WIND MICROCLIMATE ASSESSMENT

for the

THE REDEVELOPMENT OF THE FORMER CHIVER'S FACTORY SITE

at

COOLOCK DRIVE
DUBLIN 17

for

PLATINUM LAND LTD.

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EXECUTIVE SUMMARY

METEC Consulting Engineers have been instructed by our client, Platinum Land Ltd, to carry out a pedestrian level wind microclimate assessment for the proposed redevelopment of the former Chivers Factory Site, Coolock Drive, Coolock.

The assessments conclusions are sumarised are follows:

- Pedestrian comfort is achieved in all areas of the site in summer;
- In winter, the site is subject to higher and more frequent winds from the southwest which means pedestrian areas in-between Block B and Block C, in-between Block A1 and Block A2, and areas at the west corner of the service building have higher than desirable wind speeds;
- A limited number of areas of the site were identified as being uncomfortable for pedestrians in the **worst-case** winter season. These were identified to be south of the pedestrian spaces in-between Block B and Block C, and the southern corner of Block C;
- No areas of the site exceed the Lawson distress threshold for able-bodied pedestrians;
- There are areas that receive less frequent winds that exceed the 15m/s distress threshold for vulnerable pedestrians:
    - South of the pedestrian areas in-between Block B and Block C;
    - The pedestrian areas in-between Block A1 and Block A2;
    - West corner of the service building; and
    - Small areas at the southernmost corner of the site.
- The distress threshold wind speed of 15m/s for vulnerable pedestrians was found to occur for no more than 5 hours annually in the worst case area i.e. South area in-between Block B and Block C.

However, with the introduction of the proposed landscape masterplan, it is expected all pedestrian spaces outlined above to be safe for their purpose of use.

1.0 INTRODUCTION

METEC Consulting Engineers have been instructed by our client, Platinum Land Ltd, to carry out a pedestrian level wind microclimate assessment for the proposed redevelopment of the former Chivers Factory Site, Coolock Drive, Coolock. The methodology used in the study is presented in Section 2 Study Methodology with further details in Appendix C CFD Modelling Methodology. Section 3 Results of the Assessment gives results of Pedestrian Comfort and Pedestrian Distress. Pedestrian level wind speed plots are given in Appendix B Additional Wind Data. A summary of the assessment and findings are presented in Section 4 Summary.

2.0 STUDY METHODOLOGY

2.1 LAWSON PEDESTRIAN COMFORT AND DISTRESS CRITERIA

This study uses the Lawson Pedestrian Comfort and Pedestrian Distress [1] criteria to assess the wind microclimate at pedestrian level for the proposed Chivers site redevelopment.

The pedestrian comfort criteria given in Table 1 quantify a person’s comfort or discomfort due to the wind based on their activity. The criteria gives an hourly average wind speed threshold that must not be exceeded for more than 5% of the assessment period. In this study, assessments covering the summer, winter, autumn and spring periods, plus a whole year were undertaken. The report provides results of the summer assessment and the winter (worst case seasonal) assessment.

Comfort Rating	Threshold Speed	Exceedance Time
Uncomfortable	10 m/s	> 5 %
Business walking	10 m/s	<= 5%
Strolling	8 m/s	<= 5%
Standing	6 m/s	<= 5%
Long-term sitting	4 m/s	<= 5%

Table 1: Lawson Pedestrian Comfort Criteria

Usage	Description	Target
Outdoor seating	For long periods of sitting such as for an outdoor café / bar	'Long-term sitting' in summer
Entrances, waiting areas, shop fronts	For pedestrian ingress / egress at a building entrance / window shopping, or short periods of sitting or standing such as at a bus stop, taxi rank, meeting point, etc.	'Standing' in all seasons
Recreational spaces	For outdoor leisure uses such as a park, children's play area, etc.	'Strolling' from spring through autumn
Leisure Thoroughfare	For access to and passage through the development and surrounding area	'Strolling' in all seasons
Pedestrian Transit (A-B)	For access to and passage through the development and surrounding area	'Business walking' in all seasons

Table 2: Recommended Target Comfort Rating for Different Public Space Usage

Distress Rating	Threshold Speed
Unsuitable for General Public (this covers vulnerable pedestrians, e.g. the elderly, children and cyclists)	15 m/s
Unsuitable for Able-Bodied	20 m/s

Table 3: Lawson Pedestrian Distress Criteria

2.2 ACCOUNTING FOR THE EFFECT OF GUSTS

Pedestrian comfort and pedestrian distress are not only affected by the mean wind velocity but also by shorter timescale wind gusts due to the turbulent nature of wind. Therefore, in this study wind gust speed is accounted for by calculating the equivalent mean wind speed, considering the standard deviation of the mean wind speed, in particular the turbulent kinetic energy, k:

$$\sigma_U = \sqrt{k * {}^{2}/_{3}}$$

Based on the work of Melbourne [4], the peak gust wind speed is derived as:

$$\ddot{U} = U_{MEAN} + 3.5\sigma_U$$

And the Gust Equivalent Mean (GEM) is derived as:

$$U_{GEM} = \ddot{U}/1.85$$

2.3 MODEL GEOMETRY

Figure 1 shows the CFD model geometry used in the study. The geometry of the surroundings and terrain were built from aerial photographs taken in 2018 using photogrammetry techniques to digitise points that define the geometry over which a surface mesh was generated. Further details of the CFD geometry, mesh and solution method are given in Appendix C: CFD Modelling Methodology.

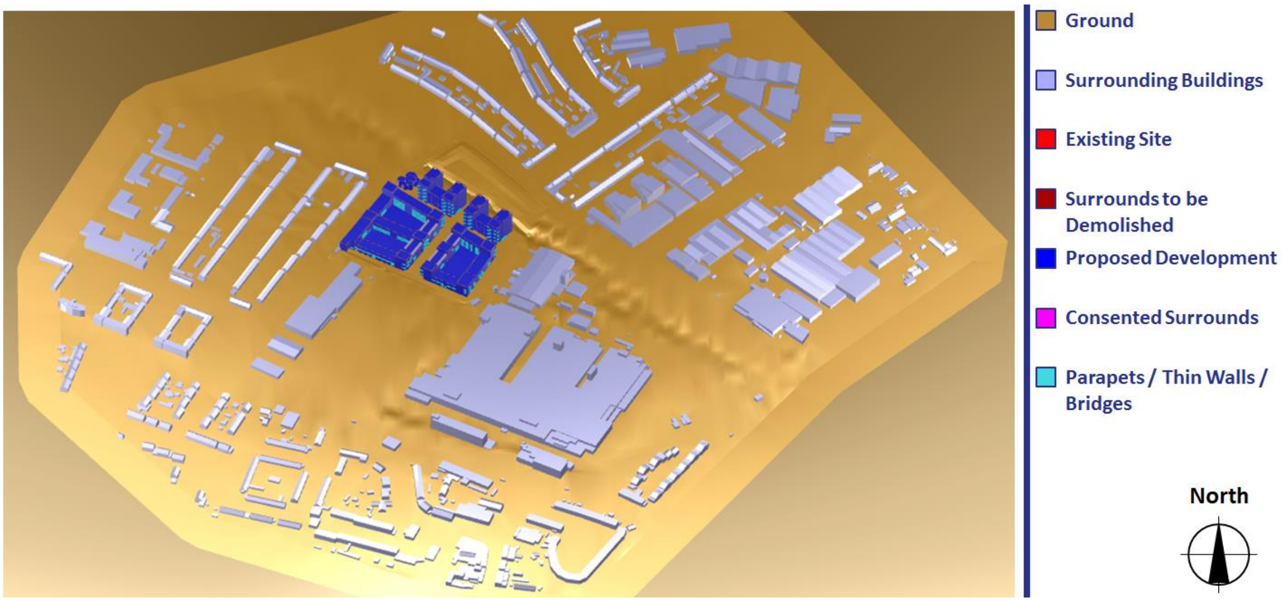

Figure 1: CFD Model Geometry

2.4 SITE AND SURROUNDINGS

An aerial view of the Chivers site and surrounding terrain can be seen in Figure 2. In the top left of Figure 2 is Dublin airport from which the weather data set used in this study was sourced.

The site, located along Coolock Drive, Dublin, is surrounded by low-rise residential housing and warehouse buildings. There are open areas to the north across the Santry River, and to the south to the Oscar Traynor Road.

Figure 2: Site Location

Figure 3 shows the extent of the redevelopment site within its immediate surroundings. The area north of the river Santry will be landscaped but will be without buildings.

Figure 3: Extent of the Proposed Redevelopment Site

Figure 4: Site Layout Plan

Figure 4 shows the site layout plan for the proposed redevelopment of the former Chivers Factory Site.

2.5 SITE WIND MICROCLIMATE ASSESSMENT

Figure 5 and Figure 6 show wind roses for the Chivers Site at the reference height of 100m for the summer and winter periods. Additionally, annual, spring and autumn period wind roses are shown in Appendix B Additional Wind Date.

The wind roses were calculated using wind data from Dublin Airport (USAF-WBAN_ID STATION: 039690 99999 DUBLIN) between January 1998 and December 2018 adjusted for the site location based on terrain analysis using the EDSU methodology [6].

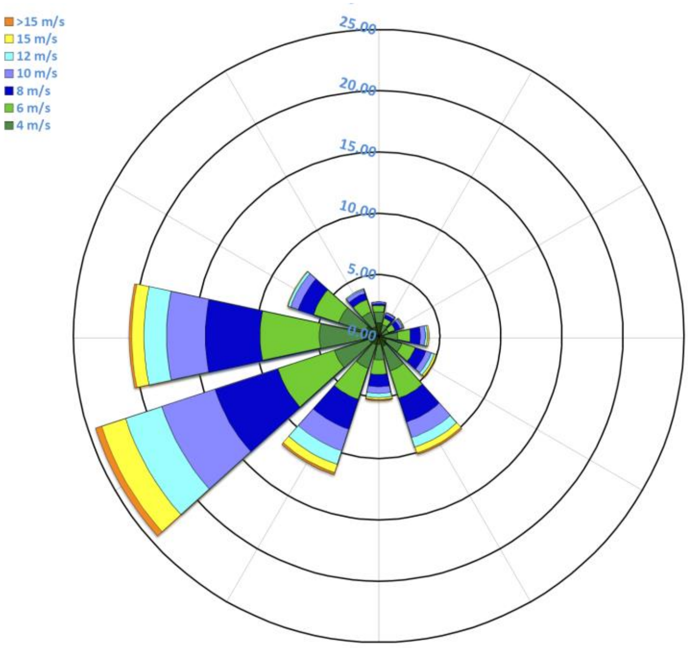

Figure 5: Winter Period Wind Rose at Reference Height for the Chivers Site, Dublin

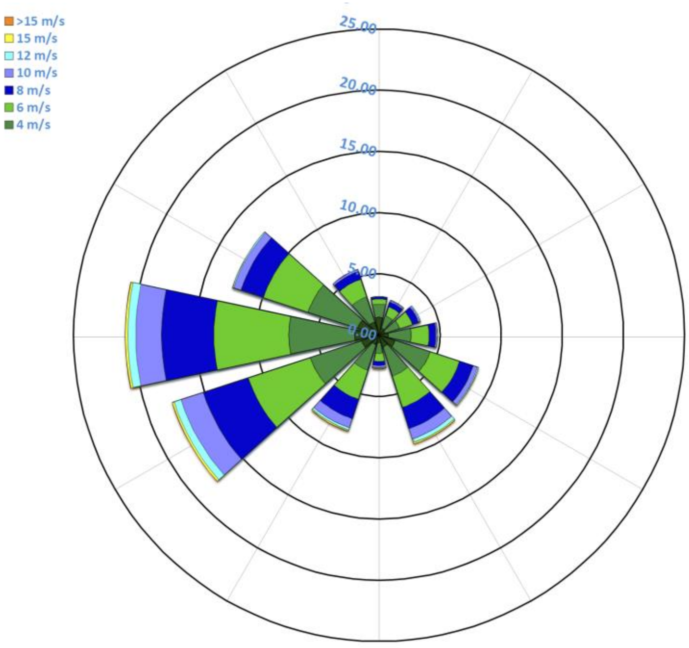

Figure 6: Summer Period Wind Rose at Reference Height for the Chivers Site, Dublin

3.0 RESULTS OF THE ASSESSMENT

The main body of the report contains results for Pedestrian Comfort and Pedestrian Distress. Additionally, plots of velocity ratio for each of the 12 wind directions modelled are provided in Appendix A Velocity Ratio.

3.1 PEDESTRIAN COMFORT

Figure 7 shows a plot of Pedestrian Comfort rating at 1.5m above ground level for the worst seasonal conditions, which at this site occurs during winter. Figure 8 shows a plot of Pedestrian Comfort for the summer period.

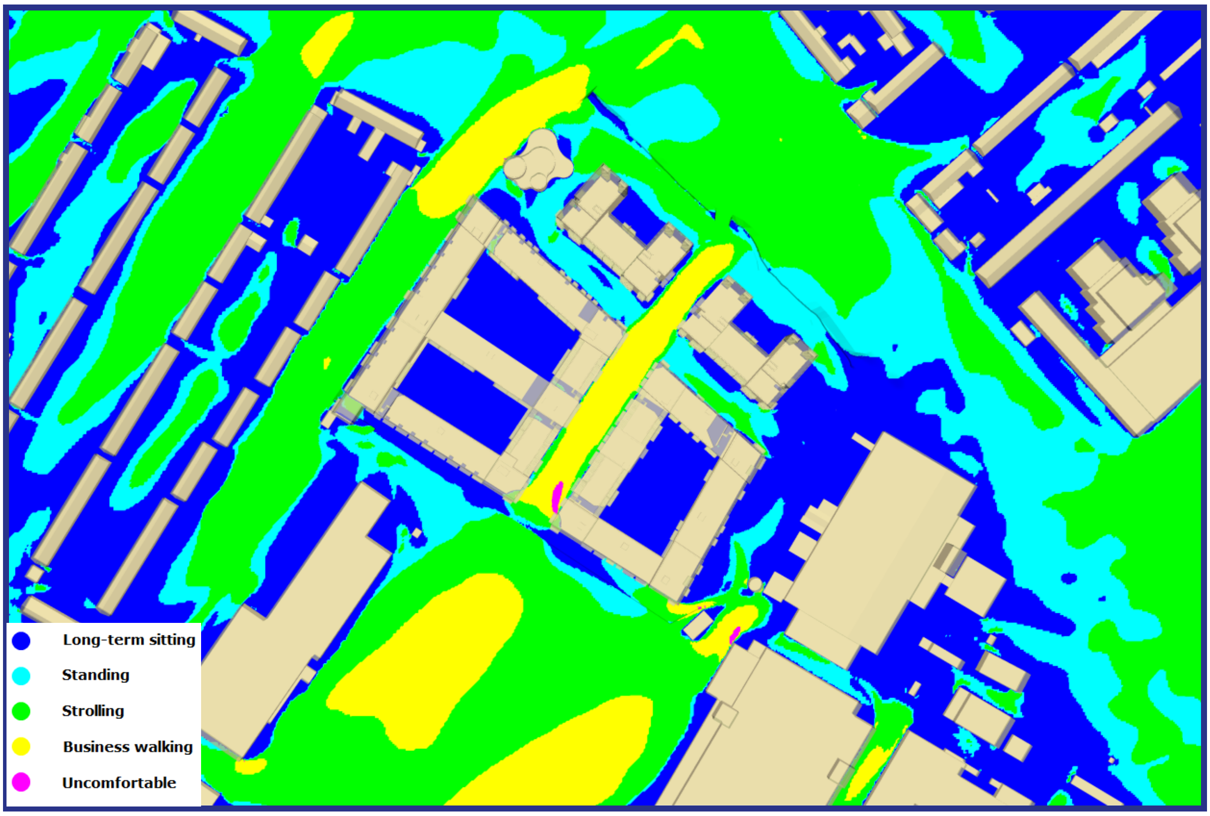

Figure 7: Pedestrian Comfort Rating for Worst Seasonal Conditions

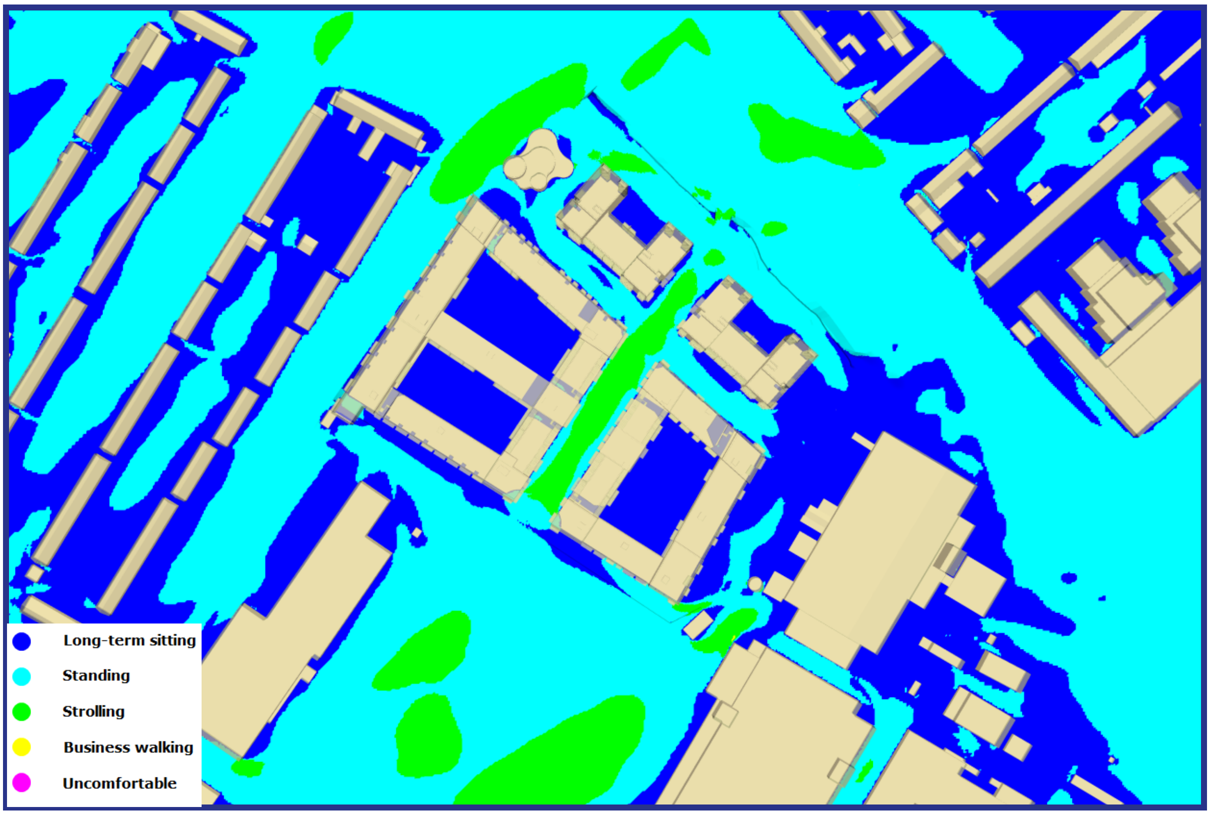

Figure 8: Pedestrian Comfort Rating for Summer Period

3.2 PEDESTRIAN DISTRESS

Figure 9 shows a plot of Pedestrian Distress Rating at 1.5m above ground level, where the Lawson Pedestrian Distress Criteria are exceeded for 1 hour (or more) per year.

Figure 9: Pedestrian Distress Rating

Note: the General Public Distress Rating covers vulnerable pedestrians, e.g. the elderly, children and cyclists.

Figure 10 shows a plot of where the mean wind speed exceeds 15m/s and the amount of time in hours that this wind speed occurs annually.

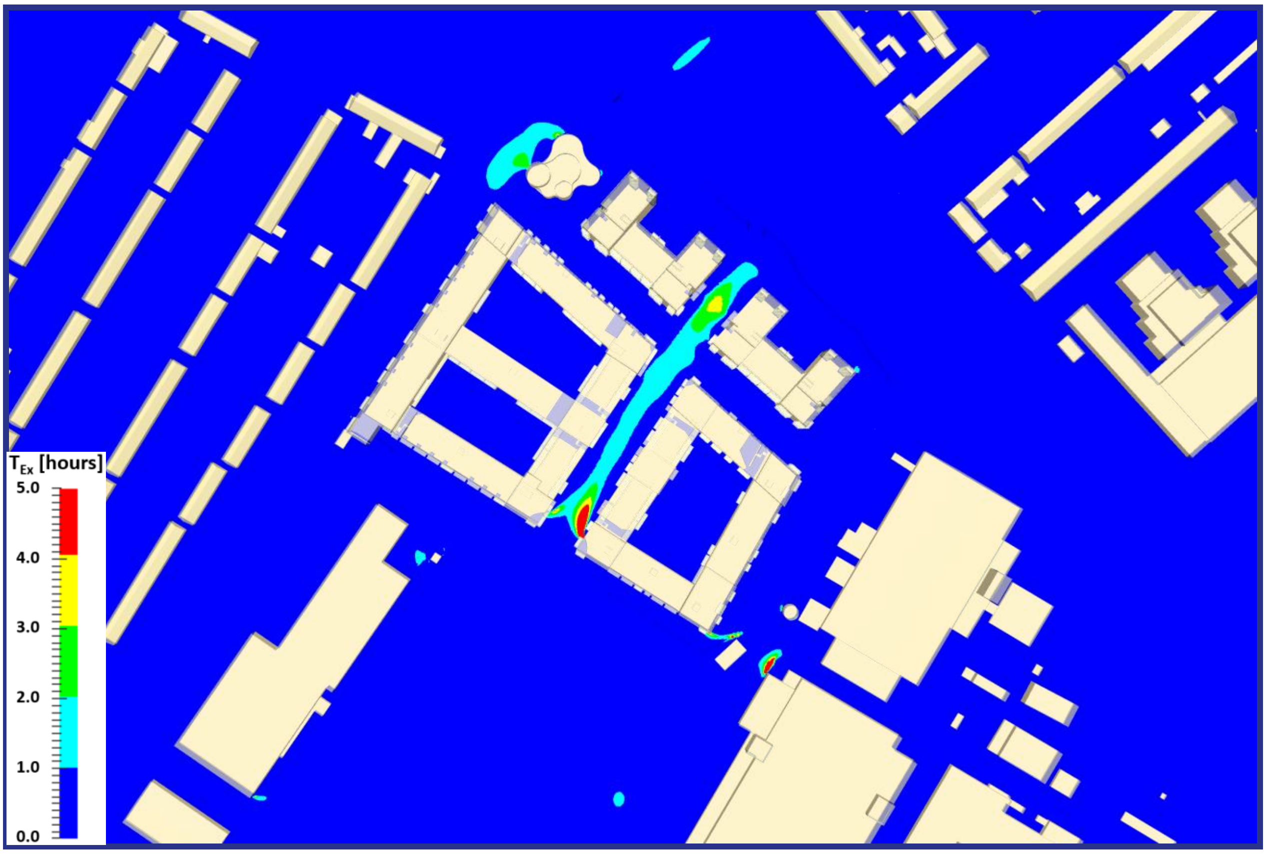

Figure 10: 15m/s Mean Wind Speed Exceedance Time

4.0 SUMMARY

4.1 PEDESTRIAN COMFORT

The wind microclimate assessment for the proposed development has identified the following regarding pedestrian comfort.

- All internal courtyard spaces were assessed as suitable for 'Long-term sitting' in both winter and summer periods;
- Pedestrian comfort is achieved in all areas of the site in summer and is assessed as suitable for 'Strolling' or better in all regions;
- In winter, pedestrian areas in-between Block B and Block C, in-between Block A1 and Block A2, and areas at the west corner of the GYM, Creche, and Café building (along Coolock Drive) are assessed as suitable for 'Business Walking'. These are areas where pedestrians will not want to linger during the winter season;
- A limited number of areas of the site were identified as being uncomfortable for pedestrians in the **worst-case** winter season. These were identified to be south of the pedestrian spaces in-between Block B and Block C, and the southern corner of Block C;
- However, with the introduction of the proposed landscape masterplan, it is expected that all pedestrian spaces outlined above will have improved comfort levels and to be suitable for their purpose of use.

4.2 PEDESTRIAN DISTRESS

With regards to pedestrian distress, the assessments key findings are as follows.

- All internal courtyard spaces were assessed as having no issues with Pedestrian Distress;
- No areas of the site exceed the Lawson distress threshold for able-bodied pedestrians;
- A limited number of locations of the site are expected to be unsuitable for more vulnerable pedestrians (e.g. the elderly, children and cyclists) in the following locations:
  - South of the pedestrian areas in-between Block B and Block C;
  - The pedestrian areas in-between Block A1 and Block A2;
  - West corner of the service building; and
  - Small areas at the southernmost corner of the site.
- The distress threshold wind speed of 15m/s for vulnerable pedestrians was found to occur for no more than 5 hours annually in the worst case area i.e. South area in-between Block B and Block C.

However, with the introduction of the proposed landscape masterplan, it is expected all pedestrian spaces outlined above to be safe for their purpose of use.

4.3 ENTRANCES

The entrances to the Proposed Development are expected to be suitable for the intended use. Entrances on the eastern facades of Block B and Block A1, western facades of Block C and A2, and western façade of the service building are in regions where air speeds are greater than desired in the winter season. Although, the recessed nature of the entrances across the site mean it is expected that wind conditions near to the entrances are suitable for the intended use.

4.4 FUTURE DEVELOPMENT ON ADJOINING Z6 LANDS

An overall potential masterplan has been developed by the project architects which allows for future development of the adjoining Z6 lands (see Figure 28 in Appendix D Potential Masterplan). If this future development occurs, the buildings to the south will act to shelter the Chivers Site redevelopment from the more frequent, and in winter stronger, winds from the southwest quadrant. Thus, it is anticipated that further development in line with the masterplan will have a positive effect on pedestrian comfort and distress. It is recommended that should development on the adjoining Z6 lands be proposed that a wind microclimate study be undertaken to determine the effects on pedestrian comfort and distress.

APPENDIX A – VELOCITY RATIO

Figure 11 to Figure 22 show contour plots of velocity magnitude ratio in and around the proposed redevelopment site for each of the 12 wind direction modelled. The velocity magnitude is calculated by dividing the local air speed by the reference air speed: the wind speed at 100m above ground level at the start of the explicitly modelled inner area of the domain as calculated by terrain and wind profile analysis using the EDSU methodology [6].

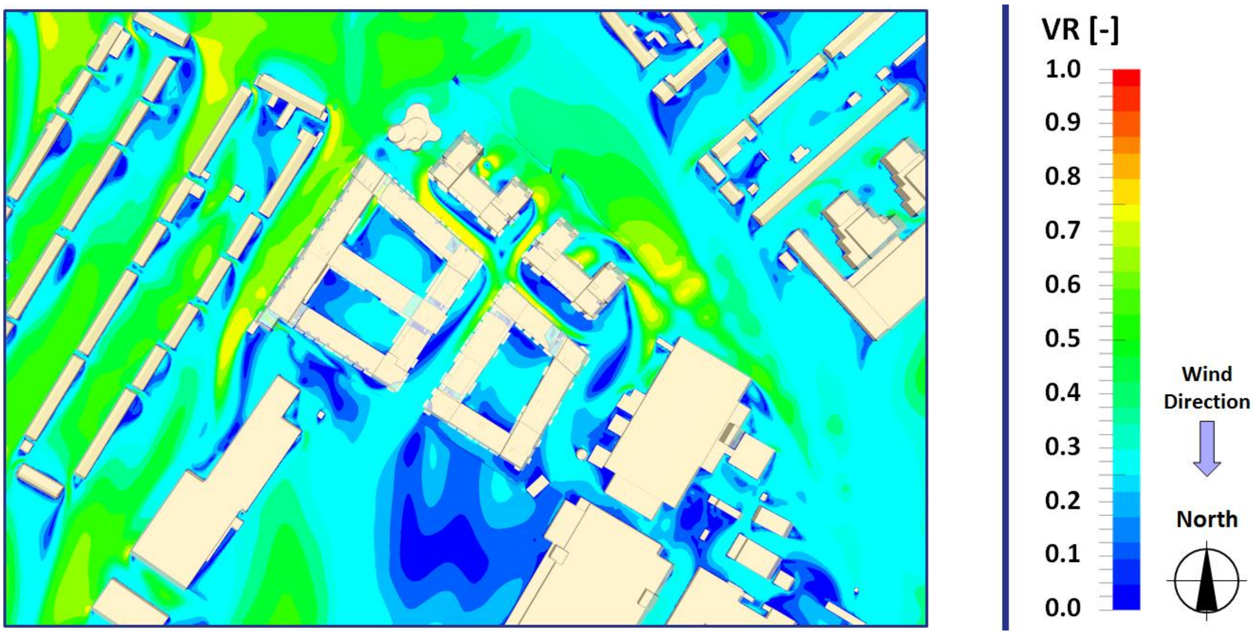

Figure 11: Velocity Ratio, Wind Direction of 0 Degrees (Northerly)

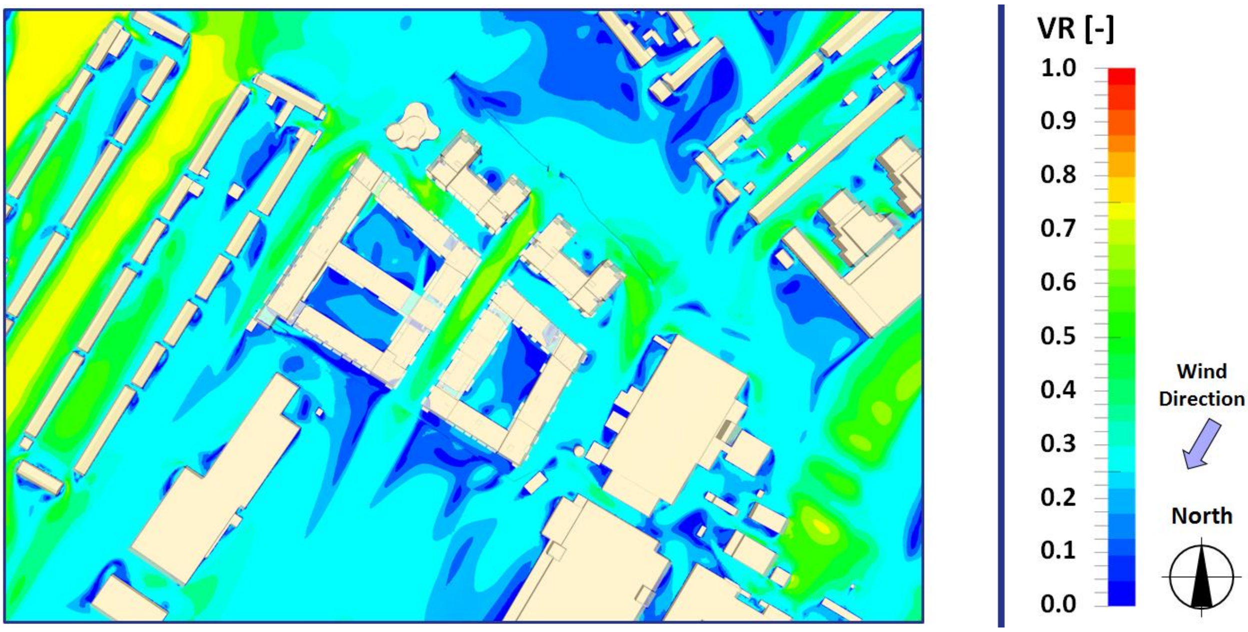

Figure 12: Velocity Ratio, Wind Direction of 30 Degrees

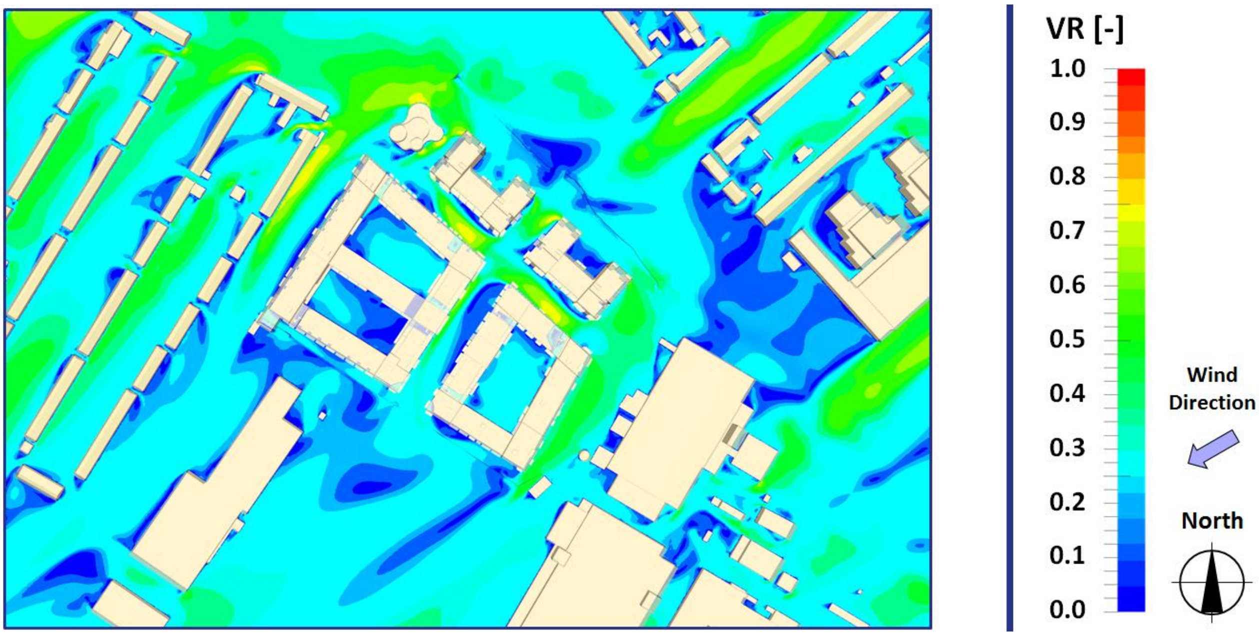

Figure 13: Velocity Ratio, Wind Direction of 60 Degrees

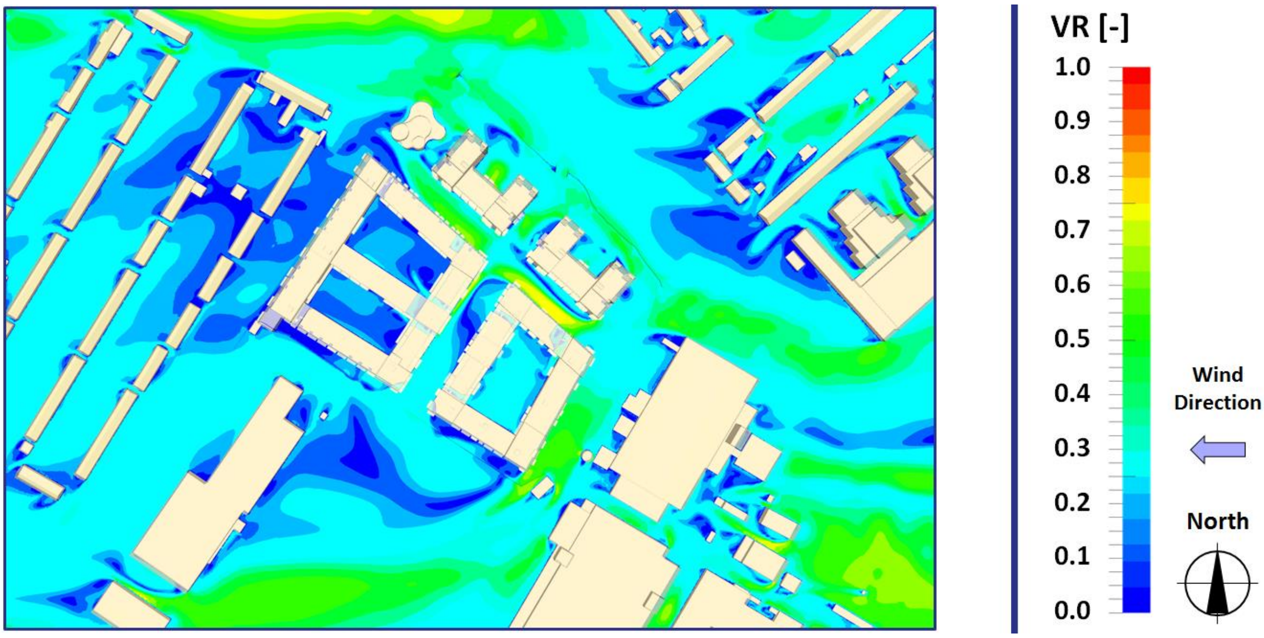

Figure 14: Velocity Ratio, Wind Direction of 90 Degrees (Easterly)

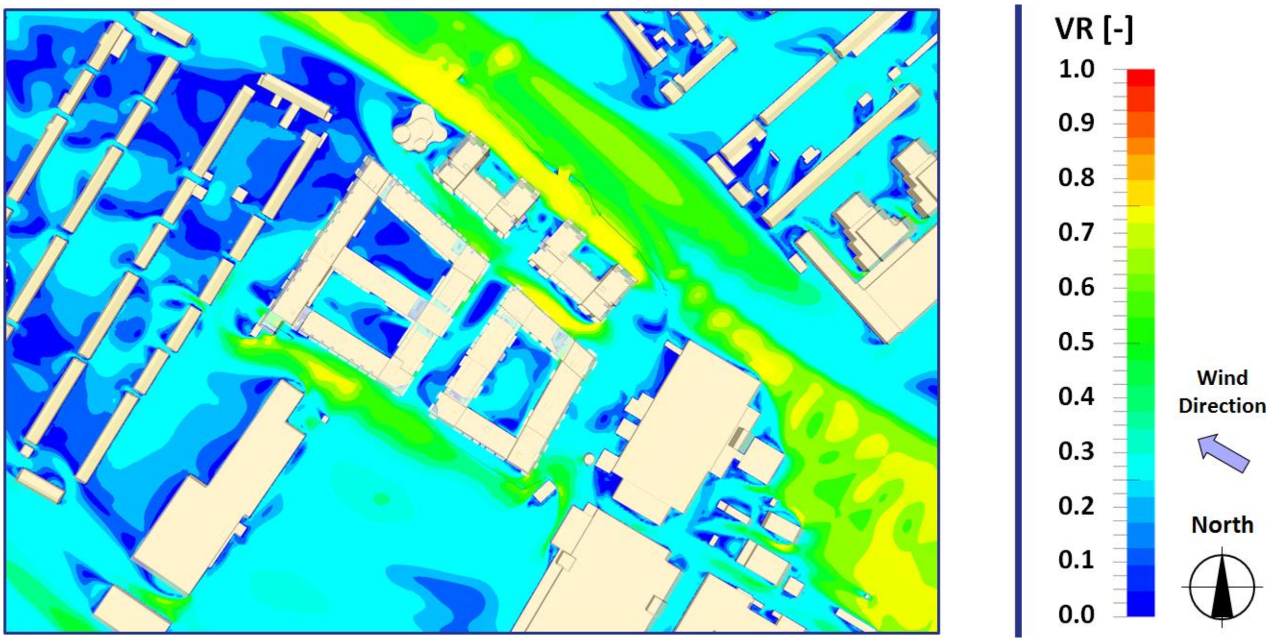

Figure 15: Velocity Ratio, Wind Direction of 120 Degrees

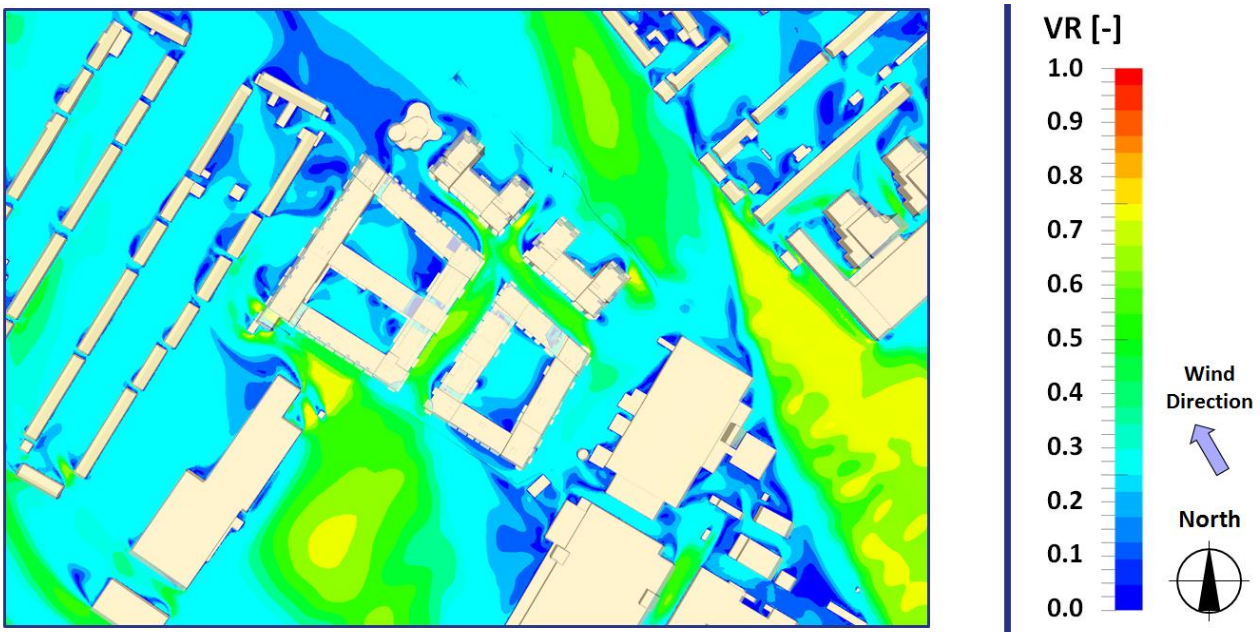

Figure 16: Velocity Ratio, Wind Direction of 150 Degrees

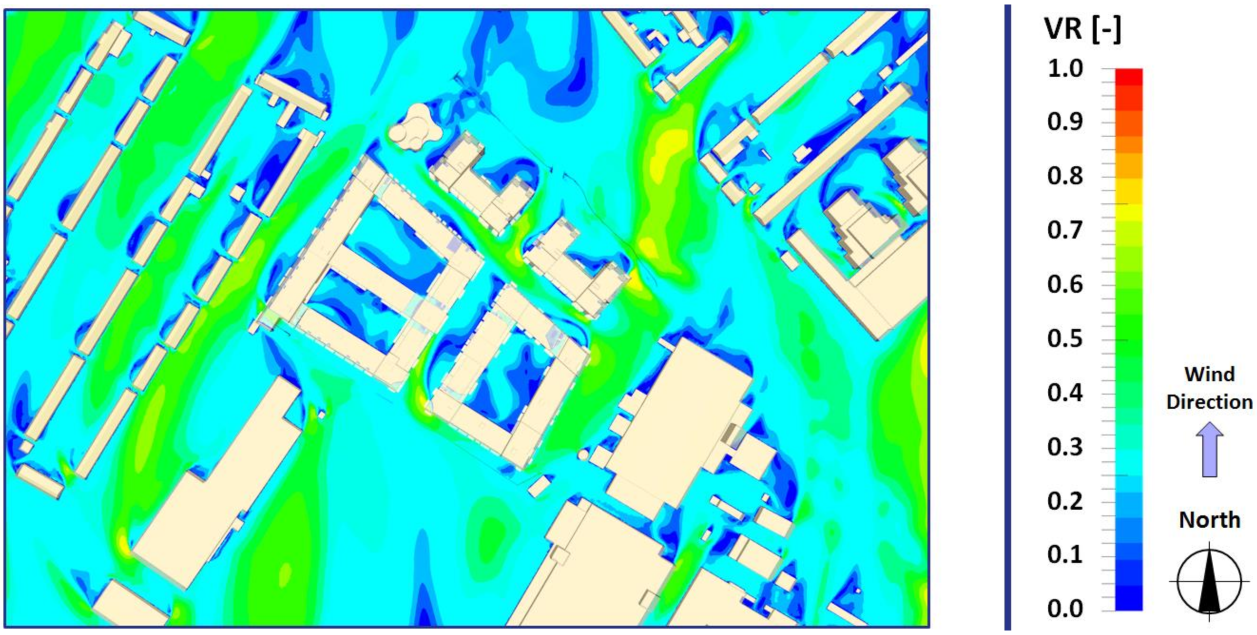

Figure 17: Velocity Ratio, Wind Direction of 180 Degrees (Southerly)

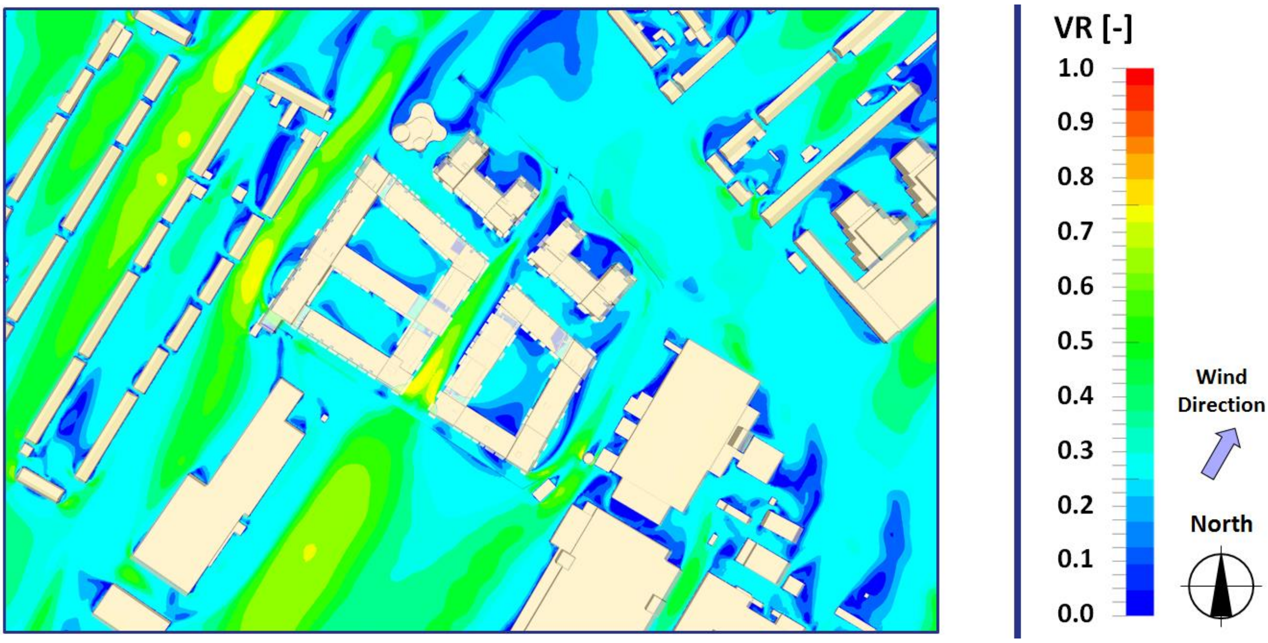

Figure 18: Velocity Ratio, Wind Direction of 210 Degrees

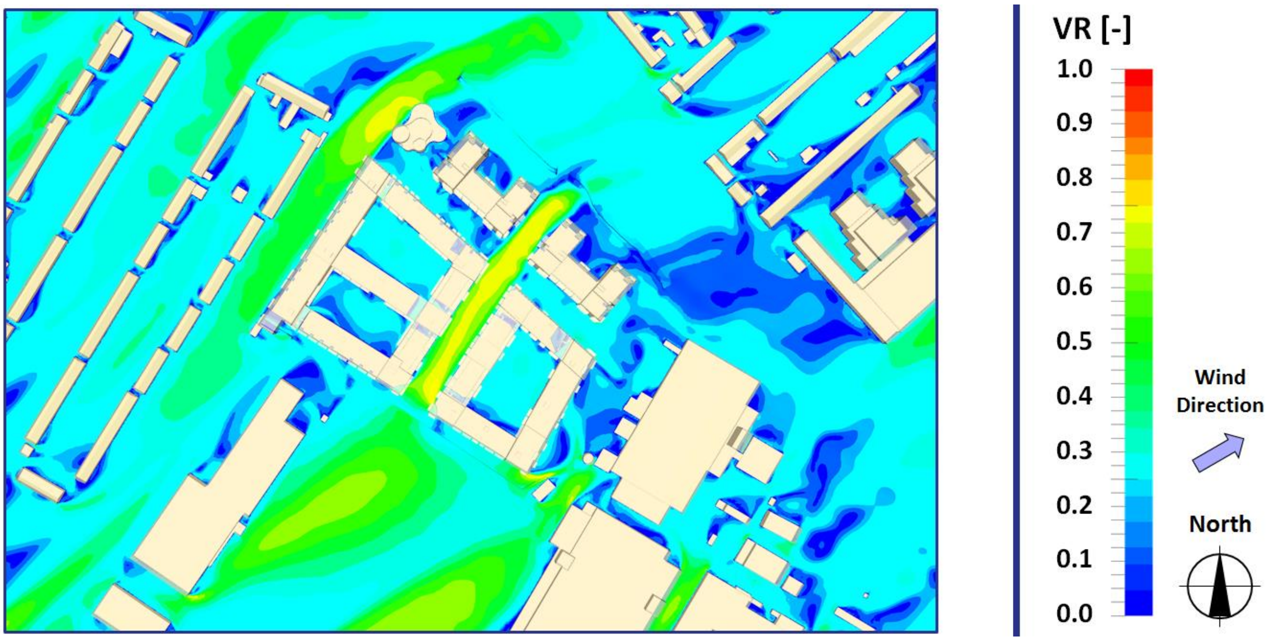

Figure 19: Velocity Ratio, Wind Direction of 240 Degrees

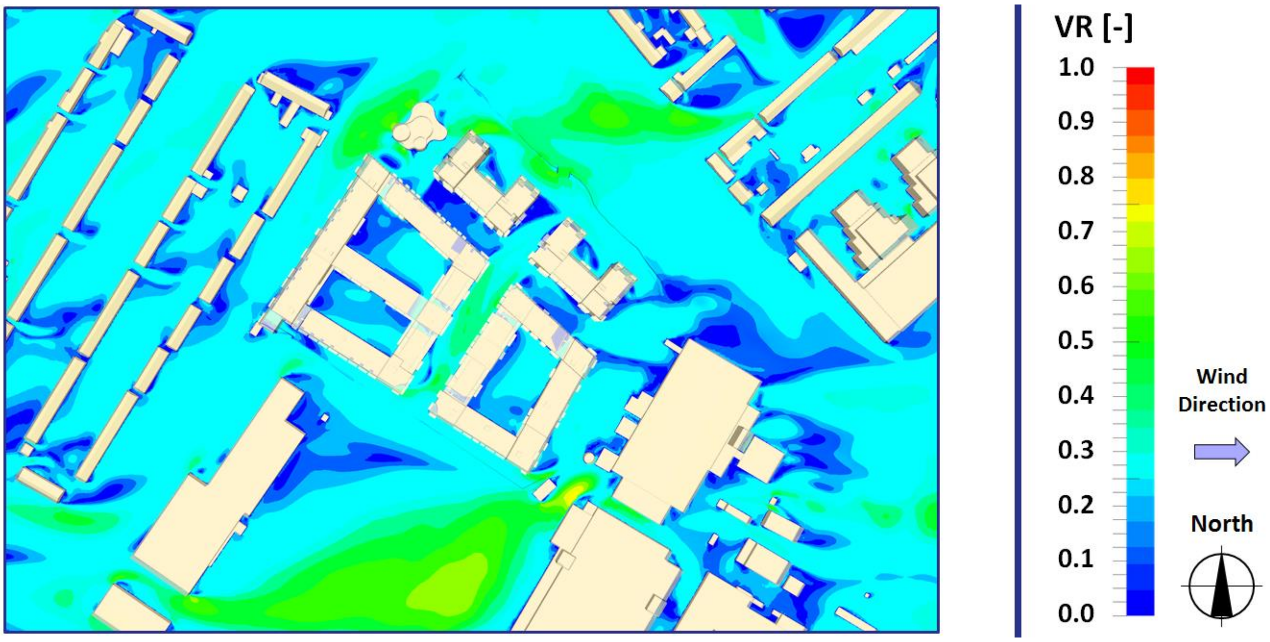

Figure 20: Velocity Ratio, Wind Direction of 270 Degrees (Westerly)

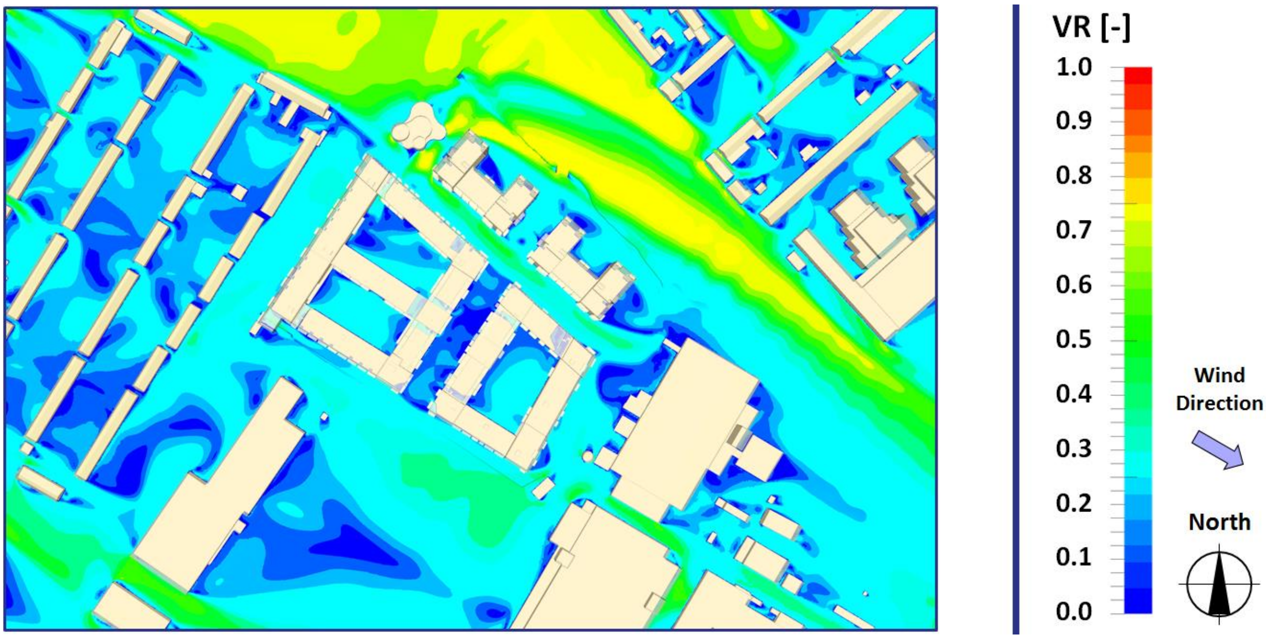

Figure 21: Velocity Ratio, Wind Direction of 300 Degrees

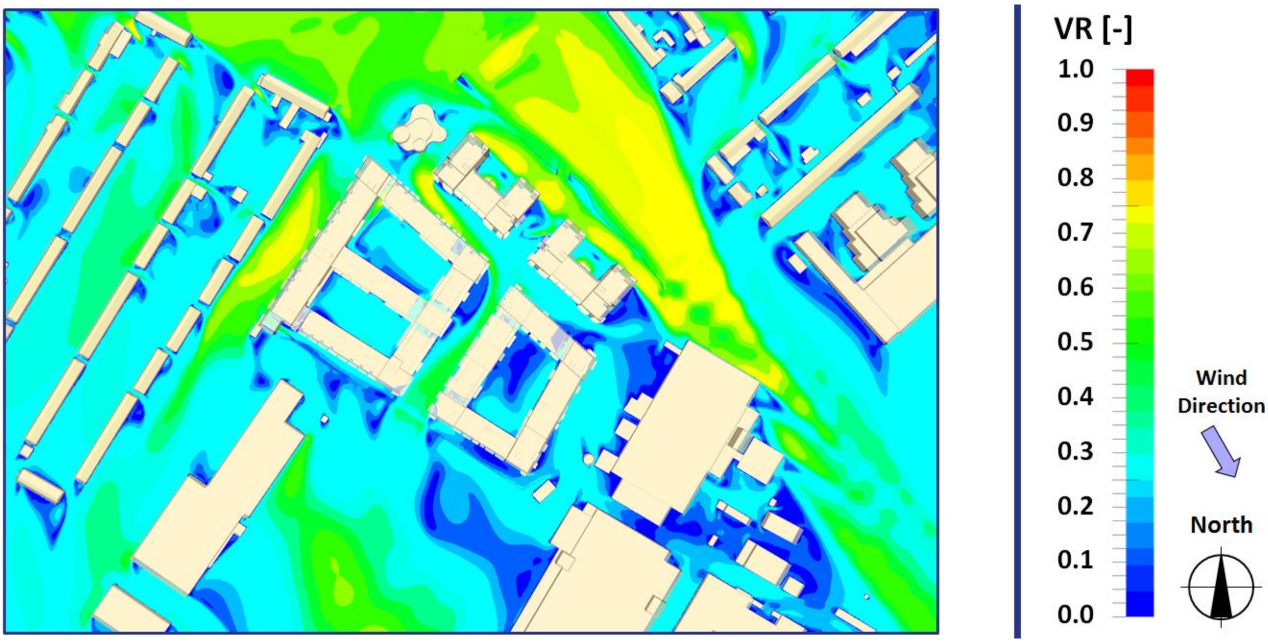

Figure 22: Velocity Ratio, Wind Direction of 330 Degrees

APPENDIX B – ADDITIONAL WIND DATA

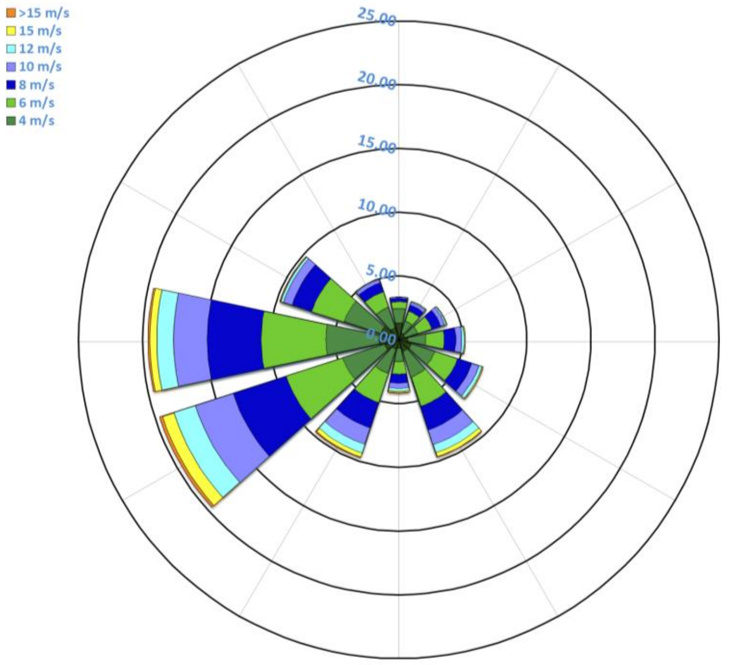

Figure 23: Annual Wind Rose at Reference Height for the Chivers Site, Dublin

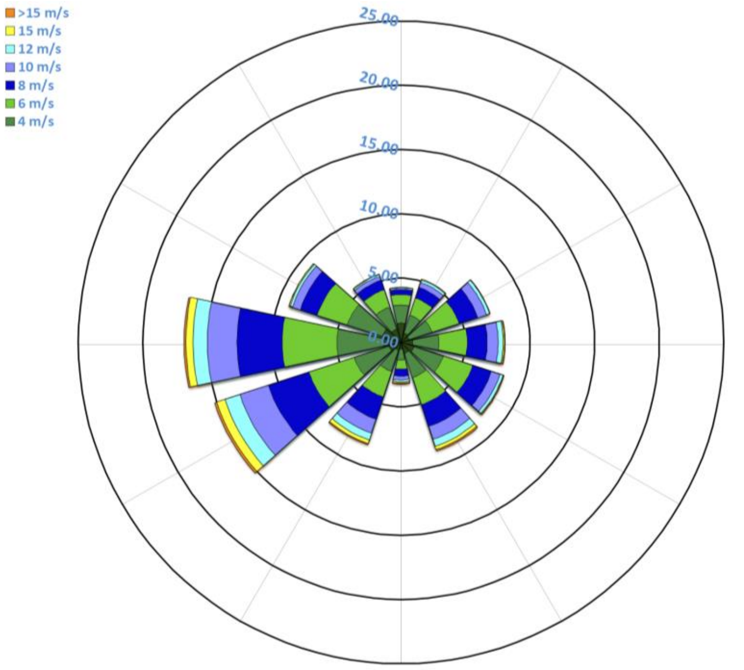

Figure 24: Spring Period Wind Rose at Reference Height for the Chivers Site, Dublin

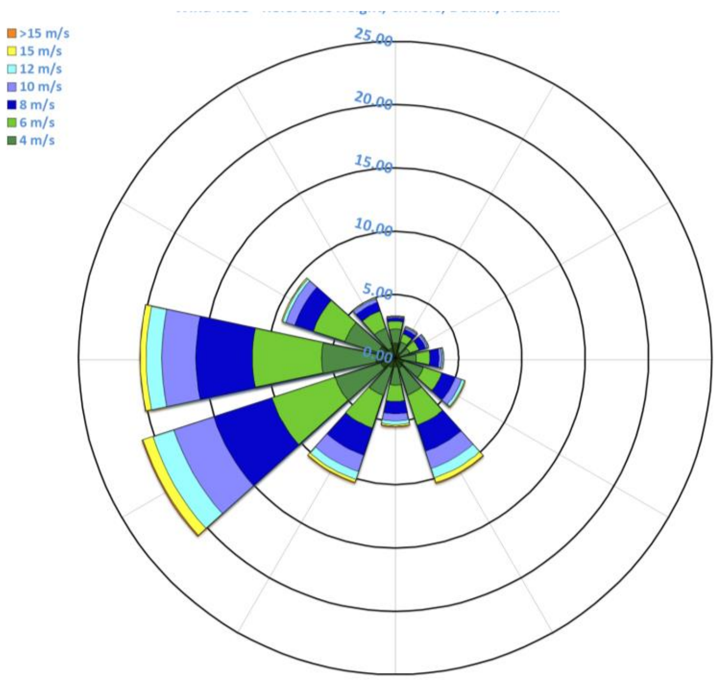

Figure 25: Autumn Period Wind Rose at Reference Height for the Chivers Site, Dublin

APPENDIX C – CFD MODELLING METHODOLOGY

GENERAL:

The multi-purpose CFD software OpenFoam® (www.openfoam.com, version 2.0) was used for the wind environment simulations. A total of 12 steady state atmospheric boundary layer simulations were completed for the assessment, covering 360 degrees of approaching winds, with a wind sector increment of 30 degrees.

SPATIAL DISCRETIZATION:

The spatial discretization of the 3D model was completed with snappyHexMesh utility, part of the CFD code OpenFoam®. Computational meshes, consisting of approximately 14 million hexahedral and polyhedral elements, were constructed for one site configuration: the proposed development within the existing surrounds

The generated numerical grids are shown in Figure 26 and Figure 27. The computational domain included the proposed development site, the surrounding buildings and terrain explicitly modelled to approximately 500 m from the development, 1000 m in radius ground surface and the outer boundaries (side and upper at 1000 m height from the ground).

The base cell size in the numerical grid was defined to 25.0 m. The refinement level increased to 0.1 m in the zone closest to the proposed site, in order to capture the detailed geometrical features. Additionally, 5 prism surface layers were introduced to all pedestrian ground level surfaces, with the first layer height of approximately 0.15 m.

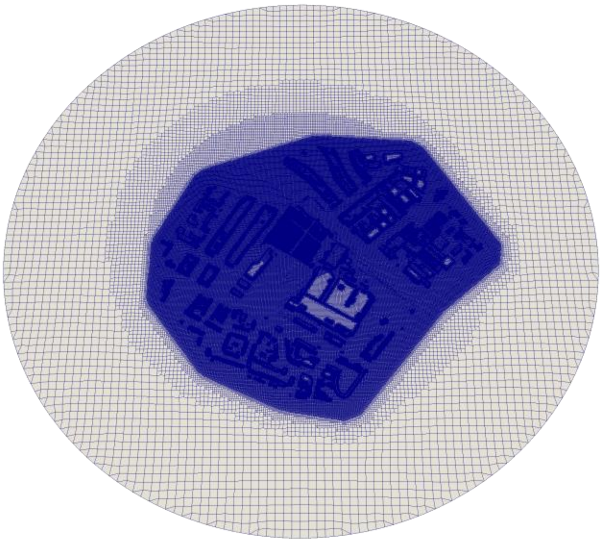

Figure 26: Spatial Discretization

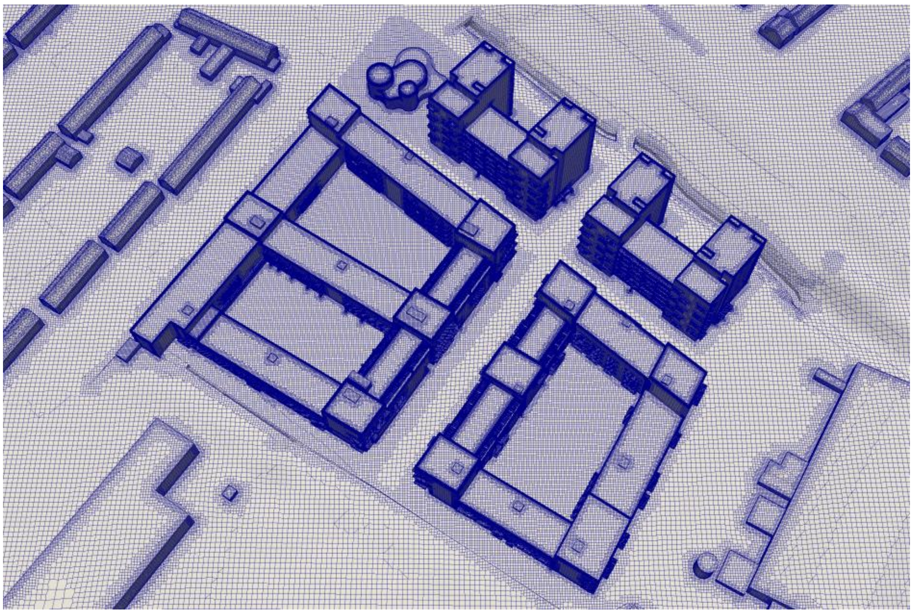

Figure 27: Spatial Discretization, Close-up View of Buildings in Proposed Development

SOLUTION METHOD:

The RANS (Reynolds-averaged Navier–Stokes) CFD simulations were performed using the simpleFoam solver. The modelling of an incompressible fluid flow was completed using the semi-implicit method for pressure-linked equations (SIMPLE) algorithms. The resulted flow turbulent features were modelled using the Shear Stress Transport (SST) k-ω turbulence model. This model by Menter [2] and is based on a two-equation eddy-viscosity approach, where the SST model formulation combines the use of a k-ω in the inner parts of the boundary layer, but also switches to a k-ε behaviour in the free-stream regions of the solutions. Further details for the selected turbulence model are provided in the work of Menter [3].

BOUNDARY CONDITIONS:

The atmospheric boundary layer flow was simulated by implementing a logarithmic velocity profile model presented by Richards and Hoxey [4], with the following main assumptions:

- The vertical velocity component at the domain boundary is negligible;
- The pressure gradient and shear stress are constant.

The model implies the following equation for the mean inlet velocity at the CFD domain:

$$U(z) = \frac{U^*}{\kappa} ln\left(\frac{z + z_0}{z_0}\right)$$

where:

κ - is the von Karman's constant;

z - is the distance from the ground surface in vertical direction;

z_o - is the ground surface roughness length in meters.

The friction velocity U* is calculated by the following equations:

$$U^* = \kappa \frac{U_{ref}}{ln\left(\frac{z_{ref} + z_0}{z_0}\right)}$$

where:

z_{ref} – is the reference height in meters;

U_{ref} - is the reference velocity in m/s measured at z_{ref}.

The turbulent velocity fluctuations at the domain inlet are induced by the constant shear stress with height, maintained by the turbulent kinetic energy k:

$$k(z) = \frac{U^{*2}}{\sqrt{C_\mu}}$$

where:

$C\mu = 0.09$ - is the usual k-ε turbulence model constant.

Within the inner region of the domain (i.e. where the development, surrounding buildings and terrain were modelled) all surface boundary conditions were modelled as smooth walls with a no-slip condition. On the surface representing the ground in the outer region of the domain (i.e. the region without explicitly modelled building geometry) a no-slip wall boundary condition with a varying roughness length based on the terrain analysis for that region was applied.

APPENDIX D – POTENTIAL MASTERPLAN

Figure 28: Potential Masterplan Drawing Showing Development of the Adjoining Z6 Lands

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[1] Lawson T.V. (2001), Building Aerodynamics, Imperial College Press

[2] Menter F., (1993), Zonal Two Equation k-ω Turbulence Models for Aerodynamic Flows, AIAA Paper 93-2906

[3] Menter F., (2011), Turbulence Modelling for Engineering Flows, ANSYS Inc.

[4] Richards, P.J. and Hoxey, R.P., Appropriate boundary conditions for computational wind engineering models using the k-ε turbulence model, Journal of Wind Engineering and Industrial Aerodynamics, vol. 46 & 47, pp. 145-153, 1993

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[6] ESDU (Engineering Science Data Unit) Item 01008. Computer Program for Wind Speeds and Turbulence Properties: Flat or Hilly Sites in Terrain with Roughness. 2001