_1 \cdot \frac{ln\frac{h_2}{z_0}}{ln\frac{h_1}{z_0}} \tag{7.1}$$

where:

- v_1 = wind speed measured at the reference height h_1
- h_1 = reference height to measure v_1
- h_2 = height of the wind speed v_2 calculated for the wind profile
- z_0 = 0.4 [m] roughness length selected (see table in Figure 11.32. below)

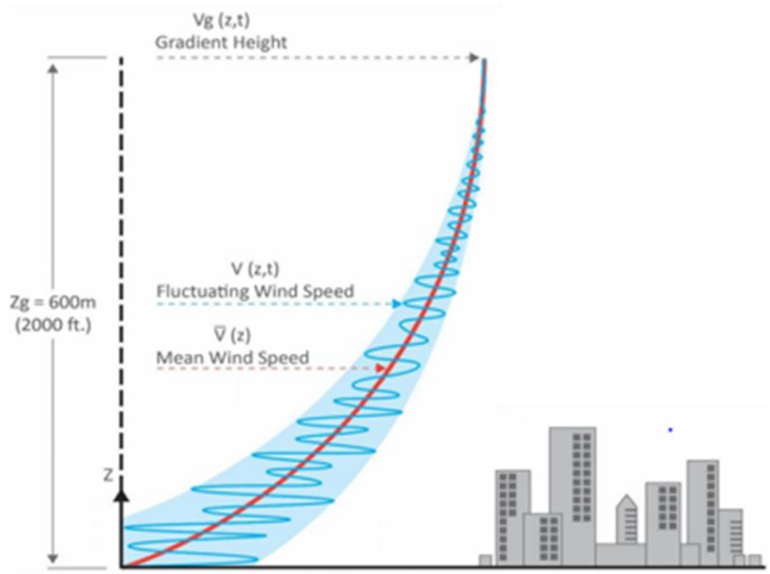


Figure 11.32.: Roughness length and class to be used for the logarithmic wind profile

Computational Mesh

The level of accuracy of the CFD results are determined by the level of refinement of the computational mesh. Details of parameters used to calculate the computational mesh are presented in Table 11.4. Figure 11.33. shows the mesh utilised in the simulations.

The grid follows the principles of the 'Finite Volume Method', which implies that the solution of the model equations is calculated at discrete points (nodes) on a three-dimensional grid, which includes all the flow volume of interest. The mathematical solution for the flow is calculated at the centre of each of these cells and then an interpolation function is used by the software to provide the results in the entire domain.

Parameters to Calculate Computational Mesh	
Air Density $_p$	1.2kg/m^3
Ambient Temperature (T)	288k (approx. 15C°)
Gravity Acceleration (g)	9.8m/s^2
dx	0.5 m at the building 1m in the surroundings 2m elsewhere
Total mesh size	Approx. cells number = 10 million

Table 11.4.: Parameters to Calculate Computational Mesh

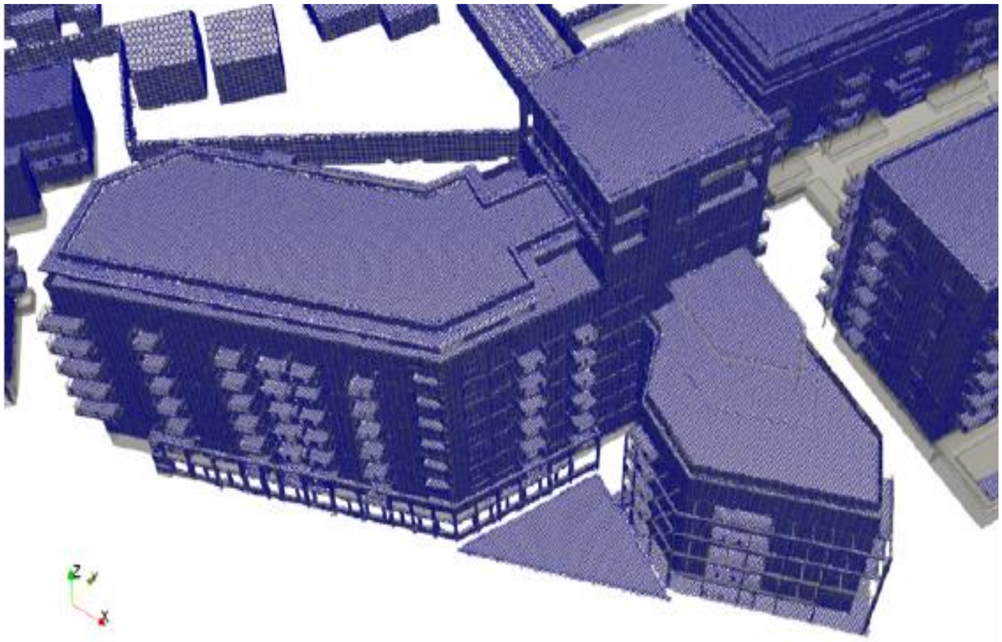


Figure 11.33.: Computational Mesh Utilized

Construction Phase

The possible effects on wind micro-climate at the site during the construction phase of Proposed development has not been directly assessed but was evaluated based on professional judgement. Statistical Dublin historical wind data have been used to carry out this analysis based on the fact that the dominant wind direction is from South-West.

As the finalization of the development proceeds, the wind setting at the site would progressively conform to those of the completed development. It is possible that in the final stages of construction, implementation of the mitigation measures would be needed in areas that are expected to be windier than others should in case some areas of the site are expected to be functional before the construction is finalized.

Due to the fact that windier conditions are acceptable within a construction area (not accessible to the public), and the proposed development would not be the reason for critical wind conditions on-Site (and are slightly calmer when the development is in site), the impacts evaluated on-Site are considered to be insignificant. Thus, the predicted impacts during construction phase are identified as not significant or negligible.

In summary, as construction of the Proposed development progresses, the wind conditions at the site would gradually adjust to those of the completed development. During the construction phase, predicted impacts are classified as negligible.

Operational Phase

This section shows CFD results of wind and microclimate assessment carried out considering the "Operational Phase" of Proposed development. In this case the assessment has considered the impact of wind on the existing area including the Proposed development. For this scenario, Proposed development has been simulated. Wind simulations have been carried out on all the various directions for which the development could show critical areas in terms of pedestrian comfort and

safety. For this, the Lawson and Distress Maps have been presented to identify the suitability of each areas to its prescribed level of usage and activity. The results present parameters outlined within the acceptance criteria previously described.
It is also of interest at this point to underline once more the objectives of simulations performed. In particular:

- Pedestrian Wind Comfort and Safety Studies are conducted to predict, assess and, where necessary, mitigate the impact of the development on pedestrian level wind conditions.

- To assess comfortable and safe pedestrian level wind conditions that are appropriate for the intended use of pedestrian areas. Pedestrian areas include sidewalks and street frontages, pathways, building entrance areas, open spaces, public spaces, amenity areas, outdoor sitting areas, etc.

Results of simulations carried out are detailed in the following sections. These results present parameters as outlined in the acceptance criteria section described previously for Proposed development. Results of wind flow speeds are collected throughout the simulation and analysed based on the Lawson Discomfort Criteria.

Figure 11.35. shows an example of wind data mapped on surface, located at 1.5m above the ground. The scale used for all flow velocity results is set out in Figure 11.34. Red colours indicate critical values while blue colours indicate tenable conditions.

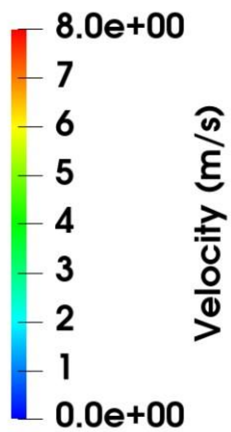


Figure 11.34.: Velocity Colour Map

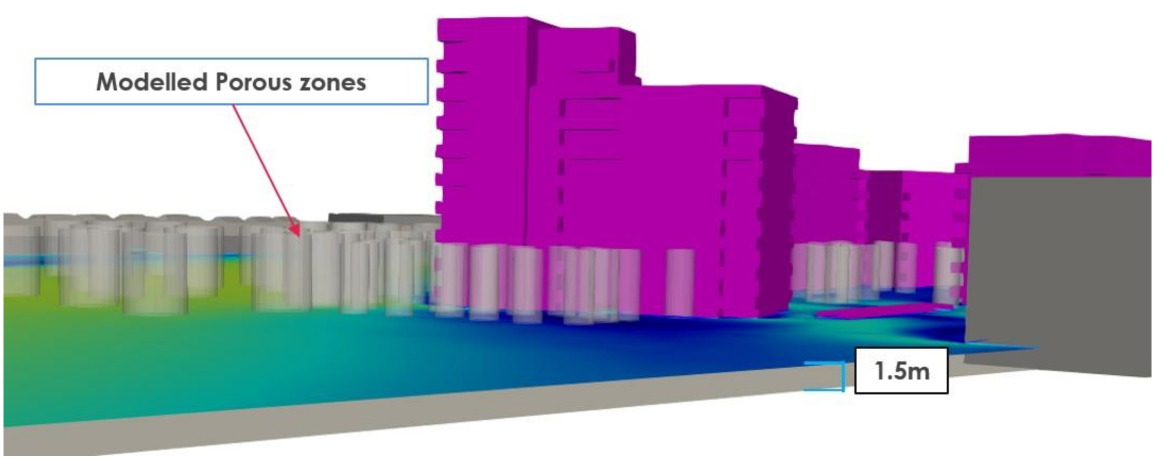


Figure 11.35.: An example of wind data mapped on surface at 1.5m above the ground

Flow Velocity Results - Ground Floor Level

Results of wind speeds and their circulations at pedestrian level of 1.5m above the development ground are presented in Figures 11.36. to 11.51. in order to assess wind flows at ground floor level of the Proposed development.

Wind flow speeds are shown to be within tenable conditions. Some higher velocity indicating minor funnelling effects are found near the South-West side of the development. However, as it can be seen, both areas were mitigated with landscaping and the flow velocities shown in the Lawson map indicate that the areas can be utilised for the intended use (such as entrances and pedestrian walking area).

Therefore, it can be concluded that the wind speeds do not attain critical levels around the development. The courtyard between Block A and B is well protected. According to the Lawson Criteria (described in the next sections), this area is suitable for all different pedestrian activities.

Ground floor results- Plan views

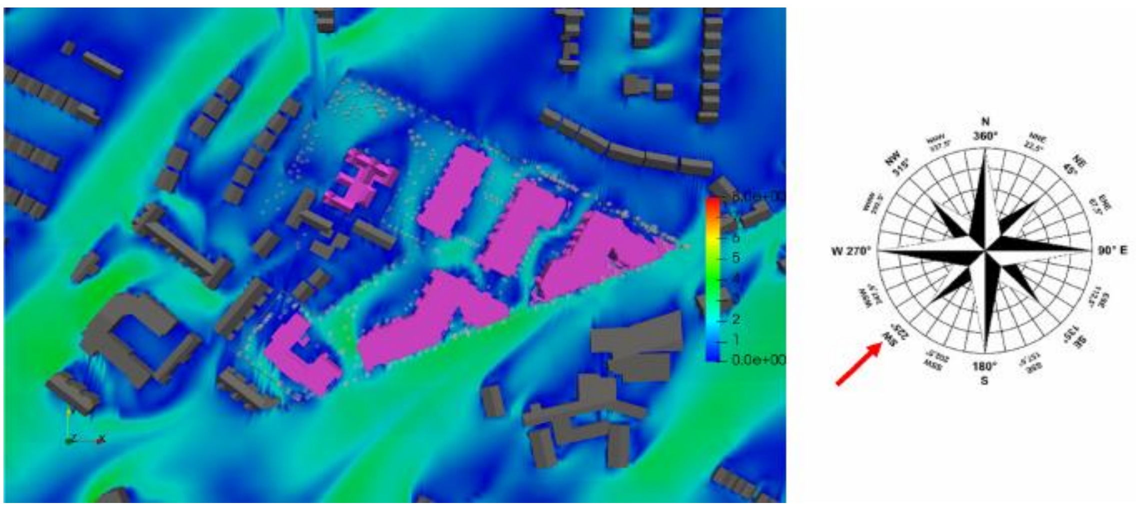


Figure 11.36.: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 225°

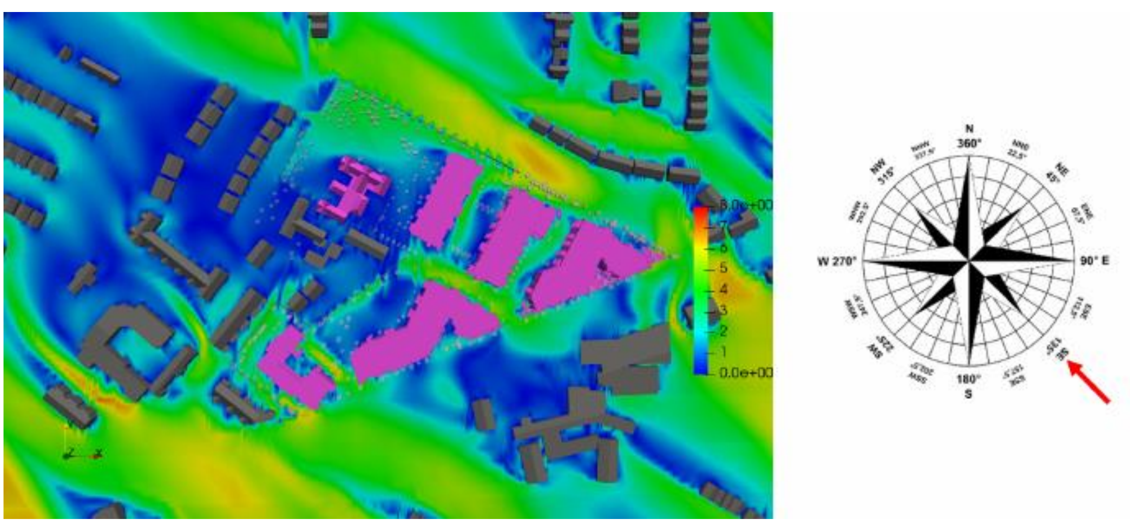


Figure 11.37.: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 135°

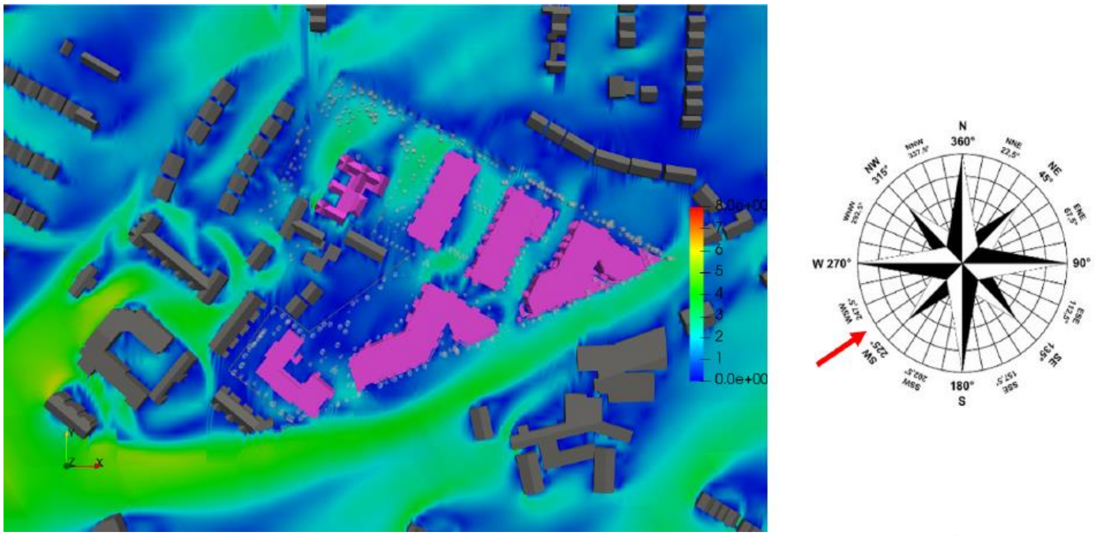


Figure 11.38.: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground - Wind Direction: 236°

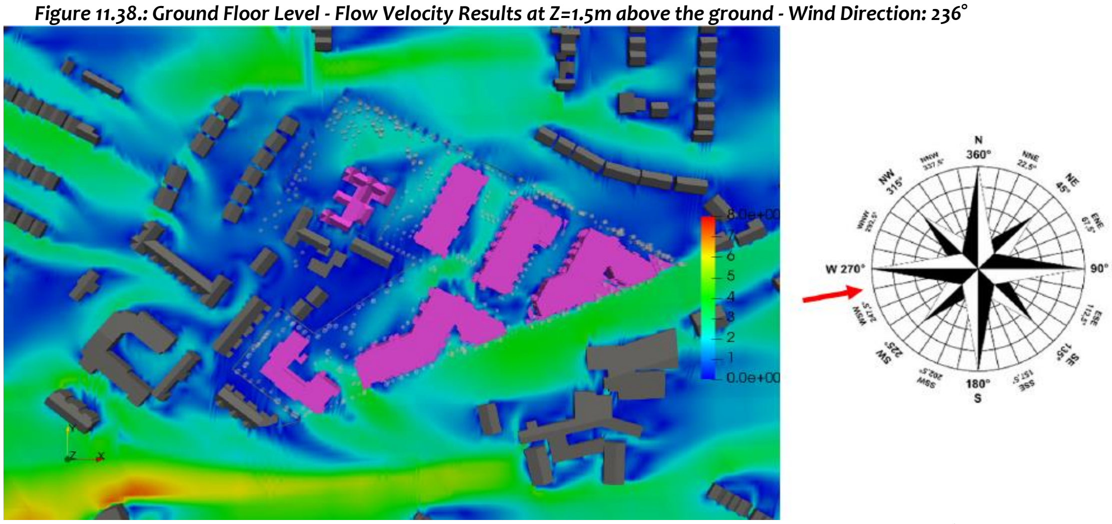


Figure 11.39.: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground Wind Direction: 258°

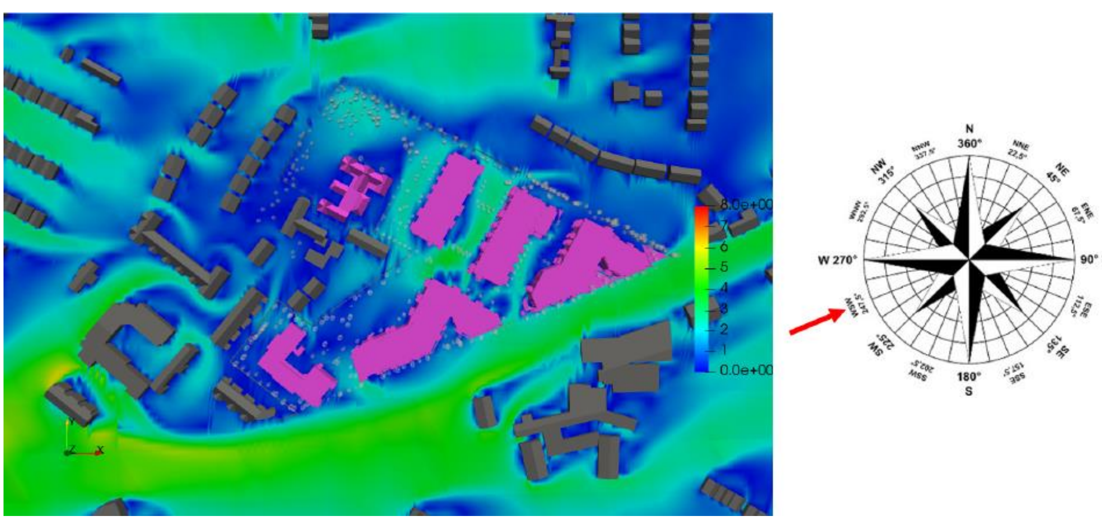


Figure 11.40.: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground Wind Direction: 247°

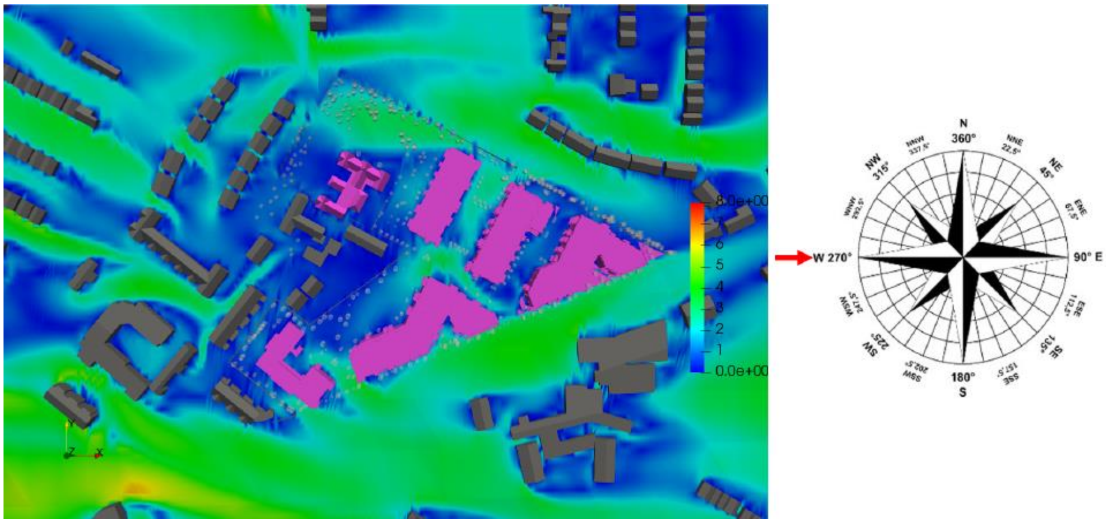


Figure 11.41.: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground wind Direction:270°

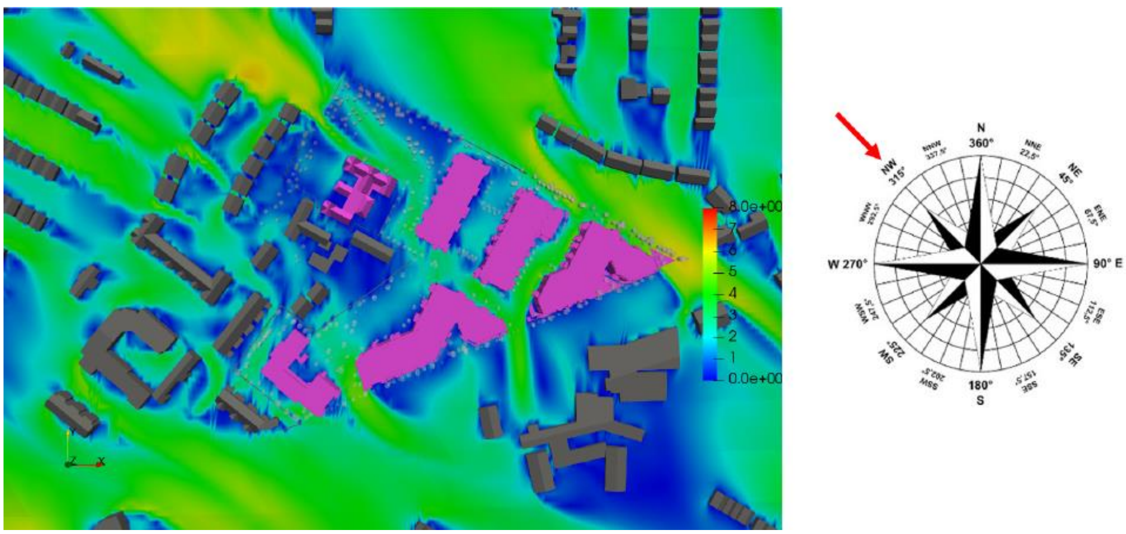


Figure 11.42.: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground Wind Direction: 315°

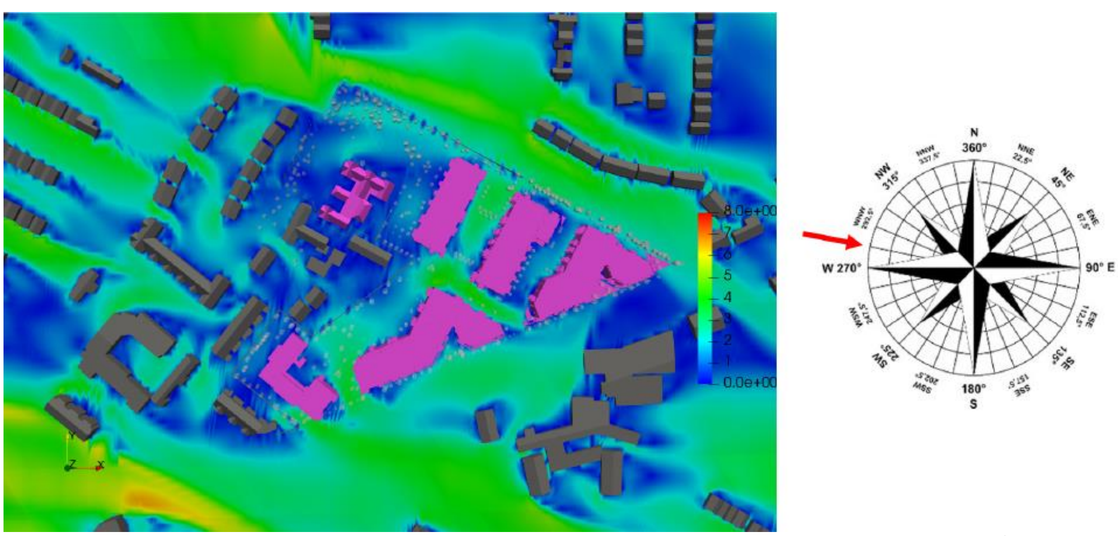


Figure 11.43.: Ground Floor Level - Flow Velocity Results at Z=1.5m above the ground Wind Direction: 281°

Ground floor results- Iso-views

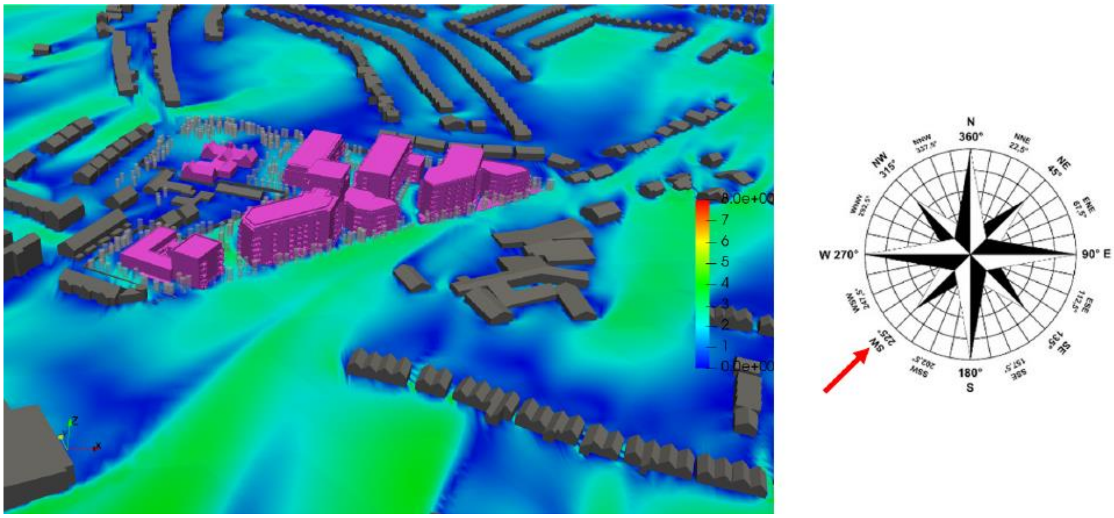


Figure 11.44.: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View Wind Direction: 225°

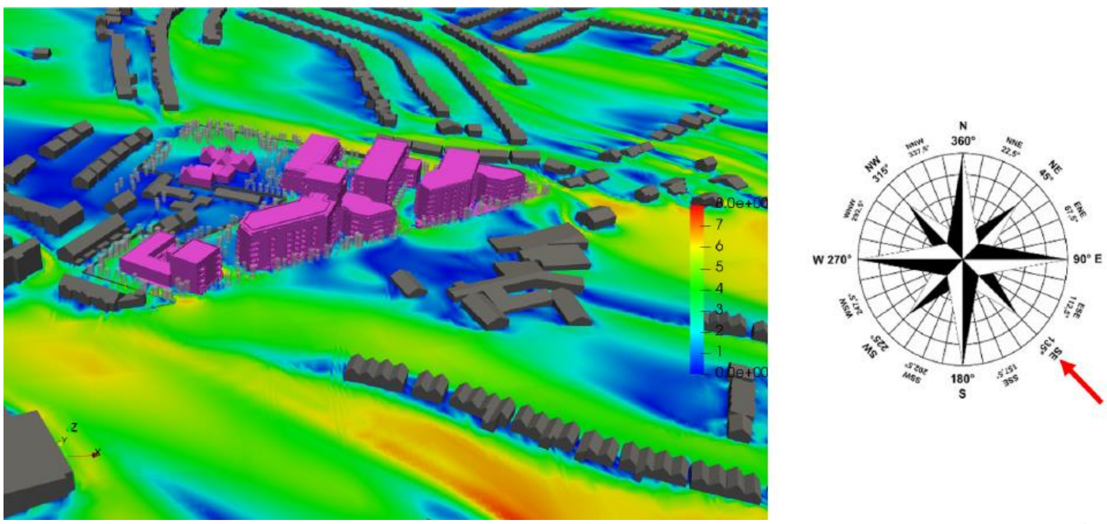


Figure 11.45.: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View Wind Direction: 135°

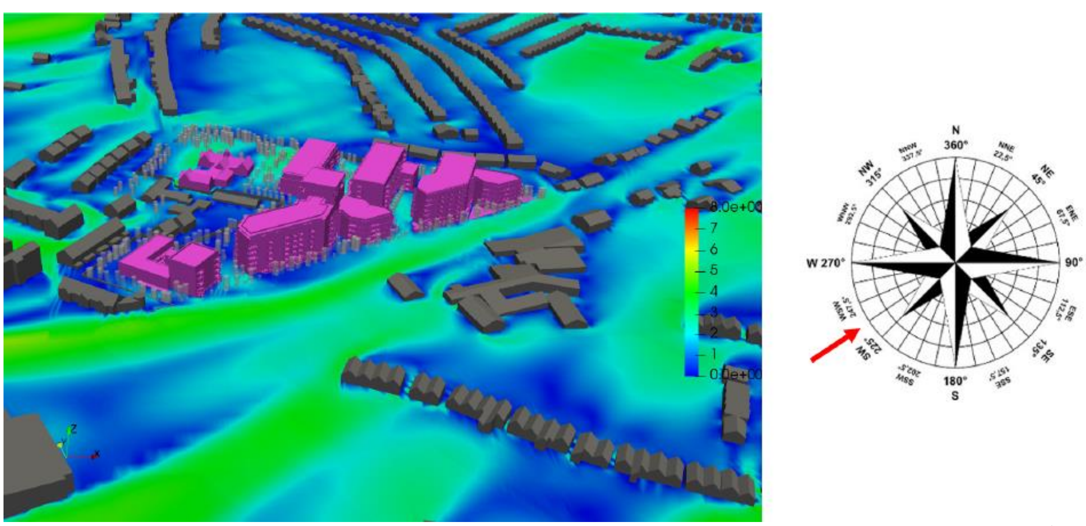


Figure 11.46.: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View Wind Direction: 236°

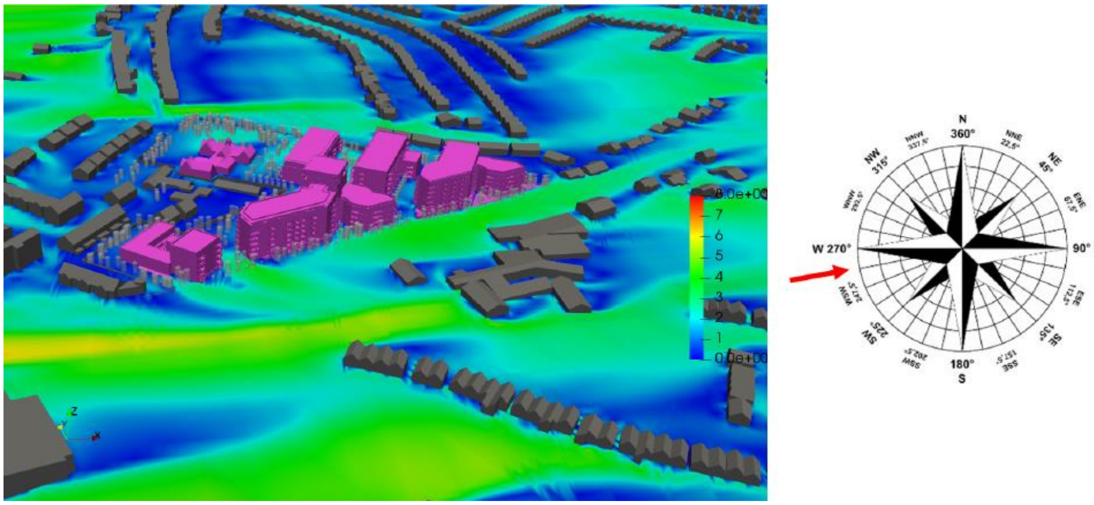


Figure 11.47.: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View Wind Direction: 258°

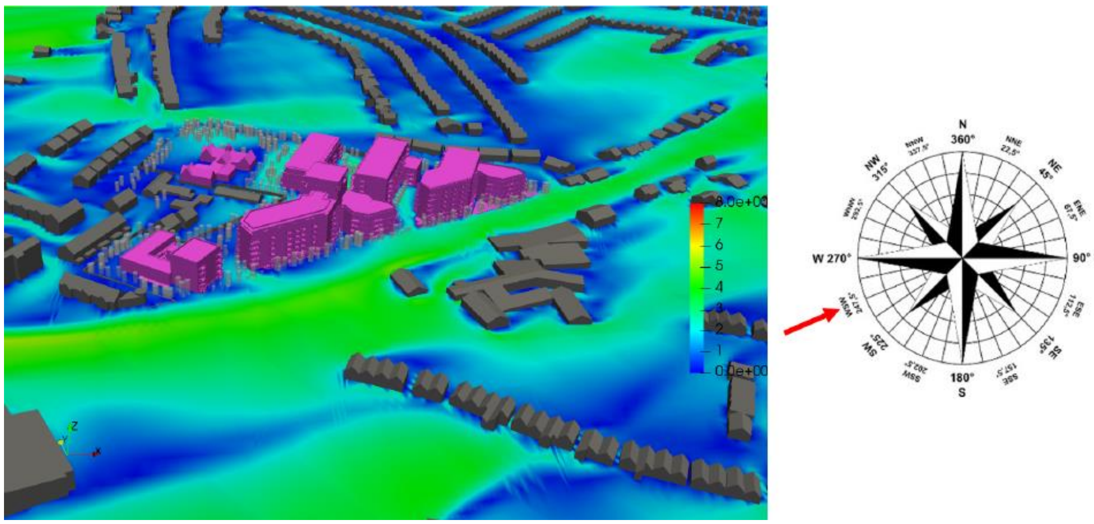


Figure 11.48.: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View Wind Direction: 247°

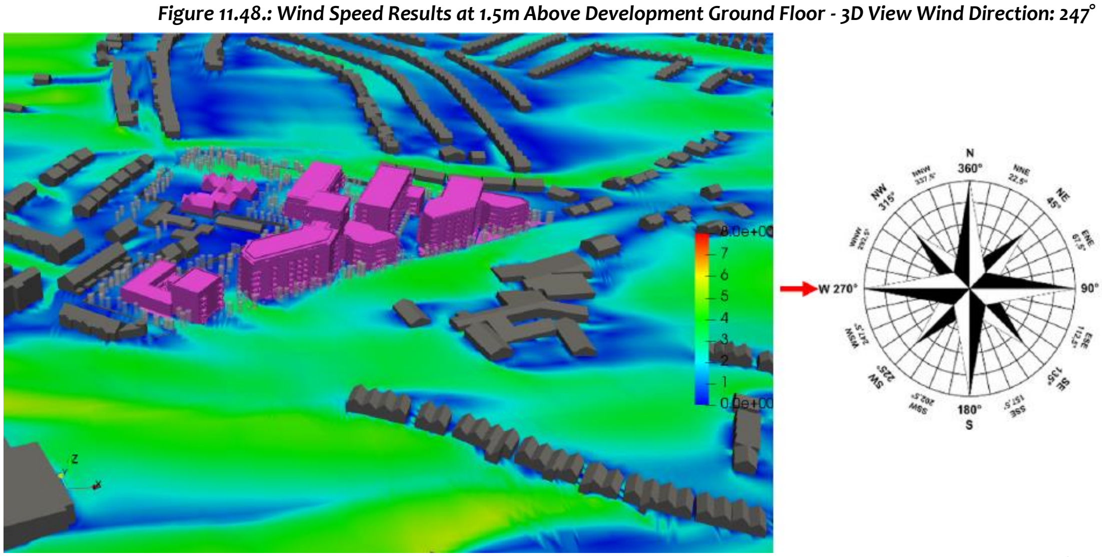


Figure 11.49.: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View Wind Direction: 270°

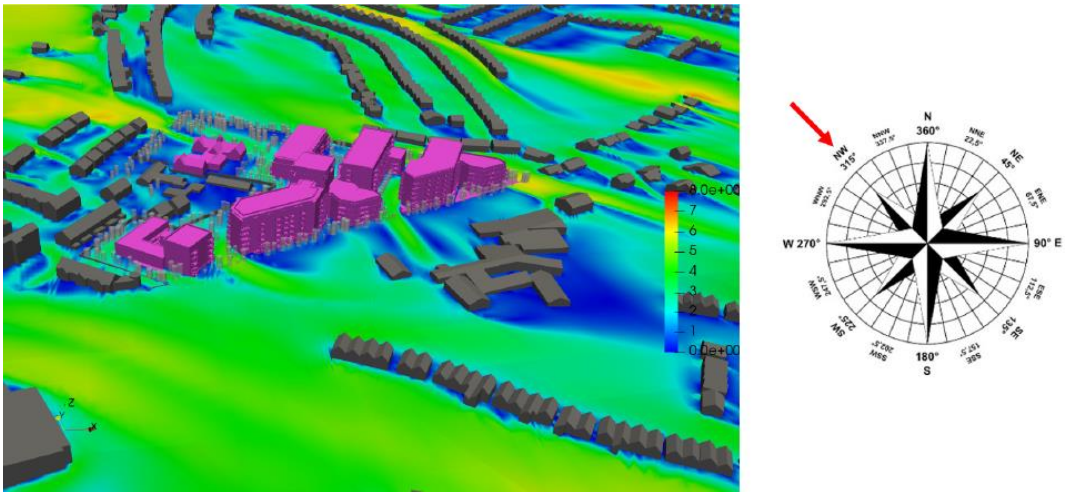


Figure 11.50.: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View Wind Direction: 315°

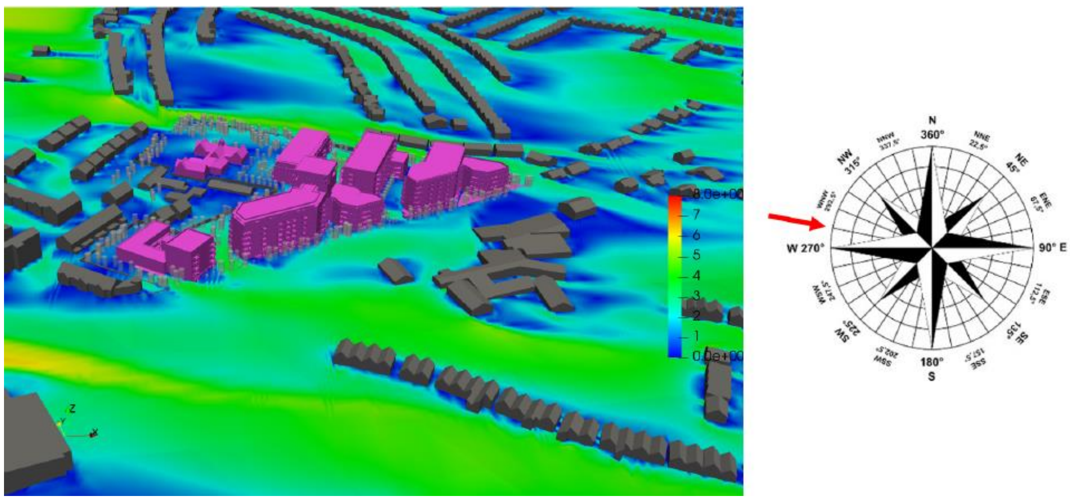


Figure 11.51.: Wind Speed Results at 1.5m Above Development Ground Floor - 3D View Wind Direction: 281°

Details of results at courtyards between Blocks A and B

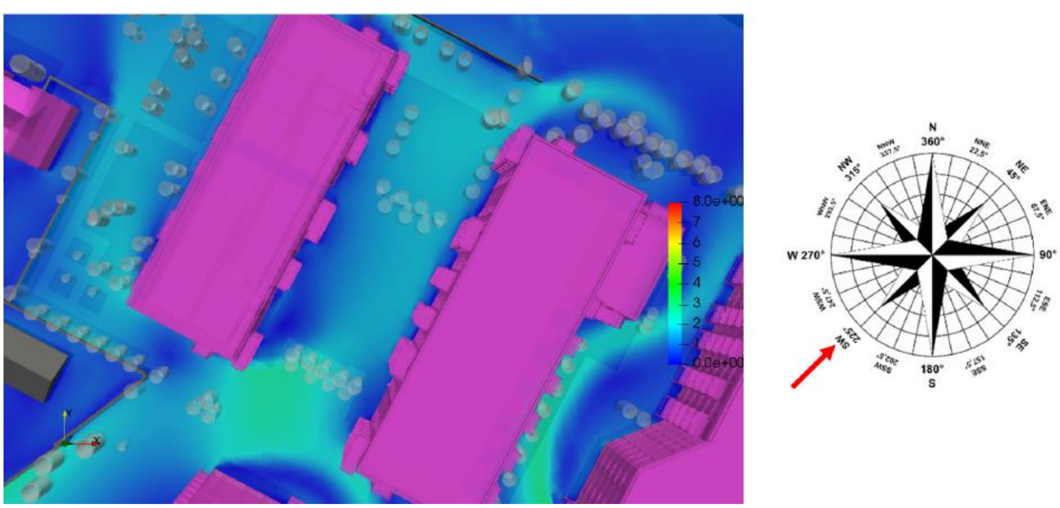


Figure 11.52.: Courtyard Between Block A and B - Flow Velocity Results at Z=1.5m above the ground - Wind Dir.: 225°

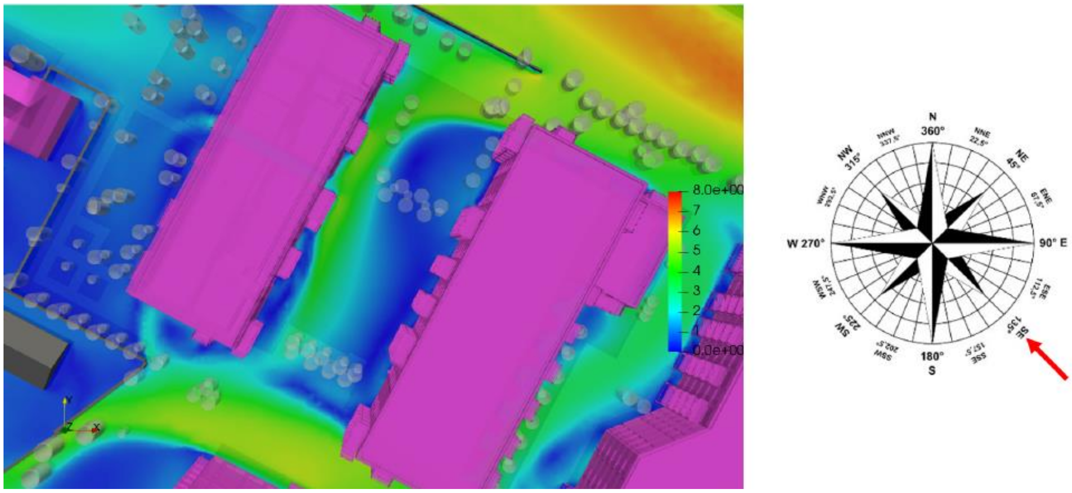


Figure 11.53.: Courtyard Between Block A and B - Flow Velocity Results at Z=1.5m above the ground - Wind Dir: 135°

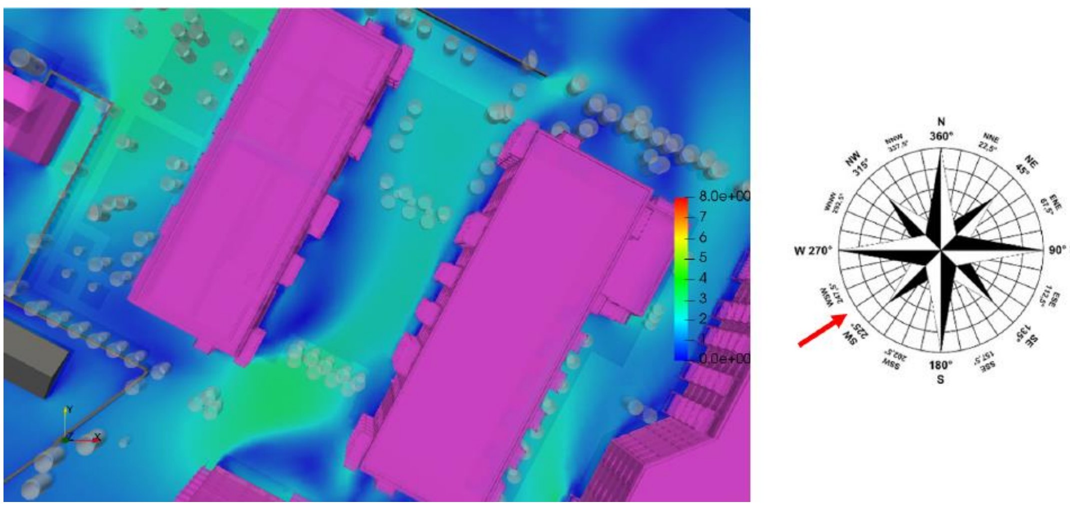


Figure 11.54.: Courtyard Between Block A and B - Flow Velocity Results at Z=1.5m above the ground - Wind Dir. 236°

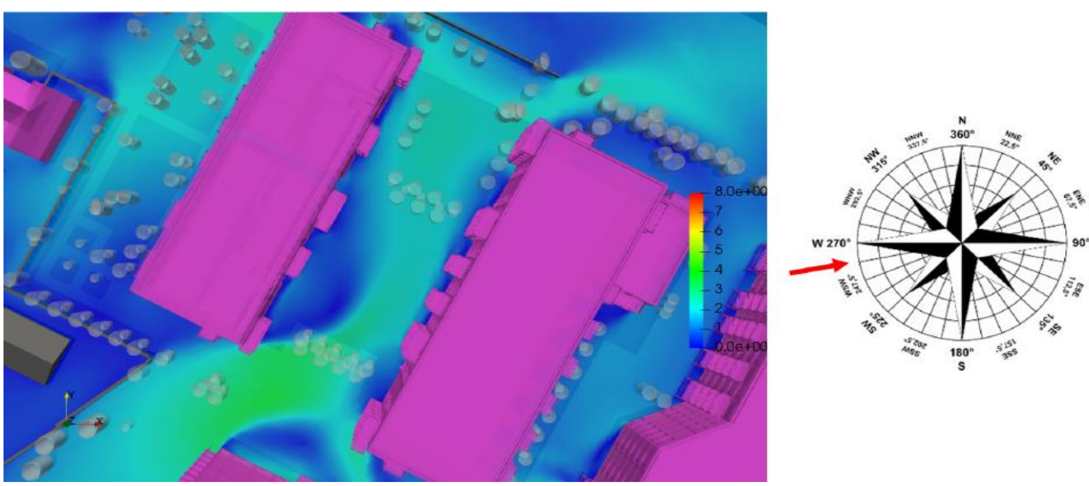


Figure 11.55.: Courtyard Between Block A and B - Flow Velocity Results at Z=1.5m above the ground - Wind Dir: 258°

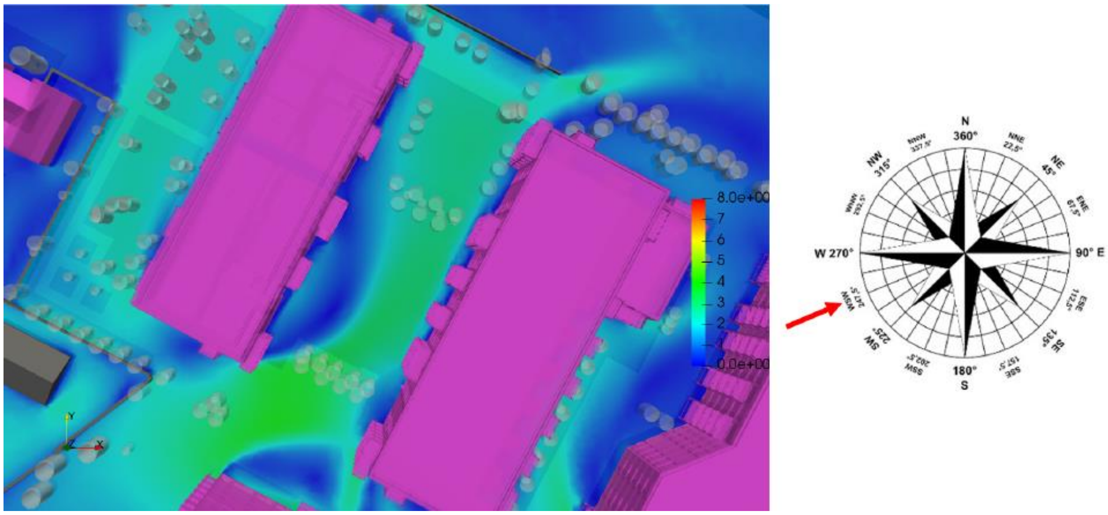


Figure 11.56.: Courtyard Between Block A and B - Flow Velocity Results at Z=1.5m above the ground Wind Dir:247°

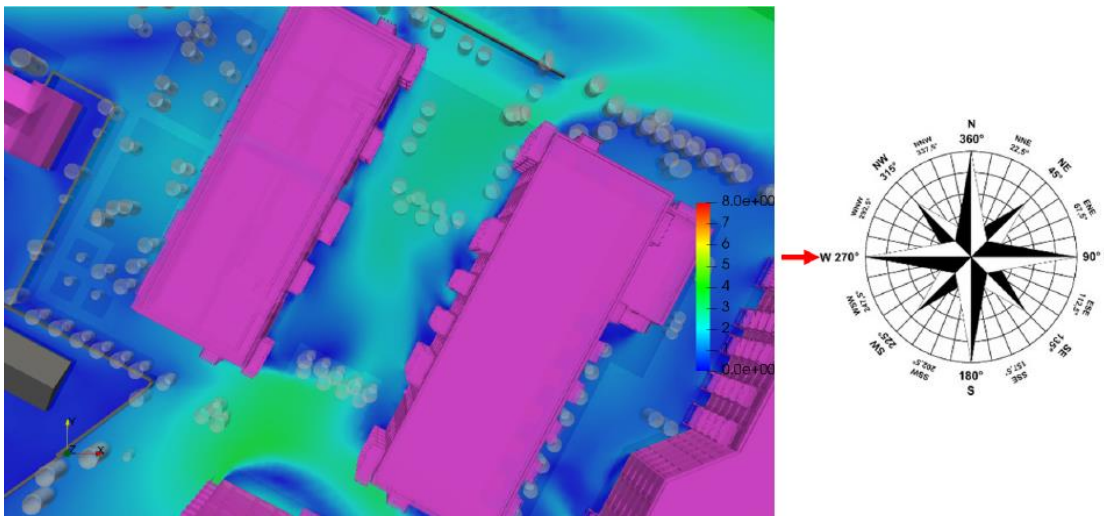


Figure 11.57.: Courtyard Between Block A and B - Flow Velocity Results at Z=1.5m above the ground - Wind Dir. 270°

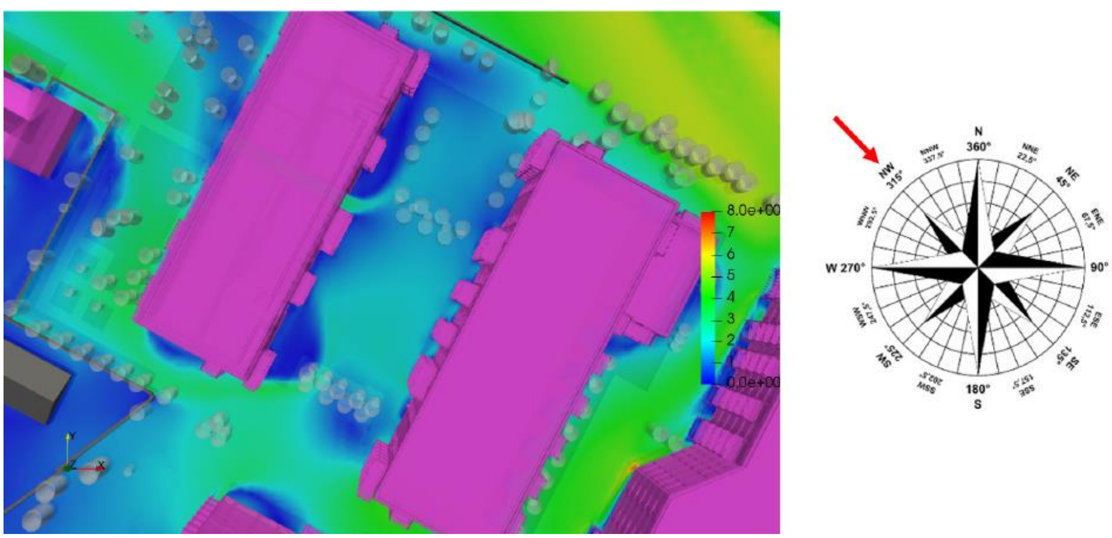


Figure 11.58.: Courtyard Between Block A and B - Flow Velocity Results at Z=1.5m above the ground - Wind Dir: 315°

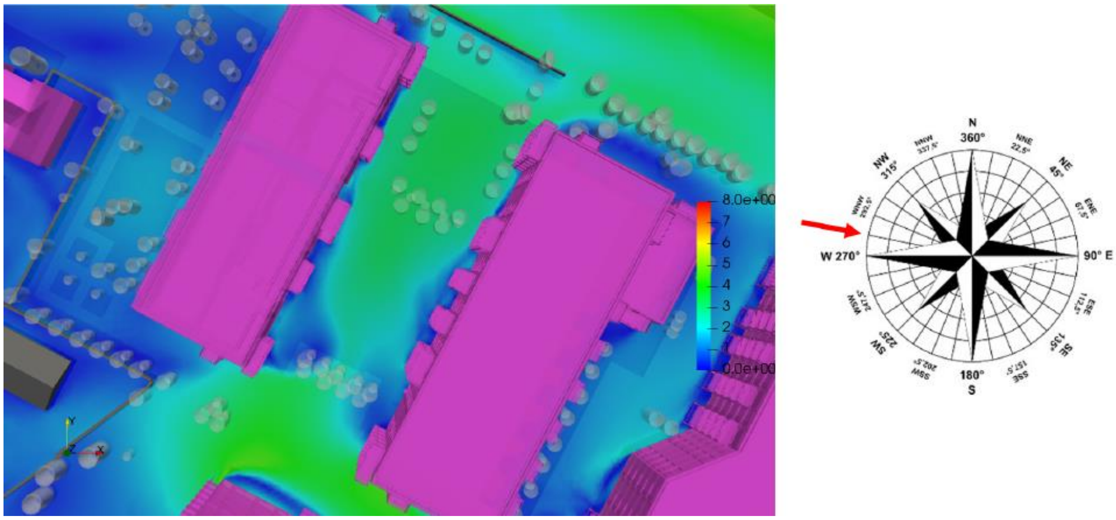


Figure 11.59.: Courtyard Between Block A and B - Flow Velocity Results at Z=1.5m above the ground - Wind Dir 281°

Flow Velocity Results – Terraces

Figures from 11.60. to 11.61. show the position of the two roof terraces on the development. Results of velocity at 1.5m above the terraces for development are presented in Figures 11.62. to 11.77., for wind assessment of the Terraces of the Proposed development (Block C and Block D).

The analysis show that the areas are well protected by a combination of glazed screen and roof coverage. The terrace on Block C is suitable for every activity, including long-term sitting. On the roof terrace on Block D, there is a small area that is suitable for short-term sitting instead of long-term sitting. However, this analysis has been performed considering the worst-case scenario conditions, considering the whole year. Terraces are not areas that are used all year around and long-term sitting is an activity performed during spring/summer months, when the frequency of such high wind is below 5%.

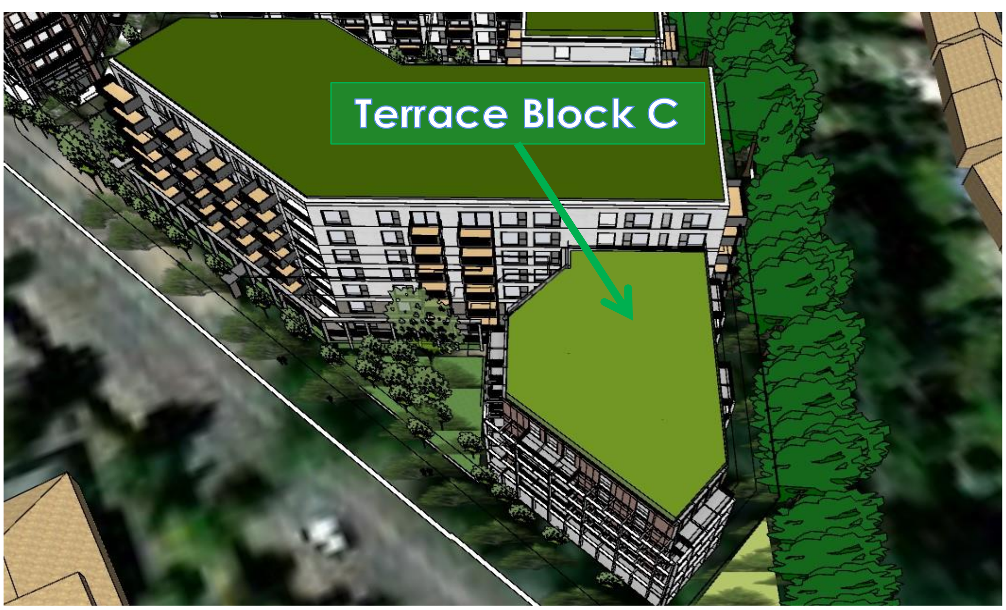


Figure 11.60.: location of roof terrace on Block C

Figure 11.61.: location of roof terrace on Block C

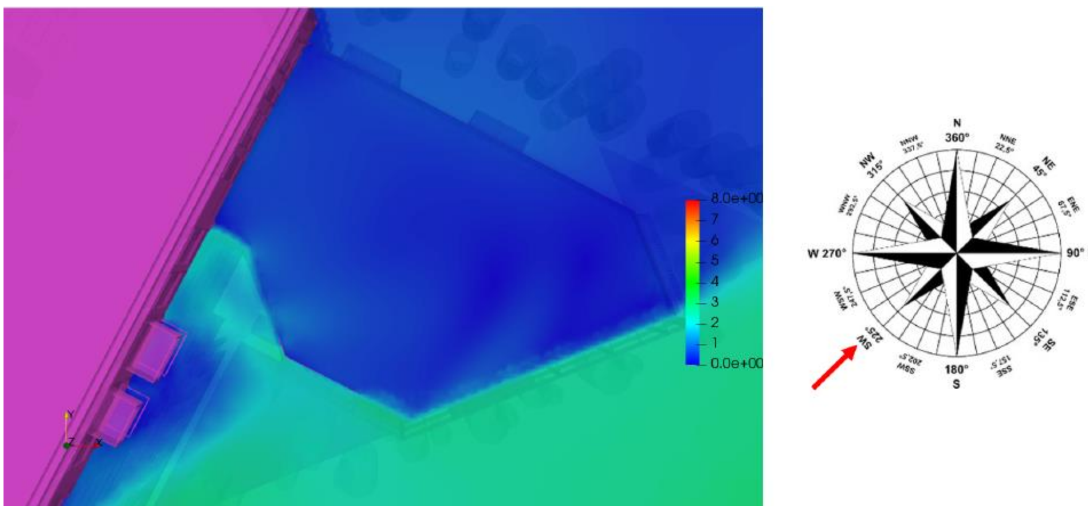


Figure 11.62.: Roof Terrace Block C - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 225°

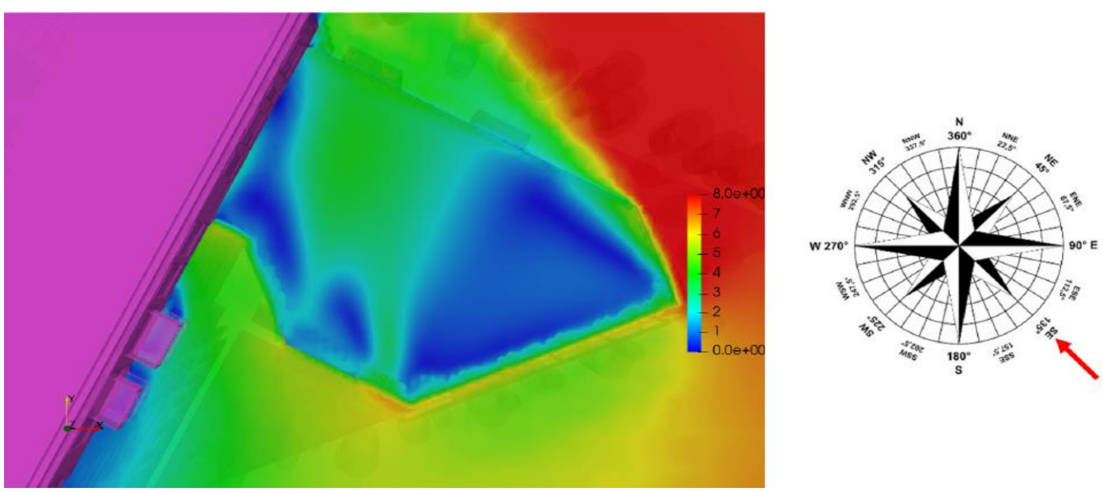


Figure 11.63.: Roof Terrace Block C - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 135°

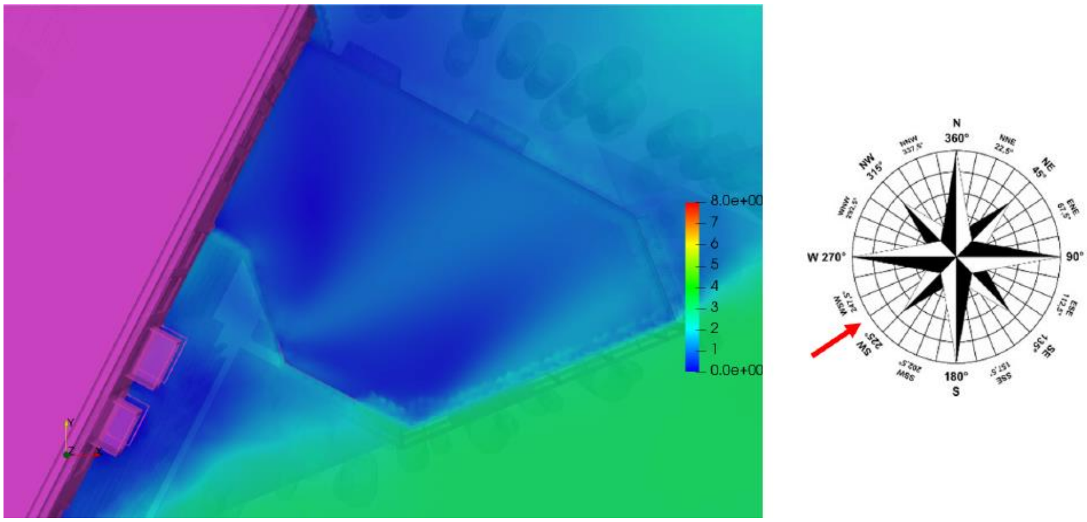


Figure 11.64.: Roof Terrace Block C - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 236°

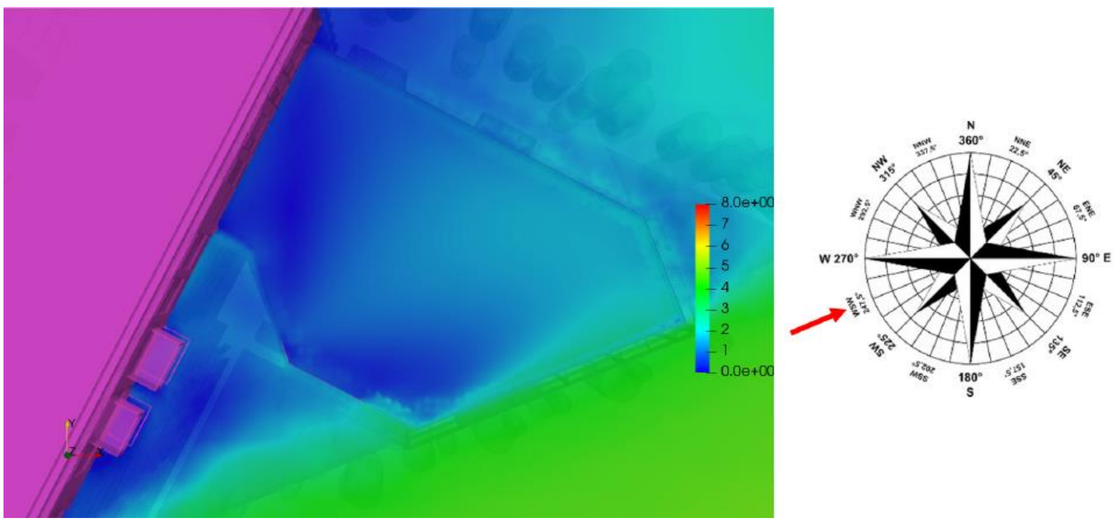


Figure 11.65.: Roof Terrace Block C - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 258°

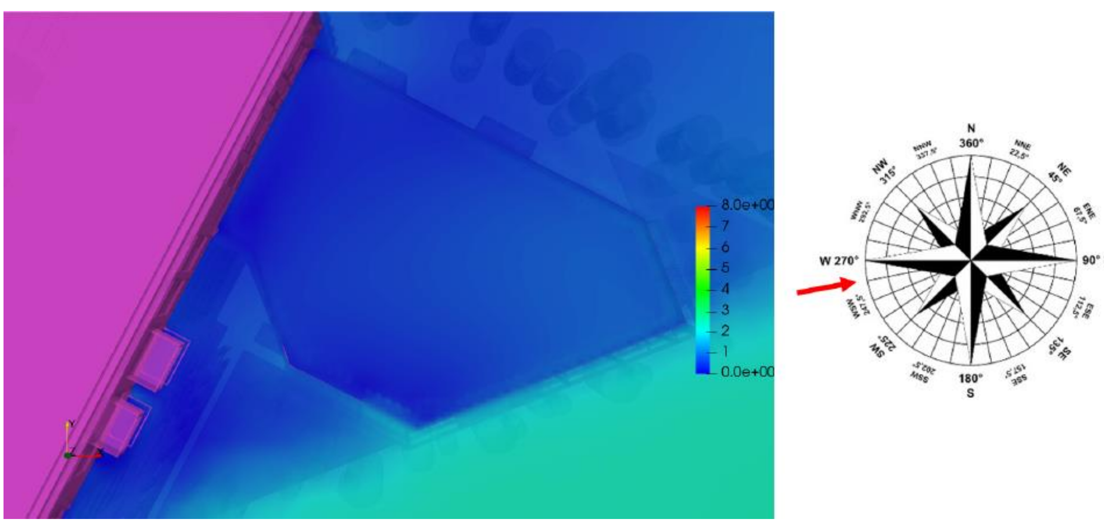


Figure 11.66.: Roof Terrace Block C - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 247°

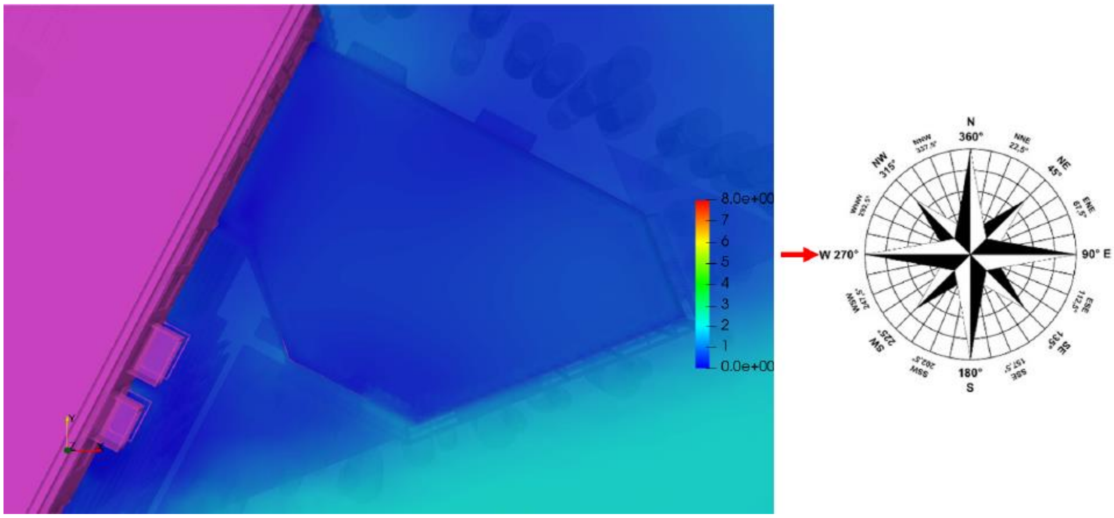


Figure 11.67.: Roof Terrace Block C - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 270°

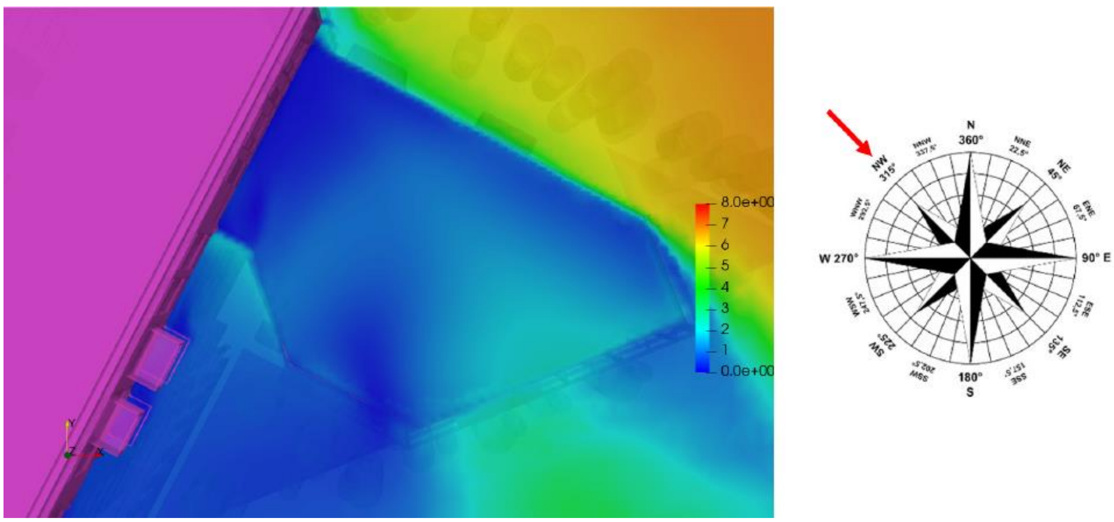


Figure 11.68.: Roof Terrace Block C - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 315°

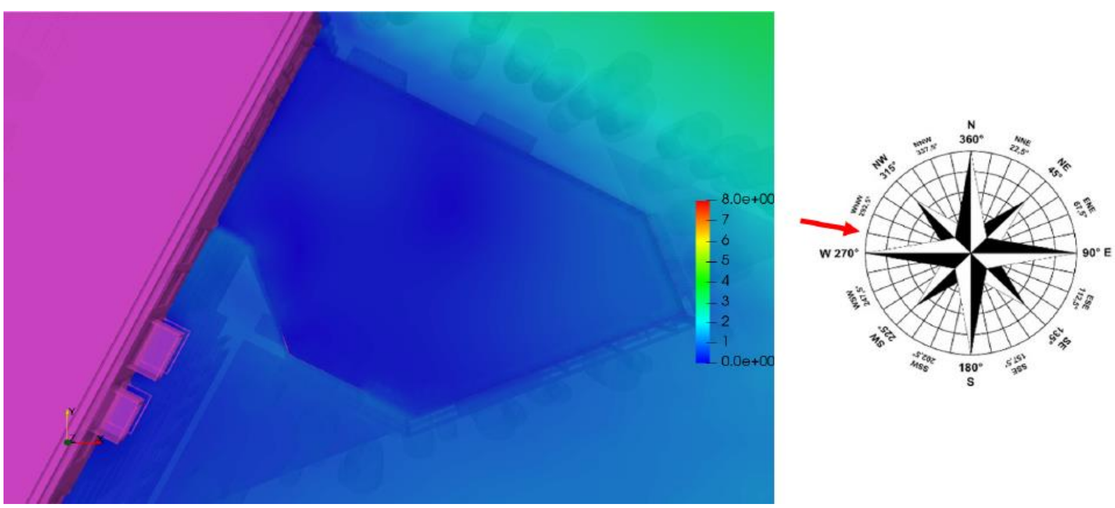


Figure 11.69.: Roof Terrace Block C - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 281°

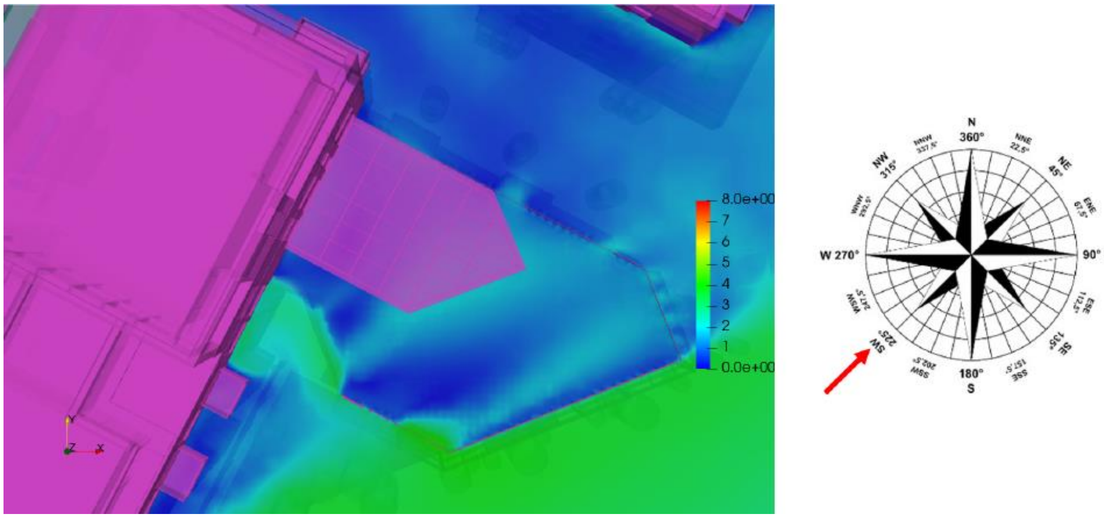


Figure 11.70.: Roof Terrace Block D - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 225°

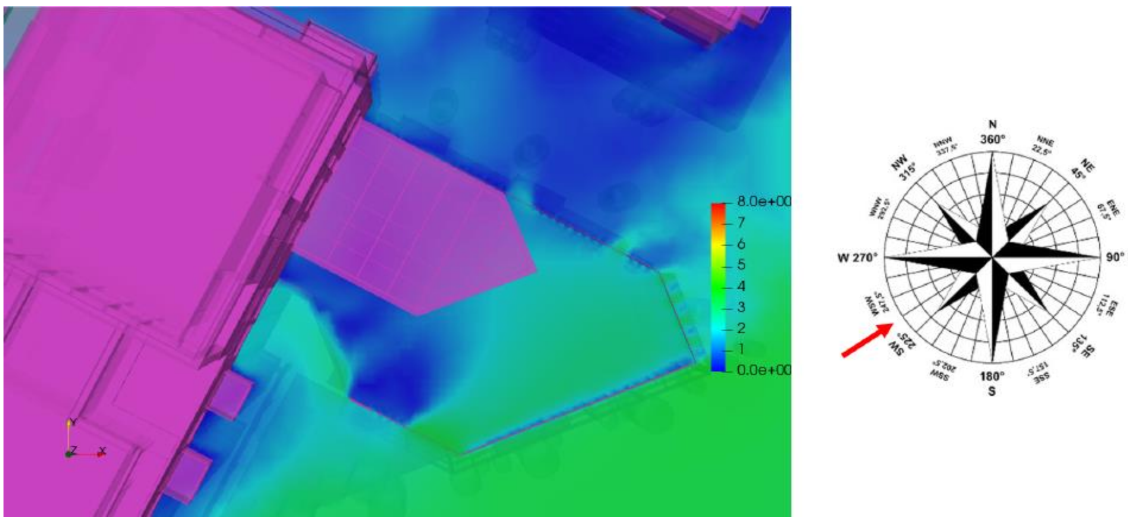


Figure 11.71.: Roof Terrace Block D - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 135°

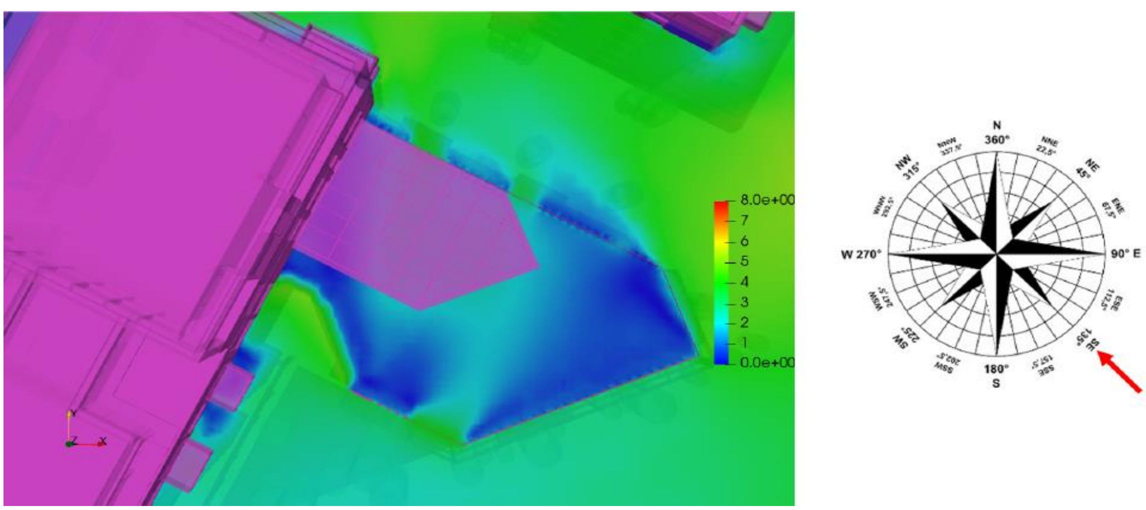


Figure 11.72.: Roof Terrace Block D - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 236°

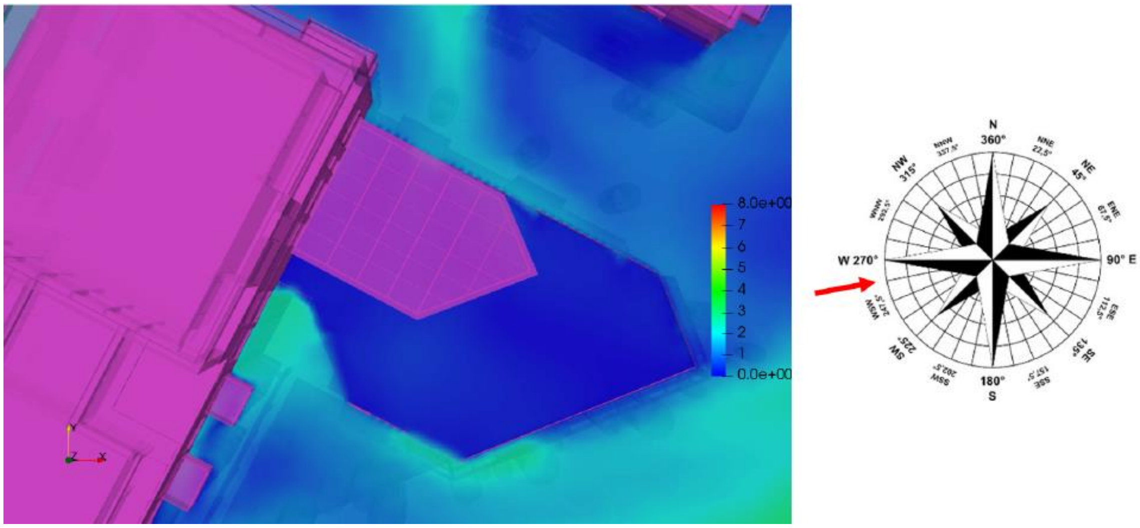


Figure 11.73.: Roof Terrace Block D - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 258°

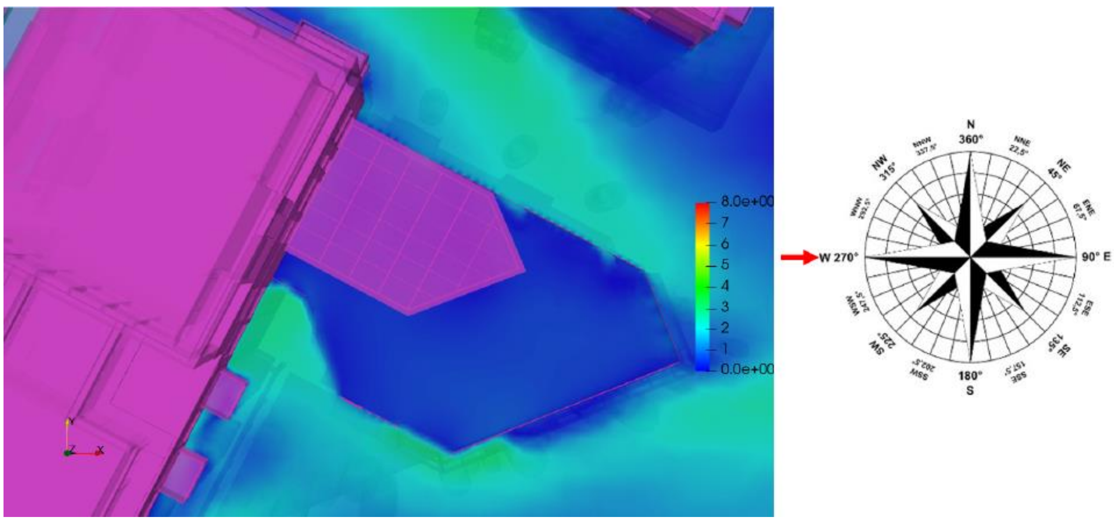


Figure 11.74.: Roof Terrace Block D - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 247°

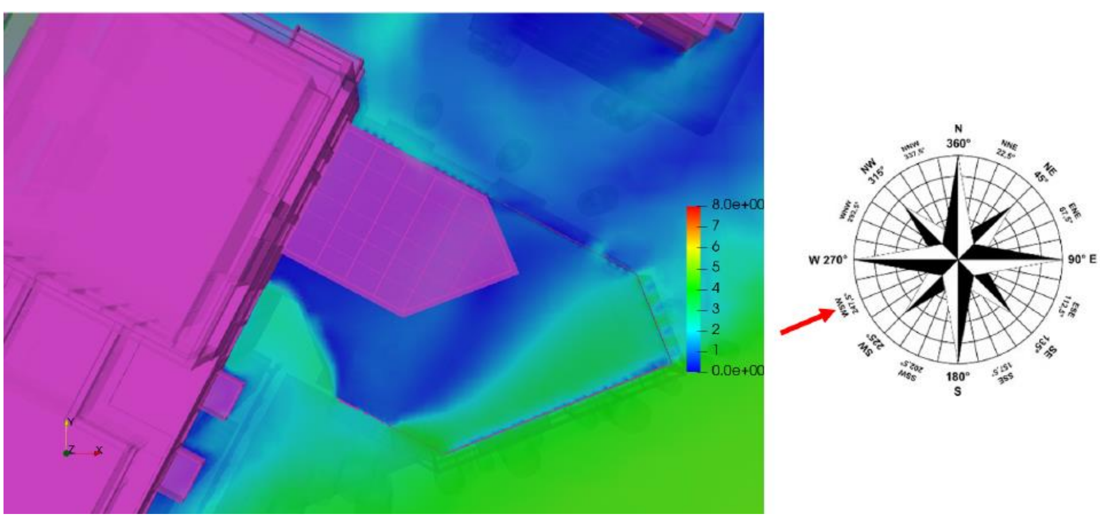


Figure 11.75.: Roof Terrace Block D - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 270°

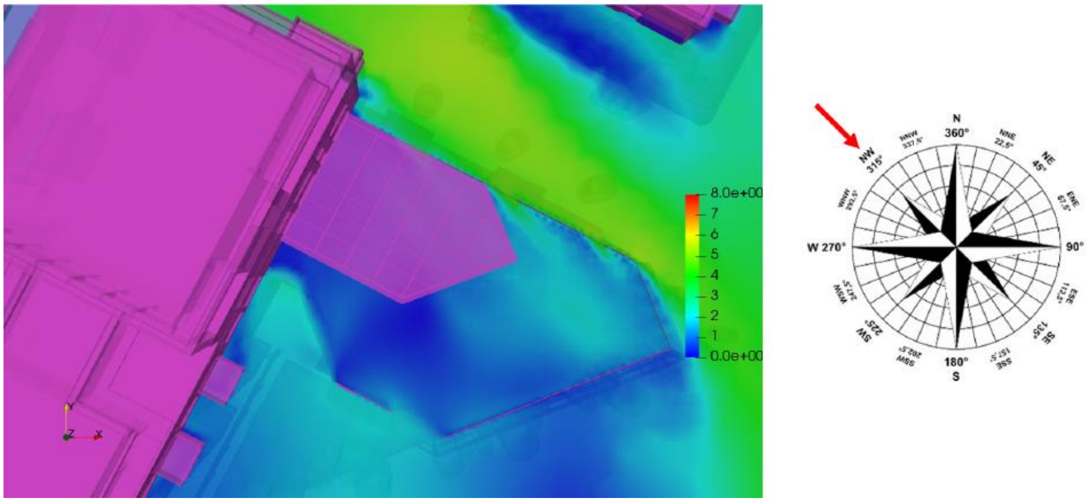


Figure 11.76.: Roof Terrace Block D - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 315°

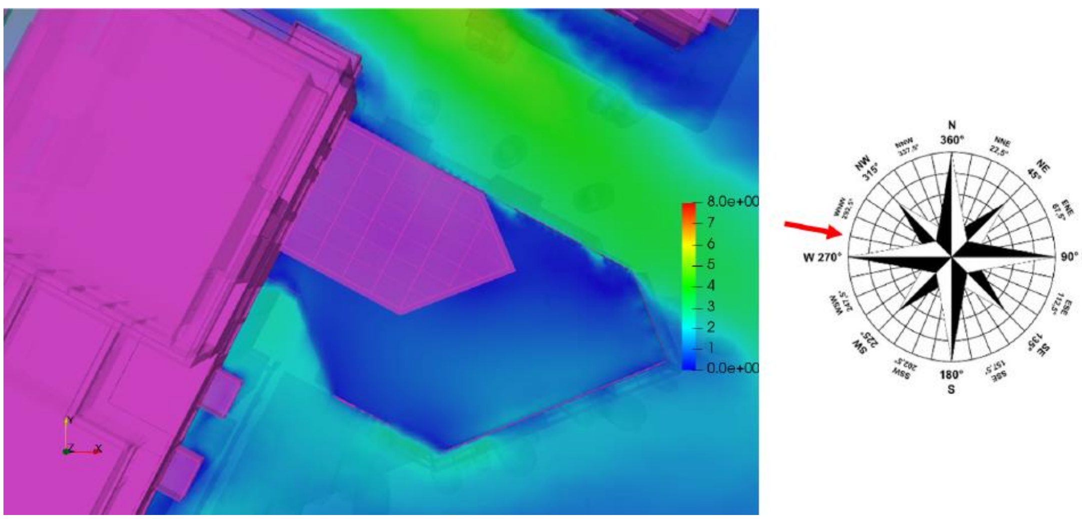


Figure 11.77.: Roof Terrace Block D - Flow Velocity Results at Z=1.5m above the terrace Wind Direction: 281°

Flow Velocity Results – Balconies

Results of velocity across some of the balconies are presented in Figures 11.78. to 11.93., for wind assessment of the balconies of the Proposed development as examples of the results extracted for the balconies.

Higher velocities can be found for the balconies exposed to South and South-West wind directions. However, these velocities are below the threshold values defined by the acceptance criteria and therefore are not critical for safety.

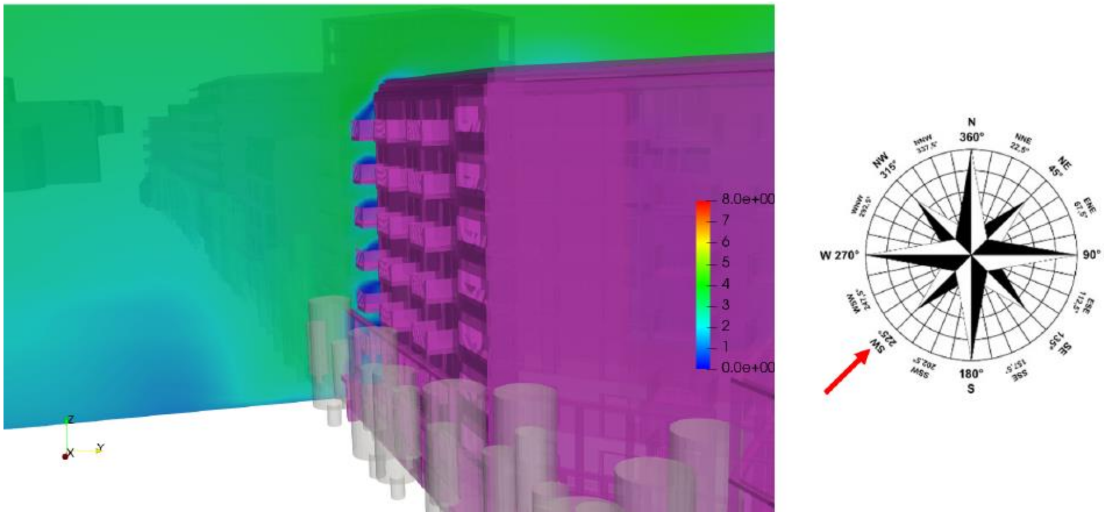


Figure 11.78.: Example of wind results on Balconies Block C - Flow Velocity Results - Wind Direction: 225°

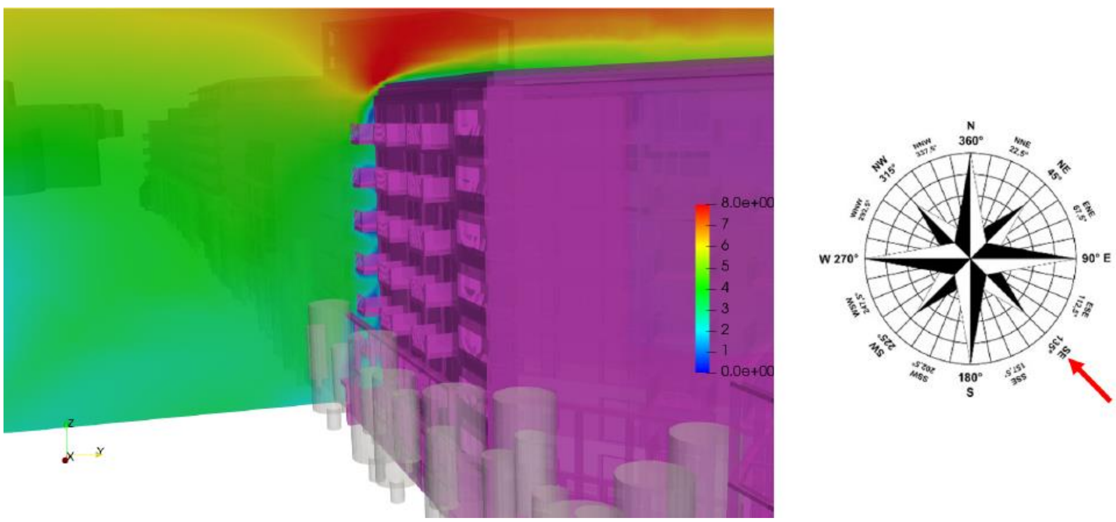


Figure 11.79.: Example of wind results on Balconies Block C - Flow Velocity Results - Wind Direction: 135°

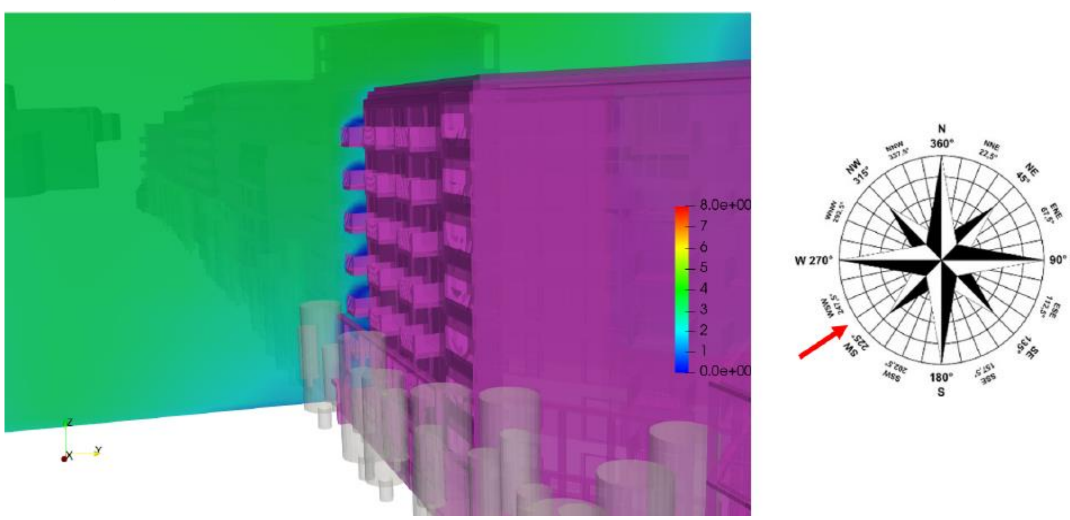


Figure 11.80.: Example of wind results on Balconies Block C - Flow Velocity Results - Wind Direction: 236°

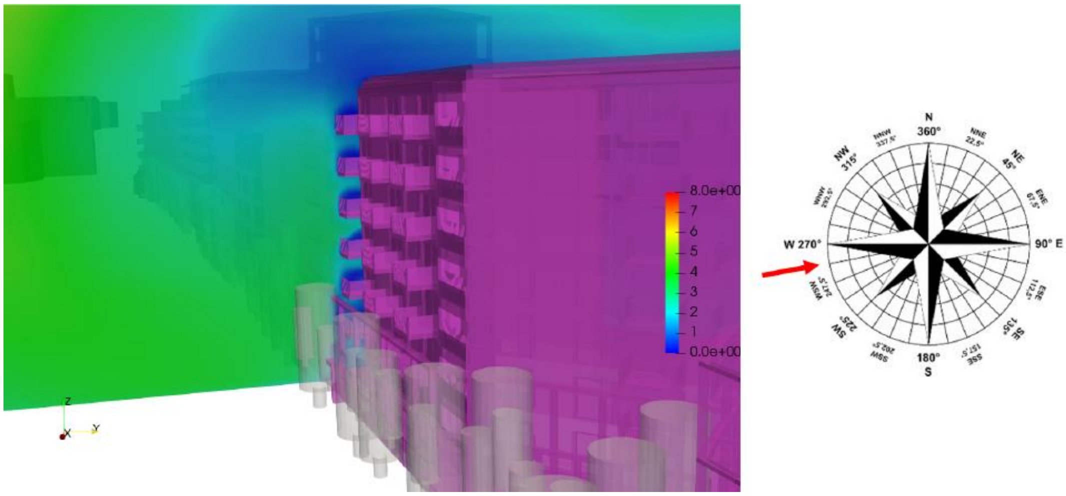


Figure 11.81.: Example of wind results on Balconies Block C - Flow Velocity Results - Wind Direction: 258°

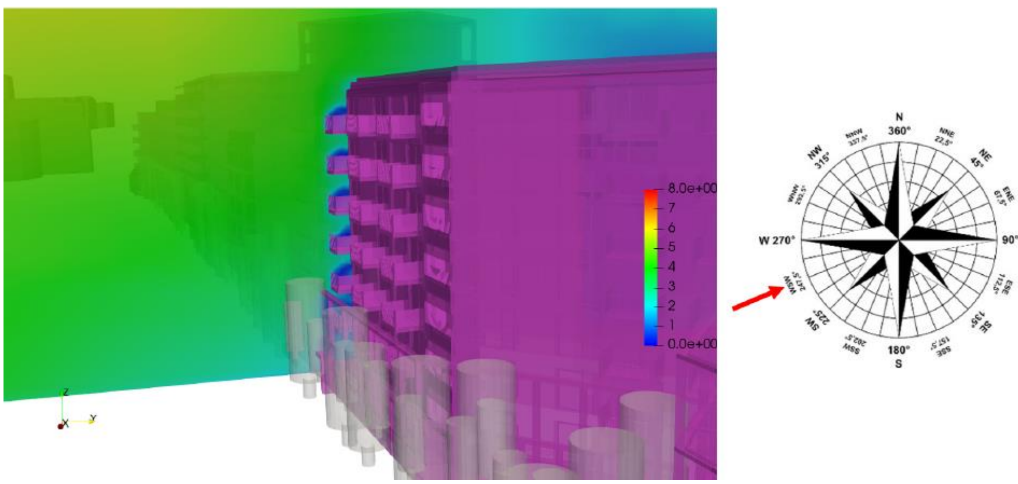


Figure 11.82.: Example of wind results on Balconies Block C - Flow Velocity Results - Wind Direction: 247°

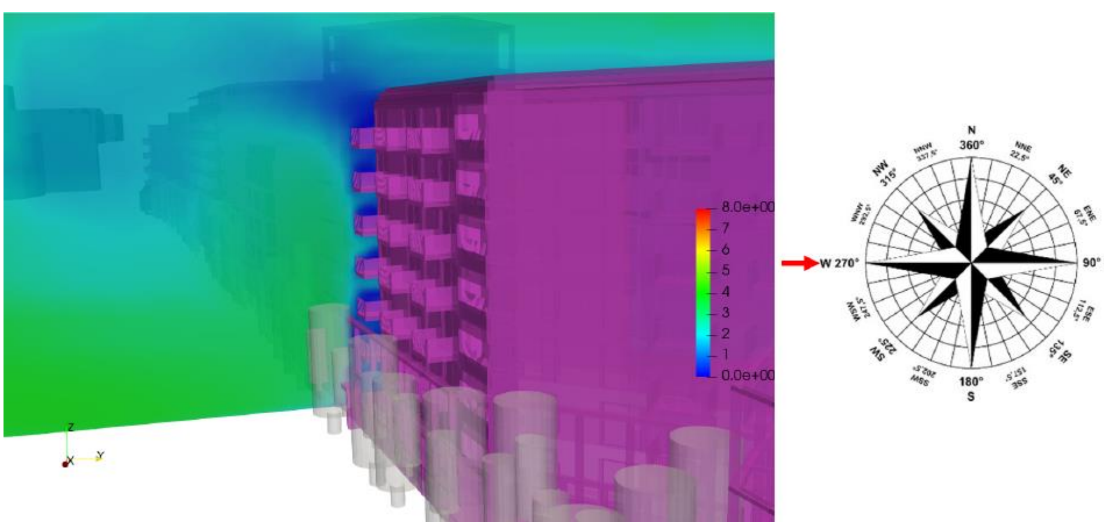


Figure 11.83.: Example of wind results on Balconies Block C - Flow Velocity Results - Wind Direction: 270°

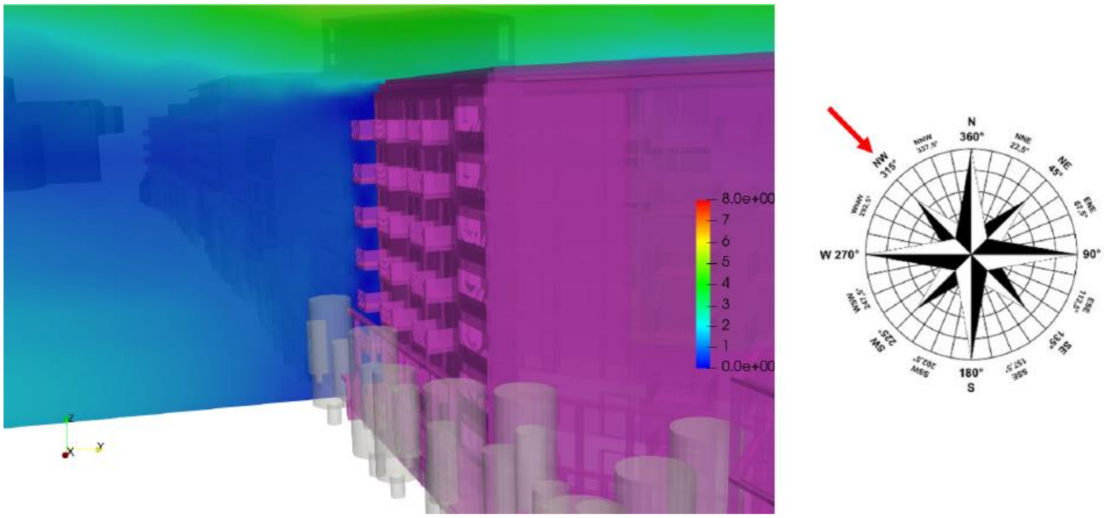


Figure 11.84.: Example of wind results on Balconies Block C - Flow Velocity Results - Wind Direction: 315°

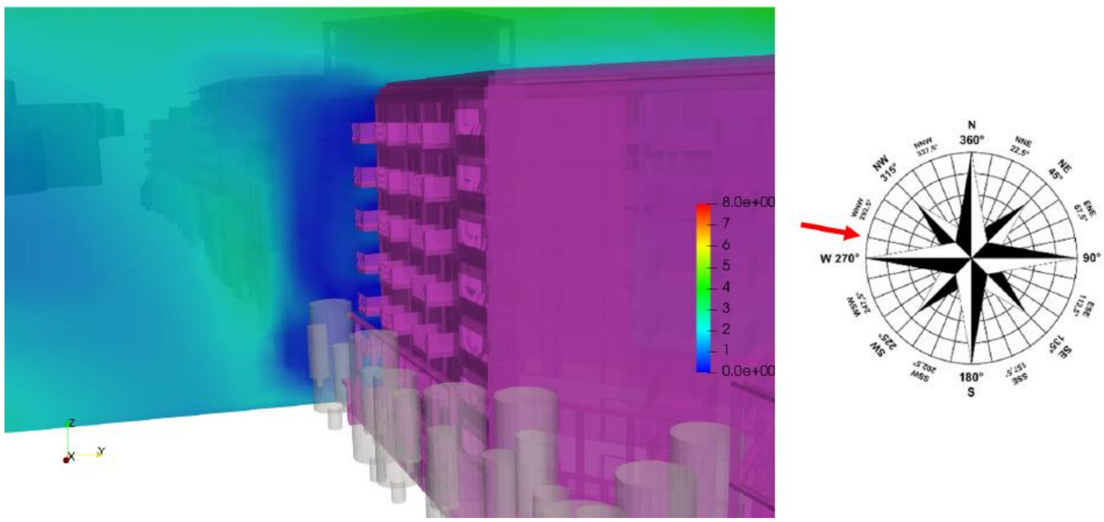


Figure 11.85.: Example of wind results on Balconies Block C - Flow Velocity Results - Wind Direction: 281°

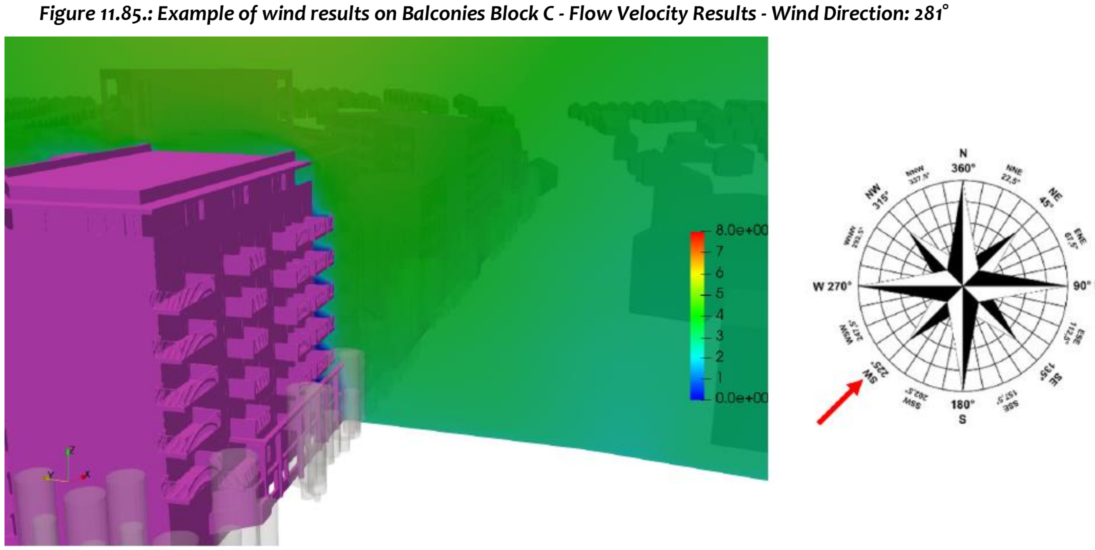


Figure 11.86.: Example of wind results on Balconies Block D - Flow Velocity Results - Wind Direction: 225°

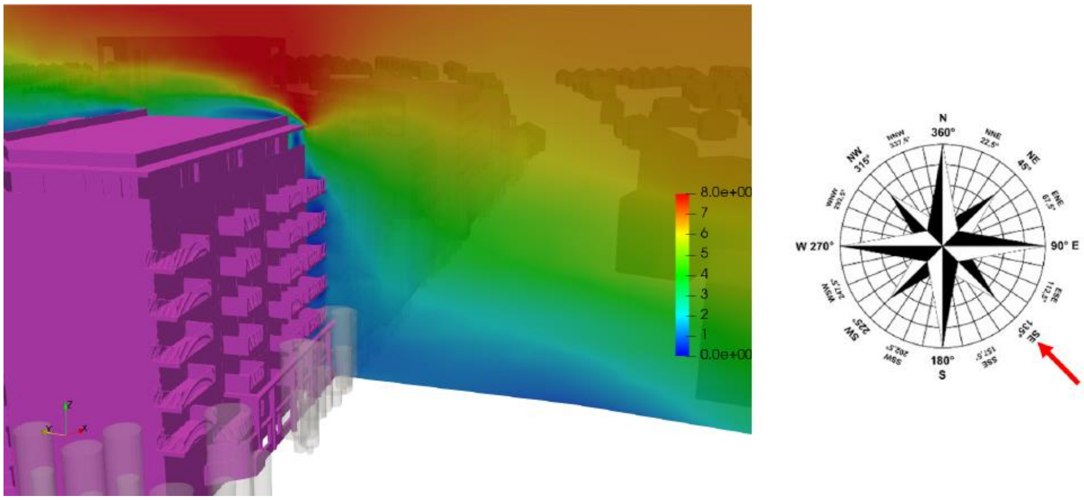


Figure 11.87.: Example of wind results on Balconies Block D - Flow Velocity Results - Wind Direction: 135°

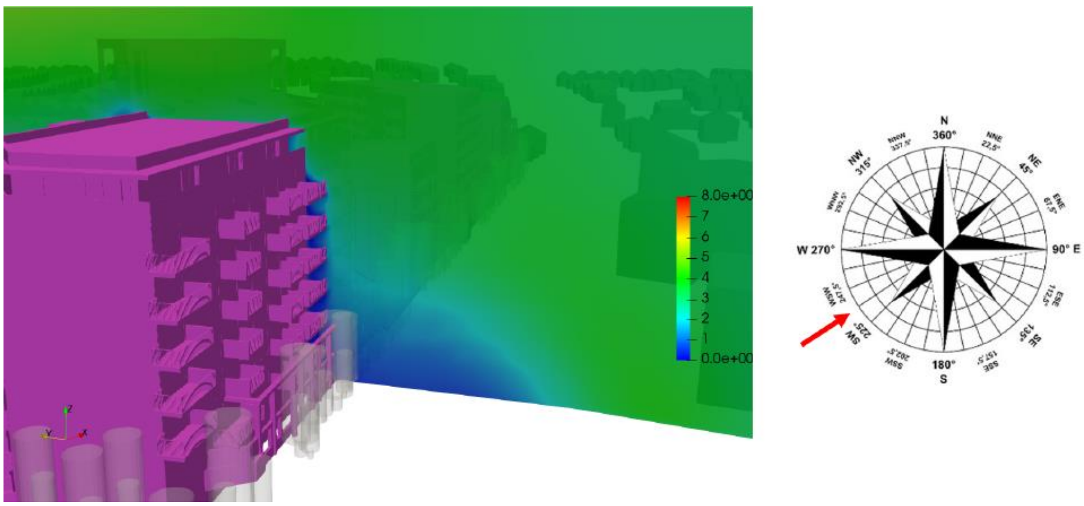


Figure 11.88.: Example of wind results on Balconies Block D - Flow Velocity Results - Wind Direction: 236°

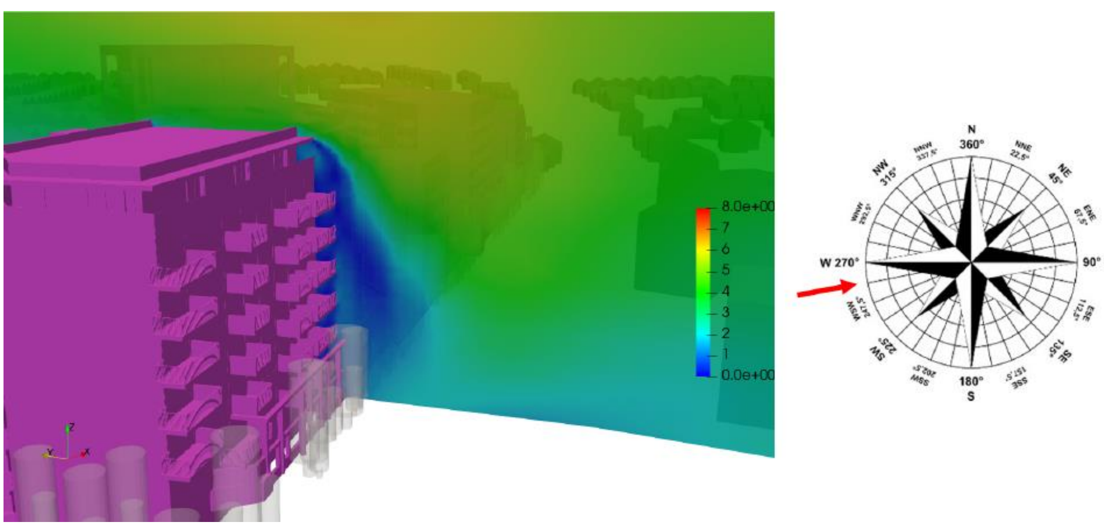


Figure 11.89.: Example of wind results on Balconies Block D - Flow Velocity Results - Wind Direction: 258°

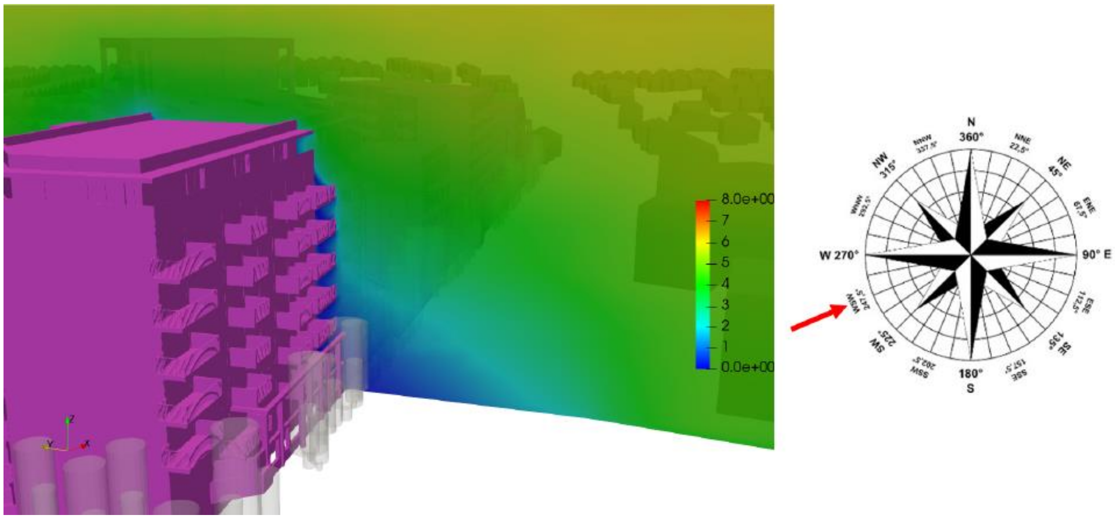


Figure 11.90.: Example of wind results on Balconies Block D - Flow Velocity Results - Wind Direction: 247°

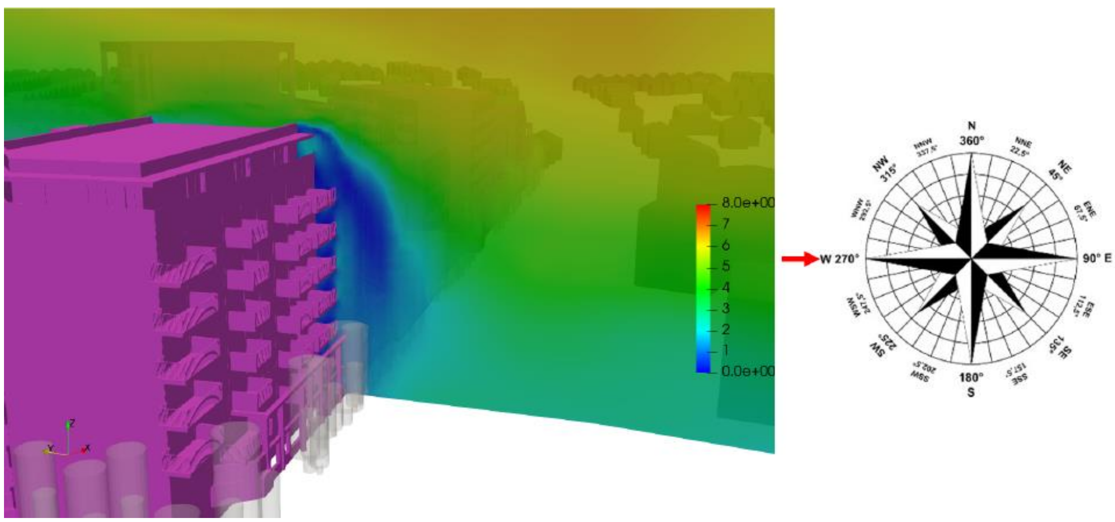


Figure 11.91.: Example of wind results on Balconies Block D - Flow Velocity Results - Wind Direction: 270°

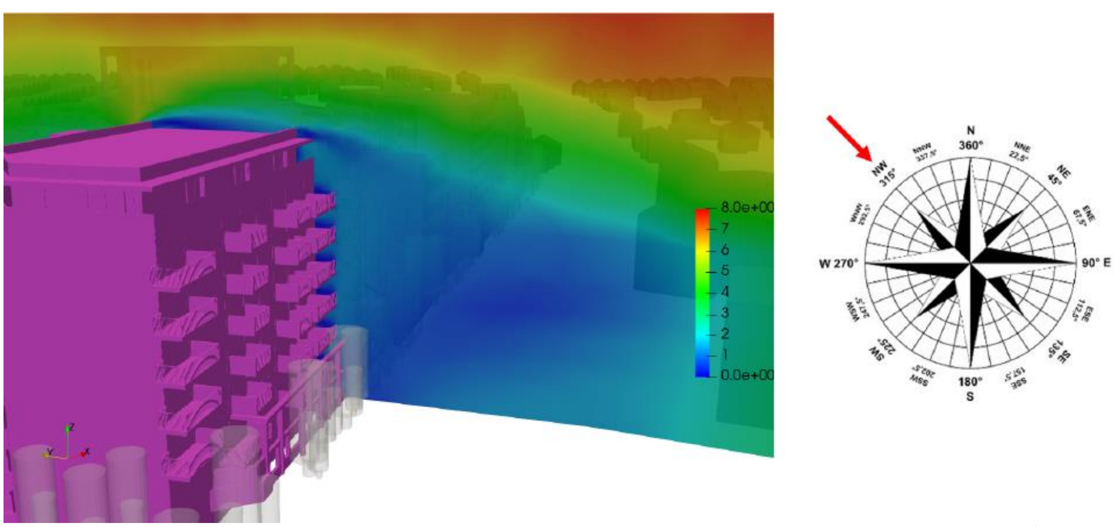


Figure 11.92.: Example of wind results on Balconies Block D - Flow Velocity Results - Wind Direction: 315°

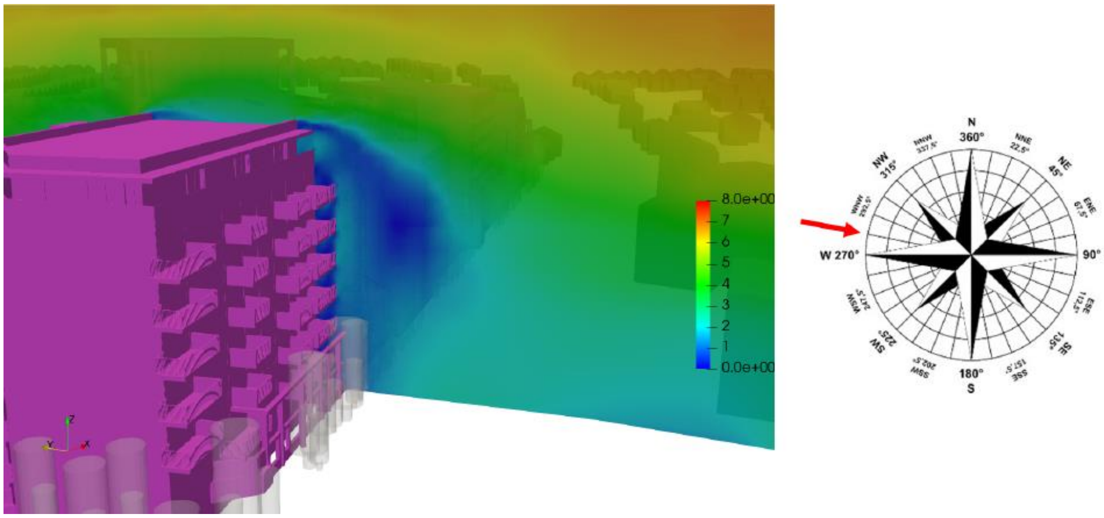


Figure 11.93.: Example of wind results on Balconies Block D - Flow Velocity Results - Wind Direction: 281°

Predicted Impact of the Proposed Development Summary

The existing environment and Proposed development would receive prevailing winds from South-West and South-East. As discussed in the previous sections and demonstrated through this assessment of CFD modelling, all adverse wind impacts have been considered and shows to be suitable to its intended use.

The existing site cumulative assessment has accounted for the modelling and simulation of all the topography and existing developments in the surrounding as the presence of adjacent buildings dictates how the wind will approach the proposed development.

From the wind modelling results, the Proposed development will introduce no negative wind effect on adjacent and nearby developments.

11.8. Risks to Human Health

This subsection aims to identify areas of Proposed development where the pedestrian safety and comfort could be compromised (in accordance with the Lawson Acceptance Criteria previously described). Pedestrian comfort criteria are assessed at 1.5m above ground level.

Discomfort Criteria

Figures from 11.95. to 11.97. show the Lawson comfort categories over the ground floor area around Proposed development. In all cases, the scale used is set out in Figure 11.94.

For the Lawson discomfort criteria, the onset of discomfort depends on the activity in which the individual is engaged and it is defined in terms of a mean hourly wind speed (or GEM) which is exceeded for 5% of the time. Depending on the wind direction, the suitability of the different areas can be assessed using the maps. It can be seen that the wind conditions range from "suitable for long-term sitting" to "suitable for walking and strolling" and really rarely are only suitable for "business walking" or "unacceptable for pedestrian comfort".

The results shown in these maps show that there are no critical area which are unacceptable for pedestrian comfort. Some higher velocity indicating minor funnelling effects are found near the South-West side of the development and the area between Block D and F. However, as it can be seen, both areas were mitigated with landscaping and the flow velocities shown in the Lawson map indicate that the areas can be utilised for the intended use.

Figure 11.94.: Lawson Comfort Categories

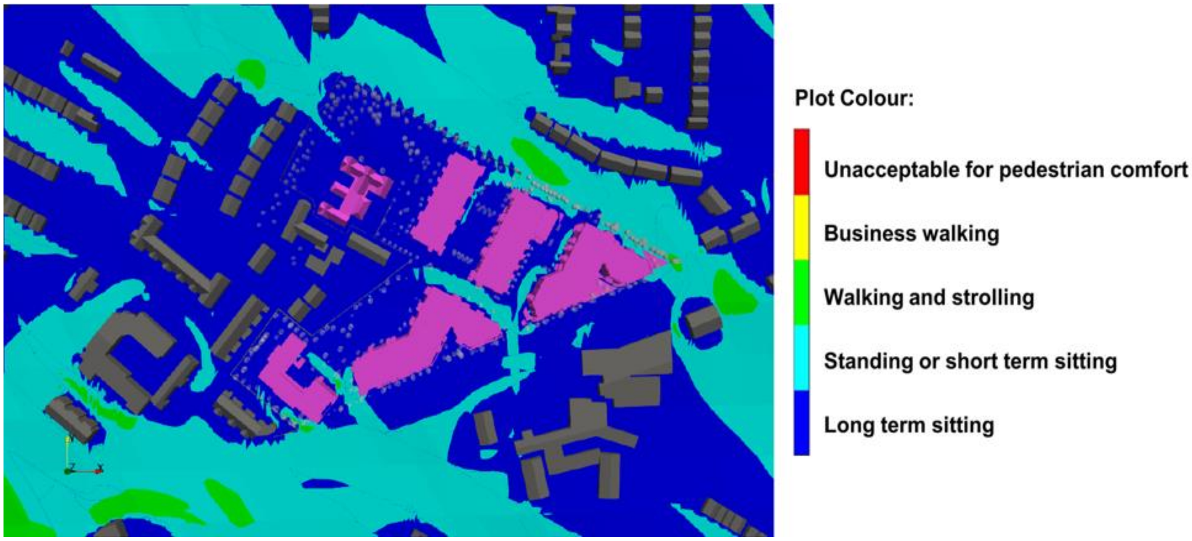


Figure 11.95.: Ground Floor - Lawson Discomfort Map - Top View

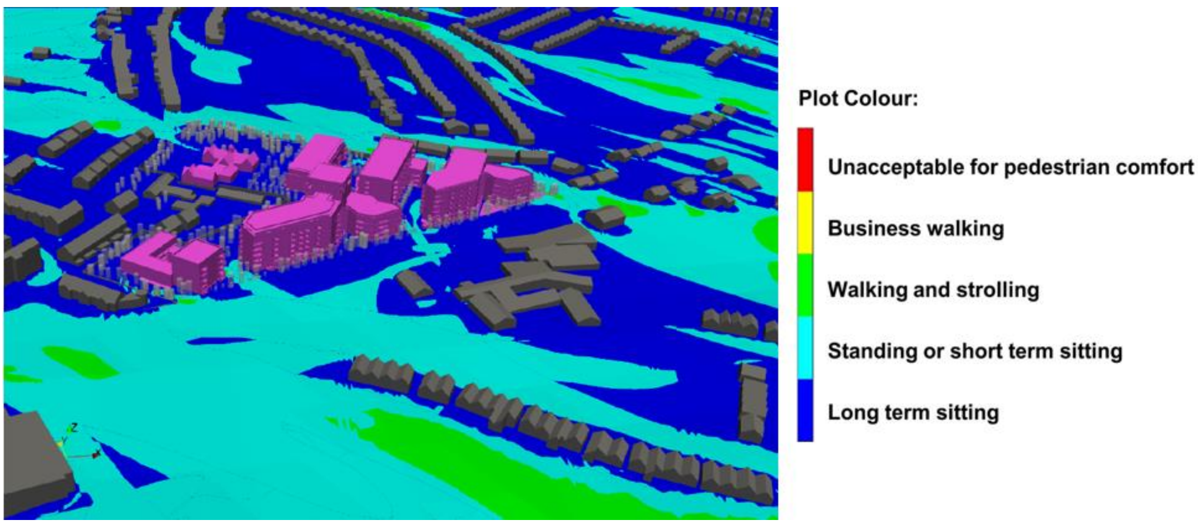


Figure 11.96.: Ground Floor - Lawson Discomfort Map - 3D view

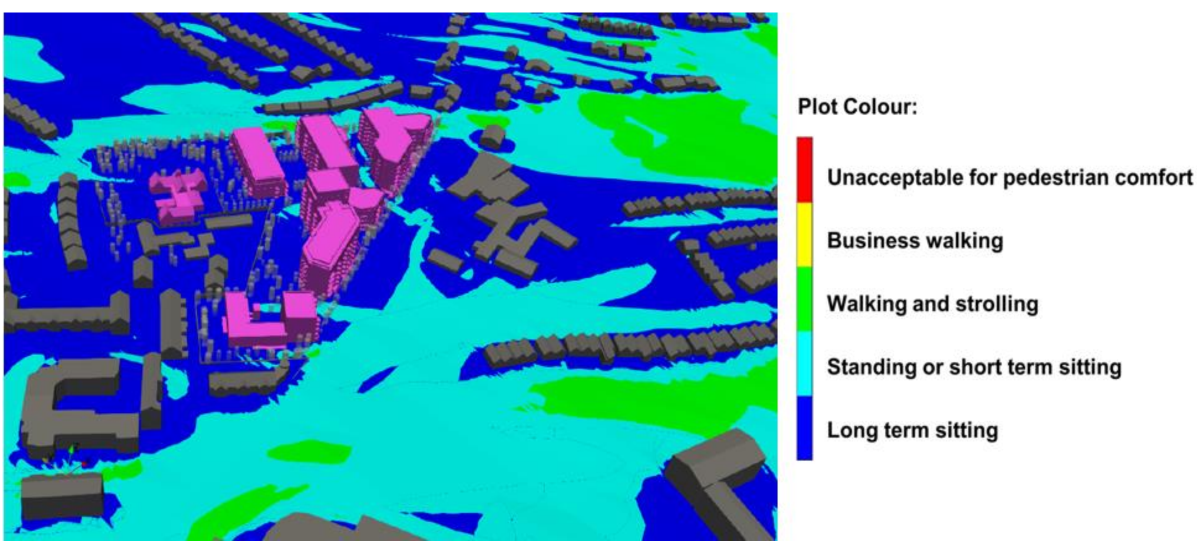


Figure 11.97.: Ground Floor - Lawson Discomfort Map - 3D view

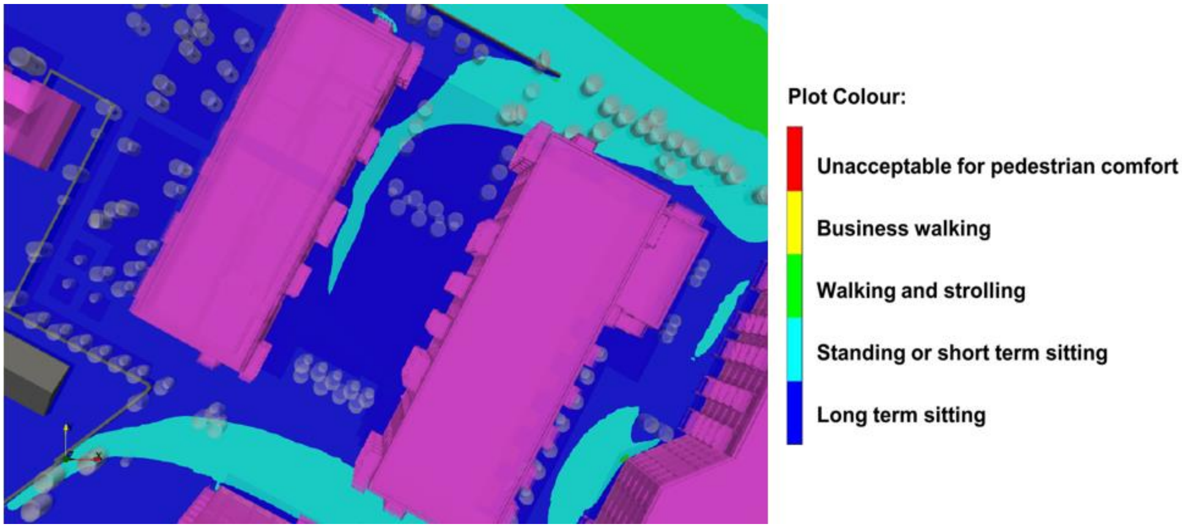


Figure 11.98.: Between Block A and B - Lawson Discomfort Map

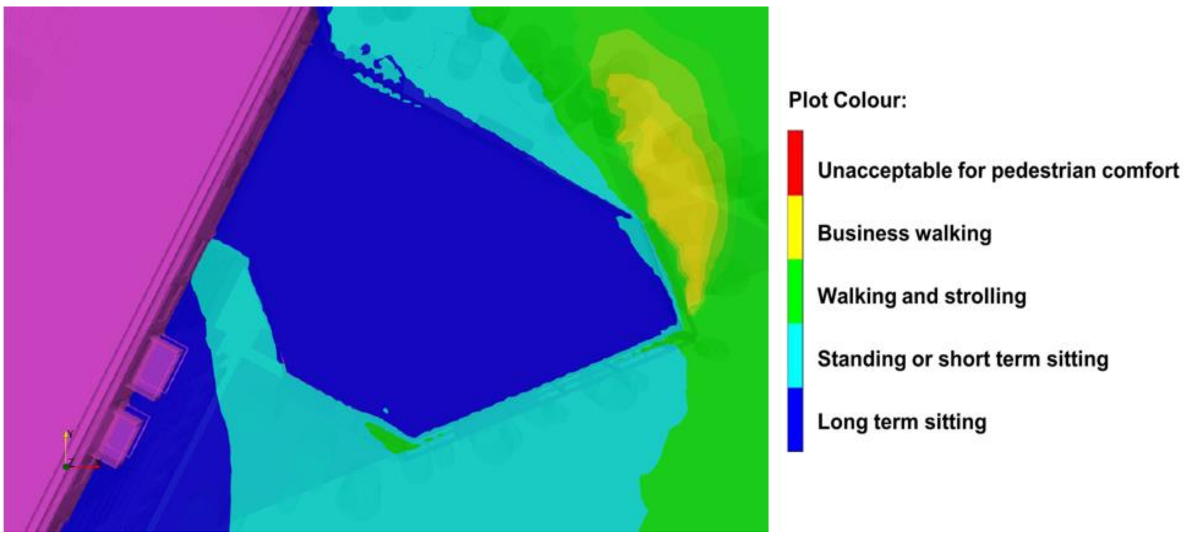


Figure 11.99.: Roof Terrace Block C - Lawson Discomfort Map at Z=1.5m above the terrace

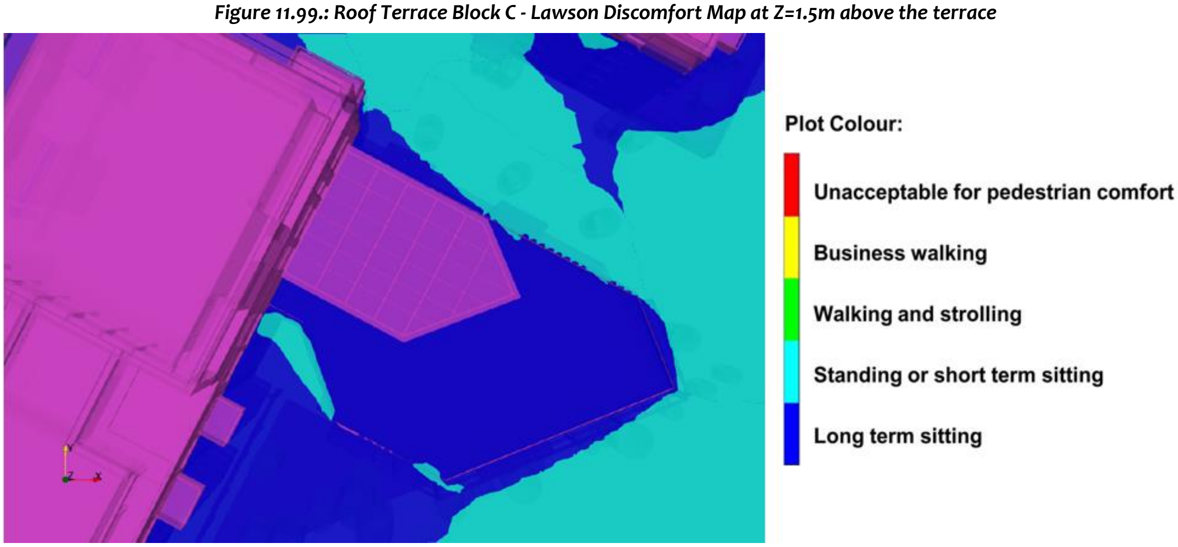


Figure 11.100.: Roof Terrace Block D - Lawson Discomfort Map at Z=1.5m above the terrace

Distress Criteria

In addition to the criteria for "discomfort" the Lawson method presents criteria for "distress". The discomfort criteria focus on wind conditions which may be encountered for hundreds of hours per year. The distress criteria require higher wind speeds to be met but focus on two hours per year. These are rare wind conditions but with the potential for injury rather than inconvenience.

Figure 11.101. shows the hourly wind gust rose for Dublin, from 1990 to 2020. This will be necessary to assess how many hours per year on average the velocity exceed the threshold values.

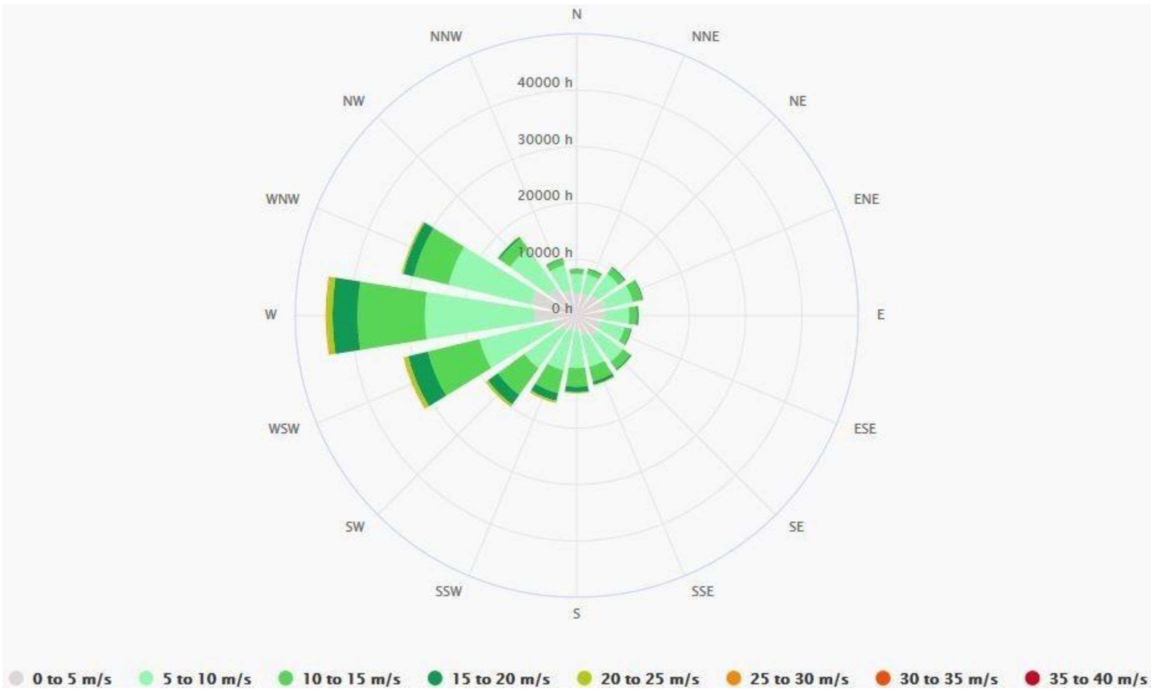


Figure 11.101: Hourly Dublin Wind Gust Rose

The criteria for distress for a frail person or cyclist is 15m/s wind occurring for more than two hours per year. Limiting the results from the above wind rose to the only values above 15m/s (as reported in Figures 11.102. and 11.103. respectively as cumulative hours and cumulative percentage), it is possible to see how many hours in 30 years the gust velocity of 15m/s is exceed at pedestrian level in each direction.

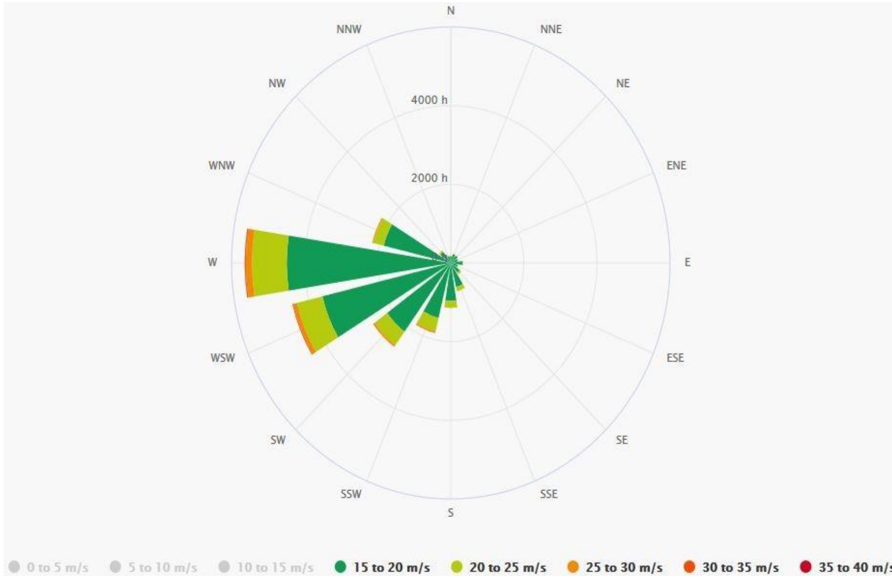


Figure 11.102.: Hourly Dublin Wind Gust Rose - Cumulative hours when the velocity is above 15m/s

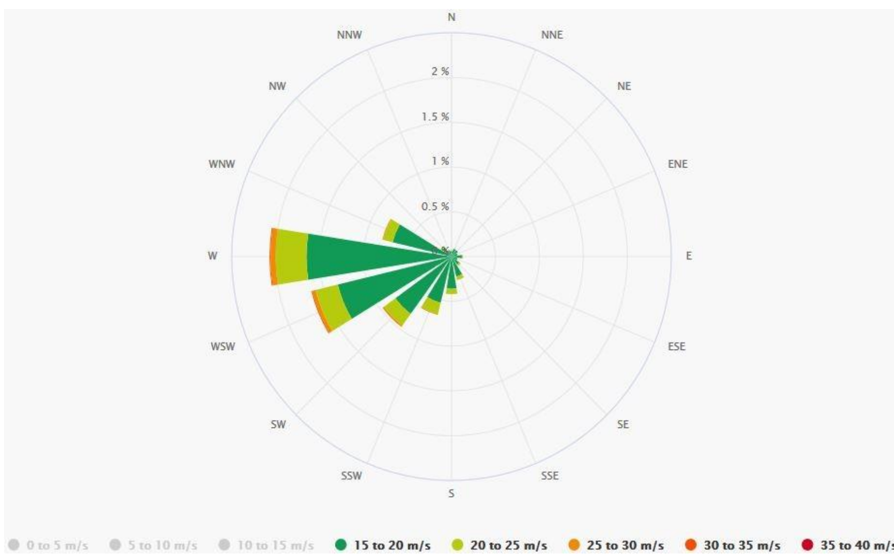


Figure 11.103.: Hourly Dublin Wind Gust Rose - Cumulative percentage of time when the velocity is above 15m/s

A total of 2 hours per year corresponds to 0.02% in one year, which means 0.6% in 30 years. Looking at the wind roses above, it is possible to notice that a velocity of 15m/s was reached in Dublin only for the following directions (in increasing order of percentage) over the years 1990-2020:

1. West 270°
2. West-South-West 247.5°
3. South-West 225°

For this reason, it is of interest to show the distress results for these directions. Figure 11.105. below combines all the above directions together and shows the areas where the measured velocity is above 15 m/s. Figure 11.104. shows the scale used in this case. Results show that there are not critical areas where the velocity increases above 15 m/s, thus the criteria is always satisfied.

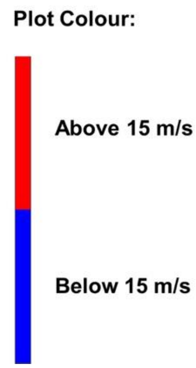


Figure 11.104.: Lawson Distress Categories - Frail Person or Cyclist

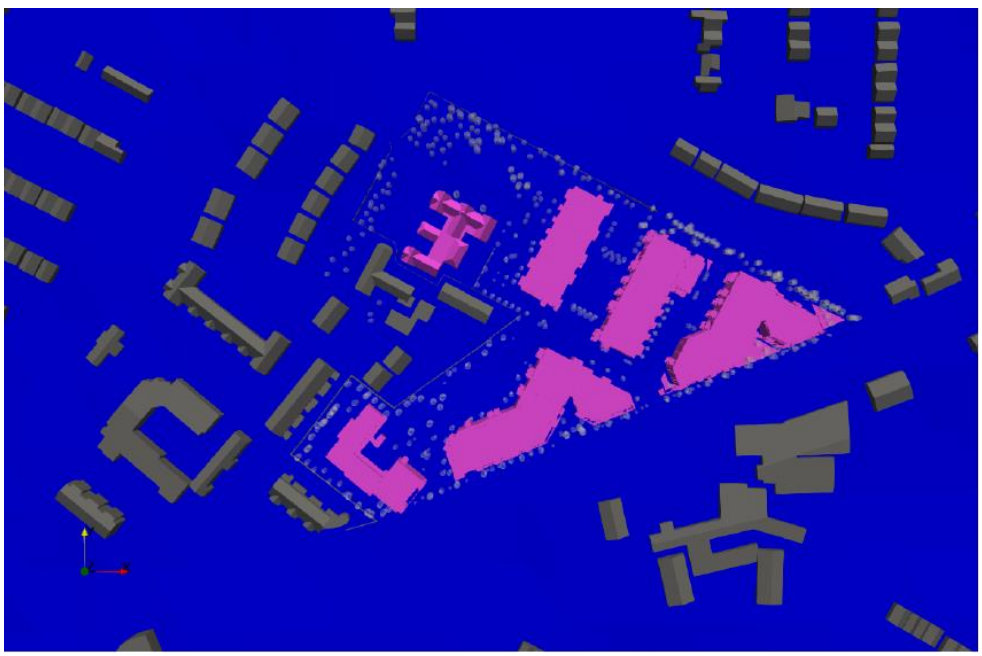


Figure 11.105.: Lawson Distress Map - Frail Person or Cyclist

The criteria for distress for a member of the general population is 20m/s wind occurring for more than two hours per year. As explained above, a velocity of 20m/s was never reached in Dublin over the years 1990-2020. For this reason, it is not of interest to show the distress results for any of the wind directions and the criteria is always satisfied.

Summary of Cumulative Predicted Impact of the Proposed Development

From the simulation results the following observations are pointed out:

- The proposed development has been designed in order to produce a high quality environment that is attractive and comfortable for pedestrians of all categories. To achieve this objective, throughout the design process, the impact of wind has been considered and analysed, in the areas where critical patterns were found, the appropriate mitigation measures were introduced.

- As a result of the final proposed, wind flow speeds at ground floor are shown to be within tenable conditions. Some higher velocity indicating minor funnelling effects are found near the South-West side of the development. However, as it is shown in the Lawson map indicate that the area can be utilised for the intended use.

- Due to re-circulation effects between Block D and F, this area is suitable for short term sitting instead of long term sitting. These conditions are not occurring at a frequency that would compromise the pedestrian comfort, according to the Lawson Criteria.

- Regarding the balconies, higher velocities can be found for some directions, only on some of the balconies. However, these velocities are below the threshold values defined by the acceptance criteria and therefore are not critical for safety.

- Tree planting all around the development has been utilised, with particular attention to the corners of the Blocks has positively mitigated any critical wind effects. Thus, it can be concluded that at ground floor good shielding is achieved everywhere.

- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings. Moreover, in terms of distress, no critical conditions were found for "Frail persons or cyclists" and for members of the "General Public" in the surrounding of the development.

- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings.

11.9. Monitoring

Construction Phase

There is no particular requirement to monitor wind impact during construction phase as the designated amenity areas will not be in use during this phase of the project.

Operational Phase

During the development operational phase, it has been designed to conform to acceptable Lawson Criteria for Comfort and Distress in accordance with the Wind Beaufort Scale.

11.10. Reinstatement

Construction Phase

Not applicable.

Operational Phase

Not applicable.

11.11. Do Nothing Scenario

In the absence of the proposed development being constructed, the permitted development (D17A/0337/PL06D.249248) would likely be implemented. The seven large, detached houses on large plots fronting Leopardstown Road (i.e. the part of the site added subsequent to the granting of the above permission) would remain in use as individual dwellings. This would not fully realise the potential of the subject site for sustainable residential use in line with the current national policy mandate."

11.12. Difficulties Encountered

No difficulties were encountered during the assessment of wind and microclimate impacts on Proposed development or its existing environments.

11.13. Conclusions

Conclusions and Comments on Microclimate Study

This report presents the CFD modelling assumptions and results of Wind and Microclimate Modelling of Proposed development, located at Leopardstown Road, Dublin 18.

This study has been carried out to identify the possible wind patterns around the area proposed, under mean and peak wind conditions typically occurring in Dublin, and also to assess impacts of the wind on pedestrian level comfort.

The results of this wind microclimate study are utilized by Homeland Silverpines Limited to configure the optimal layout for Proposed development for the aim of achieving a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian) and not to introduce any critical wind impact on the surrounding areas and on the existing buildings.

Existing Receiving Environment Summary:

The wind desktop study of the existing receiving environment showed that:

- The wind profile was built using the annual average of meteorology data collected at Dublin Airport Weather Station. In particular, the local wind climate was determined from historical meteorological data recorded 10 m above ground level at Dublin Airport.

  18 different scenarios were selected in order to take into consideration all the different relevant wind directions. In particular, a total of 18 compass directions on the wind rose are selected. For each direction, the reference wind speed is set to the 5% exceedance wind speed for that direction, i.e. the wind speed that is exceeded for over 5% of the time whenever that wind direction occurs.

- The wind profile built using the data from Dublin Airport, is also compared with the one obtained using the data collected on-site. Except few differences, both the wind speed daily mean and the wind gust daily mean recorded on site follow the same patterns as the ones recorded at Dublin Airport. The speed levels registered on-site are in few cases slightly lower. This is due to the fact that, the site is located close to the urban environment thus much more shielded if compared with Dublin Airport. This confirms the fact that using wind data from Dublin Airport still ensures a conservative analysis of the wind impact on the development.

- The prevailing wind directions for the site are identified in the West, West South-West, and South-East with magnitude of approximately 6m/s.

Potential And Cumulative Impact Of The Proposed Development Summary:

Micro-climate Model Assessment of Proposed development and it's environment was performed utilizing a CFD (Computational Fluid Dynamics) methodology. 8 worst case wind scenarios are selected for presentation in this report, as these scenarios and directions showed to be the most relevant wind speeds.

CFD modelled results of the development scheme showed that:

- The Proposed development has been designed in order to produce a high-quality environment that is attractive and comfortable for pedestrians of all categories. To achieve this objective, throughout the design process, the impact of wind has been considered and analysed, in the areas where critical patterns were found, the appropriate mitigation measures were introduced.

- As a result of the final proposed, wind flow speeds at ground floor are shown to be within tenable conditions. Some higher velocity indicating minor funnelling effects are found near the South-West side of the development. However, as it is shown in the Lawson map indicate that the area can be utilised for the intended use.

- The courtyard between Block A and B is well protected. According to the Lawson Criteria, this area is suitable for all different pedestrian activities.

- Due to re-circulation effects between Block D and F, this area is suitable for short-term sitting instead of long-term sitting. These conditions are not occurring at a frequency that would compromise the pedestrian comfort, according to the Lawson Criteria.

- Regarding the balconies, higher velocities can be found for some directions, only on some of the balconies. However, these velocities are below the threshold values defined by the acceptance criteria and therefore are not critical for safety.

- Tree planting all around the development has been utilised, with particular attention to the corners of the Blocks has positively mitigated any critical wind effects. Thus, it can be concluded that at ground floor good shielding is achieved everywhere.

- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings. Moreover, in terms of distress, no critical conditions were found for "Frail persons or cyclists" and for members of the "General Public" in the surrounding of the development.

- The proposed development does not impact or give rise to negative or critical wind speed profiles at the nearby adjacent roads, or nearby buildings.

- During Proposed development construction phase the predicted impacts are classified as negligible

Therefore, the CFD study carried out has shown that under the assumed wind conditions typically occurring within Dublin for the past 30 years:

- **The development is designed to be a high-quality environment for the scope of use intended of each areas/building (i.e. comfortable and pleasant for potential pedestrian), and,**

- **The development does not introduce any critical impact on the surrounding buildings, or nearby adjacent roads.**

11.14. References

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