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MULTIDISCIPLINARY CONSULTING ENGINEERS

L333: FORTFIELD ROAD RESIDENTIAL DEVELOPMENT

WIND/ MICROCLIMATE STUDY

For

1 Celbridge West Land Ltd.

28 August 2024

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1 EXECUTIVE SUMMARY

This report outlines the predicted climatic wind conditions experienced within and surrounding the proposed development located on Fortfield Road, Terenure, Dublin 6.

Local climate conditions are largely responsible for the exceedance of a comfort class, especially when buildings are located close to open, flat ground, or adjacent to the coast or where there is little to no obstruction of the wind, as may be considered the case in certain areas of this development.

A conscious effort was made by the design team during the design stages to mitigate the risk of localised increased wind speed conditions due to the proposed development. The shape of the developments massing and building façade plays a key role in helping to mitigate excessive wind speed around the proposed development. The positioning of the apartment blocks allows for wind to gently move and eventually dissipate while a combination of protrusions and set backs of key locations between the apartment blocks further encourages the dissipation of wind speeds. Furthermore, careful consideration of landscape elements along the South of the development help to reduce the wind speed as it comes from the predominant South West wind direction.

Based on the CFD modelling results, the proposed development will be a comfortable environment for occupants. Certain areas have been highlighted as experiencing minor discomfort for a limited period of time, such as certain areas at ground floor level. However, these concerns have been largely addressed through the incorporation of detailed landscaping which will mitigate excessive wind speeds in these areas.

Overall, the proposed development may be classified as a high-quality, comfortable environment for occupants throughout the year.

2 INTRODUCTION

The intention of this report is to outline the predicted climatic wind conditions experienced within and surrounding the proposed development located on Fortfield Road, Terenure, Dublin 6.

The proposed method for compliance validation is via the industry best practice standard for pedestrian comfort (Lawson Criteria). The Lawson Criteria sets acceptable levels of wind speed and velocity for various human activities. The frequency of occurrences is used here as an indicator of the likely duration of certain wind speeds. The Lawson criteria indicates that the threshold mean hourly wind speed for each pedestrian activity should not be exceeded for more than 5% of the time to maintain pedestrian comfort.

Given the specific location of the building within the development, as well as recorded metrological data available for the area, and standard interpolation calculation procedures, it is possible to predict the expected wind speeds and their annual occurrence.

3 PROPOSED DEVELOPMENT

The development will comprise a Large-Scale Residential Development (LRD) on a site at Fortfield Road, Terenure of 284 no. units delivering 19 no. houses and 265 no. apartments made up of studios; 1 beds; 2 beds; 3 beds; and 4 beds. The development will also provide community, cultural and arts space and a creche. Communal internal space for residents will also be delivered. Provision of car, cycle and motorbike parking will be provided throughout the development, including at basement and surface level. Vehicular/pedestrian/cyclist access from Fortfield Road. Proposed upgrade works to the surrounding road network is also included. All associated site development works, open space, services provision, ESB substations, plant areas, waste management areas, landscaping (both public and communal) and boundary treatments.

Figure 1: Proposed Site Layout

4 PEDESTRIAN COMFORT COMPLIANCE

The Lawson criteria gives guidance to quantify the effect of wind velocity on pedestrian comfort and safety. The Lawson recommended guidance indicates that for the comfort and safety assessment of the wind environment, it is not only the velocity of wind that is considered but also the frequency of occurrence of these velocities. The frequency of occurrences is used here as an indicator of the likely duration of certain wind speeds. The Lawson criteria indicates that the threshold mean hourly wind speed for each pedestrian activity should not be exceeded for more than 5% of the time to maintain pedestrian comfort.

Table 1: Lawson Criteria for Pedestrian Comfort

Pedestrian activity	Threshold mean hourly wind speed not to be exceeded for more than 5% of the time [m/s]
Business Walking	10
Leisure Walking	8
Standing or Short Term Sitting	6
Long Term Sitting	4

5 ASSESSMENT METHODOLOGY

The methodology adopted for the study combines the use of Computational Fluid Dynamics (CFD) to predict air flow patterns and wind velocities around the proposed development, the use of wind data from the nearest suitable meteorological station and the recommended comfort and safety standards (The Lawson Criteria).

The study considered the following factors:

- The effect of the geometry, height and massing of the proposed development and existing surroundings on local wind speed and direction;
- The wind speed as a function of the local environment such as topography, ground roughness and nearby obstacles (buildings, bridges, etc.);
- The effects of site location (open field, inner city, etc.);
- Orientation of the buildings relative to the prevailing wind direction; and
- The pedestrian activity to be expected (long term sitting, standing or short term sitting, leisure and business walking).

The wind analysis focuses on the potential variation of the wind velocities from the reference wind data due to the proposed development.

5.1 EXTENT OF CFD STUDY AREA

The extent of the built area that is represented in the computational domain is dependent on the influence of the features on the region of interest which includes the site and its nearby surroundings. The analytical CFD model analyses the proposed development. It also includes existing buildings surrounding the development with the extent of the buildings included in the study area illustrated in Figure 2.

The analytical CFD model is assessed against the full Lawson Criteria to identify the pedestrian comfort and safety conditions surrounding the development.

The analytical CFD model has been constructed based on the information provided below:

- Plans, sections and elevations received from Urban Agency Architects;
- Topographical survey drawings available of surrounding buildings;
- Available aerial photographic data via Google Maps;
- Meteorological wind data closest to the site - Dublin Airport.

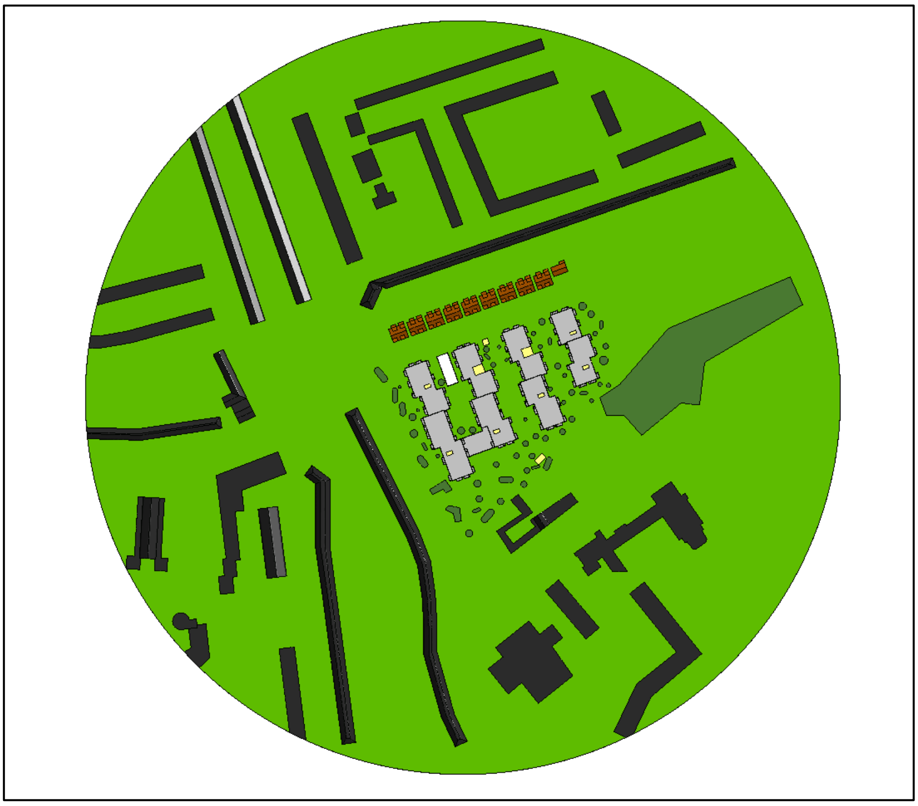


Figure 2: Extend of CFD Study Area

Figure 3: Rendering of CFD Model

5.2 WIND CLIMATE

The wind climate analysis is based on the wind data obtained from the Dublin Airport weather station which incorporates hourly wind data over a 30-year period (1989 until 2019). Figure 4 illustrates the percentage of hours per wind direction over a period of 30 years for 12 no. wind directions.

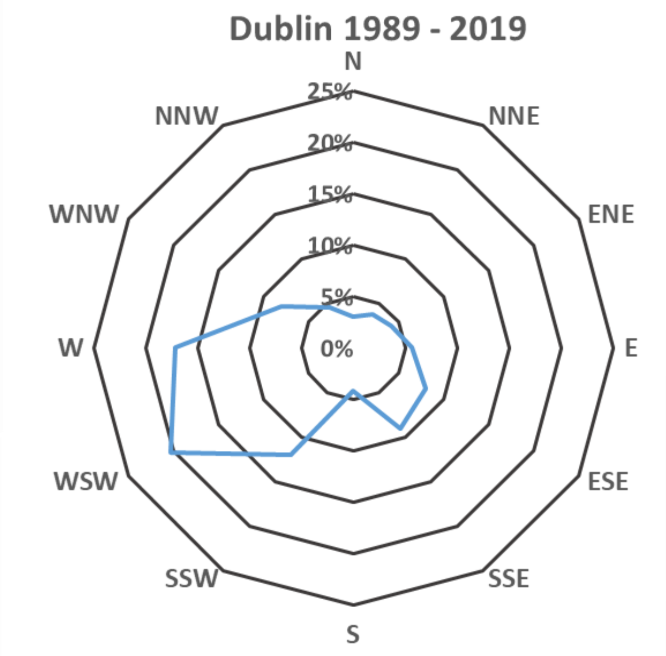


Figure 4: Percentage of Hours per Wind Direction over 30 years

The hourly wind data is the basis for the wind climate analysis. The number of hours that wind occurs from a given wind direction and velocity influences the local wind climate. The CFD simulation is used to calculate the wind-factor (local wind velocity relative to reference wind velocity). The wind-factor is a measure to calculate the number of hours that a given threshold wind velocity is exceeded based on statistical wind data. The yearly average frequency of a wind velocity occurrence per wind direction is outlined in Table 2.

Table 2: Frequency of Wind Velocity Occurrence per Wind Direction

Wind dir.	N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	n/a
	0	30	60	90	120	150	180	210	240	270	300	330	Still
Speed [m/s]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]	[hrs]
0-1	24	19	12	23	31	26	16	17	23	30	30	26	43
1-2	52	41	25	53	74	64	34	47	63	70	63	49	0
2-3	51	54	50	87	122	108	51	94	130	143	102	63	0
3-4	43	48	67	92	132	121	49	124	191	194	133	66	0
4-5	32	45	66	75	109	121	43	140	224	219	121	62	0
5-6	24	38	51	53	85	107	42	148	234	211	94	47	0
6-7	16	30	37	37	57	84	38	130	228	169	63	33	0
7-8	10	21	24	25	36	60	30	111	195	134	41	24	0
8-9	6	11	17	18	22	41	22	85	159	105	25	14	0
9-10	4	7	11	12	12	27	17	59	121	80	14	7	0
10-11	2	4	4	8	9	16	11	39	82	56	7	3	0
11-12	1	3	2	5	5	10	6	23	52	36	5	1	0
12-13	0	2	1	2	2	5	3	13	32	21	2	1	0
13-14	0	0	0	1	2	3	1	8	18	11	1	0	0
14-15	0	0	0	1	1	1	0	5	11	6	1	0	0
15-16	0	0	0	1	0	1	0	2	6	4	0	0	0
16-17	0	0	0	0	0	0	0	1	2	2	0	0	0
17-18	0	0	0	0	0	0	0	0	1	1	0	0	0
18-19	0	0	0	0	0	0	0	0	1	1	0	0	0
19-20	0	0	0	0	0	0	0	0	1	1	0	0	0

5.3 WIND PROFILE

A rectangular computational domain was created to simulate the effect of the atmospheric boundary layer surrounding the region of interest. The extents of the computational domain are illustrated in Figure 5, where H is the height of the highest structure/ building/ tower within the proposed development.

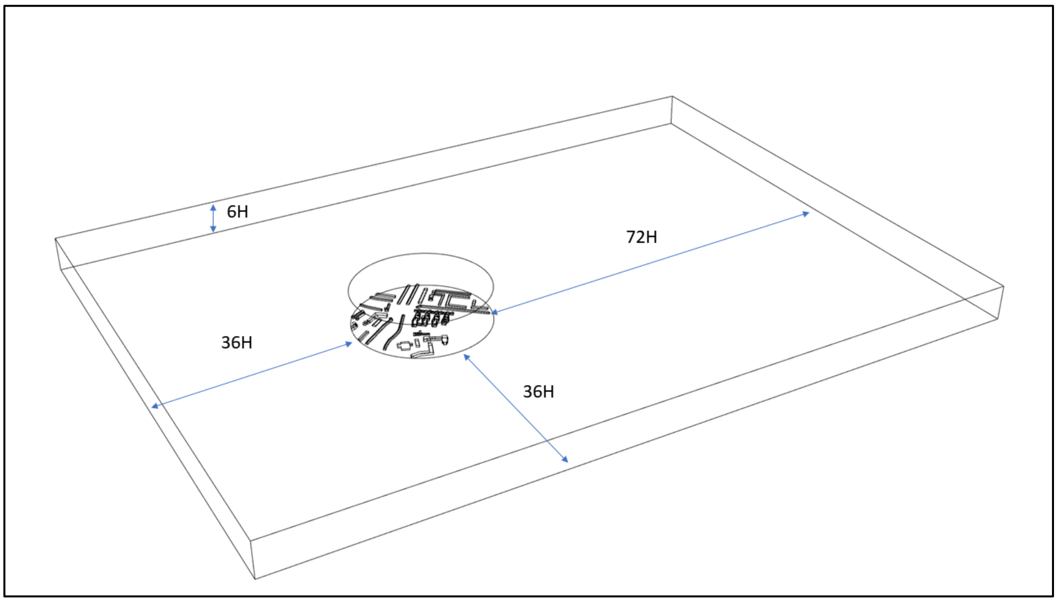


Figure 5: Computational Domain Surrounding the Region of Interest

An atmospheric boundary layer wind profile (v_{wind}) is applied to the boundaries of the computational model. To incorporate the effect of small height differences and small objects at street level, which are not explicitly included in the model, a roughness has been applied to the ground surface of the detailed CFD model. For the wind profile a roughness length (z_0) of 0.4 m has been estimated.

Based on the reference velocity, reference height, and roughness length, a wind profile can be defined. The wind profile (v_{wind}) is defined as follows.

$$v_{wind} = v_{ref}\left(\frac{\ln\left(\frac{z}{z_0}\right)}{\ln\left(\frac{z_{ref}}{z_0}\right)}\right)$$

Where:

$\boldsymbol{v_{wind}}$	***Wind velocity***	$[^{m}/_{s}]$
$\boldsymbol{v_{ref}}$	*Reference velocity*	$[m]$
$\boldsymbol{z}$	*Height above the ground*	$[m]$
$\boldsymbol{z_0}$	*Roughness length*	$[m]$
$\boldsymbol{z_{ref}}$	*Reference height*	$[m]$

5.4 WIND FACTOR

The CFD simulations are used to calculate the wind factor. The wind factor is a factor which indicates if the wind speed is locally increased (wind factor > 1.0) or decreased (wind factor < 1.0) due to buildings (or other geometry), relative to the applied reference wind speed at 10m height. The wind factor is independent of the magnitude of the reference wind speed at 10m height, making the obtained wind factor valid for all wind speeds in a specific wind direction range. Hence, one simulation can be applied per wind direction covering all wind speeds in this direction.

To explain the wind factor in more detail, the wind factor results for the 0-degree wind direction (i.e. North) are illustrated in Figure 6. The wind factor arrows that are coloured green, cyan or dark blue indicate that the local wind speed has been reduced (wind factor < 1.0), while wind factor arrows which are coloured light Orange/ Red indicate the local wind speed has increased (wind factor > 1.0). Using the wind factors, the quantity of hours that a wind speed is exceeded can be calculated (per wind direction) which is then used to assess compliance against the Lawson Criteria.

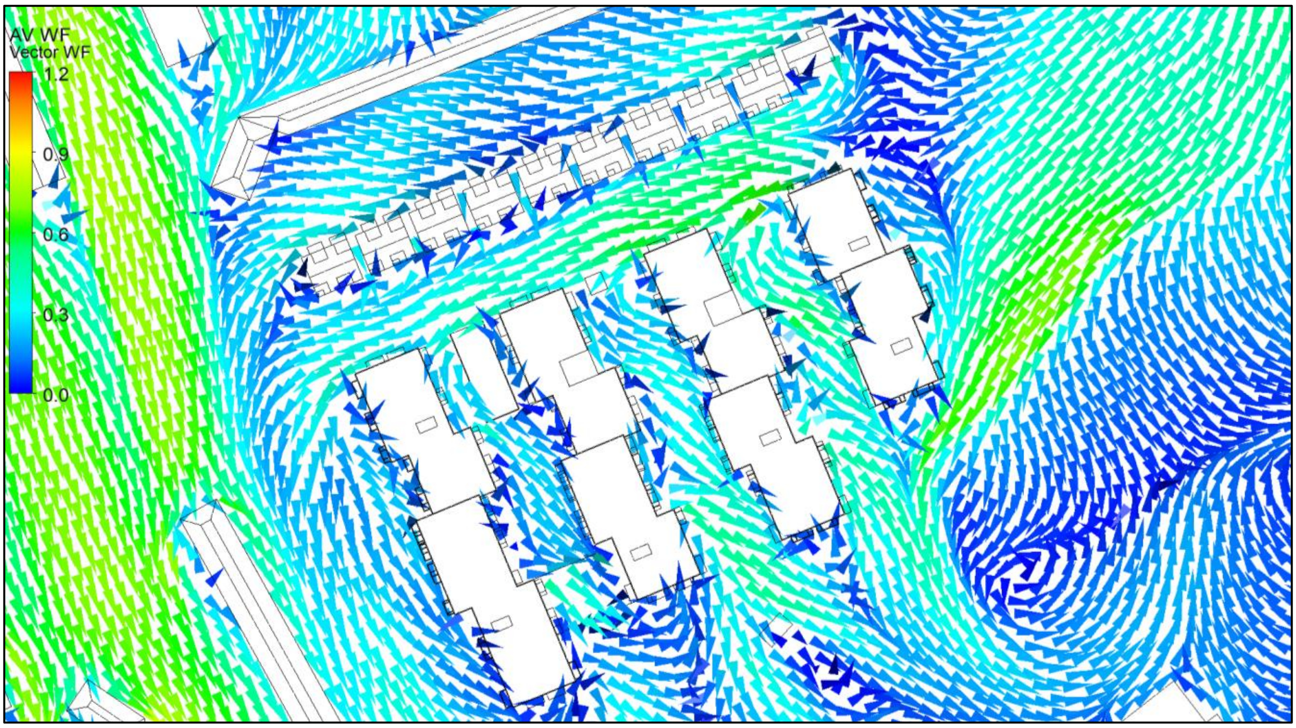


Figure 6: Wind Factor - 0 Degree (N) Wind Orientation

The wind factor results for all 12 no. wind directions are included in Appendix A.

5.5 CFD MODELLING

The CFD simulation has been performed using the software package ANSYS CFX version 2023 R1. This software package can be used for a large range of applications and has been extensively validated.

A full 3D CFD model of the proposed development and surrounding buildings was created and split into a large number of control volumes or cells. The standard equations for fluid motion and energy transport are applied to each cell. The equations are then solved using numerical techniques. The CFD settings used for the analysis are summarised in Table 3.

Table 3: Summary of CFD Model Settings

CFD settings	Description
Grid type	Hybrid, mixture of tetrahedrons, pyramids and prisms
Cell size	Dynamic, ranging from 0.025 up to 2 m at the building surfaces and streets, growing to 10 m in the volume
Number of cells	28.4 million
Simulation type	Steady state
Convergence	< 1·10-4
Simulation time	1500 s
Fluid	Air fixed properties
Turbulence model	RANS, RNG Kappa-Epsilon model
Walls	Smooth, no slip
Wind volume	Profile for velocity and turbulence
Roughness	Volumetric sources for momentum and turbulence
Vegetation	Volumetric loss coefficient

5.6 ASSUMPTIONS AND LIMITATIONS

Computational Fluid Dynamic (CFD) is a widely recognised method for modelling airflow problems and as computer power develops, it increasingly improves its applicability. However, there are some limitations with CFD in relation to the modelling of wind environments. The method uses mean hourly wind values and presents a limitation to capture gusts.

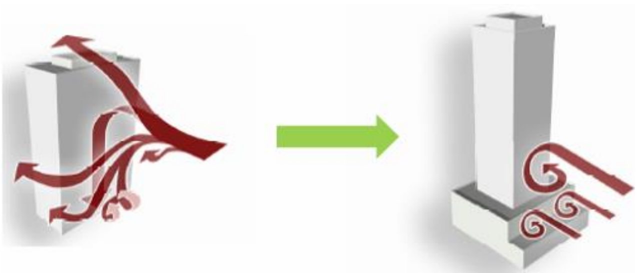
The Lawson criteria for pedestrian comfort focus on the effect of wind and do not factor in other environmental variables such as air temperature, solar radiation and relative humidity. However, overlaying all these factors would be a complex process and Lawson's simplified method presents the best available methodology for anticipating wind effects in the built environment.

The buildings were modelled as blocks, i.e. with smooth surfaces and sharp corners, which is generally sufficient detail to represent buildings in airflow modelling. This assumption is industry accepted as further detail to the model such as the window reveals and façade texture would add an impractical and unnecessary complexity to the model without adding greater quality results. Certain landscaping features, such as pergolas and trellis structures as examples, are not generally modelled within the simulation as they would provide an extra level of complexity to an otherwise large CFD model. Furthermore, a very limited number of trees and hedges were modelled locally to prove their impact on mitigating wind speeds. Incorporating all landscape additions, such as all trees and hedges, would be impractical on a model this size.

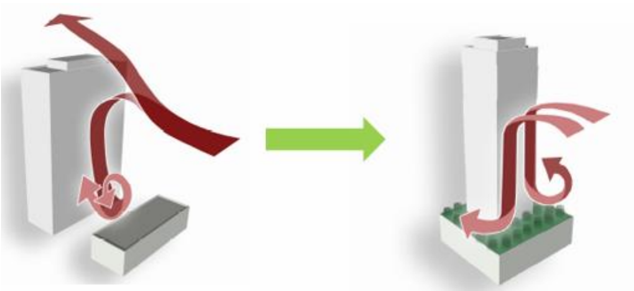
6 WIND MITIGATION MEASURES

The following are common strategies to mitigate excessive wind speeds associated with building developments[1].

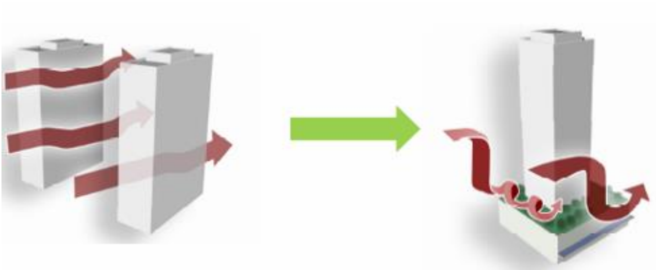
- When wind hits the windward face of a building, the building deflects the wind downwards (downwashing), causing accelerated wind speeds at pedestrian level and around the corners of the building. By introducing a base building or podium, the downward wind flow can be deflected, resulting in a reduction of wind speed at pedestrian level.



- When the leeward face of a low building faces the windward face of a tall building, it causes an increase in the downward wind flow. By landscaping the base building roof, wind speeds can be further reduced.



- Wind speed is accelerated when wind is funnelled between two buildings. A horizontal canopy on the windward face of a base building can improve pedestrian comfort conditions.



The following specific mitigation measures have been incorporated into the proposed design to prevent excessive wind speeds.

[1] *Pedestrian Wind Comfort and Safety Studies,* (City of Mississauga, 2014).

6.1 DEVELOPMENT MASSING/ BUILDING LINE

The shape of the developments massing and building façade plays a key role in helping to mitigate excessive wind speed around the proposed development. The positioning of the apartment blocks allows for wind to gently move and eventually dissipate while a combination of protrusions and set backs of key locations between the apartment blocks further encourages the dissipation of wind speeds. Furthermore, careful consideration of landscape elements along the South of the development help to reduce the speed of the wind as it comes from the predominant South West wind direction.

Figure 7: Wind Mitigation Measure – Permeability Paths

Figure 8: Wind Mitigation Measure – Façade Protrusions and Set-backs

6.2 SOLID BALCONY BALUSTRADES

Generally, open rail balconies will provide a comfortable space for users. On selected balcony locations (namely to the South of each black and in other select locations), the addition of solid glazed balustrades will be installed in order to ensure all balconies can be thoroughly enjoyed by occupants year round. Glazed balustrades block wind directly entering the balcony space, slowing the wind speed down within the balcony area to help with providing a better environment for users. Figure 9 below summarises the wind categorisation (safe/ unsafe) with the incorporation of the glazed balconies.

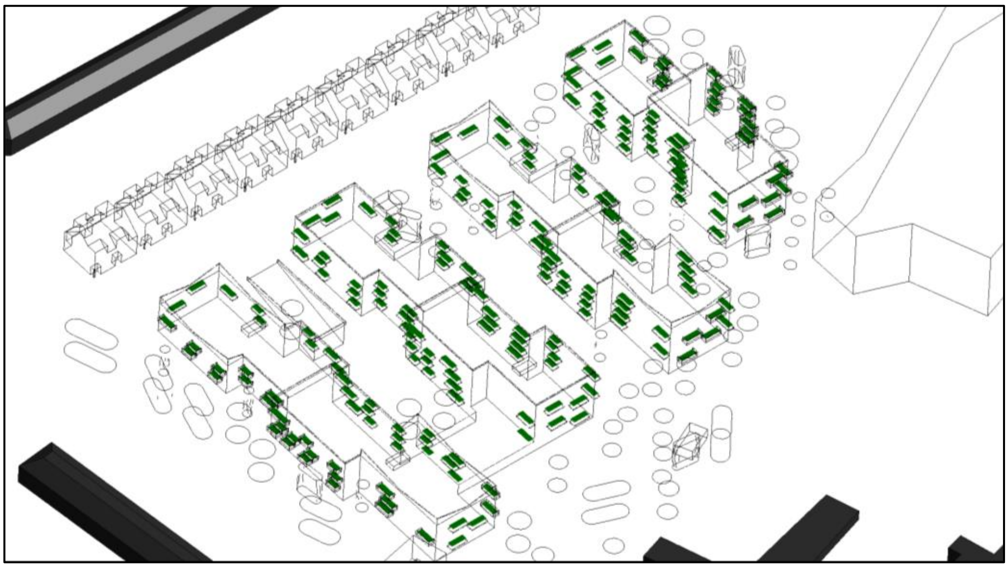


Figure 9: Wind Mitigation Measure – With Glazed Balcony Additions

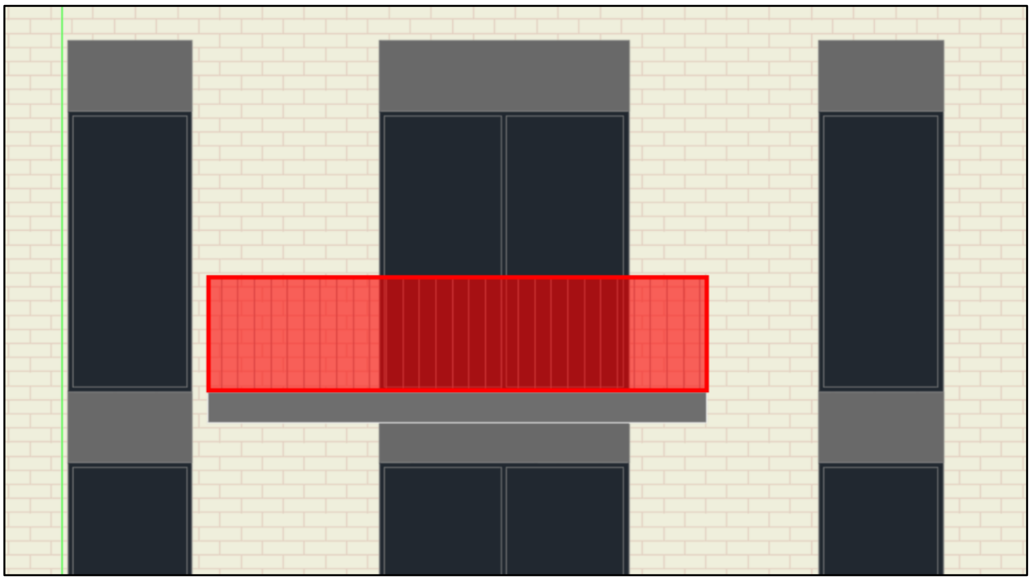


Figure 10: Wind Mitigation Measure - Solid Balcony Balustrades

6.3 LANDSCAPING

The landscaping has been strategically designed to mitigate increased wind speeds and to provide shelter for pedestrians at street level, in the central spaces and on the rooftop amenity areas.

The proposed ground floor landscaping design is illustrated in Figure 11. Trees are to be planted close to primary entrance ways and along the streetscape, mitigating excessive wind speeds and providing shelter for pedestrians at street level. The use of trees and low-level shrubs all assist in the localised reduction of wind speed.

Figure 11: Wind Mitigation Measure - Landscaping Design – Ground Floor

The proposed rooftop terrace landscaping design is illustrated in Figure 12. Perimeter planting is proposed along the boundaries/ edges, mitigating excessive wind speeds and providing shelter for users at terrace level. The use of perimeter planting and low-level shrubs all assist in the localised reduction of wind speed.

Figure 12: Wind Mitigation Measure - Landscaping Design – Rooftop Terraces

6.4 WIND/ MICROCLIMATE COMFORT RESULTS

The number of hours for all wind directions are summed to calculate the total number of hours that a given pedestrian activity class exceeds the 5% yearly threshold with the results for Ground/ Podium level presented in Figure 13, and rooftop terrace spaces summarised in Figure 14.

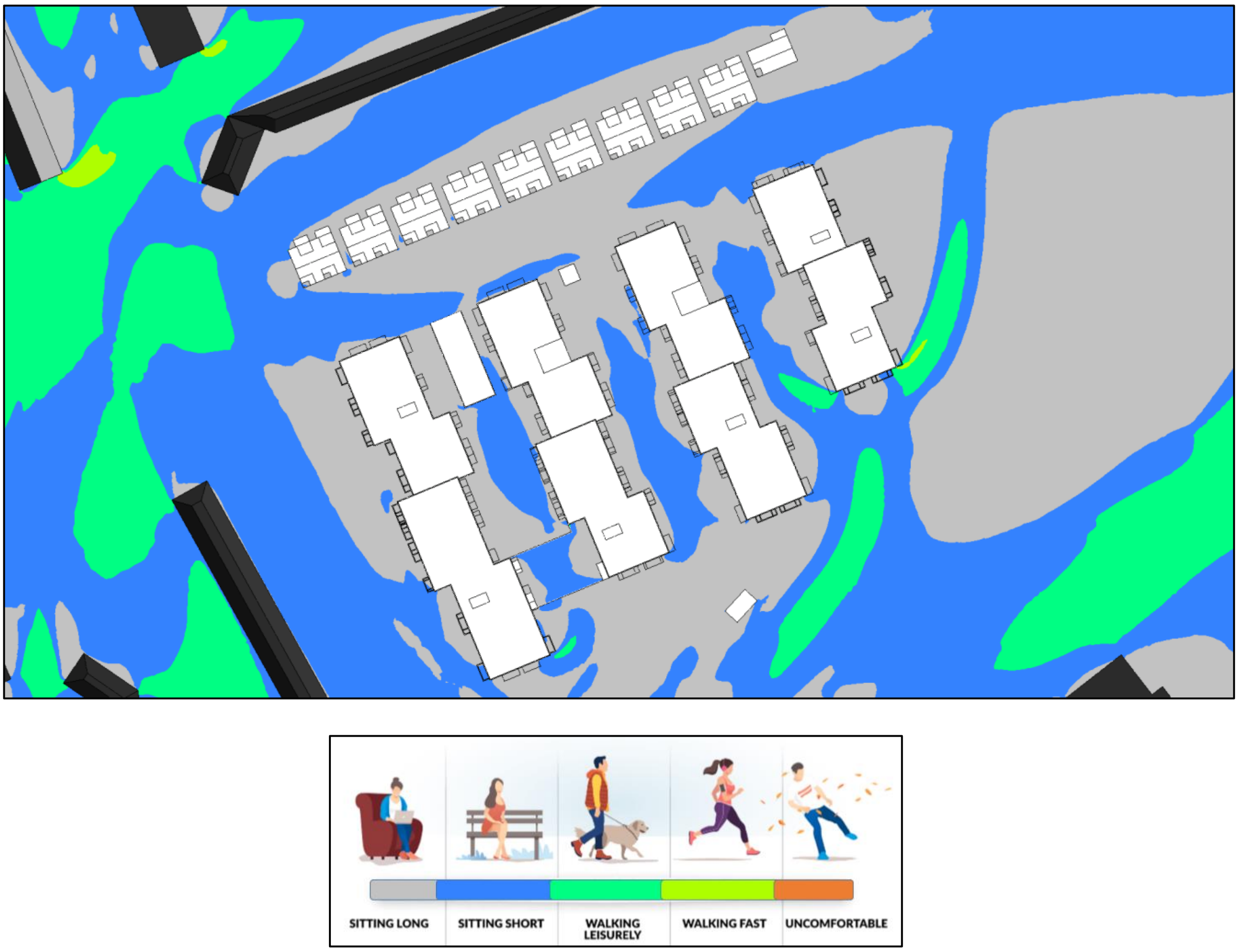


Figure 13: Wind/ Microclimate Comfort Results – Ground Floor

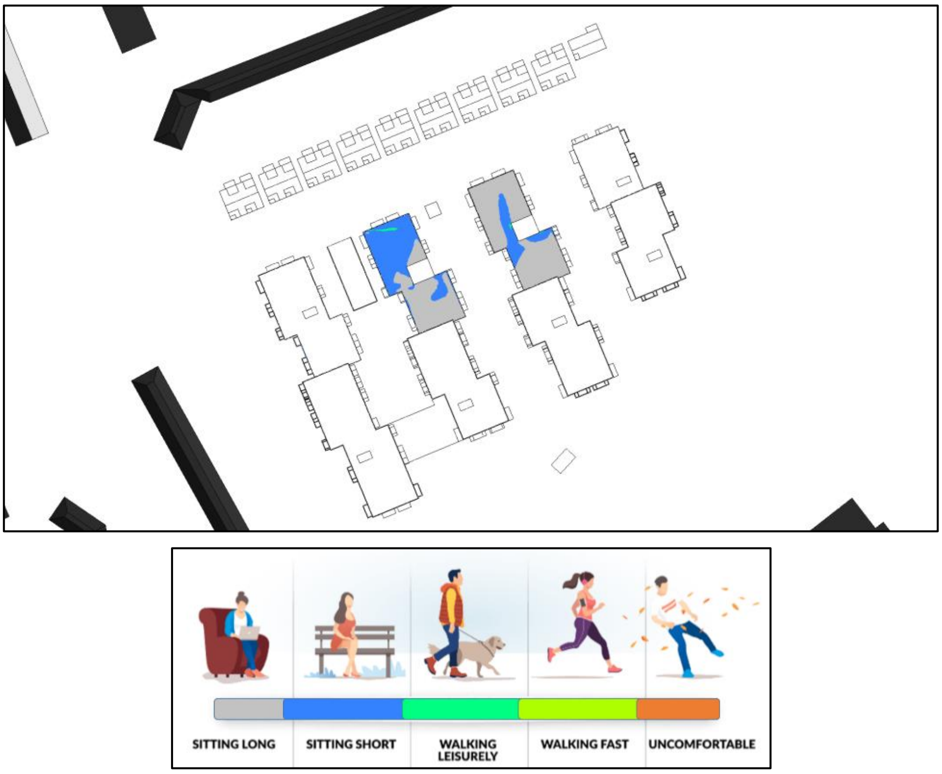


Figure 14: Wind/ Microclimate Comfort Results – Rooftop Terraces

The results of the simulations are explained as follows:

- Ground Floor/ Podium Areas: The majority of the ground floor/ podium areas comply with either the "Long Term Sitting" or ""Standing or Short Term Sitting" class. Additional landscaping elements will also ensure wind speeds are further reduced. Thus, this can be classified as a comfortable area for occupants year-round.

- Block B - Level 4 Terrace: The majority of the Level 4 terrace complies with the "Long Term Sitting" and "Standing or Short Term Sitting" class. Small areas of localised planting at the South-West and North-East corner of the North side of the terrace will mitigate increased wind speeds in this area and provide a comfortable environment for occupants year-round, as is proposed in the landscape design.

- Block C - Level 4 Terrace: The vast majority of the Level 4 terrace complies with the "Long Term Sitting" class, with a small pocket exceeding the "Long Term Sitting" class. Additional landscaping elements will also ensure wind speeds are further reduced. This can be classified as a very comfortable area for occupants year-round.

- Private Balconies: All private balconies comply with the "Long Term Sitting" class - resulting in a very comfortable environment for occupants year-round. Some localised areas will utilise a glazed balustrade to ensure a comfortable environment is maintained year round in order to ensure all balconies achieve this classification.

- It is important to note that the Dublin climate is largely responsible for the exceedance of the given comfort classes, especially when buildings are located close to open, flat ground, or adjacent to the coast or where there is little to no obstruction of the wind, as may be considered the case in certain areas of this development.

It should also be noted that a pedestrian activity class is only a statistical assessment of the local wind climate. When a region does not meet a certain criterion (e.g. sitting), this does not mean that one can never do this activity in this region. It only means that for more than 5% of the time per year the wind speed for this activity is exceeded. The remaining time of the year this activity is possible. For this reason, the percentage of time that "Standing or Short-Term Sitting" is comfortable is illustrated in Figure 15 and Figure 16 below. It is evident from this image that "Standing or Short-Term Sitting" is comfortable for more than 90% of the year on the vast majority of ground floor and podium level areas, with certain terrace areas being classified as marginally less comfortable. However, as outlined above, the landscaping design will ensure the areas that exceed the pedestrian classes will be comfortable spaces and will mitigate excessive wind speeds.

Finally, the wind speed threshold for a certain pedestrian class is only meant to provide guidance on where to locate certain areas where a certain type of activity is expected to be performed. In practice, the experience of the outdoor climate depends on more than just wind speed. Other factors such as clothing, air temperature, solar irradiation, age and relative humidity must also be considered.

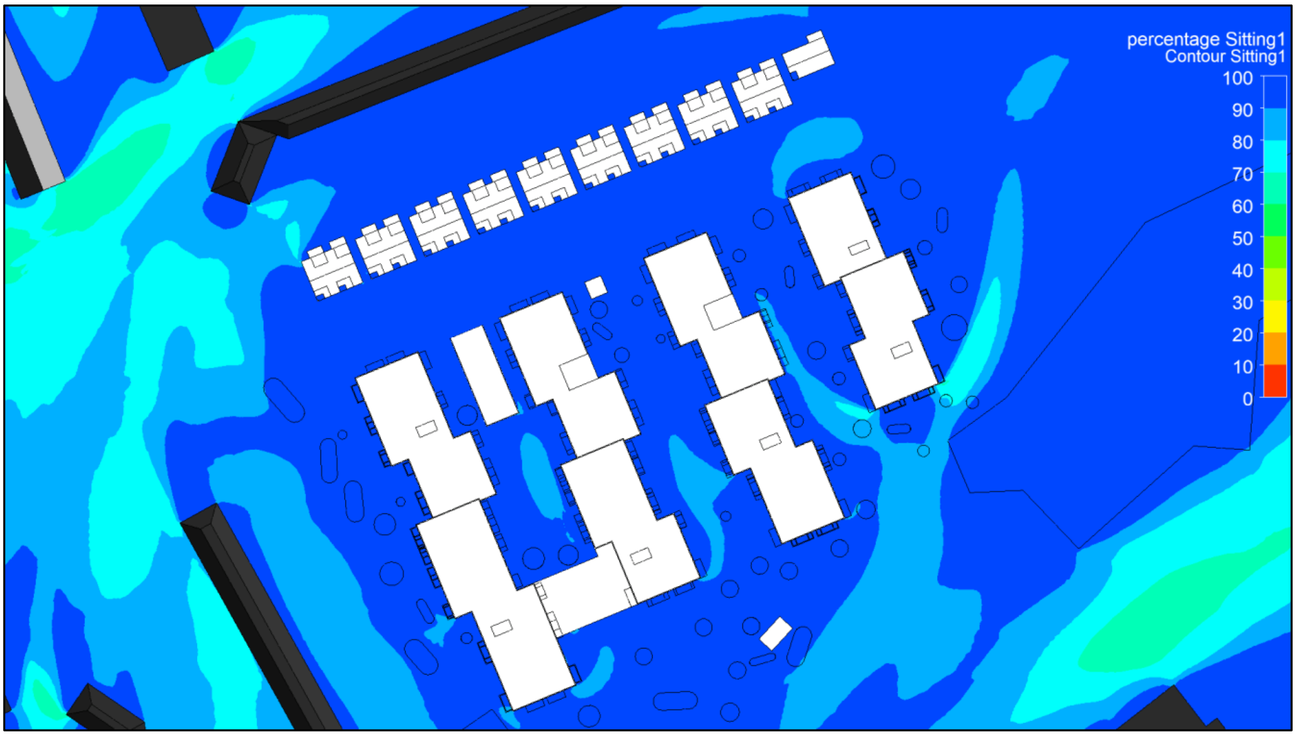


Figure 15: Percentage of Time that Standing or Short-Term Sitting is Comfortable – Ground Floor

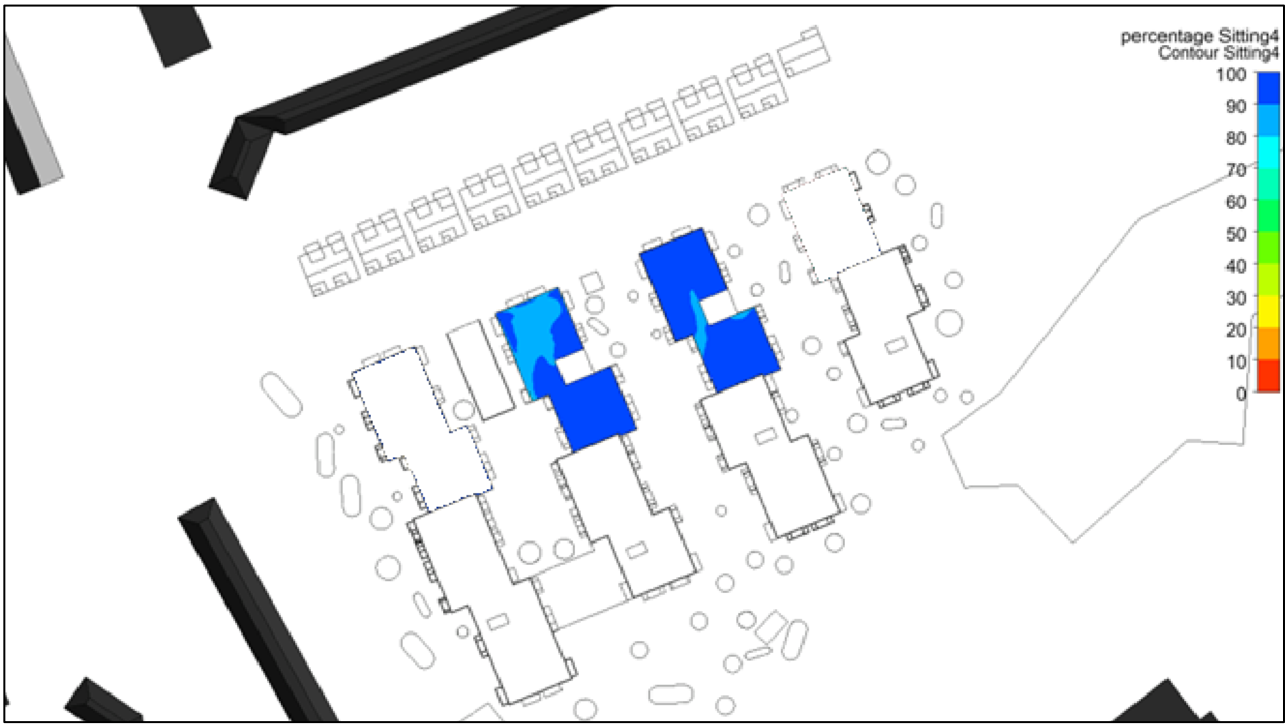


Figure 16: Percentage of Time for Standing/ Short-Term Sitting is Comfortable – Rooftop Terraces

7 CONCLUSION

This report outlines the predicted climatic wind conditions experienced within and surrounding the proposed development on Fortfield Road, Terenure, Dublin 6.

As part of this assessment, the industry accepted standard of the Lawson Criteria was utilised. The Lawson Criteria gives guidance to quantify the effect of wind velocity on pedestrian comfort and safety. The wind climate analysis is based on the wind data obtained from the Dublin Airport weather station which incorporates hourly wind data over a 30-year period (1989 until 2019).

A conscious effort was made by the design team during the design stages to mitigate the risk of localised increased wind speed conditions due to the proposed development. The introduction of mitigation measures such as the corridor spaces between buildings, building line, façade protrusions, solid balcony balustrades, as well as the strategic location of extensive landscaping, all assist in reducing the potential development of local increased wind speed and the negative impact on local climatic conditions.

Based on the CFD modelling results, the proposed development will be a comfortable environment for occupants. Certain areas have been highlighted as experiencing minor discomfort for a limited period of time, such as certain areas at ground floor level. However, these concerns have been largely addressed through the incorporation of detailed landscaping which will mitigate excessive wind speeds in these areas.

Overall, the proposed development may be classified as a high-quality, comfortable environment for occupants throughout the year.

8 VERIFICATION

This report was compiled and verified by:

Karla Reyes – M.Sc. Renewable Energy Systems, B. Hons Environmental Engineering

Energy Engineer

O'Connor Sutton Cronin & Associates

Appendix A CFD SIMULATION RESULTS

The CFD wind factor results included in this section are for all 12 No. wind directions as referenced within the body of the report. The wind directions referenced in the wind rose below correspond to the wind directions referenced in the CFD results.

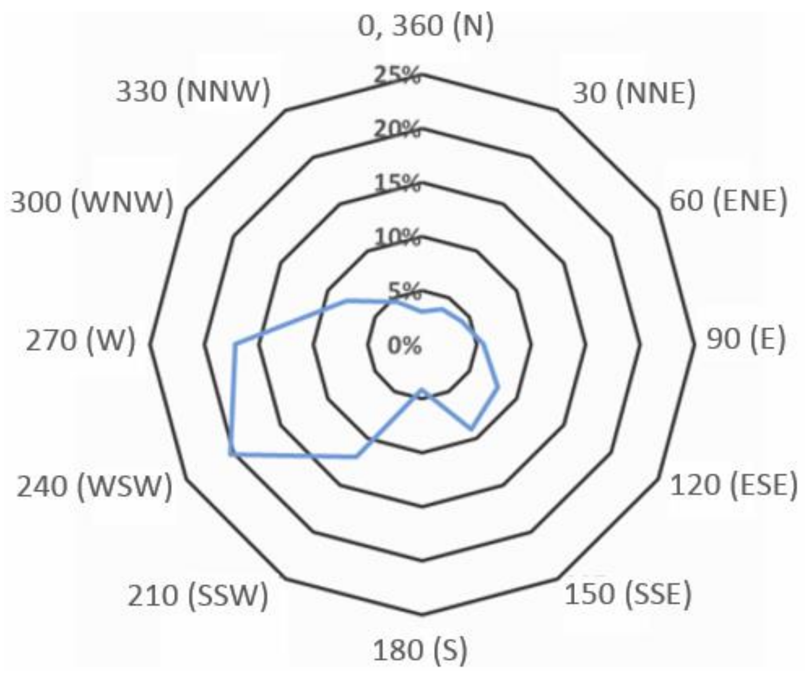


Figure 17: Dublin Airport Wind Rose Data (1989 - 2019)

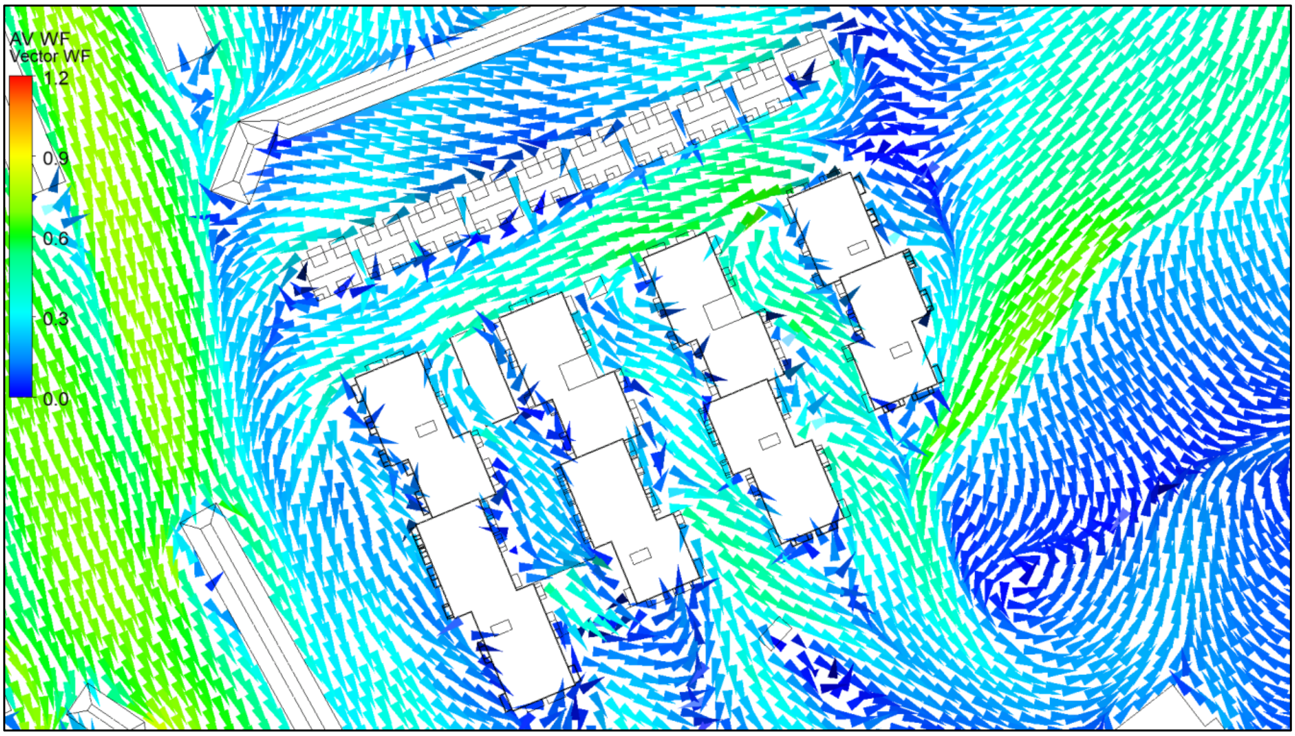


Figure 18: Wind Factor - 0 Degree (N) Wind Direction

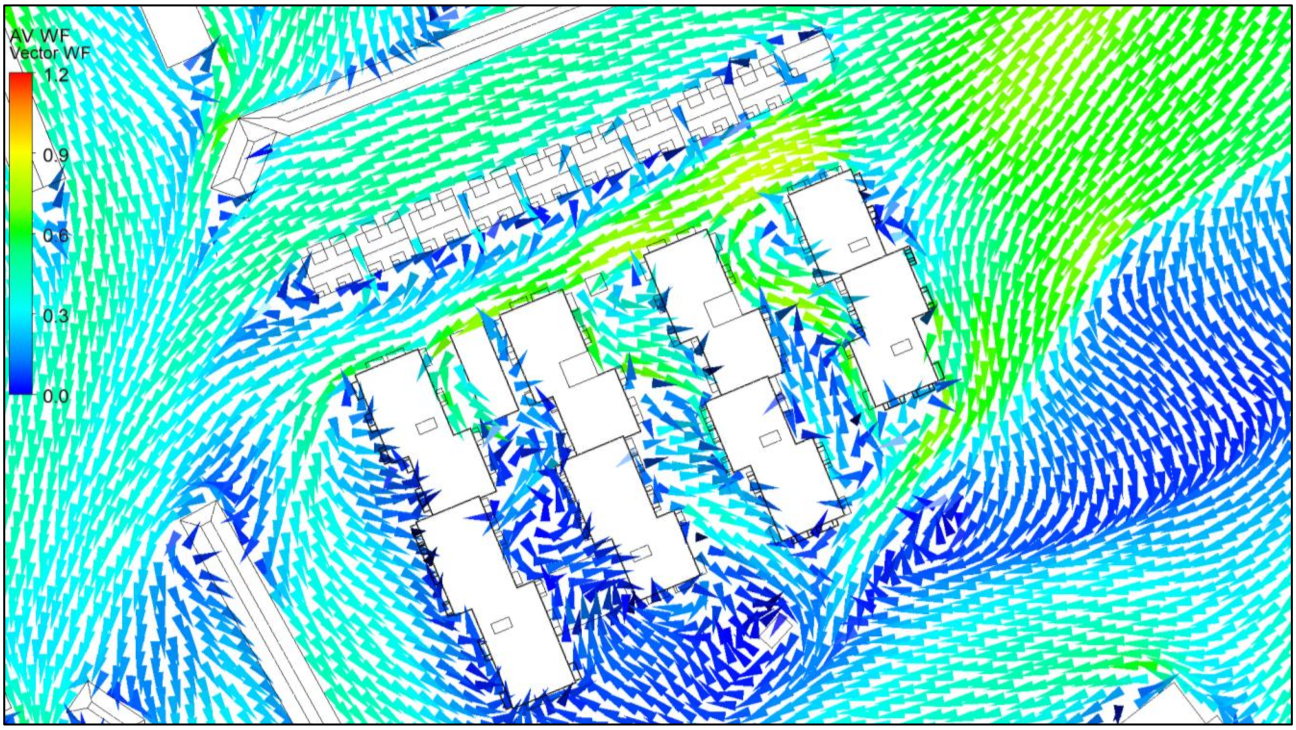


Figure 19: Wind Factor - 30 Degree (NNE) Wind Direction

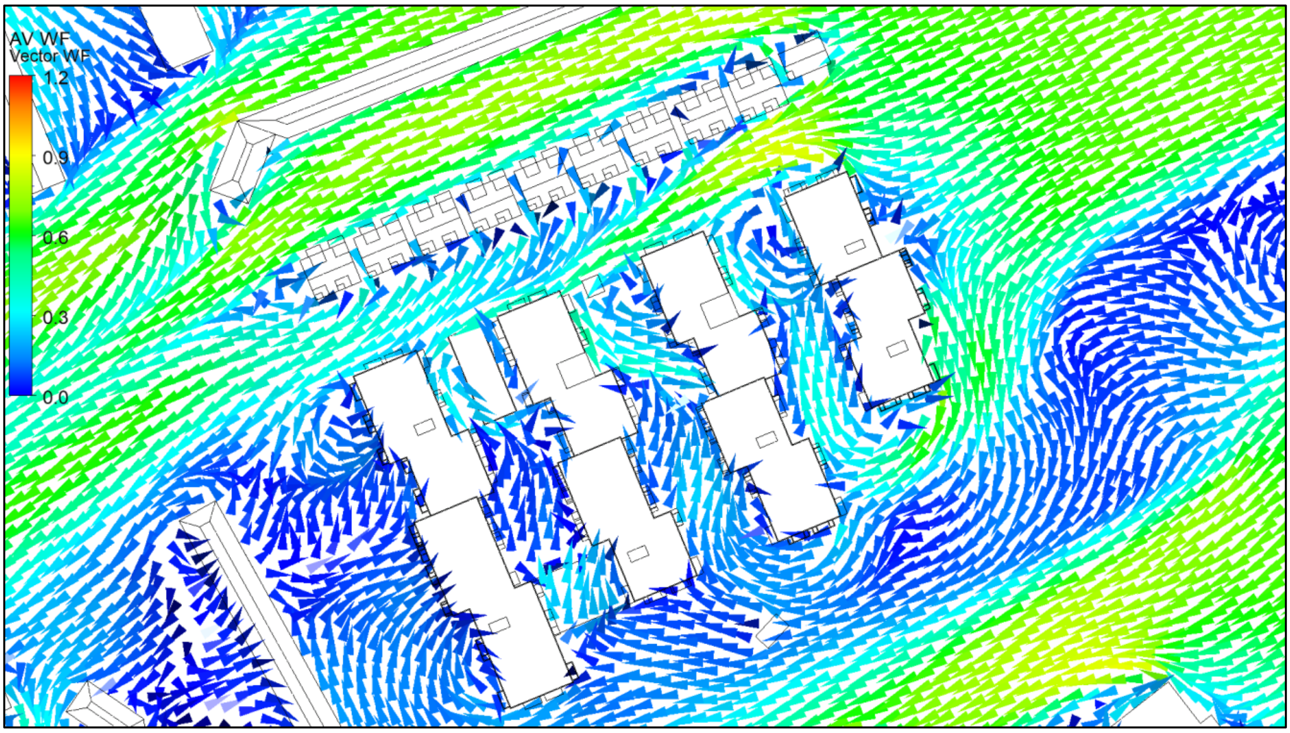


Figure 20: Wind Factor - 60 Degree (ENE) Wind Direction

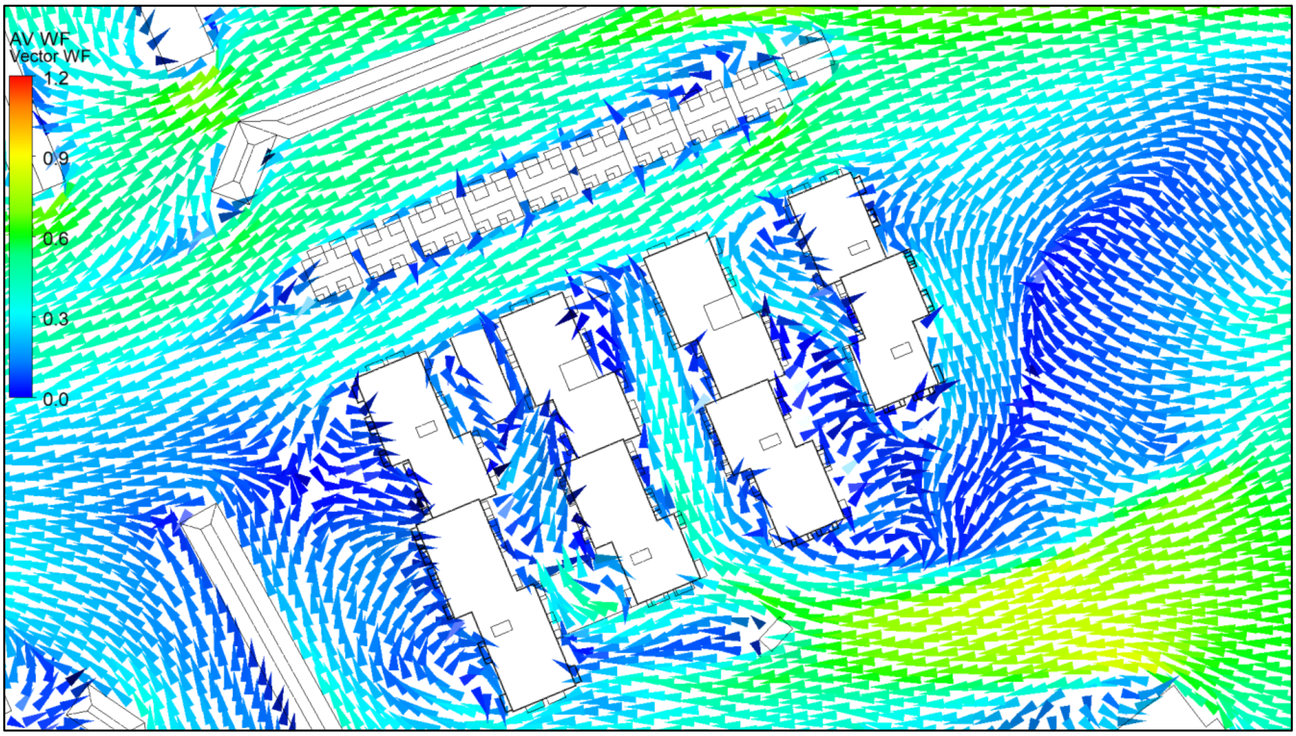


Figure 21: Wind Factor - 90 Degree (E) Wind Direction

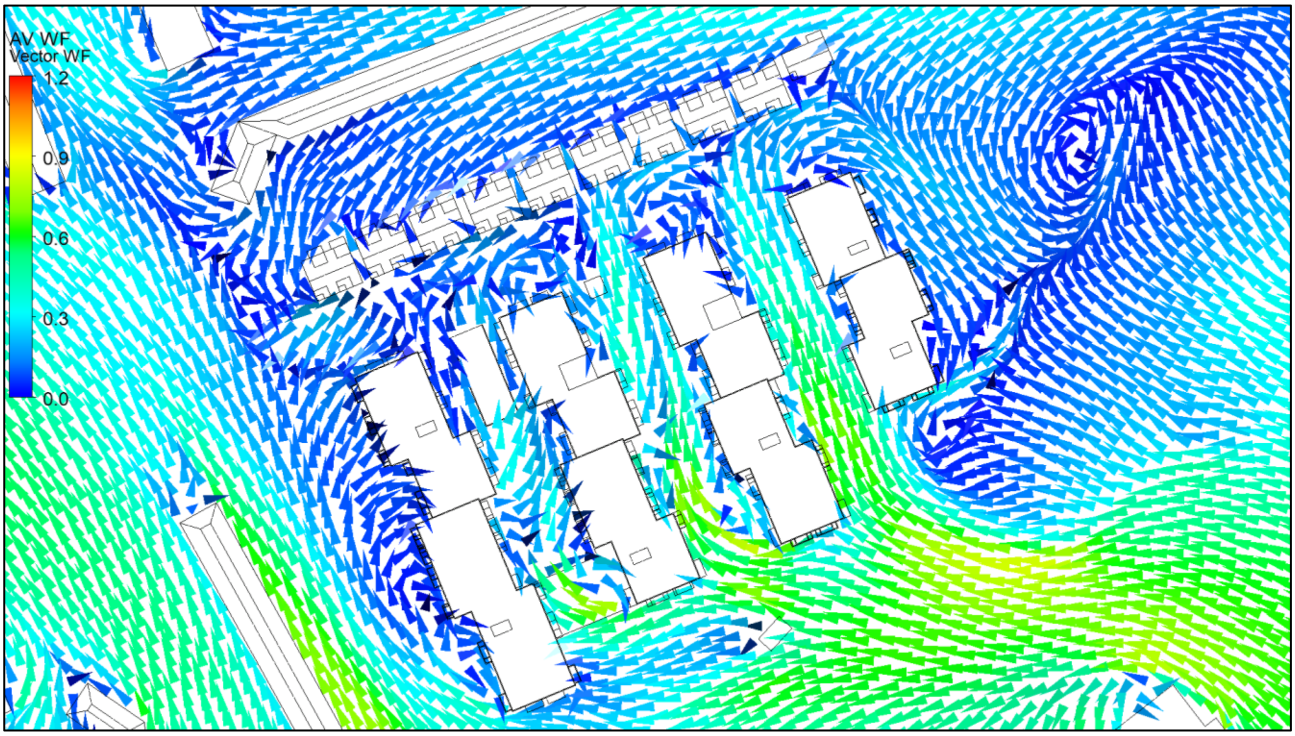


Figure 22: Wind Factor - 120 Degree (ESE) Wind Direction

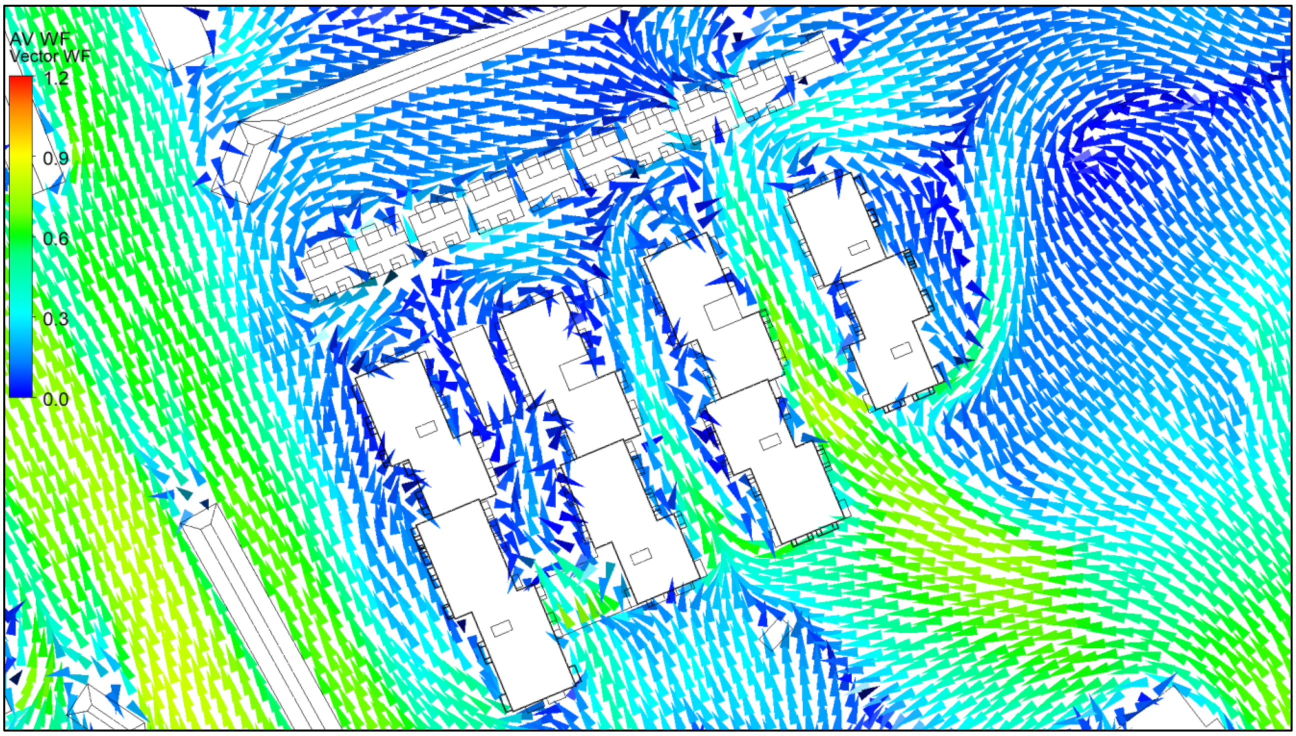


Figure 23: Wind Factor - 150 Degree (SSE) Wind Direction

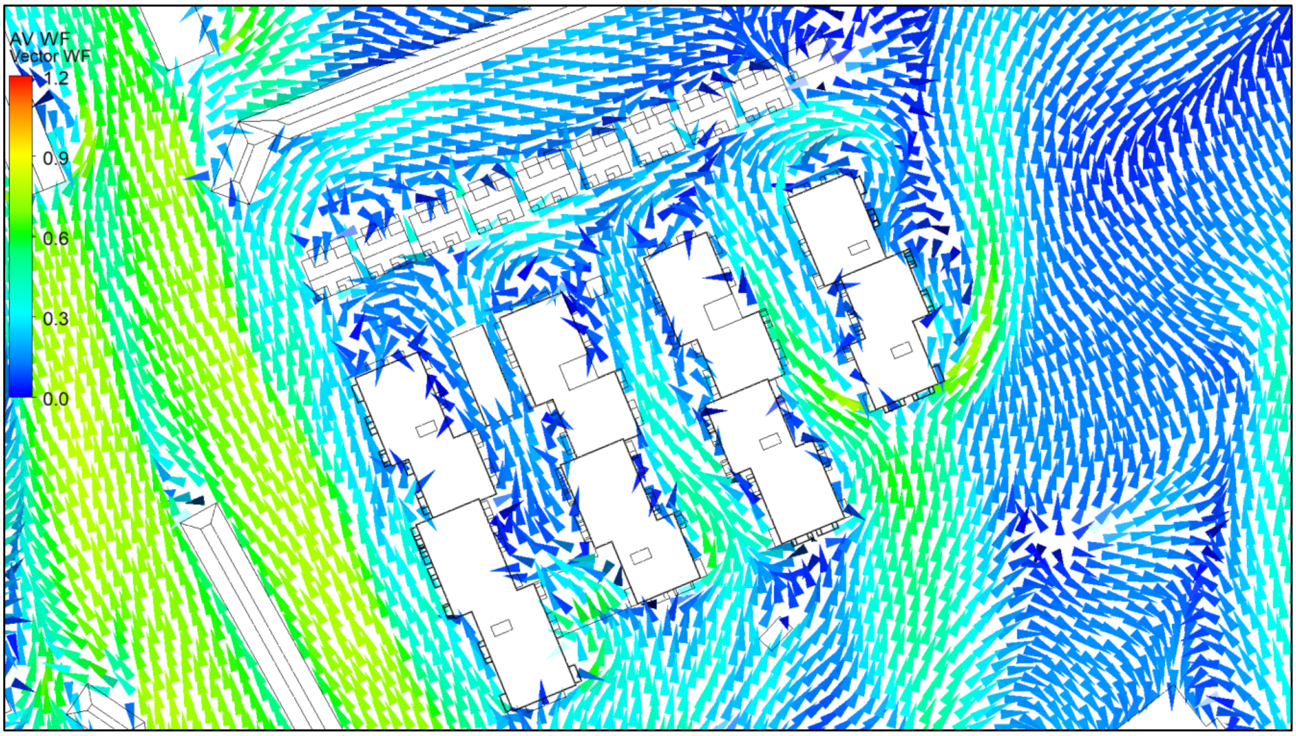


Figure 24: Wind Factor - 180 Degree (S) Wind Direction

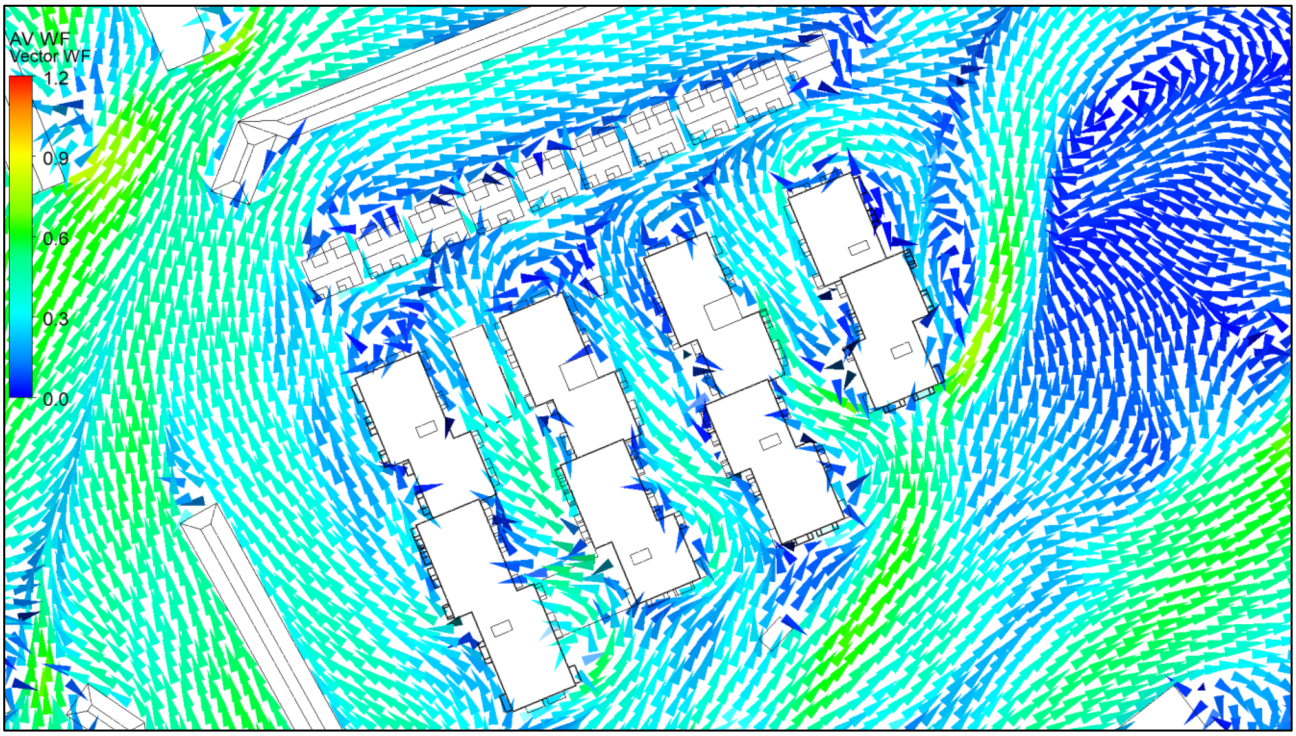


Figure 25: Wind Factor - 210 Degree (SSW) Wind Direction

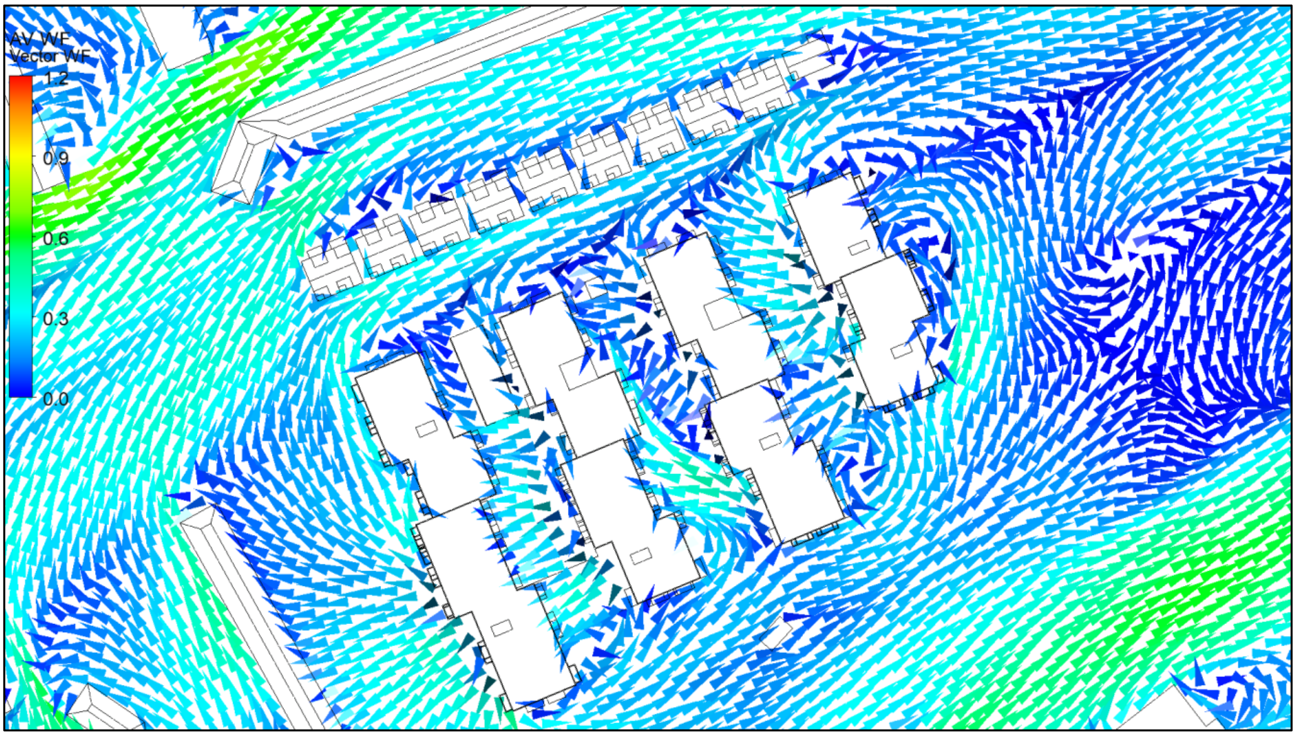


Figure 26: Wind Factor - 240 Degree (WSW) Wind Direction

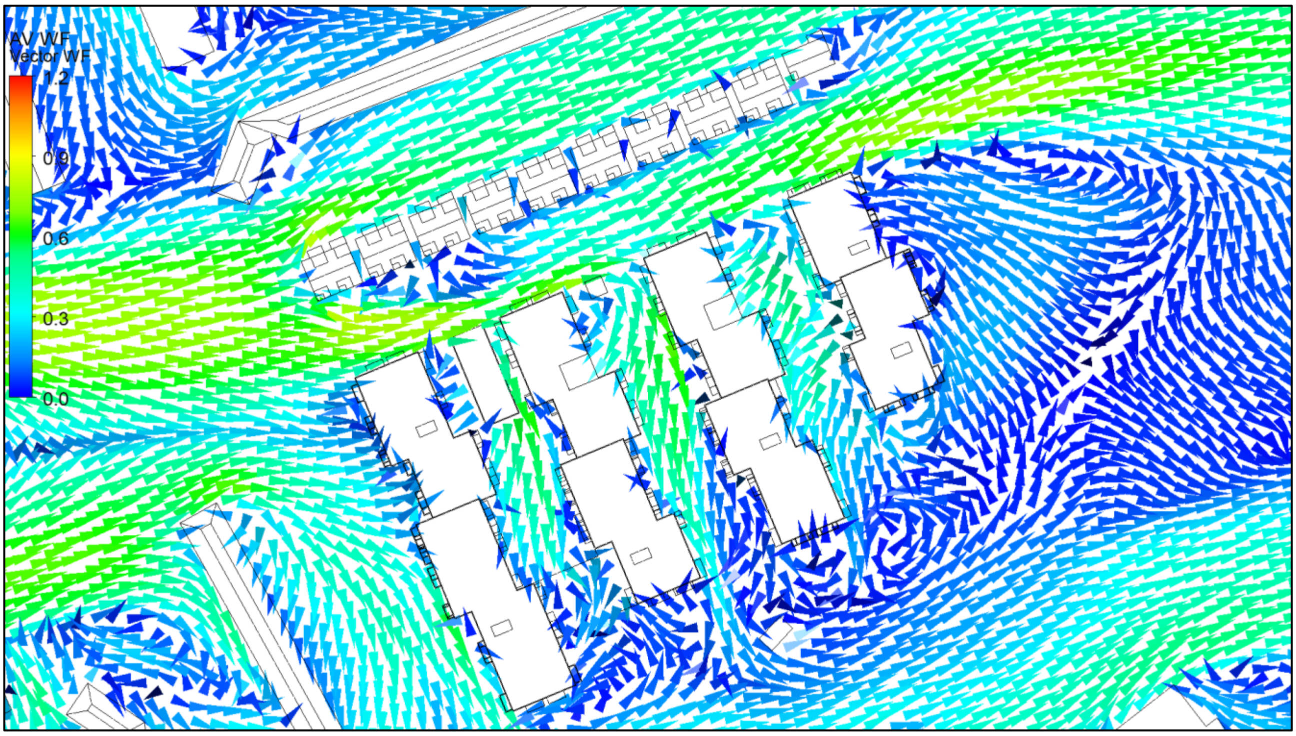


Figure 27: Wind Factor - 270 Degree (W) Wind Direction

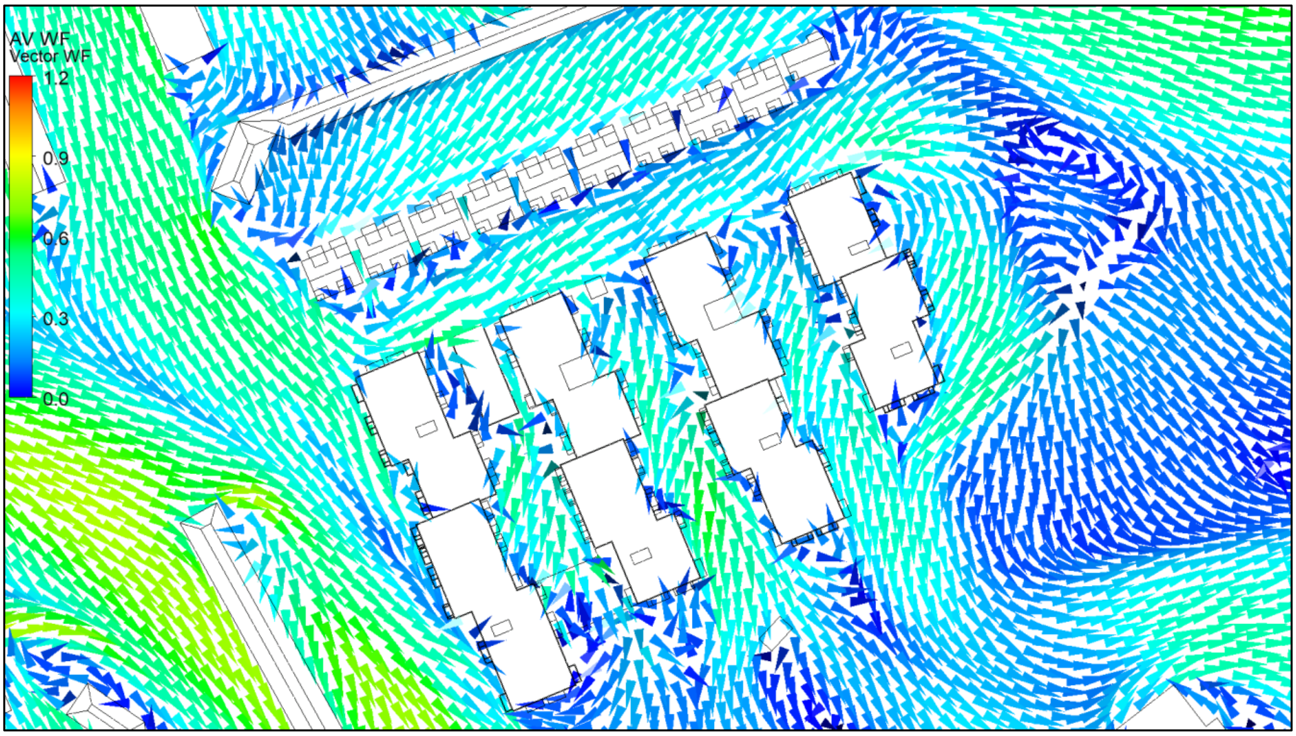


Figure 28: Wind Factor - 300 Degree (WNW) Wind Direction

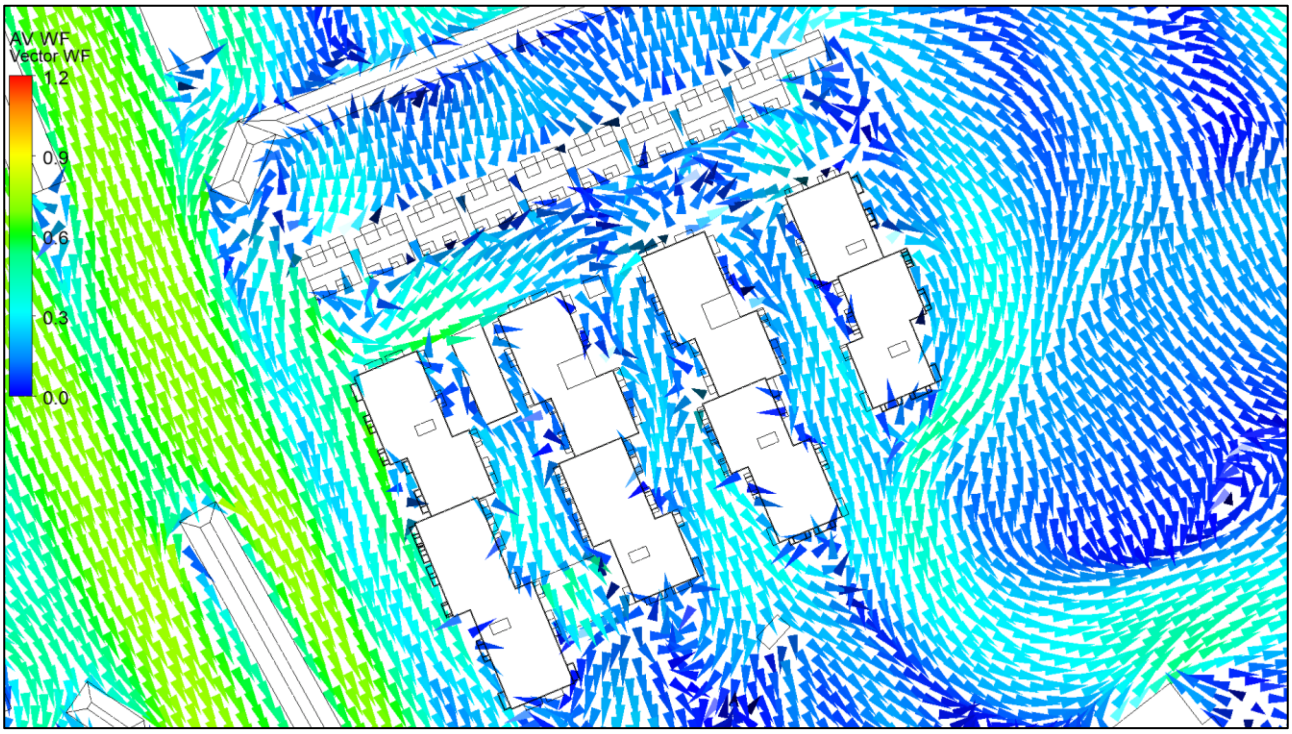


Figure 29: Wind Factor - 330 Degree (NNW) Wind Direction

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